

## VIRESCENT RENEWABLE ENERGY TRUST

(Registered in the Republic of India as an irrevocable trust set up under the Indian Trusts Act, 1882 and registered as an infrastructure investment trust under the Securities and Exchange Board of India (Infrastructure Investment Trusts) Regulations, 2014, as amended, ("SEBI InvIT Regulations") on February 25, 2021 having registration number IN/InvIT/20-21/0018)

**Principal place of business:** 2<sup>nd</sup> Floor, Piramal Tower, Peninsula Corporate Park, Lower Parel, Mumbai-400 013, Maharashtra;  
**Tel:** +91 98205 50707; **Compliance Officer:** Ms. Charmy Bhoot  
**E-mail:** invit@virescent.co.in; **Website:** www.virescent.co.in

**Sponsor**  
Terra Asia Holdings II Pte. Ltd.

**VIRESCENT**  
INFRASTRUCTURE  
**Investment Manager**  
Virescent Infrastructure Investment Manager Private  
Limited

**AXIS TRUSTEE**  
**Trustee**  
Axis Trustee Services Limited

Virescent Renewable Energy Trust ("Terra InvIT") is proposing an initial offer by way of fresh issue of up to 4,60,00,000 Units\* through a private placement at a price of ₹100 per Unit (the "Issue Price"), aggregating up to ₹46,00,000 lakhs (the "Issue").

\*subject to allotment of units by the board of directors of the Investment Manager

### THE ISSUE IS BEING MADE ONLY TO THE ELIGIBLE INVESTORS IN RELIANCE UPON REGULATION 14(2) OF THE SEBI INVIT REGULATIONS.

The Units are proposed to be listed on the National Stock Exchange of India Limited (the "NSE" or the "Stock Exchange"). In-principle approval for listing of the Units has been received from the NSE on August 6, 2021. NSE is the Designated Stock Exchange. Applications shall be made to the Stock Exchange for obtaining the final listing and trading approval for the Units to be Allotted pursuant to the Issue. The Stock Exchange assumes no responsibility for the correctness of any statements made, opinions expressed or reports contained herein. Admission of the Units to be Allotted pursuant to the Issue for trading on the Stock Exchange should not be taken as an indication of the merits of the Terra InvIT or of the Units.

A copy of the Draft Placement Memorandum, the Placement Memorandum and this Final Placement Memorandum has been delivered to the Securities and Exchange Board of India (the "SEBI") and the Stock Exchange. This Final Placement Memorandum has not been, and will not be, registered as a prospectus, will not be circulated or distributed to the public at large in India or any other jurisdiction, and will not constitute a public offer in India or any other jurisdiction.

This is an initial offer of Units by way of fresh issue and there is no pre-existing formal market for the Units. The Issue Price (determined in accordance with the SEBI InvIT Regulations by the Investment Manager in consultation with the Lead Manager), should not be taken to be indicative of the market price of the Units, after the Units are listed. No assurance can be given regarding an active or sustained market for trading in the Units or regarding the price at which the Units will be traded after listing.

The Investment Manager, having made all reasonable inquiries confirms that this Final Placement Memorandum contains all information with regard to the Terra InvIT, the Units and the Issue, which is material in the context of the Issue, that the information contained in this Final Placement Memorandum is true, correct and adequate in all material aspects and is not misleading in any material respect, that the opinions and intentions expressed herein are honestly held and have been reached after considering all relevant circumstances and are based on reasonable assumptions and information presently available with the Investment Manager and that there are no other facts, the omission of which makes this Final Placement Memorandum as a whole or any of such information or the expression of any such opinions or intentions misleading in any material respect.

The Units have not been and will not be registered under the United States Securities Act of 1933, as amended (the "Securities Act") and may not be offered or sold within the United States except pursuant to an exemption from, or in a transaction not subject to, the registration requirements of the Securities Act and applicable U.S. state securities laws. Accordingly, the Units are being offered and allotted outside the United States in offshore transactions in reliance on Regulation S under the Securities Act ("Regulation S") and applicable law of the jurisdictions where such offers and allotments occur.

**THIS FINAL PLACEMENT MEMORANDUM IS PERSONAL TO THE ELIGIBLE INVESTORS AND DOES NOT CONSTITUTE AN ISSUE OR INVITATION OR SOLICITATION OF AN ISSUE TO THE PUBLIC OR ANY OTHER PERSON OR CLASS OF INVESTORS WITHIN OR OUTSIDE INDIA. THIS FINAL PLACEMENT MEMORANDUM HAS BEEN PREPARED BY THE TERRA INVIT SOLELY FOR PROVIDING INFORMATION IN CONNECTION WITH THE ISSUE.**



**YOU MAY NOT, AND ARE NOT AUTHORISED TO, (1) DELIVER THIS FINAL PLACEMENT MEMORANDUM TO ANY OTHER PERSON; OR (2) REPRODUCE THIS FINAL PLACEMENT MEMORANDUM IN ANY MANNER WHATSOEVER. ANY DISTRIBUTION OR REPRODUCTION OF THIS FINAL PLACEMENT MEMORANDUM, IN WHOLE OR IN PART, IS UNAUTHORISED. FAILURE TO COMPLY WITH THIS INSTRUCTION MAY RESULT IN A VIOLATION OF THE SEBI INVIT REGULATIONS, AND/ OR OTHER APPLICABLE LAWS OF INDIA AND/ OR OF OTHER JURISDICTIONS.**

### RISKS IN RELATION TO THE ISSUE

**INVESTMENTS IN UNITS INVOLVE RISKS AND ELIGIBLE INVESTORS SHOULD NOT INVEST ANY FUNDS IN THE ISSUE UNLESS THEY CAN AFFORD TO TAKE THE RISK OF LOSING ALL OR PART OF THEIR INVESTMENT. FOR MAKING AN INVESTMENT DECISION, ELIGIBLE INVESTORS MUST RELY ON THEIR OWN EXAMINATION OF THE TERRA INVIT, THE UNITS, THE ISSUE AND THE PLACEMENT MEMORANDUM. ELIGIBLE INVESTORS ARE ADVISED TO CAREFULLY READ THE PLACEMENT MEMORANDUM, INCLUDING THE SECTIONS 'RISK FACTORS' AND 'RIGHTS OF UNITHOLDERS' ON PAGES 19 AND 193, RESPECTIVELY, BEFORE MAKING AN INVESTMENT DECISION. THE UNITS HAVE NOT BEEN RECOMMENDED OR APPROVED BY SEBI NOR DOES THE SEBI GUARANTEE THE ACCURACY OR ADEQUACY OF THE CONTENTS OF THIS FINAL PLACEMENT MEMORANDUM. THE ELIGIBLE INVESTORS ARE ADVISED TO CONSULT THEIR OWN ADVISORS ABOUT THE CONSEQUENCES OF AN INVESTMENT IN THE UNITS BEING ISSUED PURSUANT TO THIS FINAL PLACEMENT MEMORANDUM.**

Unless a serially numbered Placement Memorandum along with an Application Form is addressed to Eligible Investors, no invitation to offer shall be deemed to have been made to the Eligible Investors to make an offer to subscribe to Units pursuant to the Issue. For further details, see the section 'Issue Information' on page 302. The distribution of the Draft Placement Memorandum, the Placement Memorandum and this Final Placement Memorandum or the disclosure of its contents without the Trustee's or Investment Manager's prior consent to any person other than the Eligible Investors is unauthorised and prohibited. The addressee, by accepting delivery of this Final Placement Memorandum, agrees to observe the foregoing restrictions and to make no copies of this Final Placement Memorandum or any documents referred to in this Final Placement Memorandum.

The information on the Sponsor's, Investment Manager's, Lead Manager's or Terra InvIT's website, as applicable, any website directly or indirectly linked to such websites, or the website of the Trustee does not form part of this Final Placement Memorandum and Eligible Investors should not and shall not be entitled to rely on such information contained in, or available through, any such websites.

LEAD MANAGER	REGISTRAR AND UNIT TRANSFER AGENT
	
<b>Axis Capital Limited</b> Axis House, 1 <sup>st</sup> Floor, Wadia International Centre, Pandurang Budhkar Marg, Worli Mumbai – 400 025 <b>Tel.:</b> + 91 22 4325 2183 <b>E-mail:</b> virescent.invit@axiscap.in <b>Website:</b> www.axiscapital.co.in <b>Investor grievance mail:</b> compliants@axiscap.in <b>Contact Person:</b> Ankit Bhatia/Akash Aggarwal <b>SEBI Registration No:</b> INM000012029	<b>Link Intime India Private Limited</b> 247 Park, C-101 1st Floor, L B S Marg Vikhroli (West) Mumbai 400 083 Maharashtra, India <b>Tel:</b> +91 22 4918 6000 <b>E-mail:</b> ajit.patankar@linkintime.co.in <b>Website:</b> www.linkintime.co.in <b>Investor grievance ID:</b> bonds.helpdesk@linkintime.co.in <b>Contact Person:</b> Ajit Patankar <b>SEBI Registration No.:</b> INR000004058

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## NOTICE TO THE ELIGIBLE INVESTORS

The statements contained in this Final Placement Memorandum relating to the Terra InvIT and the Units are material, true, correct and adequate in all material respects to enable investors to make an informed decision. The opinions and intentions expressed in this Final Placement Memorandum with regard to the Terra InvIT and the Units are honestly held, have been reached after considering all relevant circumstances and are based on reasonable assumptions and information presently available with the Investment Manager, Project Manager or the Sponsor, as applicable. There are no other facts in relation to the Terra InvIT and the Units, the omission of which would, in the context of the Issue, make any statement in this Final Placement Memorandum misleading in any material respect. Further, each of the Investment Manager, Project Manager, Trustee and the Sponsor, severally with respect to itself, has made all reasonable enquiries to ascertain such facts and to verify the accuracy of all such information and statements disclosed in this Final Placement Memorandum in all material respects.

The Lead Manager nor any of its shareholders, employees, counsel, officers, directors, representatives, agents, associates or affiliates make any express or implied representation, warranty or undertaking and accept no responsibility or liability as to the accuracy or completeness of the information contained in this Final Placement Memorandum or any other information supplied in connection with the Issue or the distribution of the Units, other than in relation to themselves. Each Eligible Investor who will receive this Final Placement Memorandum acknowledges that such person has neither relied on the Lead Manager nor any of its shareholders, employees, counsel, officers, directors, representatives, agents, associates or affiliates in connection with their investigation of the accuracy of such information or such person's investment decision. The Eligible Investors must rely on its own examination of the Terra InvIT and the merits and risks involved in investing in the Units. The Eligible Investors should not construe the contents of this Final Placement Memorandum as legal, tax, accounting or investment advice. The Eligible Investors who will receive this Final Placement Memorandum acknowledge that in making an investment decision, they have relied solely on the information contained in the Placement Memorandum and not on any other disclosure or representation by the Investment Manager, Sponsor, Trustee or any other party.

The delivery of this Final Placement Memorandum, at any time, does not imply that the information contained in it, is correct as of any time subsequent to its date. This Final Placement Memorandum is personal to the Eligible Investors. This Final Placement Memorandum shall not be relied upon by, and the Investment Manager, Sponsor, Trustee or the Project Manager and/ or the Lead Manager shall not be liable to any subsequent acquirer, transferee or investor of the Units.

This Final Placement Memorandum contains summaries of some terms of certain documents which are qualified in their entirety by the terms and conditions of those documents.

The distribution of the Placement Memorandum, and this Final Placement Memorandum or the disclosure of their contents to any person, other than the Eligible Investors to whom it is addressed and retained by the Eligible Investors to enable them to make a decision with respect to its subscription to the Units, is unauthorised and prohibited. The Eligible Investors, by accepting delivery of the Placement Memorandum and this Final Placement Memorandum, agree to observe the foregoing restrictions and make no copies of the Placement Memorandum and this Final Placement Memorandum or any other material in connection with the Issue or the Units.

### **Certain U.S. Matters**

The Units have not been, and will not be, registered under the Securities Act or any other applicable state securities laws of the U.S. and, unless so registered, may not be offered or sold within the U.S. except pursuant to an exemption from, or in a transaction not subject to, the registration requirements of the Securities Act and applicable state securities laws. Accordingly, the Units are being offered and sold only outside the United States in offshore transactions in reliance on Regulation S, in compliance with the applicable laws of the jurisdictions where those offers and sales occur.

The Eligible Investors will be deemed to have made the representations, agreements and acknowledgments as described in this section '*Notice to Investors*' and elsewhere herein in '*Notice to the Investors – Representations by the Eligible Investors*'.

**THE UNITS OFFERED HEREBY HAVE NOT BEEN AND WILL NOT BE REGISTERED WITH, OR APPROVED OR DISAPPROVED BY THE U.S. SECURITIES AND EXCHANGE COMMISSION (THE "SEC") OR ANY STATE SECURITIES COMMISSION IN THE U.S. OR ANY OTHER U.S. REGULATORY AUTHORITY. ACCORDINGLY, THE UNITS MAY NOT BE OFFERED, SOLD,**

**RESOLD OR OTHERWISE TRANSFERRED WITHIN THE UNITED STATES OR THE TERRITORIES OR POSSESSIONS THEREOF, EXCEPT IN A TRANSACTION EXEMPT FROM THE REGISTRATION REQUIREMENTS OF THE SECURITIES ACT. THE UNITS REFERRED TO IN THIS FINAL PLACEMENT MEMORANDUM ARE BEING OFFERED AND SOLD IN OFFSHORE TRANSACTIONS OUTSIDE THE UNITED STATES IN COMPLIANCE WITH REGULATION S UNDER THE SECURITIES ACT TO PERSONS LOCATED IN JURISDICTIONS WHERE SUCH OFFER AND SALE OF THE UNITS IS PERMITTED UNDER LAWS OF SUCH JURISDICTIONS. THE OFFERING TO WHICH THIS FINAL PLACEMENT MEMORANDUM RELATES IS NOT, AND UNDER NO CIRCUMSTANCES IS TO BE CONSTRUED AS, AN OFFERING OF ANY UNITS FOR SALE IN THE UNITED STATES OR AS A SOLICITATION THEREIN OF AN OFFER TO BUY ANY OF THE SAID SECURITIES. ACCORDINGLY, YOU SHOULD NOT FORWARD OR TRANSMIT THIS FINAL PLACEMENT MEMORANDUM IN OR INTO THE UNITED STATES AT ANY TIME. FURTHERMORE, THE FOREGOING AUTHORITIES HAVE NOT PASSED ON OR ENDORSED THE MERITS OF THE OFFERING OR THE ACCURACY OR ADEQUACY OF THIS FINAL PLACEMENT MEMORANDUM. ANY REPRESENTATION TO THE CONTRARY IS A CRIMINAL OFFENSE IN THE U.S.**

#### **Notice to Investors in certain other jurisdictions**

The distribution of the Placement Memorandum, this Final Placement Memorandum and the issue of the Units in certain jurisdictions may be restricted by law. As such, the Draft Placement Memorandum, the Placement Memorandum, this Final Placement Memorandum does not constitute, and may not be used for, or in connection with, an offer or solicitation by anyone in any jurisdiction in which such offer or solicitation is not authorised or to any person to whom it is unlawful to make such offer or solicitation. In particular, no action has been taken by the Investment Manager or the Lead Manager which would permit an issue of the Units in any jurisdiction other than India. Accordingly, the Units may not be offered or sold, directly or indirectly, and neither the Draft Placement Memorandum, the Placement Memorandum, this Final Placement Memorandum nor any Issue materials in connection with the Units be distributed or published in or from any country or jurisdiction that would require registration of the Units in such country or jurisdiction.

#### **Representations by the Eligible Investors**

References herein to “you” or “your” is to the Eligible Investors in the Issue.

By purchasing, or subscribing to the Units pursuant to the Issue, you are deemed to have represented, and you acknowledge and agree as follows:

1. You are permitted to acquire the Units under the laws of any applicable jurisdiction and that you have necessary capacity and authority, and have obtained all necessary consents and authorisations to enable you to commit to this participation in the Issue and to perform your obligations in relation thereto (including, without limitation, on behalf of any person) and honour such obligations;
2. You undertake to (i) hold, manage or dispose of any Units that are Allotted to you in accordance with the SEBI InvIT Regulations and all other applicable laws; and (ii) to comply with all requirements under applicable law in relation to reporting obligations, if any, in this relation;
3. You have been provided a serially numbered copy of the Placement Memorandum and this Final Placement Memorandum and will be deemed to have read the Placement Memorandum and this Final Placement Memorandum in its entirety, including, in particular, the section entitled ‘*Risk Factors*’ on page 19;
4. You will make all necessary filings, in relation to the Issue and your investment in Units, with appropriate governmental, statutory or regulatory authorities, including the RBI, as may be required, in accordance with applicable law;
5. You agree to provide on request in a timely manner, and consent to the use and disclosure (including to any taxation or other regulatory authorities) of, any information or documentation in relation to yourself and, if and to the extent required, the direct or indirect beneficial ownership of your Units (if any), as may be necessary for the Terra InvIT (or the Trustee and its agents) and the Investment Manager to comply with any regulatory obligations and/or appropriate withholding of taxes in accordance with the IT Act or other penalties under FATCA, the CRS or other similar exchange of tax information regimes,



as maybe applicable. You acknowledge and agree that you shall have no claim against the Terra InvIT (or the Trustee and its agents) and the Investment Manager for any losses suffered by you (including in relation to the direct or indirect beneficial ownership of your Units (if any)) as a result of such use by or disclosure of such information or documentation to, any relevant regulatory, governmental or statutory authority;

6. You are aware that the Units have not been, and will not be registered through a prospectus under the SEBI InvIT Regulations, or under any other law in force in India. This Final Placement Memorandum will be submitted to the SEBI and Stock Exchange and would be displayed on the website of SEBI and the Stock Exchange;
7. You confirm that, either: (i) you have not participated in or attended any investor meetings or presentations by the Terra InvIT or its agents (“**Presentations**”) with regard to the Trust, the Units or the Issue; or (ii) if you have participated in or attended any Presentations, you understand and acknowledge that the Lead Manager, the Investment Manager, the Sponsor or the Trustee may not have knowledge of the statements that the Terra InvIT or its agents may have made at such Presentations and are therefore unable to determine whether the information provided to you at such Presentations may have included any material misstatements or omissions, and, you acknowledge that the Lead Manager, the Trustee (or its agents), the Investment Manager or the Sponsor have advised you not to rely in any way on any information that was provided to you at such Presentations;
8. None of the Sponsor, the Investment Manager, the Trustee or the Lead Manager or any of their respective shareholders, directors, officers, employees, counsel, representatives, agents or affiliates is making any recommendations to you or advising you regarding the suitability of any transactions it may enter into in connection with the Issue and that participation in the Issue is on the basis that you are not and will not, up to the Allotment, be a client of the Lead Manager. None of the Sponsor, the Trustee, the Investment Manager, the Lead Manager or any of their respective shareholders, employees, counsel, officers, directors, representatives, agents or affiliates have any duties or responsibilities to you for providing the protection afforded to their clients, or for providing advice in relation to the Issue and are in no way acting in a fiduciary capacity towards you;
9. All statements, other than statements of historical fact included in this Final Placement Memorandum, including, without limitation, those regarding the Terra InvIT’s financial position, business strategy, plans and objectives for future operations, the Investment Objectives, and the Projections, are forward-looking statements. Such forward-looking statements involve known and unknown risks, uncertainties and other important factors that could cause actual results to be materially different from the results, performance or achievements expressed or implied by such forward-looking statements. Such forward-looking statements are based on numerous assumptions regarding the Terra InvIT’s present and future business strategies and the environment in which the Terra InvIT will operate in the future. You should not place undue reliance on forward-looking statements, which speak only as of the date of this Final Placement Memorandum. The Terra InvIT, the Trustee, the Sponsors, the Investment Manager and the Lead Manager or any of their respective shareholders, directors, officers, employees, counsel, representatives, agents, associates or affiliates assume no responsibility to update any of the forward-looking statements contained in this Final Placement Memorandum;
10. You are aware and understand that the Units are being offered only to you and are not being offered to the general public and the Allotment shall be on a discretionary basis;
11. You understand that the Units have not been, and will not be, registered under the Securities Act or with any securities regulatory authority of any state of the United States and accordingly, may not be offered or sold within the United States, except in reliance on an exemption from the registration requirements of the Securities Act; the Units are being offered and sold outside the United States in an offshore transaction within the meaning of Regulation S and the applicable law of the jurisdictions in which those offers and sales occur. You are not in United States and are eligible to acquire, and are acquiring, the Units in an offshore transaction meeting the requirements of Regulation S. You further understand that no offer or sale of the Units is the result of any “directed selling efforts” in the United States (as such term is defined in Regulation S). You further acknowledge and agree that Terra InvIT and the Lead Manager, and their respective affiliates and representatives (including their legal counsel), will rely upon the truth and accuracy of the foregoing acknowledgements, representations, warranties and agreements and agree that, if at any time any of the acknowledgements, representations, warranties and agreements made in connection with the Units is no longer accurate, it shall immediately notify Terra InvIT and the

Lead Manager in writing;

12. In making your investment decision, you have (i) relied on your own examination of the Terra InvIT, the Units and the terms of the Issue, including the merits and risks involved, (ii) consulted your own independent advisors or otherwise have satisfied yourself concerning, without limitation, the effects of local laws and (iii) received all information in the Placement Memorandum that you believe is necessary or appropriate in order to make an investment decision in respect of Terra InvIT and the Units;
13. You acknowledge that an investment in the Units involves a high degree of risk and that the Units are, therefore, a speculative investment. You are seeking to subscribe to the Units in the Issue for your own investment and not with a view to resell or distribute in any manner that could characterise you as an underwriter or similar party in any jurisdiction;
14. The Trustee, the Sponsor, the Investment Manager, the Lead Manager or any of their respective shareholders, directors, officers, employees, counsel, representatives, agents or affiliates have not provided you with any legal, financial or tax advice or otherwise made any representations regarding the tax consequences of the Units (including but not limited to, the Issue and the use of the proceeds of the Issue). You will obtain your own independent legal, financial or tax advice and will not rely on the Investment Manager, the Sponsor, the Trustee, the Lead Manager or any of their respective shareholders, employees, counsel, officers, directors, representatives, agents or affiliates or the Investment Manager when evaluating the tax consequences in relation to the Units (including but not limited to the Issue and the use of the proceeds of the Issue). You waive and agree not to assert any claim against the Lead Manager, the Sponsor, the Trustee or the Investment Manager with respect to the tax aspects of the Units or the Issue or as a result of any tax audits by tax authorities, in relation to the Units and the Issue, wherever situated;
15. You are not the Trustee, or the Valuer or an employee of the Valuer involved in the valuation of the Asset SPVs;
16. You are aware that (i) we have received in-principle approval from NSE dated August 6, 2021 and (ii) the application for the final listing and trading approval will be made only after Allotment. There can be no assurance that the final approval for listing and trading of the Units will be obtained in a timely manner, or at all. The Terra InvIT, the Trustee, the Investment Manager, Sponsor, shall not be responsible for any delay or non-receipt of such final approval (except to the extent prescribed under the SEBI InvIT Regulations) or any loss arising from such delay or non-receipt. Further, you shall not undertake any trade in the Units credited to your demat account until such time that the final listing and trading approval for the Units have been issued by the Stock Exchange;
17. You understand that, none of the Terra InvIT, the Investment Manager, the Lead Manager or the Trustee has any obligation to purchase or subscribe to all, or any part, of the Units subscribed by you in the Issue or to support any losses directly or indirectly sustained or incurred by you for any reason whatsoever in connection with the Issue;
18. The only information you are entitled to rely on, and on which you have relied, in committing yourself to acquire the Units is contained in the Placement Memorandum, such information being all that you deem necessary to make an investment decision in respect of the Units and that you have neither received nor relied on any other information given or representations, warranties or statements made by the Trustee, the Lead Manager, the Investment Manager or the Sponsor, and neither the Trustee, the Lead Manager, the Investment Manager nor the Sponsor will be liable for your decision to accept an invitation to participate in the Issue based on any other information, representation, warranty or statement that you have obtained or received;
19. You understand that the Units to be Allotted in this Issue will, when issued, be credited as fully paid and rank pari passu in all respects with all other Units, including in respect of the right to receive all distributions declared, made or paid in respect of the Units after the Allotment, except as permitted under applicable law. For details, see '**Distribution**' on page 190;
20. You are eligible to Bid for, and hold, Units, so Allotted. Your holding after the Allotment of the Units shall not exceed the investment level permissible as per any applicable law and regulation;
21. You agree to indemnify and hold the Terra InvIT, the Trustee, the Investment Manager, the Sponsor and

the Lead Manager harmless from any and all actual and direct costs, claims, liabilities and expenses (including legal fees and expenses) arising out of or in connection with any breach of the representations and warranties in this section;

22. The Trustee, the Investment Manager, the Sponsor, the Lead Manager, their respective shareholders, employees, counsel, offices, directors, representatives, agents or affiliates, will rely on the truth and accuracy of the foregoing representations, warranties, acknowledgements and undertakings which are given to the Lead Manager on their own behalf and on behalf of the Terra InvIT, the Sponsor, the Investment Manager, the Trustee, and the same are irrevocable;
23. You are eligible to invest in India and in the Units under applicable law, including the FEMA Regulations, and have not been prohibited by SEBI or any other statutory, regulatory or judicial authority from buying, selling or dealing in securities;
24. Any dispute arising in connection with the Issue will be governed by, and construed in accordance with, the laws of the Republic of India and shall be subject to the jurisdiction of the courts at Mumbai, Maharashtra;
25. You have made the representations, warranties, acknowledgements and agreements provided in this section and each of the representations, warranties, acknowledgements and agreements set out above shall continue to be true and accurate at all times, until and including the Allotment of Units in the Issue; and

## SECTION I – GENERAL

### DEFINITIONS AND ABBREVIATIONS

*This Final Placement Memorandum uses certain definitions and abbreviations, which unless the context otherwise indicates or implies shall have the meanings ascribed to such terms herein and which you should consider when reading the information contained herein.*

*References to any legislation, act, regulation, rule, guideline, circular, notification, clarification or policy shall be to such legislation, act, regulation, rule, guideline, circular, notification, clarification or policy as amended, supplemented, or re-enacted from time to time and any reference to a statutory provision shall include any subordinate legislation made under that provision.*

*The words and expressions used in this Final Placement Memorandum, but not defined herein shall have the meaning ascribed to such terms under the SEBI InvIT Regulations, the SEBI Act, the Depositories Act, and the rules and regulations made thereunder.*

*Notwithstanding the foregoing, the terms not defined but used in the sections entitled ‘Risk Factors’, ‘Statement of Tax Benefits’, ‘Industry Overview’, ‘Business’, ‘Regulations and Policies’, ‘Combined Financial Statements’, ‘Legal and Other Information’ and ‘Projections of Revenue from Operations and Cash Flows from Operating Activities’ on pages 19, 78, 105, 132, 183, 214, 292 and 309, respectively, shall have the meanings ascribed to such terms in those respective sections.*

*In this Final Placement Memorandum, unless the context otherwise requires, a reference to “we”, “us” and “our” refers to the Terra InvIT and the Asset SPVs on a combined basis.*

#### Terra InvIT Related Terms

Term	Description
Associate	Associate shall have the meaning under Regulation 2(1)(b) of the SEBI InvIT Regulations
Asset SPVs	Assets SPVs means the Project SPVs (Solar Edge, Terralight Kanji, TN Solar, UMD and Terralight Rajapalayam) and the Specified SPVs (PLG, TSET, TSEC, and USUPL)
Auditor/ Statutory Auditor	MSKA & Associates
Combined Financial Statements	The Combined Financial Statements of the Asset SPVs, prepared in accordance with the requirements of the SEBI InvIT Regulations and Ind AS, as at March 31, 2021, 2020 and 2019, and the related combined statements of profit and loss (including other comprehensive income), combined cash flow statements and combined statements of changes in equity for the years ended March 31, 2021, 2020 and 2019 and the notes thereon, prepared in accordance in with Ind AS.
Completion Date	The date on which the transactions contemplated under the Securities Acquisition Agreement-I and the Securities Acquisition Agreement-II is complete
Formation Transactions	The transactions pursuant to which the Terra InvIT will acquire: (i) 14,90,00,000 equity shares and 12,15,32,667 CCDs of Solar Edge; (ii) 4,05,00,800 equity shares, 70,000 CCPS and 24,18,22,113 CCDs of Terralight Kanji; (iii) 4,35,00,000 equity shares, 1,91,20,000 CCPS and 13,44,58,559 CCDs of TN Solar; (iv) 1,10,000 equity shares and 18,53,33,277 CCDs of Terralight Rajapalayam; (v) 4,69,01,000 equity shares, 2,01,00,000 CCPS and 15,06,58,705 CCDs of UMD; (vi) 10,89,447 equity shares of PLG; (vii) 9,83,22,741 equity shares of TSEC; and (viii) 1,67,33,985 equity shares of USUPL held by the Sponsor and 11,45,000 CCPS of USUPL held by TSET and respective transferor entities in such Asset SPVs in consideration for Units to be issued and consideration payable to the Sponsor and in form of cash to be paid to respective transferor entities other than the Sponsor after the Bid/Issue Closing Date and prior to Allotment in the Issue
Holding Company/ HoldCo(s)	A holding company, as defined under Regulation 2(1)(sa) of the SEBI InvIT Regulations
Investment Management Agreement	The investment management agreement dated January 29, 2021 between Trustee (on behalf of Terra InvIT, Investment Manager and Project SPVs read with deed of adherence to this agreement dated September 17, 2021 entered between the Trustee (on behalf of Terra InvIT), the Investment Manager, Project SPVs and Specified SPVs
Investment Manager	Virescent Infrastructure Investment Manager Private Limited
KKR	KKR & Co. Inc., and its subsidiaries (unless the context requires otherwise)
O&M Agreements -I	The operations and management agreements each dated February 1, 2021 entered amongst each of Terralight Kanji, TN Solar, UMD, and Terralight Rajapalayam , Project Manager and the respective O&M Contractors and operations and management agreement dated August 20, 2021 entered amongst Solar Edge, Project Manager and respective O&M Contractor

Term	Description
O&M Agreements - II	The operations and management agreements each dated June 25, 2021 entered amongst the Specified SPVs, Project Manager and the respective O&M Contractors
O&M Agreements	Collectively, O&M Agreements-I and O&M Agreements-II
O&M Contractors	The operations and management contractors namely AVI Solar Energy Private Limited, Param Renewable Energy Private Limited, Mitars Energy Private Limited and Meera Corporation with which the Project Manager, Project SPVs and Specified SPVs have entered into O&M Agreements
Parties to the Terra InvIT	The Sponsor, the Trustee, the Investment Manager and the Project Manager
PLG	PLG Photovoltaic Private Limited
PLG PPA	The power purchase agreement dated May 7, 2010 executed between PLG and GUVNL, read with supplemental power purchase agreement between PLG, PLG Photovoltaic Limited and GUVNL dated January 6, 2011, as described in section ' <b>Summary of Power Purchase Agreements</b> ' on page 154
Project Management Agreement/ PMA	The project management agreement dated March 3, 2021, entered amongst the Trustee, the Project Manager, the Investment Manager and Project SPVs read with deed of adherence to this agreement dated September 17, 2021 entered amongst Trustee, Project Manager, Investment Manager, Project SPVs and Specified SPVs
Project Manager	Virescent Renewable Energy Project Manager Private Limited
Project SPVs	Unless the context otherwise requires, Solar Edge, Terralight Kanji (formerly known as Solar PV), TN Solar, UMD, and Terralight Rajapalayam (formerly known as SP Suryaprakash)
Projections	The combined projections of revenue from operations and cash flows from operating activities and the underlying assumptions of the Terra InvIT Assets as described in the prospective combined financial information for the years ending March 31, 2022, 2023 and 2024 and also of each of the Project SPV and Specified SPV for the years ending March 31, 2022, 2023 and 2024. For details see, ' <b>Projections of Revenue from Operations and Cash Flows from Operating Activities</b> ' on page 309.
QCA	Qualified Coordinating Agency
Related Parties	Related parties of the Terra InvIT, as defined under Regulation 2(1)(zv) of the SEBI InvIT Regulations
RPT Policy	Related Party Transactions Policy
Sale CCDs	The aggregate of (i) 12,15,32,667 compulsorily convertible debentures of Solar Edge; (ii) 24,18,22,113 compulsorily convertible debentures of Solar PV; (iii) 18,53,33,277 compulsorily convertible debentures of Terralight Rajapalayam; (iv) 13,44,58,559 compulsorily convertible debentures of TN Solar; and (v) 15,06,58,705 compulsorily convertible debentures of UMD and which will be acquired by the Terra InvIT from the Sponsor in consideration of which Terra InvIT will issue Units to the Sponsor, in accordance with Securities Acquisition Agreement- I
Sale CCPS	11,45,000 CCPS of the USUPL which will be acquired by the Terra InvIT from TSET in consideration of which Terra InvIT will pay the consideration amount, in accordance with Securities Acquisition Agreement – II
Securities Acquisition Agreement - I	The amended and restated securities acquisition agreement dated September 17, 2021 executed between the Terra InvIT (acting through the Trustee), the Investment Manager, the Sponsor, and the Project SPVs, in relation to the transfer of the equity shares, CCPS and CCDs held by the Sponsor in such Project SPVs, in consideration for Units
Securities Acquisition Agreement - II	The securities acquisition agreement dated September 17, 2021 executed between the Terra InvIT (acting through the Trustee), the Investment Manager, the Sponsor, and the Specified SPVs, in relation to the transfer of the equity shares and CCPS held by the Sponsor and the respective transferor entities in such Specified SPVs, in consideration for Units and consideration payable to the Sponsor and respective transferor entities
Securities Acquisition Agreements/SAA	Collectively, Securities Acquisition Agreement – I and Securities Acquisition Agreement – II
Solar Edge	Solar Edge Power and Energy Private Limited
Solar Edge Expiry Date	The date occurring 25 years from the COD of the Solar Edge Project subject to that supply of power shall be limited for a period of 25 years from the unit COD of respective unit(s) unless extended by the parties as per Solar Edge PPA
Solar Edge PPA	The power purchase agreements, each dated February 10, 2017 executed between Solar Edge and SECI, as described in section ' <b>Summary of Power Purchase Agreements</b> ' on page 154
Solar Edge Project	Solar power generation facility of contracted capacity of 30 MW (AC) located at Village Mhatargoan, Tehsil Dharur, District Beed, Maharashtra, India, solar power generation facility of contracted capacity of 50 MW (AC) located at Village Mhatargoan, Tehsil Dharur, District Beed, Maharashtra, India and solar power generation facility of contracted capacity of 50 MW (AC) located at Village Mauje Wadhawe, Tehsil Muktainagar, District Jalgaon, Maharashtra, India

Term	Description
Solar Edge Refinancing	The rupee term loan agreement dated June 28, 2021, amended by way of agreement dated August 27, 2021 availed for repayment of outstanding debt facility of existing lenders of Solar Edge
Solar PV	Shapoorji Pallonji Solar PV Private Limited (currently, known as Terralight Kanji)
Specified SPVs	Unless the context otherwise requires, PLG, TSET, TSEC and USUPL
Sponsor	Terra Asia Holdings II Pte. Ltd.
Sponsor SPA	Master securities purchase agreement dated July 23, 2021 executed, <i>inter alia</i> among the Sponsor, Focal Renewable Energy Holdings Limited, Focal Energy Solar Limited, Focal Energy Projects Limited, Focal Energy Photovoltaic Holdings Limited, Focal Energy Solar Three Limited and Belectric Photovoltaic India Private Limited for acquisition of 100% equity of four entities owning and operating solar assets located in Rajasthan, Punjab and Madhya Pradesh
SPICCPPL	Shapoorji Pallonji Infrastructure Capital Company Private Limited
SP Suryaprakash	Shapoorji Pallonji Suryaprakash Private Limited (currently, known as Terralight Rajapalayam)
Technical Consultant	SgurrEnergy India Private Limited
Technical Report	The technical reports prepared by the Technical Consultant for each of the power projects, attached as Annexure II
Terra I	Terra Asia Holdings I Pte. Ltd.
Terra InvIT	Virescent Renewable Energy Trust
Terra InvIT Assets	The aggregate of the immovable, movable and other assets and cash (including cash equivalents) owned by the Terra InvIT, whether directly, or through holding companies or special purpose vehicles, and includes all rights, interests and benefits arising from and incidental to ownership of such assets, in accordance with the SEBI InvIT Regulations and applicable law
Terra InvIT Documents	Trust Deed, the Investment Management Agreement, the Securities Acquisition Agreements, PMA, any agreement between the Trustee and/or the Investment Manager and/or the Project Manager with respect to the Terra InvIT or to which the Investment Manager or the Trustee is a party in their capacity as the manager or trustee of the Terra InvIT or Units or any other obligations, securities or instruments as permitted under the applicable law, executed for the purpose of the Terra InvIT, the Draft Placement Memorandum, the Placement Memorandum, this Final Placement Memorandum or any offer document, and such other documents in connection therewith, as originally executed and amended, modified, supplemented or restated from time to time
Terralight Kanji	Terralight Kanji Solar Private Limited (formerly known as Shapoorji Pallonji Solar PV Private Limited)
Terralight Kanji Effective Date	The date of execution of power purchase agreement between Terralight Kanji and TANGEDCO i.e. September 19, 2015
Terralight Kanji Expiry Date	The date occurring after 25 years from COD, as specified in Terralight Kanji PPA
Terralight Kanji Project	Solar power generation facility of contracted capacity of 30 MW (AC) located at Aliyandhal Village, Tiruvannamalai District, Tamil Nadu, India
Terralight Kanji PPA	Energy purchase agreement dated September 19, 2015 executed between Terralight Kanji and TANGEDCO read with power purchase agreement dated September 27, 2017 between SPICCPPL and TANGEDCO and addendum dated October 27, 2020 amongst SPICCPPL and TANGEDCO, as described in section ' <b>Summary of Power Purchase Agreements</b> ' on page 154
Terralight Rajapalayam	Terralight Rajapalayam Solar Private Limited (formerly known as Shapoorji Pallonji Suryaprakash Private Limited)
Terralight Rajapalayam Effective Date	The date of execution of power purchase agreement between SPICCPPL and TANGEDCO (which was subsequently assigned to Terralight Rajapalayam) and the date on which the agreement shall come into effect i.e. September 27, 2017
Terralight Rajapalayam Expiry Date	The date occurring after 25 years from COD, as specified in the Rajapalayam PPA
Terralight Rajapalayam Project	Solar power generation facility of contracted capacity of 50 MW (AC) located at Thenkarai Village, Rajapalayam Taluk, Virudhunagar District, Tamil Nadu
Terralight Rajapalayam PPA	Power purchase agreement dated September 27, 2017 between SPICCPPL and TANGEDCO read with addendum dated October 27, 2020 amongst SPICCPPL and TANGEDCO pursuant to which the power purchase agreement was assigned to Terralight Rajapalayam (formerly known as SP Suryaprakash), as described in section ' <b>Summary of Power Purchase Agreements</b> ' on page 154
TN Solar	TN Solar Power Energy Private Limited
TN Solar Effective Date	The date of execution of power purchase agreements between TN Solar and TANGEDCO and the date on which the agreements shall come into effect, i.e., March 5, 2015, March 17, 2015 and May 20, 2015 for the respective projects
TN Solar Expiry Date	The date occurring after 25 years from COD, as specified in TN Solar PPA

<b>Term</b>	<b>Description</b>
TN Solar Project	Solar power generation facility of contracted capacity of 8 MW (AC) at Muthuramalingam Village, Virudhunagar District, Tamil Nadu, India, 10 MW (AC) at Chithavanayakanpatti Village, Vilathikulam Taluk, Tuticorin District, Tamil Nadu, India and 5 MW (AC) at Perumpalli Village, Vedasandur Taluk, Dindigul District, Tamil Nadu, India
TN Solar PPA	Energy purchase agreements dated March 5, 2015, March 17, 2015 and May 20, 2015 executed between TN Solar and TANGEDCO, as defined in section ' <i>Summary of Power Purchase Agreements</i> ' on page 154
Trust Deed	The trust deed dated January 28, 2021, entered into between the Sponsor and the Trustee
Trustee	Axis Trustee Services Limited
TSEC	Terralight Solar Energy Charanka Private Limited (formerly known as Sindicatum Solar Energy Gujarat Private Limited)
TSEC PPA	The power purchase agreement dated May 29, 2010 between TSEC (formerly known as Sindicatum Solar Energy Gujarat Private Limited) and GUVNL as supplemented by agreements dated September 21, 2011, July 19, 2012, December 28, 2012 and September 8, 2017 as described in section ' <i>Summary of Power Purchase Agreements</i> ' on page 154
TSET	Terralight Solar Energy Tinwari Private Limited (formerly known as Sindicatum Solar Energy Private Limited)
TSET PPA	The power purchase agreement dated October 15, 2010 between TSET (formerly known as Sindicatum Solar Energy Private Limited ) and NVVN as supplemented by agreements dated October 15, 2010, May 12, 2011 and May 30, 2017 as described in section ' <i>Summary of Power Purchase Agreements</i> ' on page 154
UMD	Universal Mine Developers and Service Providers Private Limited
UMD Effective Date	The date of execution of power purchase agreements between UMD and TANGEDCO and the dates on which the agreements shall come into effect i.e. March 25, 2015 and May 20, 2015 for the respective projects.
UMD Expiry Date	The date occurring after 25 years from COD, as specified in UMD PPA
UMD Project	Solar power generation facility of contracted capacity of 12 MW (AC) at Ondipulinayakanoor Village, Aruppukottai Taluk, Virudunagar District, Tamil Nadu, India and 13 MW (AC) at Kattarakulam Village, Tuticorin District, Tamil Nadu, India
UMD PPA	Energy purchase agreements dated March 25, 2015 and May 20, 2015 executed between UMD and TANGEDCO, as described in section ' <i>Summary of Power Purchase Agreements</i> ' on page 154
USUPL	Universal Saur Urja Private Limited
USUPL PPA	The power purchase agreement dated April 6, 2015 between USUPL and UPPCL read with amendment to the power purchase agreement dated December 30, 2017 as described in section ' <i>Summary of Power Purchase Agreements</i> ' on page 154
Unitholder	Any person who owns any Unit in the Terra InvIT
Units	An undivided beneficial interest in the Terra InvIT, and such Units together represent the entire beneficial interest in the Terra InvIT
VGF Securitisation Agreements	VGF Securitisation Agreement each dated February 10, 2017 including all schedules and all amendments and documents supplemental or incidental, entered by SECI with Solar Edge for creation of charges, perfection and enforcement of claim on the assets of the Solar Edge Project.
Virescent Infrastructure	The Investment Manager, Virescent Infrastructure Investment Manager Private Limited
Virescent Renewable	The Project Manager, Virescent Renewable Energy Project Manager Private Limited
Valuation Report	The valuation report dated July 22, 2021 issued by the Valuer, which sets out his opinion as to the enterprise value of the Asset SPVs as on March 31, 2021
Valuer	Mr. S. Sundararaman

#### Issue Related Terms

<b>Term</b>	<b>Description</b>
Allocated/ Allocation	The allocation of Units, by the Investment Manager to Eligible Investors on the basis of the Application Form submitted by them.
Allot/ Allotment/ Allotted	Unless the context otherwise requires, the issue and allotment of Units to the Eligible Investors, pursuant to the Issue
Allottees	Bidders to whom Units are issued and Allotted pursuant to the Issue
Application Form	The serially numbered form pursuant to which Eligible Investors shall submit a Bid for the Units in the Issue
Bid(s)	Indication of interest of the Eligible Investor, as provided in the Application Form, to subscribe for the Units at the Issue Price, in terms of the Placement Memorandum and the Application Form
Bid Amount	The amount payable by a Bidder for the number of Units Bid for at the Issue Price specified in the Placement Memorandum

Term	Description
Bid/Issue Closing Date	September 28, 2021, which is the last date up to which the Application Forms shall be accepted
Bid/Issue Opening Date	September 27, 2021, which is the date on which a serially numbered copy of the Placement Memorandum along with the Application Form was circulated to each Eligible Investor by the Investment Manager and the date from which, the Investment Manager accepted Application Forms
Bid/Issue Period	Period between the Bid/Issue Opening Date and the Bid/Issue Closing Date, inclusive of both days, during which Eligible Investors can submit their Bids
Bidder	Any Eligible Investor who made a Bid pursuant to the terms of the Placement Memorandum and the Application Form
Bodies Corporate	Bodies corporate as defined in Regulation 2(1)(d) of the SEBI InvIT Regulations, whether Indian or foreign
Cash Escrow Agreement	The cash escrow agreement dated September 17, 2021 entered into amongst the Terra InvIT (acting through the Trustee), the Investment Manager, the Lead Manager, the Sponsor and the Escrow Collection Bank, as applicable, for, among others, collection of the Bid Amounts and for remitting refunds, if any, of the amounts collected, to the Bidders
Client ID	Client identification number maintained with one of the Depositories in relation to a demat account
Closing Date	The date on which Allotment of Units pursuant to the Issue shall be made, i.e. on or about September 30, 2021
Demographic Details	Details of the Bidders, including the Bidder's address and bank account details
Designated Account	The account wherein the Bidders should transfer money through direct credit/NEFT/NECS/RTGS in respect of the Bid Amount when submitting a Bid
Designated Stock Exchange	The National Stock Exchange of India Limited
Draft Placement Memorandum	The draft placement memorandum dated July 23, 2021, in relation to this Issue, filed with SEBI and the Stock Exchange, and issued in accordance with the SEBI InvIT Regulations, which does not contain the complete particulars of the Issue, including any modifications, amendments, supplements, notices, corrections or corrigenda thereto
Eligible Investors	Institutional Investors and Bodies Corporate, whether Indian or foreign
Escrow Collection Bank	Axis Bank Limited
Final Placement Memorandum	This final placement memorandum dated September 28, 2021 issued in relation to this Issue, in accordance with the SEBI InvIT Regulations
Institutional Investors	Institutional investor as defined in Regulation 2(1)(ya) of the SEBI InvIT Regulations
Issue	The initial offer by way of fresh issue of up to 460 lakhs Units* at an Issue Price of ₹100 per Unit, aggregating to ₹46,000 lakhs, on a private placement basis to the Eligible Investors <i>*Subject to allotment of units by the board of directors of the Investment Manager</i>
Issue Price	₹100 being the price at which Units will be Allotted to Eligible Investors in terms of the Placement Memorandum
Issue Proceeds	The proceeds of the Issue of up to ₹46,000 lakhs.  For further details about the use of the Issue Proceeds, please see 'Use of Proceeds' on page 73
Issue Size	The initial offer by way of fresh issue of up to 460 lakhs Units* aggregating up to ₹46,000 lakhs to the Eligible Investors <i>*S subject to allotment of units by the board of directors of the Investment Manager</i>
Listing Agreement	The listing agreement to be entered into with the Stock Exchange by the Terra InvIT, in line with the format as specified under the Securities and Exchange Board of India circular number CIR/CFD/CMD/6/2015 dated October 13, 2015 on "Format of uniform Listing Agreement"
Lead Manager	Axis Capital Limited
Minimum Bid Size	₹2,500 lakhs
Placement Agreement	The placement agreement dated July 23, 2021 entered into among the Terra InvIT (acting through its Trustee), the Trustee, the Investment Manager, the Sponsor, the Project Manager and the Lead Manager
Placement Memorandum	The placement memorandum dated September 20, 2021 issued in relation to this Issue in accordance with the SEBI InvIT Regulations
Qualified Institutional Buyers or QIB(s)	Qualified institutional buyers, as defined under Regulation 2(1)(ss) of the SEBI ICDR Regulations, which currently includes (i) a mutual fund, a VCF, an AIF and an FVCI registered with SEBI, (ii) an FPI, other than individuals, corporate bodies and family offices, (iii) a public financial institution as defined in section 2(72) of the Companies Act, 2013, (iv) a scheduled commercial bank as included in the second schedule to the Reserve Bank of India Act, 1934, (v) a multilateral and bilateral development financial institution, (vi) a state industrial development corporation, (vii) an insurance company registered with the IRDAI, (viii) a provident fund with minimum corpus of ₹2,500 lakhs, (ix) a pension fund with minimum corpus of ₹2,500 lakhs, (x) National Investment Fund set up by resolution no. F.



Term	Description
	No. 2/3/2005-DDII dated November 23, 2005 of the Government published in the Gazette of India, (xi) insurance funds set up and managed by army, navy or air force of the Union of India, (xii) insurance funds set up and managed by the Department of Posts, India, and (xiii) systemically important non-banking financial companies
Registrar and Agent or Registrar	Link Intime India Private Limited
Working Day	Working Day, with reference to (a) Bid/Issue Period, shall mean all days, excluding Saturdays, Sundays and public holidays, on which commercial banks in Mumbai are open for business; and (b) the time period between the Bid/Issue Closing Date and the listing of the Units on the Stock Exchange, shall mean all trading days of Stock Exchange, excluding Sundays and bank holidays

### Technical and Industry Related Terms

Term	Description
AD Benefit	Accelerated Depreciation Benefit
APERC	Andhra Pradesh Electricity Regulation Commission
APTEL	Appellate Tribunal for Electricity
Buying Utilities	Discoms, or state utilities or bulk consumers (as may be specified in the relevant power purchase agreements) who have entered the power sale agreement(s) with off-takers for purchase of power
COD	Commercial Operations Date, as may be specified in the relevant power purchase agreements
CDM	Clean Development Mechanism
CPSU	Central public sector undertaking
CUF	Capacity Utilisation Factor
Discom(s)	The electricity distribution companies which purchase power from solar projects, as may be specified in the relevant power purchase agreements
EEZ	Exclusive Economic Zone
FITs	Feed in tariffs
F&S Regulations	Forecasting and Scheduling Regulations, 2019
GEDA	Gujarat Energy Development Agency
GERC	Gujarat Electricity Regulatory Centre
GUVNL	Gujarat Urja Vikas Nigam Limited
GETCO	Gujarat Energy Transmission Corporation Limited
Grid Code	Central Electricity Regulatory Commission (Indian Electricity Grid Code) Regulations, 2010 and the orders and procedures issued thereunder
IREDA	Indian Renewable Energy Development Agency Limited
JNNSM	Jawaharlal Lal Nehru National Solar Mission
KVarh	kilo volt ampere reactive hour
PLF	Plant Load Factor
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MEDA	Maharashtra Energy Development Agency
MoP	Ministry of Power
MNRE	Ministry of New and Renewable Energy
NDCF	Net distributable cash flows
NSFI	National Solar Federation of India
NSM	National Solar Mission
NVVN	NTPC Vidyut Vyapar Nigam Limited
NTPC	NTPC Limited
O&M	Operations and Management
PGCIL	Power Grid Corporation of India Limited
PPA	Power Purchase Agreement
RPO	Renewable Purchase Obligations
RE	Renewable Energy
REC	Renewable Energy Certificate
RRECL	Rajasthan Renewable Energy Corporation Limited
RTU	Remote Terminal Unit
SECI	Solar Energy Corporation of India Limited
SLDC	State Load Dispatch Centre
TANGEDCO	Tamil Nadu Generation and Distribution Company
TANTRANSCO	Tamil Nadu Transmission Corporation Limited
TNERC	Tamil Nadu Electricity Regulatory Commission

Term	Description
T&D	Transmission and distribution
UPNEDA	Uttar Pradesh New & Renewable Energy Development Agency
UPPCL	Uttar Pradesh Power Corporation Limited
VGF	Viability Gap Funding

## Abbreviations

Term	Description
AIIB	Asian Infrastructure Investment Bank
AIF	Alternative Investment Fund as defined in and registered with SEBI under the SEBI AIF Regulations
Air Act	Air (Prevention and Control of Pollution) Act, 1981
AUM	AUM is the adjusted enterprise value as set out by the Valuer under the Valuation Report. For details, see ' <b>Valuation Report</b> ' attached as Annexure I on page 329
Board/Board of Directors	The board of directors of the Investment Manager
CAGR	Compound annual growth rate
CCDs	Compulsorily convertible debentures
CCPS	Compulsorily convertible preference shares
CDSL	Central Depository Services (India) Limited
CERC	Central Electricity Regulatory Commission
Civil Code	Code of Civil Procedure, 1908
Companies Act	Companies Act, 1956 and/or the Companies Act, 2013, as amended, as applicable
Companies Act, 1956	Companies Act, 1956 and the rules, regulations, modifications and clarifications made thereunder as the context requires, repealed as of January 30, 2019
Companies Act, 2013	Companies Act, 2013, as amended and read with the rules, regulations, notifications, clarifications and modifications thereunder
COVID-19	A public health emergency of international concern as declared by the World Health Organization on January 30, 2020 and a pandemic on March 11, 2020
CPCB	The Central Pollution Control Board of India
CRISIL	CRISIL Limited
CRISIL Report	A report titled " <b>Renewable Power Market in India</b> " dated July 2021, prepared by CRISIL
DDUGJY	Deendayal Upadhyaya Gram Jyoti Yojana
Depositories	Depositories registered with SEBI under the Securities and Exchange Board of India (Depositories and Participant) Regulations, 2018, being the NSDL and the CDSL
Depositories Act	Depositories Act, 1996
Depository Participant	A depository participant as defined under the Depositories Act
DIN	Director Identification Number
DP ID	Depository Participant ID
EIA	Environment Impact Assessment
Environment Act	Environment (Protection) Act, 1986
FEMA	Foreign Exchange Management Act, 1999, read with rules and regulations thereunder
FEMA Rules	Foreign Exchange Management (Non-Debt Instrument) Rules, 2019
Fiscal/Financial Year	Period of 12 months ended March 31 of that particular year, unless otherwise stated
FPI	Foreign Portfolio Investors
GIR	General index registrar number
GoI or Government	Government of India
ICAI	Institute of Chartered Accountants of India
Ind AS	Indian Accounting Standards prescribed under Section 133 of the Companies Act, 2013, as notified under Rule 3 of the Companies (Indian Accounting Standards) Rules, 2015, notified on February 19, 2015 by the MCA, including any amendments or modifications thereto
Indian GAAP	Accounting principles generally accepted in India, including the Accounting Standards as prescribed under Section 133 of the Companies Act, 2013 read with Rule 7 of the Companies (Accounts) Rules, 2014
InvIT	Infrastructure Investment Trust
Indian Trusts Act	Indian Trusts Act, 1882
IST	Indian Standard Time
IT Act	The Income Tax Act, 1961
MCA	Ministry of Corporate Affairs
MoEF	Ministry of Environment, Forest and Climate Change
Mutual Funds	Mutual funds registered with SEBI under the Securities and Exchange Board of India (Mutual Funds) Regulations, 1996
NAPCC	National Action Plan on Climate Change
NCD	Non-convertible debentures

Term	Description
NEFT	National Electronic Funds Transfer
NISE	National Institute of Solar Energy
NRE	Non Resident External
NSDL	National Securities Depository Limited
PAN	Permanent Account Number
PCB	Pollution Control Boards
RBI	Reserve Bank of India
Regulation S	Regulation S under the Securities Act
Rs./Rupees/INR/₹	Indian Rupees
RTGS	Real Time Gross Settlement
SCRA	The Securities Contracts (Regulation) Act, 1956
SEBI	Securities and Exchange Board of India
SEBI Act	The Securities and Exchange Board of India Act, 1992
SEBI AIF Regulations	Securities and Exchange Board of India (Alternative Investments Funds) Regulations, 2012
SEBI FPI Regulations	Securities and Exchange Board of India (Foreign Portfolio Investors) Regulations, 2014
SEBI Intermediaries Regulations	Securities and Exchange Board of India (Intermediaries) Regulations, 2008
SEBI InvIT Regulations	Securities and Exchange Board of India (Infrastructure Investment Trusts) Regulations, 2014 and circulars issued by SEBI from time to time
SERC	State Electricity Regulatory Commissions
Securities Act	U.S. Securities Act of 1933, as amended
Securities Exchange Act	U.S. Securities Exchange Act of 1934, as amended
Tax	(i) all forms of direct and indirect taxes, duties, charges, levies, including without limitation corporate income tax, withholding tax, minimum alternate tax, sales tax, goods & services tax, value added tax, customs and excise duties, service tax, capital gains tax and all charges, interest, penalties and fines incidental or relating to any taxation falling within paragraph (i) above or which arise as a result of the failure to pay any taxes on the due date or to comply with any obligation relating to Tax
U.S./U.S.A/United States	United States of America, including the territories and possessions thereof
USD/US\$	United States Dollars
Water Act	Water (Prevention and Control of Pollution) Act, 1974

## PRESENTATION OF FINANCIAL, INDUSTRY AND MARKET DATA

### Certain Conventions

All references in this Final Placement Memorandum to “India” are to the Republic of India.

Unless stated otherwise, all references to page numbers in this Final Placement Memorandum are to the page numbers of this Final Placement Memorandum.

### Financial Data

Unless stated otherwise, the financial information in this Final Placement Memorandum is derived from the Combined Financial Statements. The Combined Financial Statements have been prepared in accordance with the accounting principles generally accepted in India, including the Ind AS notified under the Companies (Indian Accounting Standards) Rules, 2015 prescribed under the Companies Act, 2013, as applicable and other provisions relating to disclosures required as per of the SEBI InvIT Regulations and the SEBI Circular (CIR/IMD/DF/114/2016) dated October 20, 2016 on ‘Disclosure of Financial Information in Placement Memorandum or any offer document for InvITs’ (“**SEBI Circular on Financial Disclosures**”). For further details, please see ‘*Combined Financial Statements*’ on page 214.

This Final Placement Memorandum includes projections of revenue from operations and cash flows from the operating activities and the underlying assumptions of the Terra InvIT and the Asset SPVs for the Financial Years ending March 31, 2022, March 31, 2023 and March 31, 2024 prepared in accordance with Standard on Assurance Engagement 3400, ‘The Examination of Prospective Financial Information’, issued by the Institute of Chartered Accountants of India (the “**Projections**”). For further details, please see ‘*Projections of Revenue from Operations and Cash Flow from Operating Activities*’ on page 309.

Further, this Final Placement Memorandum includes summary financial statements of the (i) Sponsor, for the period from January 6, 2020 (date of incorporation of the Sponsor) to December 31, 2020, prepared in accordance with International Financial Reporting Standards, and (ii) Investment Manager, as at March 31, 2021 and for the period from August 22, 2020 (date of incorporation of the Investment Manager), to March 31, 2021, prepared in accordance with Ind AS. For further details, please see ‘*Summary Financial Information of the Sponsor*’ and ‘*Summary Financial Information of the Investment Manager*’ on pages 58 and 63.

The financial year for the Terra InvIT, the Asset SPVs and our Investment Manager commences on April 1 of the immediately preceding calendar year and ends on March 31 of that particular calendar year. The financial year for our Sponsor commences on January 1 and ends on December 31 of the same calendar year. Accordingly, all references to a particular financial year (unless stated otherwise or with respect to our Sponsor) are to the 12-month period commencing on April 1 of the immediately preceding calendar year and ending on March 31 of that particular calendar year.

The degree to which the financial information included in this Final Placement Memorandum will provide meaningful information is entirely dependent on the reader’s level of familiarity with Indian accounting policies and practices, the Companies Act, the Indian GAAP, Ind AS and the SEBI InvIT Regulations. Any reliance by persons not familiar with Indian accounting policies and practices on the financial disclosures presented in this Final Placement Memorandum should accordingly be limited.

In this Final Placement Memorandum, any discrepancies in any table between the total and the sums of the amounts listed are due to rounding off. All figures and percentage figures have been rounded off to two decimal places.

### Currency and Units of Presentation

All references to:

- “Rupees” or “Rs.” or “INR” or “₹” are to Indian Rupees, the official currency of the Republic of India; and
- “USD” or “US\$” or “\$” or “U.S. dollars” are to United States Dollars, the official currency of the United States.

Except otherwise specified, numerical information in this Final Placement Memorandum has been presented in “lakh” units. However, certain numerical information in this Final Placement Memorandum has been presented in “million” units where one million represents 10,00,000 or “crore” units where one crore represents 1,00,00,000.

Unless the context requires otherwise, any percentage amounts, as set forth in this Final Placement Memorandum, have been calculated on the basis of the Combined Financial Statements.

## Exchange Rates

This Final Placement Memorandum contains conversion of certain other currency amounts into Indian Rupees. These conversions should not be construed as a representation that these currency amounts could have been, or can be converted into Indian Rupees, at any particular rate.

The following table sets forth, for the periods indicated, information with respect to the exchange rate between the Rupee and the US\$:

(in ₹)			
Currency	Exchange Rate as on March 31, 2021	Exchange Rate as on March 31, 2020	Exchange Rate as on, March 31, 2019*
1 US\$	73.50	75.39	69.17

Source: [www.rbi.org.in](http://www.rbi.org.in) and [www.fbil.org.in](http://www.fbil.org.in)

\*Exchange rate as on March 29, 2019, as FBIL reference rate is not available for March 31, 2019 and March 30, 2019 being a Sunday and Saturday, respectively.

## Industry and Market Data

Unless stated otherwise, industry and market data used in this Final Placement Memorandum has been obtained or derived from the CRISIL Report with respect to the renewable power market in India which is a commissioned report, and publicly available information as well as other Government and industry publications and sources. The Investment Manager has commissioned the CRISIL Report, to provide an independent estimation of the renewable power market in India, which is based on historical data and certain assumptions. The CRISIL Report is issued by CRISIL Research and is subject to the following disclaimer:

*“CRISIL Research, a division of CRISIL Limited (**CRISIL**) has taken due care and caution in preparing this report (**Report**) based on the Information obtained by CRISIL from sources which it considers reliable (**Data**). However, CRISIL does not guarantee the accuracy, adequacy or completeness of the Data / Report and is not responsible for any errors or omissions or for the results obtained from the use of Data / Report. This Report is not a recommendation to invest /disinvest in any entity covered in the Report and no part of this Report should be construed as an expert advice or investment advice or any form of investment banking within the meaning of any law or regulation. CRISIL especially states that it has no liability whatsoever to the subscribers / users / transmitters/ distributors of this Report. Without limiting the generality of the foregoing, nothing in the Report is to be construed as CRISIL providing or intending to provide any services in jurisdictions where CRISIL does not have the necessary permission and/or registration to carry out its business activities in this regard. Virescent Renewable Energy Trust/Virescent Infrastructure Investment Manager Limited will be responsible for ensuring compliances and consequences of non-compliances for use of the Report or part thereof outside India. CRISIL Research operates independently of, and does not have access to information obtained by CRISIL Ratings Limited / CRISIL Risk and Infrastructure Solutions Ltd (**CRIS**), which may, in their regular operations, obtain information of a confidential nature. The views expressed in this Report are that of CRISIL Research and not of CRISIL Ratings Limited / CRIS. No part of this Report may be published/reproduced in any form without CRISIL’s prior written approval.”*

Industry publications as well as government publications generally state that the information contained in such publications has been obtained from various sources believed to be reliable but that their accuracy and completeness are not guaranteed and their reliability cannot be assured. Accordingly, no investment decisions should be based solely on such information. Although the Investment Manager and the Sponsor believe that the industry and market data used in this Final Placement Memorandum is reliable, it has not been independently verified by the Investment Manager or the Sponsor or the Trustee or the Lead Manager and none of such entities make any representation as to the accuracy of such information. The data used in these sources may have been re-classified for the purposes of presentation. Data from these sources may also not be comparable. Such data involves risks, uncertainties and numerous assumptions and is subject to change based on various factors, including those disclosed in the section ‘**Risk Factors**’ on page 19. Accordingly, investment decisions should not be based solely on such information.

The extent to which the market and industry data used in this Final Placement Memorandum is meaningful depending on the reader's familiarity with and understanding of the methodologies used in compiling such data. There are no standard data gathering methodologies in the industry in which the business of the Terra InvIT is conducted, and methodologies and assumptions may vary widely amongst different industry sources.

## FORWARD LOOKING STATEMENTS AND FINANCIAL PROJECTIONS

Certain statements contained in this Final Placement Memorandum are not statements of historical fact but constitute 'forward-looking statements'. Investors can generally identify forward-looking statements by terminology such as 'aim', 'anticipate', 'believe', 'continue', 'could', 'estimate', 'expect', 'intend', 'may', 'objective', 'plan', 'potential', 'project', 'propose', 'pursue', 'seek', 'shall', 'should', 'will', 'would', or other words or phrases of similar import. Similarly, statements that describe our strategies, objectives, plans or goals, including the Terra InvIT's business strategy, revenue and profitability (including, without limitation, any financial or operating projections or forecasts) are also forward-looking statements.

All statements regarding the Terra InvIT's expected financial conditions, results of operations, cash flows, business plans and prospects are forward-looking statements. These forward-looking statements include statements as to the Terra InvIT's business strategy, revenue, cash flows and profitability (including, without limitation, any financial or operating projections or forecasts) and other matters discussed in this Final Placement Memorandum that are not historical facts.

These forward-looking statements and any other projections contained in this Final Placement Memorandum (whether made by us or any third party), are based on current plans, estimates, presumptions and expectations. In accordance with the SEBI InvIT Regulations, the Projections have been included in this Final Placement Memorandum. The Projections should be read together with the underlying assumptions and notes thereto. See '*Projections of Revenue from Operations and Cash Flows from Operating Activities*' on page 309.

The Valuation Report included in this Final Placement Memorandum, is based on certain projections and accordingly, should be read together with assumptions and notes thereto. For further details, see the '*Valuation Report*' attached as Annexure I on page 329.

The CRISIL Report include assumptions and estimates in relation to the information contained therein, and accordingly, should be read in conjunction with the relevant estimates and assumptions thereto.

Actual results may differ materially from those suggested by forward-looking statements and financial projections due to certain known or unknown risks or uncertainties associated with the Investment Manager's expectations with respect to, but not limited to, the actual growth in the infrastructure sector, the Investment Manager's ability to successfully implement the strategy, growth and expansion plans, technological changes, cash flow projections, exposure to market risks, general economic and political conditions in India, changes in competition in the infrastructure sector, the outcome of any legal or regulatory proceedings and the future impact of new accounting standards. By their nature, certain of the market risk disclosures are only estimates and could be materially different from what actually occurs in the future. As a result, actual future gains, losses or impact on net income could materially differ from those that have been estimated.

Factors that could cause actual results, performance or achievements of the Terra InvIT to differ materially include, but are not limited to those discussed under '*Risk Factors*', '*Industry Overview*', '*Business*' and '*Management's Discussion and Analysis of Financial Condition and Results of Operations*', on pages 19, 105, 132 and 265, respectively. Some of the factors that could cause the Terra InvIT's actual results, performance or achievements to differ materially from those in the forward-looking statements, financial projections and financial information include, but are not limited to, the following:

- We are heavily reliant on certain off-takers and significant part of our revenue is generated from solar power projects in certain states and any adverse development in economic, regulatory and political environment may adversely affect our business, financial condition, results of operations, and prospects.
- Our revenues are exposed to changes in electricity tariffs and tariff regulations and structuring in accordance with the relevant PPAs which may be non-negotiable or untested, and the PPAs may contain certain restrictive terms and conditions and any failure to comply with such terms and conditions could result in adverse consequences, including termination of the relevant PPAs.
- The ability to deliver electricity to our various counterparties requires the availability of and access to interconnection facilities and transmission systems which we do not own or control, and the extent and reliability of the Indian power grid and its dispatch regime may materially and adversely affect our business, prospects, financial condition, results of operations and cash flows.

- Counterparties to our PPAs may not fulfil their obligations which could result in a material adverse impact on our business, prospects, financial condition, results of operations and cash flows.
- Our business will be subject to seasonal fluctuations and natural calamities that could have a material adverse effect on our business, financial condition and results of operations.

The forward-looking statements, Projections, the Valuation Report and the CRISIL Report are not a guarantee of future performance or returns to Bidders. These statements and projections are based on certain beliefs and assumptions, which in turn are based on currently available information. Although we believe that the expectations and the assumptions upon which such forward-looking statements are based, are reasonable at this time, we cannot assure Bidders that such expectations will prove to be correct or accurate. Given these uncertainties, investors are cautioned not to place undue reliance on such forward-looking statements and not to regard such statements as a guarantee of future performance.

In accordance with the SEBI InvIT Regulations, the assumptions underlying the Projections have been examined by the Auditors. The Projections have been prepared for inclusion in this Final Placement Memorandum for the purposes of this Issue, using a set of assumptions that include hypothetical assumptions about future events and management's actions that are not necessarily expected to occur, and have been approved by the Board. Consequently, Bidders are cautioned that the Projections may not be appropriate for purposes other than that described above. In any event, these statements speak only as of the date of this Final Placement Memorandum or the respective dates indicated in this Final Placement Memorandum.

The Terra InvIT, the Investment Manager, the Sponsor, the Trustee or the Lead Manager or their respective affiliates or advisors, (financial, legal or otherwise), undertake no obligation to update or revise any of the statements reflecting circumstances arising after its date or to reflect the occurrence of underlying events, whether as a result of new information, future events or otherwise after the date of this Final Placement Memorandum. If any of these risks and uncertainties materialise, or if any of the Investment Manager's underlying assumptions prove to be incorrect, the actual results of operations or financial condition or cash flows of the Terra InvIT could differ materially from that described herein as anticipated, believed, estimated or expected. All subsequent forward-looking statements attributable to the Terra InvIT are expressly qualified in their entirety by reference to these cautionary statements. Given these uncertainties, Bidders are cautioned not to place undue reliance on such forward-looking statements and financial projections, and not to regard such statements to be a guarantee or assurance of the Terra InvIT's future performance or returns to investors.



## SECTION II – RISK FACTORS

*An investment in the Units involves risks. Eligible Investors should carefully consider all the information in this Final Placement Memorandum, including the risks and uncertainties described below, before making an investment in the Units. To obtain a complete understanding, Eligible Investors should read this section together with the sections ‘Business’, ‘Combined Financial Statements’, ‘Management’s Discussion and Analysis of Financial Condition and Results of Operations’ and ‘Rights of Unitholders’, as well as the other information contained in this Final Placement Memorandum. The risks and uncertainties described in this section may not be the only risks and uncertainties the Terra InvIT and the Asset SPVs currently face. Additional risks and uncertainties not presently known to the Trustee, Sponsor or the Investment Manager, or that the Trustee or the Investment Manager do not currently consider material, may arise or may adversely affect our business, financial condition, cash flows and results of operations. If any of the following risks, or other risks that are not currently known or are currently considered immaterial, actually occur, our business prospects, results of operations, cash flows and financial condition could suffer, the price of the Units could decline and prospective investors may lose all or part of their investment. Unless otherwise specified in the relevant risk factors, the Trustee, Sponsor and the Investment Manager are not in a position to specify or quantify the financial or other risks mentioned herein.*

*This Final Placement Memorandum also contains forward-looking statements that involve risks, uncertainties and assumptions. The actual results of the Terra InvIT and the Asset SPVs could differ materially from those anticipated in these forward-looking statements as a result of certain factors, including the considerations described below and elsewhere in this Final Placement Memorandum.*

*Eligible Investors should be aware that the price of the Units, and the income from them, may be subject to volatility. If any of the risks described below occurs, our business and prospects could be adversely affected and Eligible Investors could lose all or part of their original investment.*

*In making an investment decision, Eligible Investors must rely upon their own examinations and the terms of the Issue, including the merits and the risks involved. Eligible Investors should consult their tax, financial and legal advisors about the particular consequences of investing in the Issue.*

*In this section, unless the context otherwise requires, a reference to “we”, “us” and “our” refers collectively to the Terra InvIT and the Asset SPVs. Further, unless the context otherwise requires, the financial information used in this section is derived from the Combined Financial Statements.*

- 1. We are heavily reliant on certain off-takers and significant part of our revenue is generated from solar power projects in certain states and any adverse development in economic, regulatory and political environment may adversely affect our business, financial condition, results of operations, and prospects.***

Our Asset SPVs have entered into PPAs with SECI, TANGEDCO, NVVN, GUVNL and UPPCL. During the Financial Years ending March 31, 2021, March 31, 2020 and March 31, 2019, our revenue from central off-takers (SECI and NVVN) was ₹12,795.97 lakhs, ₹12,823.71 lakhs, and ₹11,889.47 lakhs constituting, 37.18%, 36.50%, and 36.29% of our revenue from operations on a consolidated basis respectively and from state off-takers (GUVNL, UPPCL and TANGEDCO) was ₹21,617.98 lakhs, ₹22,309.64 lakhs, and ₹20,874.57 lakhs, constituting 62.82%, 63.50%, and 63.71% of our revenue from operations on a consolidated basis, respectively.

There is limited number of creditworthy purchasers of utility scale quantities of electricity under long-term PPAs, which exposes us to purchaser concentration risk. As at the date of this Final Placement Memorandum, our solar power projects have exposure to the off-takers as set out above, and any event impacting their economic condition may adversely affect our business, financial condition, results of operations, and prospects.

Further, as at the date of this Final Placement Memorandum, our solar power projects are located in Maharashtra, Tamil Nadu, Gujarat, Rajasthan and Uttar Pradesh. Our business therefore depends on and will depend on the general economic conditions, market conditions and natural disasters in these states or in the states we intend to expand. Any adverse development in economic, regulatory and political environment that results in economic slowdown in these states resulting in a reduction in generation or off-take of solar energy may adversely affect our business, financial condition, results of operations, and prospects. For example, state government off-takers in Andhra Pradesh have filed a petition before the APERC seeking a recalculation of tariffs payable by them under various PPAs. For details on risks involving changes in the policies adopted by governmental entities, see ‘**Risk Factors – Changes in the policies adopted by governmental entities or changes in the relationships of any**

***member of the Terra InvIT and the Asset SPVs with the Government or state governments could adversely affect our business, financial performance and results of operations.***’ on page 24.

Further, we expect that we will continue to be heavily reliant on certain off-takers for the renewable energy projects for the foreseeable future. Accordingly, any failure to maintain our relationship with these off-takers or expiry or termination of the PPAs and/or negotiate and execute renewed PPAs on terms that are commercially viable, with off-takers, could have an impact on our financial condition and our growth prospects.

Since the transmission and distribution of electricity are either monopolised or highly concentrated in most regions, there are a limited number of possible purchasers for utility scale quantities of electricity in a given geographic location, including transmission grid operators and central and state-run utilities.

For instance, for projects established pursuant to the NSM, solar project developers are required to enter into PPAs with specified implementation agencies. In addition, we are focused on a limited pool of counterparties who are sovereign, investment grade entities or otherwise state Discoms with strong ratings under the annual integrated rating of the MoP. As a result, there is a concentrated pool of potential buyers for electricity generated by our solar power projects, and any delays or default by off-takers on its payment obligations under the PPAs could have a material and adverse effect on us and consequently, adversely affect our business, prospects, financial condition, results of operations and cash flows.

Furthermore, if the financial condition of these utilities and/or power purchasers deteriorate or the NSM or other solar policies to which they are currently subject and that compel them to source renewable energy supplies to change, demand for electricity produced by our solar power projects could be negatively impacted which in turn could have an adverse effect on our business, prospects, financial condition, results of operations and cash flows.

***2. Our revenues are exposed to changes in electricity tariffs and tariff regulations and structuring in accordance with the relevant PPAs which may be non-negotiable or untested, and the PPAs may contain certain restrictive terms and conditions and any failure to comply with such terms and conditions could result in adverse consequences, including termination of the relevant PPAs.***

Significant portion of our revenue is derived from the sale of electricity based on the pre-determined tariffs specified in our PPAs. If there is an industry-wide increase in tariffs, we will not be able to renegotiate the terms of the PPA to take advantage of such increased tariffs since our tariffs are pre-determined. In addition, in the event of increased operational costs which could result from, amongst other things, inflation-based price increases, we will not have the ability to reflect a corresponding increase in our tariffs.

Some instances of other conditions under the PPA that may have an impact on the predictability of tariff:

- (i) in terms of PPA with UPPCL entered for a term of 25 years, the tariffs from the 13th to 25th year will be decided by the commission determined by the Uttar Pradesh Electricity Regulatory Commission at the appropriate time taking into account the RoE, O&M expenses and the interest on working capital loan. Although the tariff rates for the first 12 years is fixed in terms of the PPA with UPPCL, the tariff rate from the 13th year onwards, cannot be determined as on date of this Final Placement Memorandum;
- (ii) pursuant to the terms of PPAs with TANGEDCO, the reactive power charges shall be specified in the order on open access by TNERC, as amended. Additionally, drawal of energy by the relevant Asset SPV from TANGEDCO shall be adjusted against the exported energy and in case drawal of power is in excess over the exported power in a month, such excess drawal shall be billed under applicable temporary supply tariff as per the Tariff Order, as amended;
- (iii) pursuant to the terms of PPAs with SECI, the relevant Asset SPV cannot claim an accelerated rate of depreciation provided for under the IT Act for the project, without a reduction in applicable tariff; and
- (iv) in accordance with the terms of the PPAs entered with GUVNL, for each kVArh drawn from the grid, the relevant Asset SPV shall pay the rate as determined by the GERC payable to GETCO from time to time. Upon implementation of ‘Intra-State Availability Based Tariff’ in the state of Gujarat, the provisions of such regulations have also become applicable on the relevant Asset SPV.

Our PPA tariffs are generally not subject to downward revisions unless there is a delay in commissioning our projects, although we may enter into contracts that provide for downward adjustments in the future. For instance, we had experienced delay in COD for our Solar Edge Project due to implementation of the GST regime pursuant to which SECI by way of its letter dated January 3, 2019, granted an additional 62 days for commissioning the

project and levied charges towards liquidated damages for our project. Liquidated damages were calculated and paid in accordance with the relevant PPA by Solar Edge.

Our PPAs have been entered into with SECI, TANGEDCO, NVVN, GUVNL and UPPCL and we have limited ability to negotiate the terms of these contracts. The standard form of the PPAs is submitted with the request for selection or proposal while bidding for the project. The PPAs entered into with TANGEDCO requires compliance with the relevant provisions contained in the Indian Electricity Grid Code, Tamil Nadu Electricity Grid Code, the Electricity Act, 2003 and other codes and regulations issued by the Tamil Nadu Electricity Regulatory Commission or Central Electricity Authority, as amended from time to time for interfacing and evacuation facilities and with respect to certain metering arrangements, including in accordance with the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006, Commission's Grid Connectivity and Intra State Open Access Regulations, 2014, Tamil Nadu Electricity Distribution Code, 2004 and the Tamil Nadu Grid Code. Any failure to adhere to such terms and conditions may attract adverse consequences including termination of the relevant PPAs.

Further, majority of our off-takers, at any time during a contract year, are not obliged to purchase any additional energy from the relevant Asset SPV beyond the specified capacity in the relevant PPA and may purchase power beyond acceptable deviations at lower tariffs. If for any contract year, it is found that the relevant Asset SPV has not been able to generate minimum energy of specified capacity with the time periods specified in the relevant PPA, on account of reasons solely attributable to the Asset SPV, then such non-compliance shall make the Asset SPV liable to pay the compensation provided in the power purchase agreement as payable to buying utilities (as defined in the relevant PPA), subject to certain conditions specified, and may lead to termination of the relevant PPA. Further, any excess generation over and above the specified quantity may be purchased by our off-takers at a lower rate at their option and often subject to conditions such as their ability to procure purchasers for such excess generation. For instance, NSFI on behalf of Terralight Kanji, TN Solar and UMD filed a petition dated December 1, 2018 before the TNERC against TANGEDCO, SLDC and TANTRANSCO regarding the non-payment by SLDC for the units of electricity supplied by Terralight Kanji, TN Solar and UMD, in excess of 19% of the annual CUF (AC). By way of an order dated December 20, 2020, the TNERC has disallowed the petition and stated that payments made to the solar power generators shall be limited to the annual generation that corresponds to the annual CUF of 19%. An appeal dated May 7, 2019, has been filed by NSFI before APTEL. The matter is currently pending. For details in relation such petition, see '*Material Litigation and Regulatory Action - Litigation and Regulatory Actions involving the Asset SPVs*' on page 294.

The PPAs of the Asset SPVs also contain certain restrictive covenants. For instance, the PPAs entered into with SECI contain substitution provisions. Such substitution clauses allow the lenders in consultation with SECI to exercise their rights, if any, under financing agreements, to seek substitutions of the relevant Asset SPV by a selectee for the residual period in the event of suspension or termination of the PPA, due to a breach or default by such Asset SPV.

In the event any off-taker or a lender invokes any restrictive provision in the relevant PPAs or interprets any term or condition in an adverse manner or there are any changes to our current tariff rates, such invocation or interpretation or amendment may adversely affect our business, financial condition and results of operations. For further details on the terms of the PPAs, see '*Summary of the Power Purchase Agreements*' on page 154.

**3. *The ability to deliver electricity to our various counterparties requires the availability of and access to interconnection facilities and transmission systems which we do not own or control, and the extent and reliability of the Indian power grid and its dispatch regime may materially and adversely affect our business, prospects, financial condition, results of operations and cash flows.***

We generally rely on transmission lines and other transmission and distribution facilities that are owned and operated by the respective state governments or public entities. Where we do not have access to available transmission and distribution networks, we may be exposed to additional costs and risks associated with developing transmission lines and other related infrastructure, including dependence on third party contractors and impediments in obtaining right of way from land owners. We may not be able to secure access to the available transmission and distribution networks at reasonable prices, in a timely manner.

India's physical infrastructure, including its electricity grid, is less developed than that of many countries. As a result of grid constraints, such as grid congestion and restrictions on transmission capacity of the grid, the transmission and dispatch of the full output of our projects may be curtailed. For instance, Terralight Kanji Project, TN Solar Project and UMD Project have faced curtailment of external grid by TANGEDCO to maintain stability of the grid by it. Further, we may have to stop producing electricity during the period when electricity cannot be

transmitted, for instance, when the transmission grid fails to work. This may affect our ability to supply the contracted amount of power to the off-taker which may result in imposition of certain adverse consequences on us under the terms of the relevant PPAs. Furthermore, if construction of power projects in India, particularly in the states and regions that we operate in, outpaces transmission capacity of power grids, we may not be in a position to transmit, or have dispatched, all of our potential electricity to the power grid and therefore may be dependent on the construction and upgrading of grid infrastructure by Government or public entities for increased capacity. The curtailment of our power projects' output levels will reduce our electricity output and limit operational efficiencies without compensation, which in turn could have an adverse effect on our business, prospects, financial condition, results of operations and cash flows.

**4. *Counterparties to our PPAs may not fulfil their obligations which could result in a material adverse impact on our business, prospects, financial condition, results of operations and cash flows.***

In India, the distribution of electricity is controlled by central agencies and state utilities and therefore there is a concentrated pool of potential buyers for grid connected, utility scale electricity generated by our projects, which may restrict our ability to find new off-takers or counterparties for the electricity generated by our projects. If, for any reason, any of our off-takers or counterparties under such PPAs become unable or unwilling to fulfil their contractual obligations under the relevant PPA or if they refuse to accept delivery of contracted power pursuant to the relevant PPA, our business, financial condition, results of operations and prospects may be adversely affected as we may not be able to find other purchasers for such contracted capacities or replace the PPA on equivalent terms and conditions.

There may also be delays associated with collection of receivables from Government-owned or controlled entities due to the financial condition of these entities, which have in some instances deteriorated significantly in the past. All the PPAs entered by the Asset SPVs are with central and state off-takers, although central and state Governments in India have taken steps to improve the liquidity, financial condition and viability of state electricity distribution utility companies in recent years, there can be no assurance that our off-takers will have the resources to pay on time or at all.

In addition, our off-takers may, for any reason, become unable or unwilling to fulfil their related contractual obligations, refuse to accept delivery of power delivered thereunder or otherwise terminate such agreements prior to the expiration thereof. Furthermore, to the extent any of our off-takers are, or are controlled by, governmental entities, bringing actions against them to enforce their contractual obligations is often difficult.

Further, our projects or our counterparties may be subject to legislative or other political action that may impair their contractual performance. If such events occur, our assets, liabilities, business, prospects, financial condition, results of operations and cash flows could be materially and adversely affected.

**5. *Our business will be subject to seasonal fluctuations and natural calamities that could have a material adverse effect on our business, financial condition and results of operations.***

Renewable power generation is highly dependent on weather conditions and the profitability of our operations depends not only on observed weather conditions at the project site but also on the consistency of those weather conditions. The revenues generated by our projects are proportional to the amount of electricity generated, which in turn is dependent upon prevailing environmental conditions. We base our investment decisions with respect to each renewable energy project on the findings of related energy studies conducted on-site prior to such acquisition. However, operating results for wind and solar energy projects vary significantly depending on natural variations from season to season and from year to year and may also change permanently because of climate change or other factors. In some periods, the wind or solar conditions may fall within our long-term estimates but not within the averages expected for such a period. In addition, the amount of electricity our projects produce and hence the revenue is highly dependent on the amount of sunlight or irradiation (in our case of the Terra InvIT Assets) and on actual wind conditions, including wind speed (in the case of wind power projects), associated weather conditions and other climate conditions (including conditions resulting from man-made causes, such as smog from crop burning), which are beyond our control. The shorter daylight hours during the winter months will reduce the irradiation and consequently will have an adverse impact on the power generation through solar projects. Additionally, our Terra InvIT Assets may be affected by the monsoon season. While the northern and western parts of India experience monsoon rains during the period from June or July until September every year, the southern parts of India, experience monsoon rains even during the months of October to December. In the case of solar power projects, because shorter daylight hours in winter months results in less irradiation, the generation capacities of our projects will vary depending on the season.

Components of our systems, such as solar panels and inverters, could be damaged by severe weather conditions, such as hailstorms, tornadoes or lightning strikes or levels of pollution, dust and humidity. Further such natural phenomena may result in delays in periodic maintenance and reduce productivity, thereby adversely affect our business, financial condition and results of operations from our cost structure as indicated in the Combined Financial Statements. The operational performance of a particular solar energy project also depends on the contour of the land on which the project is situated. In case of a highly variable contour, the output of the solar farm situated on such a surface may be sub-optimal. Our solar power projects are also affected by the monsoon season, which generally lasts from May through September.

Unfavourable weather conditions could impair the effectiveness of renewable energy projects, reduce their output beneath their rated capacity, require the shutdown of key equipment, impede the operation of renewable energy projects and could adversely affect our forecasted revenues and cash flows.

**6. *We cannot assure you that we will be able to successfully undertake future acquisitions of renewable energy projects or efficiently manage the renewable energy projects we have acquired or may acquire in the future.***

Our growth strategy in the future may involve strategic acquisitions of renewable energy projects. Such acquisitions depend on various investment criteria such as nature of the source of the energy, credit profile of the seller, size of the portfolio (in terms of installed capacity), operating history of the project, validity of the PPA and tariff rates. We may not be able to conclude appropriate or viable acquisitions in a timely manner. The success of our past acquisitions and any future acquisitions will depend upon several factors, including:

- our ability to finance and acquire renewable energy projects on a cost-effective basis;
- our ability to integrate acquired personnel, operations, products and technologies into our organisation effectively including integrating the Supervisory Control and Data Acquisition systems for efficient management of the assets;
- unanticipated problems or legal liabilities of the acquired businesses; and
- Tax or accounting or legal or contractual issues relating to the acquired businesses.

We cannot assure you that we will be able to achieve the strategic purpose of such acquisitions or operational integration or an acceptable return on such investments, which may adversely affect our profits, financial condition and distributions. For instance, the Sponsor has entered into Sponsor SPA for acquisition of 100% equity of four entities owning and operating solar assets located in Rajasthan, Punjab and Madhya Pradesh with long term power purchase agreements with a mix of state and central off-takers. The aggregated portfolio size is 49 MW(AC) / 55.4 MW(DC). The consummation of the transaction is subject to various conditions precedents including approval from lenders. The Sponsor SPA contains standard representations and warranties and indemnities (including specific indemnities) from the counter party that are customary and appropriate for a transaction of this type and nature. The Sponsor may make available these solar assets for acquisition to Terra InvIT in future. However, we may not be able to acquire such assets on account of the conditions to the transaction not being met.

As on date of this Final Placement Memorandum, our business and operations are restricted to solar power projects, however, we may acquire certain other forms of renewable energy projects in the future. We may not successfully be able to undertake future acquisitions due to lack of previous experience, cost-effectiveness and entering into arrangements for transmission of such energy. Further, PPAs for future renewable energy projects may also contain terms and conditions that are more restrictive than those under the current Asset SPVs' PPA. Any future acquisitions or investments may require significant capital and may expose us to potential risks, including risks associated with undisclosed disputes, non-compliance with applicable laws, incurring additional debt, risks that acquired properties will not achieve anticipated profitability and an inability of the project to generate sufficient potential revenue in the future to offset the costs and expenses of the acquisition. These restrictions may restrict our flexibility in managing our business or projects and could in turn adversely affect our business prospects, financial condition and results of operations. Further, we are required to maintain certain investment ratios in accordance with the SEBI InvIT Regulations, including, requirement under Regulation 18(4) of the SEBI InvIT Regulations under which, not less than 80% of the value of our assets should be eligible infrastructure projects. Compliance with these requirements may restrict us to acquire additional asset in the future.

**7. *Expansion of our portfolio of assets will require significant capital and will depend on our ability to maintain our access to multiple funding sources on acceptable terms.***

We will require significant capital for expanding our portfolio of assets to continue to grow our business. There can be no assurance that we will be able to obtain financing for new projects as we have done in the past or that the interest rates and the other terms of available financing will remain attractive. In addition, rising interest rates could adversely affect our ability to secure financing on favourable terms and increase our cost of capital.

Our future profitability will depend to a significant extent on our ability to obtain the necessary funding on acceptable terms. We may refinance our current debt or incur additional debt with proceeds from third-party financing options, including any bank loans, equity partners, financial leases and securitisation. However, we cannot guarantee that we will be successful in locating additional suitable sources of financing in the time periods required or at all, or on terms or at costs that we find attractive or acceptable.

Any additional equity financing may be dilutive to our Unitholders and any debt financing may contain restrictive covenants that limit our flexibility going forward. Furthermore, our credit ratings may be downgraded, which would adversely affect our ability to refinance debt and increase our cost of borrowing. Failure to raise additional capital or debt financing as required may adversely impact our ability to achieve our intended business objectives.

**8. *Our acquisition strategy exposes us to substantial risks which may have an adverse effect on our ability to execute our growth strategy, business, financial condition, results of operations and cash flows and ability to make distributions to our Unitholders.***

The acquisition of power generation assets is subject to substantial risks, including the failure to identify material problems during due diligence (for which we may not be indemnified post-closing), the risk of over-paying for assets or not making acquisitions on an accretive basis, the ability to obtain or retain off-takers and, the projects may use technologies where we have limited or no experience. In addition, any control deficiencies in the accounting systems of the assets we acquire may make it more difficult to integrate them into our own accounting systems. Further, we may acquire certain solar projects from our Sponsor where the Sponsor may have already entered into definitive agreements. We may have no control over the terms under which such assets may have been acquired by our Sponsor and such terms may not be completely favourable to the Terra InvIT. For instance, the Sponsor has entered into Sponsor SPA for acquisition of 100% equity of four entities owning and operating solar assets located in Rajasthan, Punjab and Madhya Pradesh with long term power purchase agreements with a mix of state and central off-takers. The aggregate portfolio size is 49 MW(AC) / 55.4 MW(DC). The Sponsor may make available these solar projects for acquisition to Terra InvIT in future. While we will perform our due diligence on such prospective acquisitions, we may not be able to discover all potential operational deficiencies in such projects. The integration and consolidation of acquisitions requires substantial human, financial and other resources and may divert management's attention from our existing business concerns, disrupt our ongoing business or otherwise fail to be successfully integrated. There can be no assurance that any future acquisitions will perform as expected or that the returns from such acquisitions will support the financing utilised to acquire them or maintain them. As a result, the consummation of acquisitions may have an adverse effect on our ability to execute our growth strategy, business, financial condition, results of operations and cash flows and ability to make distributions to our Unitholders.

**9. *Changes in the policies adopted by governmental entities or changes in the relationships of any member of the Terra InvIT and the Asset SPVs with the Government or state governments could adversely affect our business, financial performance and results of operations.***

The Asset SPVs derive almost all of their revenue from their respective PPAs with SECI, TANGEDCO, NVVN, GUVNL and UPPCL and must maintain good relationships with these organisations, the Government and the various state governments. We expect that, after the conclusion of the Formation Transactions, we will continue to depend on, and benefit from, policies relating to the solar power projects and any future projects. In addition, we expect to benefit from, and depend on, SECI, TANGEDCO, NVVN, GUVNL and UPPCL and various Government and state government entities in terms of policies, incentives, budgetary allocations and other resources provided by these entities for the solar power industry in general. For instance, the Government has laid significant thrust on climate change for which it provided a framework, NAPCC in 2008, where it proposed an eight pronged strategy which is NSM, energy efficiency, sustainable habitat, water planning, Himalayan ecosystem, afforestation, sustainable agriculture and strategic knowledge on climate change. MoP has made it mandatory for Discoms to open and maintain adequate letter of credit as payment security mechanism under power purchase agreements. Letter of credit mechanism was implemented from August 2019. However, on account of its limited success, the payment security mechanism has been proposed in draft Electricity Act

amendment bill, 2020 to ensure strict compliance across states. Further, the central government has released the draft Renewable Energy Act in July 2015 to address various issues limiting the growth potential of renewable energy sector. The Renewable Energy Act is in the consultation stage and would be proposed in the parliament once other amendments and legislations (Under National Tariff Policy 2006 and Electricity Act, 2003) to facilitate the implementation of the Act are also identified and implemented. The Act aims to boost demand for renewable energy by creating a mandatory national level RPO targets with provision for penalties on Discoms/states in case of non/under compliance. In addition, it envisages timely provisioning of infrastructure, payment security mechanisms and other steps to improve operations for developers. (Source: CRISIL Report). Given these amendments are yet to be passed by the legislature, it is uncertain whether such benefits will be available to us.

Currently, our business and operations are governed by various laws and regulations, including the Electricity Act, 2003, National Electricity Policy, 2005 and National Tariff Policy, 2016, environmental and labour laws and other legislations enacted by the Government and the relevant state governments in India. Our business and financial performance could be adversely affected by any unfavourable changes in or interpretations of existing laws, or the promulgation of new more stringent laws. Specifically, there can be no assurance that the Government or any state government in India will not implement new regulations and policies which will require us to obtain additional approvals and licences from the government and other regulatory bodies or impose onerous requirements and conditions on their operations, which could result in increased compliance costs as well as divert significant management time and other resources. Any adverse change in any existing Governmental policies, incentives, allocations or resources, or any change in our relationships with Governmental entities, could adversely affect our business, financial condition and results of operations. Also see '*Regulations and Policies*' on page 183.

The solar power industry is heavily influenced by Government regulations and policies, as well as policies adopted by electric utilities companies. Examples of Government-sponsored financial incentives to promote solar power include capital cost rebates, tax credits, net metering and other incentives to end-users, distributors, system integrators and manufacturers of solar products. The Government has accorded renewable energy "must-run" status, which means that any renewable power that is generated must always be accepted by the grid. However, certain state electricity boards may order the curtailment of renewable energy generation despite this status and there have been instances of such orders citing grid safety and stability issues being introduced in the past. This may occur as a result of the state electricity boards purchasing cheaper power from other sources or transmission congestion owing to a mismatch between generation and transmission capacities. There can be no assurance that the Government will continue to maintain the "must-run" status for renewable energy or that the state electricity boards will not make any orders to curtail the generation of renewable energy. Further, state government off-takers in Andhra Pradesh, India have filed a petition before the APERC seeking a recalculation of tariffs payable by them under various PPAs. While the High Court of Andhra Pradesh in 2019 directed APERC to dismiss the notices for revisions of tariff, we may face difficulties in receiving the tariff receivables from these off-takers in the event we expand our renewable energy projects in Andhra Pradesh or in the event a similar approach is taken any other state Discoms. Until the solar power industry reaches such a scale that it becomes cost-effective on non-subsidised basis, a significant reduction in the scope or discontinuation of Government incentive programs could reduce demand for solar power projects and, as a result, cause a decrease in the demand for our services and solutions, which could have an adverse effect on our business, prospects, financial condition and results of operations.

**10. *The continued global spread of the COVID-19 could adversely affect our business, results of operations and financial conditions.***

There have been rapid developments in the wide-spread global pandemic of a severe acute respiratory syndrome coronavirus 2 (commonly known as SARS-CoV-2) and the infectious disease novel coronavirus ("**COVID-19**"), caused by the virus, which the World Health Organisation declared a pandemic on March 11, 2020. In order to contain the spread of the COVID-19 virus, the Government declared a lockdown of the country, which included a ban on travel and imposition of transport restrictions.

The continued global spread of COVID-19 is adversely affecting the global and Indian economy, the financial markets and the prevailing business sentiment and environment. The pandemic has also adversely affected the generation of solar power projects operated by the Asset SPVs and has adversely affected the Indian economy in general, which has had an adverse effect on our business, financial condition and results of operations. Operationally, the employees of the Asset SPVs employed at our solar power projects also run the risk of contracting COVID-19. This in turn, it may reduce the possibility of our personnel and professional advisors to carry out their work at the solar power projects which could affect our business.

The COVID-19 outbreak is ongoing and the actual extent of the outbreak and its impact on the economy globally in general and in India, in particular remains uncertain at this point in time and may turn severe in future. While the direct and indirect impact of the COVID-19 pandemic remains uncertain, the Government and the RBI have announced fiscal stimulus packages in anticipation of a significant negative impact on the economy. A worsening of the current outbreak of COVID-19 virus or future outbreaks of COVID-19 virus could adversely affect the Indian economy and economic activity in the region. If the outbreak of any of these epidemics or other severe epidemics, continues for an extended period, occur again and/or increases in severity, it could have an adverse effect on economic activity worldwide, including India, and could materially and adversely affect our business, cash flows, financial condition and results of operations and other securities.

We continue to monitor developments closely as the COVID-19 pandemic continues to evolve. The impact of the COVID-19 pandemic on the Terra InvIT and Asset SPVs will depend on a range of factors which we are not able to accurately predict, including the duration, severity and scope of the pandemic, the geographies impacted, the impact of the pandemic on economic activity in India, and the nature and severity of measures adopted by the Government. These factors include, but are not limited to:

- The deterioration of socio-economic conditions and disruptions to our operations, such as power generation disruptions, which may result in increased costs due to the need for alternative arrangements;
- Significant volatility in financial markets (including exchange rate volatility) and measures adopted by governments and central banks that further restrict liquidity, which may limit our access to funds, lead to shortages of cash or increase the cost of raising such funds;
- Our ability to ensure the safety of our workforce and continuity of operations while conforming with measures implemented by the Government in relation to health and safety of our employees, which may result in increased costs;
- The potential for a resurgence of COVID-19 following any easing of government measures that have been implemented to help control or slow the spread of disease.

The ultimate extent of impact of COVID-19 on our business, financial condition and results of operations will depend on these uncertain future developments. To the extent that the COVID-19 pandemic adversely affects our business and operations, it may also have the effect of heightening many of the other risks described in this section titled '**Risk Factors**'. More generally, any epidemic, pandemic or other health crisis, whether similar to COVID-19, SARS, H1N1, MERS or Zika or other past global diseases, could adversely affect our business, financial condition and results of operations. In addition, our revenue and profitability could be impacted to the extent that a natural disaster, health epidemic or other outbreak harms the Indian economy in general.

**11. *Operational interruptions may reduce energy production below our expectations and repairing any failure could require us to expend significant amounts of capital and other resources.***

Our Terra InvIT Assets may not continue to perform as they have in the past or as they are expected due to risks of equipment failure due to, amongst other things, local conditions, wear and tear, latent defect, design error or operator error, or early obsolescence, force majeure events, which could have a material adverse effect on our assets, liabilities, business, prospects, financial condition, results of operations and cash flows. Our facilities may require periodic upgrading and improvement. Any unexpected operational or mechanical failure, including failure associated with breakdowns and forced outages, and any decreased operational or management performance, could reduce our facilities' generating capacity below expected levels and reduce our revenues as a result of generating and selling less power. Degradation of the performance of our facilities above levels provided for in the relevant PPAs may also reduce our revenues. Unanticipated capital expenditures associated with maintaining, upgrading or repairing our facilities may also reduce profitability, especially because our costs are fixed in the PPAs and we may not pass through any unexpected costs in relation to the projects to our off-takers or counterparties.

Further, any mechanical failure or shutdown of equipment sourced from third parties could result in undamaged equipment that is dependent on or interacts with damaged sections of our facilities, including any transmission facilities, also having to be shut down. Such events could have a material and adverse impact on our generating capacity. If any shutdowns continue for extended periods, this may give rise to contractual penalties or liabilities, loss of off-takers or counterparties and damage to our reputation. Although we are entitled to be compensated by manufacturers for certain equipment failures and defects in certain cases, these arrangements may not fully compensate us for the damage and loss suffered as a result thereof.



**12. *We are subject to certain operational cost overruns which may adversely affect our business, prospects, financial condition, results of operations and cash flows.***

A key driver of our profitability is our ability to manage costs during the terms of our PPAs and to operate our renewable energy projects at optimal levels. If we are unable to manage costs effectively or to operate our projects at optimal levels, our profit margins, and therefore our business and results of operations, may be adversely affected. In addition, our operational projects may not meet our return expectations due to cost overruns or revenue shortfalls or they may not generate the capacity that we anticipate or generate revenue in the originally anticipated period or at all. An inability to maintain our portfolio or to convert acquired projects into financially successful operational projects could have an adverse effect on business, prospects, financial condition, results of operations and cash flows.

While we aim to maintain a competitive cost of operations, increases in our cost structure could have a material adverse impact on our financial performance. Examples of such costs include compliance with new conditions imposed during property taxes and the increased cost of procuring materials and services required for any unforeseen operations and maintenance activities. Our current O&M expenses for our projects typically ranges from ₹29 lakhs per annum to ₹286 lakhs per annum, and escalate upto 5% per annum as per the terms of the relevant O&M Agreement. Cost increase beyond this predictable range may adversely affect our business, prospects, financial condition, results of operations and cash flows

**13. *The Asset SPVs' PPAs and associated agreements may be terminated prematurely under certain circumstances by off-takers, which may have an adverse impact on our business.***

Under the terms of our PPAs, the agreement may be terminated by off-takers for certain events as set forth in the relevant power purchase agreement, including, but not limited to the following:

- any failure by the relevant Asset SPV to comply with prescribed minimum shareholding requirements;
- any failure to commence power supply up to the contracted capacity by the end of the period specified in the relevant PPAs;
- in the event the relevant Asset SPV mortgages or charges or purports to assign, mortgage or charge any of its assets or rights in the solar power project, except as specified in the PPAs;
- in the event the relevant Asset SPV becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding up proceedings and such proceedings remain uncontested for a period of 30 days or any winding up or bankruptcy or insolvency order is passed against relevant Asset SPV, except in the event such dissolution or liquidation is for the purpose of a merger, consolidation or re-organisation and where the resulting company retains creditworthiness similar to relevant Asset SPV and expressly assumes all obligations of the relevant Asset SPV under PPA and is in a position to perform them;
- any operations and management default by the relevant Asset SPV;
- failure in operating the solar power plant as per specified grid code in the relevant PPA, SLDC instruction and prudent practices of industries;
- failure to rectify breaches within the prescribed timelines; and
- any failure by the relevant Asset SPV to comply with any other material terms of the relevant PPA.

For instance, there were delays in achieving COD for the Solar Edge project, for which liquidated damages were calculated and paid in accordance with the relevant PPAs. Solar Edge has received no further penalties or faced any consequences due to delay in such commissioning.

Further, the VGF Securitization Agreements entered into with SECI for the Solar Edge project also stipulates certain events of default which includes:

- (a) the relevant solar power project fails to generate power continuously for one year;
- (b) the relevant solar power project is dismantled and/ or its major assets are sold by relevant Asset SPV except as specified;

- (c) relevant Asset SPV misrepresented facts/ information to meet eligibility conditions stipulated;
- (d) relevant Asset SPV defaults in any terms of the loan documents and lender takes steps for recovery including winding up of the relevant Asset SPV;
- (e) Any voluntary or involuntary bankruptcy or insolvency proceedings against the relevant Asset SPV or the relevant Asset SPV goes into liquidation or has receiver appointed to manage its affairs;
- (f) Except as permitted, the relevant Asset SPV fails to maintain its controlling shareholding up to a period of one year after COD;
- (g) Any attachment or distraint is levied on the mortgaged/ charged property and or/ proceedings are taken for recovery of any dues from the relevant Asset SPV;
- (h) the relevant Asset SPV fails to comply with the applicable law in relation to the solar power project and such non-compliance results in revocation of any consent or approval obtained in relation to the solar power project;

If any of the PPAs or its associated agreements are reduced or terminated prematurely, our business, financial condition and results of operations may be adversely affected. For further details on the termination of the PPAs or its associated agreements, see '*Business*' and '*Summary of the Power Purchase Agreements*' on pages 132 and 154.

**14. *We depend on various contractors and sub-contractors for the operations of the Terra InvIT Assets. We are exposed to risks arising from the pricing, timing or quality of their services, equipment and supplies and warranties given. This may materially and adversely affect our business, profitability, financial condition and results of operations.***

We enter into contracts with contractors and sub-contractors for their services for the operation and management of our Terra InvIT Assets. We are subject to the risk that contractors or sub-contractors may not perform their obligations under their respective contracts with us, including in respect of warranties. Furthermore, the solar panels, inverters and other system components utilised in our projects are generally covered by manufacturers' warranties, which are typically for 5 to 15 years. In the event any such components fail to operate as required, we may be able to make a claim against the applicable warranty to cover all or a portion of the expense or losses associated with the faulty component. However, the warranties may not be sufficient to cover all of our expense and losses. In addition, these suppliers could cease operations and no longer honour the warranties, which would leave us to cover the expense and losses associated with the faulty component. Our Asset SPVs and our Project Manager have entered into the O&M Agreements with external O&M Contractors in order to set out the terms for operation and maintenance of the solar power project. The O&M Contractors have agreed to perform certain specified services for the operation and maintenance of the solar power project and in accordance with specified operating standards and specifications, including health, safety, and environment standards. The O&M Contractors shall be responsible for operations, maintenance and other services for the solar power projects required for a period of 5 years for the Project SPVs and 3 years for the Specified SPVs. The scope of the O&M arrangement includes amongst other things, (i) submission daily, monthly, quarterly and annual reports on the performance of the solar power project to the respective Asset SPVs; (ii) periodic cleaning of the PV and solar modules, housekeeping services, vegetation abatement and project upkeep; (iii) civil and mechanical maintenance within the premises of the solar power project along with preventive maintenance of the solar power project; (iv) providing security services at the solar power project; (v) co-coordinating with the QCA the SLDCs, distribution licensees and other government authorities for load forecasting and for carrying out joint meter reading, as applicable.; (vi) conducting visual inspections of all structures, module attachments, anchoring posts and other elements; (vii) conducting maintenance in case of any breakdowns; and (viii) regular review of the condition, operability, performance and safety of all plant systems and equipment and perform required maintenance

While certain O&M Contractors have provided unconditional and irrevocable bank guarantees to secure their obligations under the O&M Agreements, if contractors or sub-contractors fail to comply with the specified quality standards and technical specifications; do not comply with local regulations; cause or are subject to accidents on the project site; otherwise fail to perform their obligations; terminate their contracts with us; or are subject to insolvency proceedings, we may be unable to fulfil our obligations under our PPAs. We may also suffer disruptions in our operations and may need to enter into new contracts with other contractors or sub-contractors at a higher cost which we may not be able to recover from our operations. Such events could have a material and adverse effect on our ability to fulfil our obligations to our off-takers and meet agreed timelines and may cause

an increase in our working capital requirements. If any shutdowns continue for extended periods, this could give rise to contractual penalties or liabilities under our PPAs, a delay or inability to recognise revenues, loss of off-takers or counterparties and damage to our reputation.

**15. *We may face limitations and risks associated with debt financing/ servicing, refinancing and restrictions on investment, which may adversely affect our operations and our ability to make distributions to Unitholders***

As of March 31, 2021, we had a total external indebtedness of ₹94,499.73 lakhs. Our ability to meet our payment obligations under our outstanding debt depends on our ability to generate sufficient cash flow. This, to some extent, is subject to general economic, financial, competitive, legislative and regulatory factors as well as other factors that are beyond our control, such as, the general condition of global equity and debt capital markets, economic and political conditions and development of the renewable energy sector and climatic conditions of the locations where our Projects are located. If we are unable to generate sufficient cash flow to satisfy our debt obligations or other liquidity needs, we may have to undertake alternative financing plans, such as refinancing or restructuring our debt, selling assets, reducing or delaying capital investments or seeking to raise additional capital. We cannot assure you that any refinancing would be possible, that any assets could be sold or, if sold, of the timing of the sales and the amount of proceeds that may be realised from those sales, or that additional financing could be obtained on acceptable terms, if at all. Our inability to generate sufficient cash flows to satisfy our debt obligations, or to refinance our indebtedness on commercially reasonable terms, would adversely affect our financial condition and results of operations.

We are subject to regulatory restrictions in relation to our debt financing and refinancing. We may from time to time require debt financing and refinancing to carry out our investment strategy. In the event that we undertake debt financing or refinancing, we may be limited by Indian law as to the form of financing or refinancing that we may undertake. For instance, while the RBI has recently permitted scheduled commercial banks and certain financial institutions to lend to InvITs, such lending is subject to the conditions specified in the circular which include, *inter-alia*, banks putting in place a board-approved policy for exposure to InvITs and the determination of Asset SPVs not being in “financial difficulty” and lending subject to such policies.

We may require additional debt financing or the issuance of additional Units in order to support the operating business or to make acquisitions and investments. If obtained, any such additional debt financing may decrease distributable income, and any issuance of additional Units may dilute existing Unitholders’ entitlement to distributions. Pursuant to the Trust Deed, we are required to obtain Unitholders’ approval for further borrowing, in the event that the aggregate borrowing of the Terra InvIT (net of cash and cash equivalents) exceeds the limits prescribed under SEBI InvIT Regulations. For details in relation to the borrowing policy adopted by the Investment Manager, see ‘**Corporate Governance – Borrowing Policy**’ on page 181.

In the event that we undertake debt financing or refinancing, we may also be subject to risks associated with debt financing and refinancing, including the risk that our cash flow may be insufficient to meet required payments of principal and interest under such financing and to make distributions to Unitholders. Our ability to generate sufficient cash to satisfy our debt obligations will depend on our future operating performance, which may be affected by prevailing economic conditions and financial, business and other factors beyond our control. There is no assurance that we will be able to generate sufficient cash flow to meet all of our debt obligations. If we are unable to make payments due under our debt facilities, the lenders may be able to declare an event of default and initiate enforcement proceedings relating to any security provided in respect of the loan facilities, and/or call upon any guarantees, and this may adversely affect our ability to make distributions to Unitholders.

In addition to compliance with the provisions of the SEBI InvIT Regulations, due to the Sponsor being a non-resident entity, any future investment by us in holding companies or Asset SPVs may also be subject to the investment conditions prescribed under the extant foreign exchange regulations for investment in infrastructure sector. For example, any downstream or other investments made by us are subject to conditions under the extant foreign exchange regulations for investment in infrastructure sector, both in terms of investments and divestments.

We may also be subject to certain covenants in connection with any future borrowings that may limit or otherwise adversely affect our operations, our ability to make distributions to Unitholders, restrict our ability to acquire assets, make distributions or undertake other capital expenditure, restrict our ability to set aside funds for maintenance or repayment of security deposits or to maintain certain financial ratios. For further details, see ‘**Financial Indebtedness**’ on page 280.

Further, if prevailing interest rates or other factors at the time of financing or refinancing (including changes in market conditions and maturity term imposed by any lenders) result in higher interest rates, the interest expense may be significant and may have an adverse effect on our cash flow and the amount of distributions available to Unitholders.

**16. *Certain of our Asset SPVs are subject to restrictive covenants and undertakings under its financing agreements. Any non-compliance or default by the Asset SPVs could limit its flexibility in managing its business or to use cash or other assets.***

The financing agreements that certain of our Asset SPVs have entered into with certain financial institutions contain certain restrictive covenants, including, but not limited to, conditions that they obtain consent from the lenders prior to, *among others*:

- (a) not effect any change in its capital structure including shareholding pattern without the prior written approval of the lenders' agent, other than as contemplated for the project or as contemplated under the financing documents;
- (b) not, without the prior written approval of the lenders' agent, recognise or register any transfer of shares made or to be made by the promoter save and except the transfer of shares with the other companies as specified;
- (c) confirm that the promoter (as described in the relevant financing documents) retains management control of Asset SPV at all times;
- (d) not make any change in its management structure without the prior written approval of the lenders' agent (such approval not to be unreasonably withheld);
- (e) upon any change in the composition of its board of directors, provide a written intimation to the lender's agent within 15 days of such change and the lenders shall provide their objection or consent within 3 months from the receipt of such intimation from the Asset SPV;
- (f) not alter its memorandum of association or articles of association in any manner which would be detrimental to the interests of the project lenders and inconsistent with undertaking the project, or any of the project documents and/or financing documents (including security documents), without the prior approval of the lenders' agent;
- (g) not make any change to its business activity without the prior approval of the lenders' agent;
- (h) not effect any scheme of amalgamation or restructuring or reconstruction, without the prior approval of the lenders' agent, other than a 100% subsidiary or parent;
- (i) not, without the prior approval of the lenders' agent, create or effect security interest over the project assets/secured properties and contracts or any part thereof in favour of any other financial institution, bank, borrower, firms or persons other than permitted security interest;
- (j) not, without the prior approval of the lenders' agent, undertake any new project, either directly or through group companies, make any investment in any group company with recourse to project assets, or make any other investment except to the extent permitted or take any assets on lease;
- (k) other than permitted disposal, not, without the prior approval of the lenders' agent, sell or otherwise dispose any project assets, security properties or equity interest charged to/ for the benefit of the project lenders;
- (l) not, without the prior approval of the lenders' agent, augment, modernise, expand or otherwise make any changes to the project;
- (m) not, without the prior approval of the lenders' agent, initiate termination proceedings or grant any waiver under the material project documents or other project documents (if termination or waiver of such other project documents may result in a material adverse effect);

- (n) not, without the prior approval of the lenders' agent, enter into borrowing arrangements, either secured or unsecured, with any other bank or financial institution, except for those arranged as part of means of finance for the projects as approved by the project lenders save and except for permitted indebtedness;
- (o) not, without the prior approval of the lenders' agent, undertake any obligation, monetary or legal on behalf any of its group companies / subsidiaries other than its obligations under the O&M, EPC and other contracts in relation to O&M for the project;
- (p) not, without the prior approval of the lenders' agent, enter into contractual arrangements long term in nature that are prejudicial to the interests of the project lenders;
- (q) not, without the prior approval of the lenders' agent, issue any debentures, raise any loan, accept any deposits, issue any equity or preference shares or provide any loans to the promoter with any recourse to the project assets/ secured properties;
- (r) not, without the prior approval of the lenders' agent, prepay all or any part of any financial assistance or debt availed by it except as permitted under the financing documents;
- (s) not declare or pay any restricted payment unless the stipulated conditions have been complied with and a confirmation to this effect has been received from the lenders' agent; and
- (t) not, without the prior approval of the lenders' agent, open a bank account.

For details, see '**Financial Indebtedness**' on page 280. In addition, these restrictive covenants may also affect some of the Terra InvIT's rights as the shareholder of the relevant Asset SPV and the Asset SPV's ability to pay dividends if it is in breach of its obligations under the applicable financing agreement.

In accordance with Solar Edge Refinancing, Solar Edge is in the process of creating and perfecting securities, as per the timelines specified in the relevant facility agreement. In relation to TSEC, the facilities availed are secured by mortgage on the land TSEC operates for which indenture of mortgage has not been executed on account of administrative and procedural delays, and failure to create and perfect security amounts to an event of default. We cannot assure you that we will be able to successfully create such security or that the lender will not recall the availed borrowing on account of such delay or default. Further, under the facility agreements entered into by Solar Edge, PLG, TSET, TSEC and USUPL, the lenders have the right to appoint a nominee director to the board of directors of the relevant Asset SPV upon the occurrence of an event of default. Further, the facilities availed by the Asset SPVs requires them to adhere to certain financial covenants, to the satisfaction of the lenders. Subject to any applicable grade periods or cure rights, in the event of any breach of any covenant contained in these financing agreements, we may be required to immediately repay our borrowings either in whole or in part, together with any related costs. In case of such breach, we cannot assure you that we will be able to secure consents from, and/or negotiate revised terms with, the lenders on terms favourable to the Terra InvIT or at all.

Additionally, the Sponsor (and in the case of PLG, the Sponsor and USUPL and in the case of TSET, the Sponsor and TSEC) have provided certain undertakings under the facility agreements in favor of the lenders, which includes:

- (a) until final settlement date, retain at least 51% of ownership of the relevant Asset SPV;
- (b) retain management control of the relevant Asset SPVs at all times;
- (c) ensure that the relevant Asset SPV is provided with requisite technical, financials and other managerial expertise to perform its obligations;
- (d) it shall infuse / extend amounts to discharge all payments made by such Asset SPV towards penalties resulting from a breach of any applicable law by it;
- (e) it shall infuse / extend additional funds to the Asset SPV to meet the shortfall (if any) in Debt Service Reserve Account and/or Internal Rate of Return in the normal course of business; and

- (f) it shall infuse / extend additional funds to the Asset SPV, to meet the O&M expenses, in case the O&M expenses exceeds the levels envisaged under the base case model agreed with the respective lenders.

In the case of USUPL, the Sponsor has provided an undertaking that upon consummation of the acquisition of USUPL, a fresh undertaking shall be provided substantially in the same form as provided by the earlier promoters, and the undertaking is in the process of being entered into.

In the case of PLG, TSET, TSEC and USUPL, post completion of the Formation Transaction, the Terra InvIT will be required to provide such undertakings to the lenders in the same form given by the Sponsor.

In terms of Solar Edge Refinancing, the Sponsor is required to provide an unconditional undertaking until the final settlement date or until Formation Transaction, post completion of which, the Terra InvIT shall be required to execute the undertaking. There can be no assurance that we will be able to comply with the covenants or take necessary action that we believe are required to operate and grow our business.

Further, the facility availed by the Asset SPVs contain certain mandatory pre-payment clauses which requires mandatory pre-payment of the amount outstanding on the receipt of monies pursuant to occurrence of certain events specified in the relevant agreements. In case the event specified in such clauses exist, occurs or has occurred, the Asset SPVs shall be required to repay the outstanding loan together with accrued interest and all other amounts then accrued or payable under the financing documents within the time period specified in the facility agreement.

Subject to any applicable grace periods or cure rights, any non-compliance or default by Asset SPVs in adhering with the restrictive covenants and undertakings may impose penalties and adverse consequences on Asset SPVs including accelerations of loans. There can be no assurance that we will be able to comply with these financial and other covenants or that we will be able to obtain consents necessary to take actions that we believe are required to operate or grow our business. Any or all of the above restrictive covenants may restrict our ability to conduct business and any breach thereof may adversely affect our results of operations and financial condition. Further, our Asset SPVs may avail financing facilities in the future. We cannot assure you that the terms and conditions to any such financing arrangements that are entered into in the future will be favourable to the SPVs and will not adversely affect our business, results of operations, financial condition and cash flows.

**17. *The NCDs issued by our Project SPVs are subject to certain terms and conditions.***

The Project SPVs have primarily issued NCDs for a period of not more than 10 years, subject to redemption events as specified in the relevant debenture subscription agreement, with no voting rights and a rate of interest of 7% per annum payable annually. They are ranked at least *pari passu* in their right of payment with unsecured payment obligations of Project SPVs and subservient and subordinated to secured payment obligations of the Project SPVs. The NCDs are non-transferable and non-marketable, subject to the terms of the relevant securities subscription and purchase agreements. The redemption event for the NCDs issued by the Project SPVs are dependent on outcome on the certain outstanding litigation involving our Project SPVs. However, in accordance with the relevant securities subscription and purchase agreements, the debenture holders hold the right to assume control of the defence and negotiation of such legal proceedings at its cost and expense. For details in relation to terms of the NCDs and details of the legal proceedings, see '**Financial Indebtedness – NCD Terms**' and '**Material Litigation and Regulatory Action**' on pages 285 and 292. There is no assurance that these legal proceedings and regulatory matters will be decided in favour of the respective Project SPVs. Decisions in any of the aforesaid proceedings adverse to our interests may have a material, adverse effect on our or their business, future financial performance and results of operations. Additionally, if the Project SPVs fail to redeem the NCDs in accordance with the terms of the NCD documents, the debenture holders shall have the right to require the Sponsor to purchase all of the NCDs which the Project SPVs have failed to redeem, subject to applicable laws, by issuing a notice to Sponsor within 15 business days of such aforesaid failure to redeem. Upon consummation of the Formation Transaction such obligations of the Sponsor may be assigned to the Terra InvIT. Any failure to redeem the NCDs may lead us to default on our obligations under the relevant securities subscription and purchase agreements.

**18. *We are required to maintain certain licenses, approvals, registrations, consents and permits in the ordinary course of business, and the failure to maintain them may materially and adversely affect our operations.***

Our business is highly regulated and we require a number of licenses, approvals, registrations, consents and permits to operate our business in India. In addition, we may need to apply for approvals, including the renewal of approvals which may expire, from time to time, as and when required in the ordinary course of business. If we

fail to obtain or renew such licenses, approvals, registrations, consents and permits in a timely manner, we may not be able to operate our solar power projects in accordance with the terms of our PPAs and applicable law, or at all, which could affect our business, financial condition and results of operations. We are required to obtain and maintain consents, approvals, registrations and permits with respect to the provision of our PPAs.

Additionally, under Grid Code and the Central Electricity Regulatory Commission (Deviation Settlement Mechanism and related matters) Regulations, 2014, as amended, renewable energy power producers are required to forecast generation schedules. If the variation in actual generation against forecasted generation deviates beyond permissible levels, a wind and solar power producer is required to pay an unscheduled interchange charge along with penalties. If we are unable to forecast and schedule accurately within allowed variance or if we are unable to comply with these requirements in States where our projects are sited, the non-compliant project will be subject to charges until it is able to comply, which may in turn adversely affect its business and results of operations.

Furthermore, government approvals and licenses are subject to numerous conditions, including regular monitoring and compliance requirements. We may incur substantial costs, including clean up and/or remediation costs, fines and civil or criminal sanctions, as a result of violations of or liabilities under environmental or health and safety laws, which may have a material adverse effect on our business or financial condition. We cannot assure you that approvals, licenses, registrations, consents and permits issued to us would not be suspended or revoked in the event of non-compliance with any terms or conditions thereof, or pursuant to any regulatory action. Further certain Asset SPVs are in the process of obtaining certain material licenses for its operations. We cannot assure you that, our Asset SPVs will be successful in receiving such approvals for its projects in a timely manner. See '**Regulatory Approvals**' on page 298 for more details, including such approvals for which applications are pending before relevant authorities. Any failure to renew the approvals that have expired or apply for and obtain the required licenses, approvals, registrations, consents or permits, or any suspension or revocation of any approvals, licenses, registrations and permits that have been or may be issued to us, may adversely affect our operations.

**19. *We will depend on certain directors, executive officers and key employees of the Investment Manager, the Project Manager, Asset SPVs and such entities may be unable to retain such personnel or to replace them with similarly qualified personnel, which could have a material, adverse effect on the business, financial condition, results of operations and prospects of the Terra InvIT and Asset SPVs.***

Our performance will depend, in part, upon the continued service and performance of certain directors, executive officers and key employees of the Investment Manager and the Project Manager. The continued operations and growth of our business will be dependent upon the Investment Manager and the Project Manager being able to attract and retain personnel who have the necessary and required experience and expertise. The Investment Manager has designated Mr. Sanjay Grewal, Mr. Parin Mehta and Mr. Atul Raizada as the key personnel of the Investment Manager. All key personnel have more than 5 years of experience each as required under Regulation 4(2) (e) (iii) of the SEBI InvIT Regulations. Competition for qualified personnel with relevant industry expertise in India is intense due to the scarcity of qualified individuals in the renewable energy sector, and the aforesaid entities may not be able to retain their executive officers and key employees or attract and retain fresh talent in the future. Any inability by the Investment Manager or the Project Manager or Asset SPVs to retain their respective directors, executive officers and key employees, or the inability to replace such individuals with similarly qualified personnel, could have an adverse impact on the business, financial condition, results of operations and prospects of the Terra InvIT and Asset SPVs.

**20. *The cost of implementing new technologies and/or refurbishing existing equipment for operating, maintaining and monitoring our projects could adversely affect our business, financial condition and results of operations.***

Our future success will depend in part on our ability to respond to technological advances and emerging standards and practices on a cost-effective and timely basis. In addition, rapid and frequent technology and market-demand changes can often render existing technologies and equipment obsolete, requiring substantial new capital expenditures or write-downs of assets. Any failure by us to successfully adopt such technologies in a cost-effective and timely manner could increase our costs. However, changes in technology may require us to make additional capital expenditures to upgrade our facilities. As per the Technical Reports, overall, the PV plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement. The development and implementation of such technology entails technical, business risks and significant costs of employee implementation. Further, we cannot assure you that we will be able to successfully implement new technologies or adapt our processing systems to evolving off-

taker requirements or emerging industry standards. Changes in technology may make newer solutions more competitive than ours or may require us to make additional capital expenditure to upgrade our facilities and technology. If we are unable, for technical, legal, financial or other reasons, to adapt in a timely manner to changing market conditions, evolving off-taker requirements or technological changes, our business, financial condition and results of operations could be adversely affected.

In addition, some of the equipment used by the Asset SPVs at the projects have pre-determined useful lives and the Asset SPVs may be required to replace or refurbish such equipment at periodical intervals. Such replacement or refurbishment might not be undertaken in a cost effective manner and any increased costs to the Asset SPVs as a result of such replacement or refurbishment will affect the profit margins of the Asset SPVs and adversely affect their cash flows.

**21. *Our Sponsor may face competition from other renewable energy firms, funds and developers as it continues to invest and acquire renewable energy projects to grow the business globally, which may have a material adverse effect our business, financial condition, results of operations and prospects.***

Our Sponsor is engaged in investment activities primarily with an objective of earning long term capital appreciation. The Sponsor seeks to invest in companies incorporated in India that operate in “infrastructure” sector. The Sponsor is an affiliate of the funds, vehicles and/or entities managed and/or advised by affiliates of KKR which has established a dedicated infrastructure team and has been one of the more active infrastructure investors globally over the past several years. Our Sponsor intends to continue to pursue accretive inorganic growth and new business opportunities. Our market position therefore depends on our and our Sponsor’s financing, development and operation capabilities, reputation, experience and track-record and our Sponsor’s ability to consummate such acquisitions and investments for us. Any increase in competition during the acquisition process or reduction in our competitive capabilities could have a material adverse effect on our market share and on the margins we generate from our renewable energy portfolio. Our Sponsor and the Terra InvIT being controlled by an entity managed and/or advised by the affiliates of KKR may also face competition from other funds and other investee companies of KKR or its affiliates focused on expanding their portfolio in the infrastructure or renewable energy sectors.

In addition, our competitors may choose to enter into strategic alliances or form affiliations with other competitors to our detriment. There can be no assurance that our current or potential competitors will not offer the services we provide comparable or superior to those that we offer at the same or lower prices; adapt more quickly to industry challenges; or expand their operations at a faster pace than we do. Increased competition may result in price reductions, reduced profit margins and loss of market share, thereby causing an adverse effect on our operations, prospects and financial condition.

**22. *Our insurance policies may not provide adequate protection against all possible risks associated with our operations.***

The Asset SPVs’ principal types of insurance coverage include, industrial all risk policy, burglary and terrorism policy. However, we cannot assure you that all possible risks are adequately insured against or that we will be able to procure adequate insurance coverage at commercially reasonable rates in the future. Further, the solar power projects are subject to various risks that we may not be insured against, adequately or at all, including:

- changes in governmental and regulatory policies;
- design and engineering defects;
- breakdown, failure or substandard performance of the machinery and other equipment;
- improper installation or operation of the machinery and other equipment;
- labour disturbances;
- terrorism and acts of war beyond the scope of available insurance;
- inclement weather and natural disasters;
- environmental hazards, including earthquakes, flooding, tsunamis and landslides; and
- adverse developments in the overall economic environment in India.



Further, we are subject to various risks in the operation of the solar power projects, including on account of accidents at the solar power projects. Our insurance may not provide adequate coverage in certain circumstances and is subject to certain deductibles, exclusions and limits on coverage. To the extent we suffer damage or loss which is not covered by insurance, or exceed our insurance coverage, such damage or loss would have to be borne by us. We can make no assurance that material losses in excess of insurance proceeds (if any at all) will not occur in the future, which could adversely affect our financial condition, business and results of operations.

In addition, we are obliged to maintain insurance policies under certain of our PPAs and a failure to maintain adequate insurance coverage could trigger an event of default thereunder. However, we may not be able to maintain insurance of the types or at levels which we deem necessary or adequate or at rates which we consider reasonable, in particular, if our premium levels increase significantly when we renew our insurance policies. Furthermore, the occurrence of an event for which we are not adequately or sufficiently insured or for which insurance is not available in the market, or the successful assertion of one or more large claims against us that exceed available insurance coverage, or changes in our insurance policies (including premium increases or the imposition of large deductible or co-insurance requirements), could have a material adverse effect on our business, prospects, financial condition and results of operations. We cannot assure you that any claim under the insurance policies maintained by us will be honoured fully or on time. Any payments we make to cover any losses, damages or liabilities or any delays we experience in receiving appropriate payments from our insurers could have an adverse effect on our business, financial condition and results of operations. See '*Business- Insurance*' on page 153 for more details.

**23. *We have in the past entered into a number of Related Party transactions and may continue to enter into Related Party transactions in the future, and there can be no assurance that we could not have achieved more favourable terms if such transactions had not been entered into with Related Parties.***

In the ordinary course of our business, we have entered and will enter into Related Party transactions with our Sponsor. The Terra InvIT and Asset SPVs have entered and will enter into transactions either inter-se or with Related Parties, including the Investment Manager, Sponsor and their respective affiliates in relation to setting up the Terra InvIT and in relation to this Issue. The terms of such transactions may not be as favourable to us as those negotiated between unaffiliated third parties. For details in relation to related party transactions entered, see '*Related Party Transactions*' and '*Combined Financial Statements*' on pages 188 and 214. There can be no assurance to you that any future Related Party transactions that we may enter into, individually or in the aggregate, will not have an adverse effect on our business, financial condition and results of operations. Further, the transactions with our Related Parties may potentially involve conflicts of interest. Additionally, there can be no assurance that any dispute that may arise between us and Related Parties will be resolved in our favour.

**24. *Conflicts of interest may arise out of common business objectives shared by us and our Sponsor.***

Our Sponsor and its affiliates seek to invest in companies incorporated in India that operate in "infrastructure" sector. Our Sponsor is an affiliate of the funds, vehicles and/or entities managed and/or advised by affiliates of KKR which has established a dedicated infrastructure team and has been one of the more active infrastructure investors globally over the past several years and, therefore, such persons may be interested in businesses, which directly compete with our activities. If these conflicts of interest are managed to our detriment, they could adversely affect our performance. In particular, we may compete with existing and future private and public investment vehicles established and/or managed by our Sponsor and/or its affiliates, which may create differing or competing interests to ours or the Unitholders. Certain of these divisions and entities have or may have an investment strategy similar to our investment strategy and therefore may compete with it. In particular, various infrastructure funds and other investment vehicles of our Sponsor and/or its affiliates seek to invest in a broad range of renewable energy projects. As a result, conflicts of interest may arise in allocating or addressing business opportunities and strategies among our Sponsor and/or its affiliates and us, in circumstances where our interests differs from those of our Sponsor and/or its affiliates. Consequently, there can be no assurance that all potentially suitable investment opportunities that come to the attention of Sponsor and/or its affiliates will be made available to us. Our Sponsor and/or its affiliates may, and may be required, by contract or otherwise, to market these other assets in competition with the Asset SPVs, which may have an adverse effect on our business, results of operations and financial condition and our Investment Manager's ability to make cash distributions to Unitholders. Specifically, KKR Asia Pacific Infrastructure Investors SCSp (which indirectly holds investment in the Sponsor), through its affiliate(s), owns 23.69 % of the issued and outstanding unit capital of India Grid Trust, an infrastructure investment trust registered with the Securities and Exchange Board of India. India Grid Trust is managed by IndiGrid Investment Managers Limited, in which Electron IM Pte. Ltd., an entity affiliated with funds, vehicles and/or entities managed and/or advised by or otherwise controlled by KKR or its affiliates, holds 74% of the issued and outstanding share capital. India Grid Trust currently owns 100% of the issued and paid-up

share capital in (i) FRV India Solar Park II – Private Limited; and (ii) FRV Andhra Pradesh Solar Farm-I Private Limited. India Grid Trust's strategy is inter alia to acquire solar projects with long term power purchase agreements, operational track record and financially strong counterparties / off-taker such as SECI and NTPC. The business of India Grid Trust (which is managed by IndiGrid Investment Managers Limited) may compete with that of the Terra InvIT.

**25. *The Investment Manager is proposed to be the investment manager to another InvIT.***

Galaxy Investments II Pte. Ltd., an affiliate of our Sponsor, is proposing to acquire assets in the roads infrastructure sector and set up a trust under the SEBI InvIT Regulations. The Investment Manager has been appointed to act as the investment manager of the proposed InvIT. The Investment Manager is not prohibited from providing management services to investment trusts sponsored by other persons. To ensure good governance and clear segregation of the management and operations of the different InvITs being managed by the Investment Manager from time to time, the Investment Manager shall implement appropriate systems for efficient management of such InvITs. Additionally, in compliance with requirements under the SEBI InvIT Regulations, any potential transactions between the Terra InvIT and the proposed InvIT for road assets will be treated as related party transactions and shall be undertaken in accordance with the Related Party Transaction Policy. However, we cannot assure you that such systems will be effectively implemented by the Investment Manager or prevent the actions of the Investment Manager from adversely affecting the levels of service that Terra InvIT requires, which may have an adverse effect on our business.

**26. *The Asset SPVs and the Trustee are involved in certain legal and other proceedings, which may not be decided in their favour.***

The Asset SPVs and the Trustee are involved in legal proceedings or claims which are pending at different levels of adjudication before various courts, tribunals and regulatory authorities. For details of certain material outstanding legal proceedings, see '**Material Litigation and Regulatory Action**' on page 292. There is no assurance that these legal proceedings and regulatory matters will be decided in favour of the respective entities. Decisions in any of the aforesaid proceedings adverse to our interests may have a material, adverse effect on our or their business, future financial performance and results of operations. If the courts, tribunals or regulatory authorities decide against the Asset SPVs or the Trustee, we or such entities may face monetary and/or reputational losses and may have to make provisions in our financial statements, which could increase expenses and liabilities. The redemption event for the NCDs issued by the Project SPVs are dependent on outcome on the certain outstanding litigation involving our Project SPVs. In accordance with the relevant securities subscription and purchase agreements entered by the Project SPVs and the debenture holders in relation to the NCDs issued by the Project SPVs, the debenture holders hold the right to assume control of the defence and negotiation of legal proceedings on which the redemption events for NCDs issued by Project SPVs are subjected, at its cost and expense. For details in relation to terms of the NCDs, see '**Financial Indebtedness – NCD Terms**' on page 285. Pursuant to the completion of the Formation Transactions, we are responsible for legal proceedings against the Project SPVs, subject to terms of the NCDs. While the Sponsor and/or its affiliates will provide certain indemnities under the relevant Securities Acquisition Agreements, we cannot assure you that the relevant Asset SPV or the Terra InvIT will be able to successfully bring a claim against the Sponsor under the relevant Securities Acquisition Agreements or that such indemnities will be adequate to satisfy all the losses, damages, costs and expenses suffered by the Terra InvIT and the Asset SPVs arising from such proceedings or the consequences thereof.

**27. *Land title in India can be uncertain and there is no assurance that we receive a clean title on the land on which our projects are situated.***

There is no central title registry for real property in India. Property records in India are generally maintained at the state and district level and are updated manually through physical records of all land-related documents and may not be available online for inspection or updated in a timely manner. This could result in property records investigations taking a significant amount of time or being inaccurate in certain respects, which may impact the ability to rely on them. The difficulty of obtaining title guarantees in India means that title records provide only for presumptive rather than guaranteed title. The original title to lands may often be fragmented and the land may have multiple owners. In addition, title insurance is not commercially available in India to guarantee title or development rights in respect of land, which may increase our exposure to third party claims to the land on which the solar power project is situated. Land records are often handwritten, in local languages and not legible, which makes it difficult to determine the content. In addition, land records are often in poor condition and are at times untraceable, which materially impedes the title investigation process. Further, improperly executed, unregistered or insufficiently stamped conveyance instruments in a property's chain of title, unregistered encumbrances in favour of third parties, rights of adverse possessors, ownership claims of family members of prior owners or third

parties, or other defects that a purchaser may not be aware of, can affect the title to a property. As a result, potential disputes or claims regarding title to the land on which projects are situated may arise. Any defects in, or irregularities of, title or leasehold rights that we shall enjoy may prejudice Asset SPV's ability to operate the solar power projects without interference from third party claims. Specifically, the Asset SPVs are already involved in certain proceedings involving issues regarding land title over land used for their operations at different levels of adjudication before various courts, tribunals and regulatory authorities. For details of certain material outstanding legal proceedings, see '*Material Litigation and Regulatory Action - Litigation and Regulatory Actions involving the Asset SPVs*' on page 294. Further, we cannot assure you that we will not become involved in other litigation or other proceedings of similar nature in the future. Such litigations could adversely affect our business, prospects, financial condition and results of operations.

Separately, some of our Asset SPVs operate on lands leased from third party and our continuous use of these site is dependent on the such third parties maintaining their ownership rights over these sites. Their failure of maintaining their rights could adversely affect our business, prospects, financial condition and results of operations.

**28. *Compliance with, and changes in, safety, health and environmental laws and regulations in India may adversely affect our business.***

Our business will be subject to environmental, health and safety laws and regulations and various labour, workplace and related laws and regulations in India including statutes, regulations, guidelines, policies, directives and other requirements governing or relating to, amongst other things: protection of wildlife, including threatened and endangered species and their habitat; air emissions; discharges into water; water use; the storage, handling, use, transportation and distribution of dangerous goods and hazardous, residual and other regulated materials; the prevention of releases of hazardous materials into the environment; the prevention, investigation, monitoring and remediation of hazardous materials in soil and groundwater, both on- and off-site; land use and zoning matters; and workers' health and safety matters. For further details, see '*Regulations and Policies*' on page 183. Our solar power projects could experience incidents, malfunctions and other unplanned events that may result in personal injury, penalties and property damage. In addition, certain environmental laws may result in liability, regardless of fault, concerning contamination at a range of properties, including properties currently or formerly owned, leased or operated by us and properties where we disposed of, or arranged for disposal of, waste. As such, the operation of our facilities carries an inherent risk of environmental, health and safety liabilities (including potential civil actions, compliance or remediation orders, fines and other penalties), and may result in our involvement from time to time in administrative and judicial proceedings relating to such matters. While we have implemented environmental, health and safety management programs designed to continually improve environmental, health and safety performance, we cannot assure you that such liabilities, as well as the costs for complying with environmental laws and regulations will not have a material adverse effect on our business, financial condition, results of operations and cash flows. Any changes in, or amendments to, these standards or laws and regulations could further regulate our business and could require us to incur additional, unanticipated expenses in order to comply with these changed standards. For example, the Supreme Court of India has recently passed an order requiring overhead powerlines to be relocated into underground power lines in identified priority and potential areas covering portions of state of Gujarat and Rajasthan and installation of bird diverters in certain potential and priority areas to protect and preserve two endangered species of birds, Great Indian Bustard and Lesser Florican. The coverage determination and implementation of the order is currently in progress. If any of our current or future projects are affected by the order, we will be required to incur additional capital expense which could adversely affect our business, prospects, financial condition and results of operation. Further, if we fail to meet safety, health and environmental requirements, we may also be subject to administrative, civil and criminal proceedings by governmental authorities, as well as civil proceedings by environmental groups and other individuals, which could result in substantial fines and penalties against us. Penalties imposed by regulatory authorities on us or third parties upon whom we depend may also disrupt our business and operations.

We cannot assure you that we will not become involved in future litigation or other proceedings or be held responsible in any such future litigation or proceedings relating to safety, health and environmental matters in the future. Clean-up and remediation costs, as well as damages, payment of fines or other penalties, other liabilities and related litigation, could adversely affect our business, prospects, financial condition and results of operations.

**29. *The Asset SPVs have a limited period to operate the solar power projects as the term granted to the SPVs are fixed and the assets may need technology updates after a certain period.***

Each of the PPAs entered into by the Asset SPVs provides for a fixed term, at the end of which the Asset SPVs can operate the solar power projects, if other conditions like land lease, permits, approvals and clearances etc.,

allow. For example, the PPAs entered into between the relevant Asset SPV with SECI will expire in 2043 and the PPAs entered into between the relevant Asset SPVs and TANGEDCO will expire in 2040 and with GUVNL in 2037 and NVVN in 2036. In the event of expiry of the existing PPAs, such agreements may be extended in accordance with the agreed terms between the parties. For further details, see '*Summary of the Power Purchase Agreements*' on page 154. We cannot assure you that the Terra InvIT will be able to successfully enter into renewed PPAs upon expiry of the existing PPAs. The land leased by the Asset SPVs are also co-terminus with the term of their respective PPAs. Further, there is a limited period for operating solar assets, which is around 25 years as they become redundant for operation after such period due to the risk associated with expired panel warranties, other components and may also require updates and upgrades in technology. For details, see '*Annexure II - Technical Report*' on page 417 and for details in relation risks associated for the cost of implementing new technologies and/or refurbishing the existing equipment, see '-- *The cost of implementing new technologies and/or refurbishing existing equipment for operating, maintaining and monitoring our projects could adversely affect our business, financial condition and results of operations.*' on page 33. This may adversely affect will affect the profit margins of the Asset SPVs and adversely affect their cash flows. In the event, the PPAs expire, we cannot assure that we will able to extend the land lease or enter into any arrangements for the project land.

**30. *We have incurred losses in Financial Years ending March 31, 2021, March 31, 2020 and March 31, 2019 and may incur losses in the future***

Terra InvIT and the Asset SPVs, on a combined basis and as stated in the Combined Financial Statements, has incurred losses in Financial Years ending March 31, 2021, March 31, 2020 and March 31, 2019, the details of which are as follows:

(in ₹ lakhs)			
Particulars	Financial Year 2021	Financial Year 2020	Financial Year 2019
Profit /(loss) after tax	(40,792.15)	(4,045.85)	(2,981.44)

Any such losses that we may incur in the future, may adversely affect our results of operations and financial condition.

**31. *Security and information technology risks may disrupt our business, result in losses or limit our growth.***

Information technology systems are an important part of our business and these are utilised to support business processes. Our growing dependence on our information technology infrastructure, applications and data has caused us to have a vested interest in its reliability and functionality which can be affected by a number of factors, including, but not limited to, the increasing complexity of the information technology systems, frequent change and short life span due to technological advancements and data security. Such systems may fail to operate properly or become disabled as a result of tampering or a breach of the network security systems or otherwise. If our information technology systems malfunction or experience extended periods of downtime, we may not be able to run our operations safely or efficiently. In addition, such systems are, from time to time, subject to cyberattacks and security breaches, which may continue to increase in frequency in the future. Cyber security breaches, such as unauthorised access, accidents, employee errors or malfeasance, computer viruses, computer hackings or other disruptions could compromise the security of our data and infrastructure, thereby exposing such information to unauthorised access by third parties. If such systems are compromised, do not operate properly or are disabled, we could suffer a financial loss, disruption in business and reputational damage.

The information systems and technology may not continue to be able to accommodate the growth in our business and the cost of maintaining or upgrading such systems may increase in the future, including on account of the prolonged impact of the COVID-19 pandemic. Failure to accommodate growth, or an increase in costs related to such systems, could have an adverse effect on our business.

**32. *The results of operations of the Asset SPVs could be adversely affected by strikes, work stoppages or increased wage demands by its employees and sub-contractors.***

The Project Manager has been appointed to operate and maintain our Terra InvIT Assets, in furtherance of which it has entered into O&M Agreements with O&M Contractors for complete operation and maintenance of our Terra InvIT Assets. The O&M Contractor will deploy sufficient manpower at all times to ensure the performance of its services is in accordance with the O&M Agreement. Our solar power projects may experience disruptions in their operations due to disputes or other problems with labour, and efforts by workers to modify compensation and

other terms of employment may divert our management's attention and increase operating expenses. The occurrence of such events could materially and adversely affect our business, prospects, financial condition, results of operations and cash flows.

Pursuant to the O&M Agreements, the Project Manager may sub-contract its obligations to provide any of the services under the O&M Agreements to any other entity with prior written consent of the Asset SPV. Any such third-party entity may engage contract labour in order to complete the assignments sub-contracted to it. Although the Project Manager and our Terra InvIT Assets may not engage such labour directly, should the sub-contractors default on wage payments to such labour, the Project Manager and our Terra InvIT Assets may be required to absorb such wage payments as if they were employees, pursuant to the provisions of the Contract Labour (Regulation and Abolition) Act, 1970. Any requirement to fund such wage payments may materially and adversely affect our business, prospects, financial condition, results of operations and cash flows.

In the event of any strikes or work stoppages due to increased wage demands by the employees and sub-contractors or the inability by the Asset SPVs to either retain or recruit employees and sub-contractors with suitable credentials, the ability of the Asset SPVs to generate power and maintain and operate the solar power projects will be adversely affected. In addition, any disruption to the services provided by the Asset SPVs' employees will have an adverse effect on the operations of the Asset SPVs. We cannot assure you that future disruptions will not be experienced due to disputes or other problems with the work force, which may adversely affect the business and results of operations of the Asset SPVs.

**33. *The Terra InvIT is a newly settled trust with no established operating history and no historical financial information and, as a result, investors may not be able to assess its prospects on the basis of past records.***

The Terra InvIT was established by way of a trust deed dated January 28, 2021 under the provisions of the Indian Trusts Act and it is registered as an infrastructure investment trust in accordance with the SEBI InvIT Regulations. Pursuant to the Formation Transactions, the Terra InvIT will acquire the entire holding of the Sponsor in the Asset SPVs from the Sponsor in exchange for Units and consideration amount prior to the Allotment. Accordingly, the Terra InvIT does not have any operating history or historical financial information by which its past performance may be evaluated. This could make it difficult for investors to assess the future performance and prospects of the Terra InvIT. Further, we have a relatively new portfolio of assets with a limited operating history on which to base an evaluation of our business and prospects. Our prospects must be considered in light of the risks, expenses and difficulties frequently encountered by companies in their early stages of operation, particularly in a rapidly evolving industry such as ours. We cannot assure you that we will be successful in addressing the risks we may encounter, and our failure to do so could have a material adverse effect on our business, financial condition, results of operations and cash flows.

**34. *While we currently own only solar energy projects, in the future we expect to expand our acquisition strategy to include other types of energy projects. To the extent that we expand our operations to include new business segments, our business operations may suffer from a lack of experience, which may materially and adversely affect our business, financial condition, results of operations and cash flows.***

We have limited experience in energy generation operations other than those involving the generation of solar power. As a result of this lack of experience, we may be prone to errors if we expand our projects to include technologies beyond solar. We lack the technical training and experience with operating such other generation facilities. With no direct training or experience in these areas, our management may not be fully aware of the many specific requirements related to working in industries beyond solar energy generation. Additionally, we may be exposed to increased operating costs, unforeseen liabilities or risks, and regulatory and environmental concerns associated with entering new sectors of the power generation industry, which could have an adverse impact on our business as well as place us at a competitive disadvantage relative to more established non-solar electric energy market participants. In addition, such ventures could require a disproportionate amount of our management's attention and resources. Our operations, earnings and ultimate financial success could suffer irreparable harm due to our management's lack of experience in these industries. We may rely, to a certain extent, on the expertise and experience of industry consultants, and we may have to hire additional experienced personnel to assist us with our operations. We can offer no assurance that if we expand our business beyond solar energy generation, we will be able to effectively acquire and operate projects in such new areas and achieve our targeted financial goals.

## **Risks related to our organisation and the structure of the Terra InvIT**

- 35. *The interpretation and enforcement of the regulatory framework governing infrastructure investment trusts in India is still evolving, which may have an adverse effect on the ability of certain categories of investors to invest in the Units, our business, financial condition and results of operations and our ability to make distributions to Unitholders.***

The SEBI issued the SEBI InvIT Regulations with effect from September 26, 2014. The regulations have been amended pursuant to notifications, and further supplemented with additional guidelines and circulars issued by SEBI. Because the regulatory framework governing infrastructure investment trusts in India comprises a relatively new set of regulations, interpretations and enforcement by regulators and courts involves uncertainties. The regulation and processes with respect to certain aspects of infrastructure investment trusts, including but not limited to, liabilities of the Unitholders, and the procedure for dissolution and delisting of infrastructure investment trusts have not been issued. Infrastructure investment trusts operate in a new and relatively unclear regulatory environment. Changes to the issue structure, changes to agreements entered into or proposed to be entered into in connection with the Issue, cost increases, fines, legal fees or business interruptions may result from changes to regulations, from new regulations, from new interpretations by courts or regulators of existing regulations or from stricter enforcement practices by regulatory authorities of existing regulations. In addition, new costs may arise from audit, certification and/or self-assessment standards required to maintain compliance with new and existing SEBI InvIT Regulations. Such changes in regulation, interpretation and enforcement may render it economically infeasible to continue conducting business as an infrastructure investment trust or otherwise have an adverse effect on our business, financial condition and results of operations.

Because we will operate in a new and relatively unclear regulatory environment, it is difficult to forecast how any new laws, regulations or standards or future amendments to the SEBI InvIT Regulations will affect infrastructure investment trusts and the infrastructure sector in India, and no assurance can be given that the regulatory system will not change in a way that will impair our ability to comply with the regulations, conduct our business, compete effectively or make distributions. Failure to comply with changes in laws, regulations and standards may have an adverse effect on our business, financial condition, results of operations and prospects.

- 36. *The reporting requirements and other obligations of infrastructure investment trusts post-listing are still evolving. Accordingly, the level of ongoing disclosures made to and the protection granted to our Unitholders may be more limited than those made to or available to shareholders of a company that has listed its equity shares upon a recognised stock exchange in India.***

The SEBI InvIT Regulations, along with the guidelines and circulars issued by the SEBI from time to time, govern the infrastructure investment trusts in India. However, as compared with the statutory and regulatory framework governing companies that have listed their equity shares or debt securities on recognised stock exchanges in India, the regulatory framework applicable to infrastructure investment trusts is relatively nascent and thus, still evolving. Accordingly, the ongoing disclosures made to our Unitholders under the SEBI InvIT Regulations may differ from those made to shareholders of a company that has listed its equity shares on a recognised stock exchange in India in accordance with the Securities and Exchange Board of India (Listing Obligations and Disclosure Requirements) Regulations, 2015.

Further, the rights of our Unitholders may not be as extensive as the rights of shareholders of a company that has listed its equity shares on a recognised stock exchange in India, and accordingly, the protection available to our Unitholders may be more limited than those available to such shareholders.

- 37. *Our actual results may be materially different from the expectations expressed or implied in the Projections and the assumptions in the Projections are inherently uncertain and are subject to significant business, economic, financial, regulatory and competitive risks and uncertainties that could cause actual results to differ materially from those projected.***

This Final Placement Memorandum contains forward-looking statements regarding, amongst other things, the projections of revenue and cash flows for projection years 2022, 2023 and 2024 for the Terra InvIT set out in the section '**Projections of Revenue from Operations and Cash Flows from Operating Activities**' on page 309. The Projection are only estimates of possible future operating results and are not guarantees of future performance. The Projection may not be realised and, because they relate to future events, are inherently subject to significant business, economic, competitive, industry, regulatory, market and financial risks, uncertainties, contingencies and other factors, many of which are beyond our control. Such risks, uncertainties, contingencies and other factors which may cause the actual results or performance of the Terra InvIT and Asset SPVs to be materially different

from any future results or performance expressed or implied by the Projection. The actual future results or performance of the Terra InvIT and Asset SPVs will be affected by numerous factors, including those discussed in ‘**Forward-looking Statements and Financial Projections**’ on page 17. Our revenue will be dependent on the cash flows from dividends, buyback of Asset SPV shares, and principal and interest payments (net of applicable taxes and expenses) from the Asset SPVs, whose revenue in turn is dependent on a number of factors, including actual irradiation, natural climatic conditions, machine availability, external and internal grid availability and losses on account of transmission lines. Accordingly, we cannot assure you that we will be able to achieve the Projections or make the distributions set out in the Projections.

If we do not achieve the projected operating results, we may not be able to make the expected distributions. We will not, and disclaim any obligation to, furnish updated business plans or projections to Unitholders, or to otherwise make public such information. As a result, you should not rely upon the Projection in making an investment decision given the possibility that actual results may differ materially from the underlying estimates and assumptions.

**38. *The Valuation Report by Mr. S. Sundararaman is not an opinion on the commercial merits and structure of the Issue nor is it an opinion, express or implied, as to the financial condition of the Terra InvIT, and the valuation of the Asset SPVs contained in such Valuation Report may not be indicative of the true value of the Asset SPVs.***

Mr. S. Sundararaman has been appointed as the Valuer to undertake independent valuation of the Asset SPVs. The Valuation Report sets out the opinion as to the fair enterprise value of the Asset SPVs as of March 31, 2021. In order to issue the Valuation Report, the Valuer has based his assumptions on among others, (i) the financial and other information provided by and discussions with or on behalf of us, and the Investment Manager; (ii) reliance on external sources; (iii) information on legal and corporate structures; which reflects the current expectations and views regarding future events and, therefore, necessarily involves known and unknown risks and uncertainties. The Investment Manager cannot provide assurances on the accuracy of these assumptions.

Valuation is an estimate and not a guarantee, and it is dependent upon the accuracy of the assumptions as to income, expenses and market conditions. Further, the valuation methodologies used to value the Asset SPVs will involve subjective judgments and projections, which may not be accurate. The Valuation Report is neither an opinion on the commercial merits and structure of the Issue nor an opinion, express or implied, as to the financial condition of the Terra InvIT. The Valuation Report does not purport to contain all the information that may be necessary or desirable to fully evaluate the commercial or investment merits of the Issue or the Terra InvIT. The Valuation Report does not confer rights or remedies upon investors or any other person, and does not constitute and should not be construed as any form of assurance as to the financial condition or future performance of the Terra InvIT or the Asset SPVs. The Valuation Report has not been updated since the date of its issue and does not take into account any developments subsequent to the date of its issue.

We cannot assure you that the Valuation Report reflects the true value of the Asset SPVs or that other independent valuers would arrive at the same valuation. Accordingly, investors should not rely unduly on the Valuation Report in making an investment decision to purchase Units in the Issue. For details, please see the ‘**Annexure I – Valuation Report**’ on page 329.

**39. *We have referred to the data derived from Technical Reports commissioned from the Technical Consultants, which are based on certain bases, estimates and assumptions that are subjective in nature and may not be accurate.***

We have relied on Technical Reports issued by Technical Consultants, independent third-party research agencies, to forecast the future power generation by the Terra InvIT Assets, evaluate technical feasibility, analyse contractual management and risk management, assess the Terra InvIT Assets’ performance on energy yield predictions and to prepare technical reports on the Terra InvIT Assets, which are set out in ‘**Annexure II – Technical Report**’ on page 417. The Technical Reports are subject to various limitations and are based upon certain bases, estimates and assumptions that are subjective in nature and that are based, in part, on information provided by and discussions with or on behalf of us, the Project Manager and the Investment Manager. The Technical Reports reflect current expectations and views regarding future events, and therefore involve known and unknown risks and uncertainties. The Technical Reports contain forecasts, projections and other “forward - looking” statements that relate to future events, which are, by their nature, subject to significant risks and uncertainties. There can be no assurance that the bases, estimates and assumptions adopted by the Technical Consultants for the purposes of preparing the Technical Reports will prove to be accurate or completely applicable to our Asset SPVs. Further, we are required under the PPAs entered with SECI to monitor and submit a technical

report with SECI for solar irradiance, ambient air temperature, wind speed and other weather parameters and electric power generated from the relevant project. Any non-compliance with submission of such technical report may constitute an event of default in the relevant PPA and may lead to termination of such PPA. Also see '**Presentation of Financial, Industry and Market Data**' on page 14. If any of these bases or assumptions is incorrect, future power generation for the Terra InvIT Assets could be materially different from those that are set out in the Technical Reports and this Final Placement Memorandum and we cannot assure you that the Technical Report reflects the actual operations and technical details of the Asset SPVs. Accordingly, investors should not rely unduly on the Technical Report in making an investment decision to purchase Units in the Issue.

- 40. *This Final Placement Memorandum contains information from the CRISIL Report which have been commissioned by the Investment Manager from CRISIL in relation to the Issue. The Investment Manager cannot assure you that the statistical, financial and other industry information in the CRISIL Report is either complete or accurate.***

The information in the section '**Industry Overview**' on page 105 and in certain other sections in this Final Placement Memorandum is based on the report titled "Renewable Power Market in India", dated July, 2021, prepared by CRISIL. The Investment Manager commissioned this report for the purpose of inclusion of industry information in this Placement Document. Neither we, the Trustee, the Sponsor, the Lead Manager to the Issue, Investment Manager nor any other person connected with the Issue has verified the information in the report. Further, the report has been prepared based on information as of specific dates and may no longer be current or reflect current trends.

Statistical and other information in this Final Placement Memorandum relating to India, the Indian economy or the renewable energy sector have been derived from various government publications, research reports from reputable institutions and communications with various Government agencies that are believed to be reliable. However, such information might not be reliable or accurate. Further, certain data relating to the business of the Asset SPVs has been assessed and quantified by the Asset SPVs internally, as no other credible third party sources are available for such data. Such assessment is based on each Asset SPV's understanding, experience and internal estimates of its business.

The information reflected in the CRISIL Report is subject to various limitations and is based upon certain estimates and assumptions that are subjective in nature. The CRISIL Report reflects current expectations and views regarding future events, and contain forecasts, projections and other 'forward-looking' statements that relate to future events.

While reasonable care has been taken in the reproduction of the information, no assurance can be made as to the accuracy of such facts and statistics, which may not be consistent with other information compiled within or outside India. Due to possibly inconsistent or ineffective collection methods or discrepancies between published information and market practice, the statistics contained in the CRISIL Report may be inaccurate or may not be comparable to statistics produced for other economies and should not be unduly relied upon. Further, there is no assurance that the statistics are stated or compiled on the same basis or with the same degree of accuracy as may be the case with information from elsewhere. Accordingly, investors should not rely unduly on the industry report from CRISIL in making an investment decision to purchase Units in the Issue.

- 41. *The Combined Financial Statements presented in this Final Placement Memorandum may not be indicative of the Terra InvIT's future financial condition and results of operations.***

For the purpose of this Final Placement Memorandum, the Combined Financial Statements have been prepared so as to present the financial position, results of operations and cash flows of the Asset SPVs on a combined historical basis for the Financial Years ending March 31, 2021, March 31, 2020 and March 31, 2019. For details see, '**Combined Financial Statements**' on page 214. The Combined Financial Statements have been prepared for the sole purpose of the Issue and may not necessarily represent our consolidated financial position, results of operations and cash flows had the Terra InvIT (together with the Asset SPVs) been in existence during the periods presented, nor do they give an indication of our financial results, cash flows and financial position in the future. After the date of Allotment in the Issue, there may be certain changes to our cost structure, level of indebtedness and operations which may impact our financial position.

- 42. *We will assume liabilities in relation to the Terra InvIT Assets and these liabilities, if realised, may adversely affect our results of operations, cash flows, and our profitability and ability to make distributions.***



As part of the Formation Transactions, we will assume liabilities of the Terra InvIT Assets and of the Asset SPVs that own the Terra InvIT Assets from our Sponsor who has recently acquired it from third party investors. While we have conducted due diligence on the Terra InvIT Assets with the objective of identifying any material liabilities, we may not be able to identify all such liabilities prior to the consummation of the Formation Transactions. Further, the terms of the Securities Acquisition Agreements contain limited representations and warranties which are qualified by any disclosure in this Final Placement Memorandum. The indemnities under the Securities Acquisition Agreements also include limitations on account of monetary or time limits, which may adversely affect our ability to recover monetary compensation. For details in relation to Securities Acquisition Agreements, see '*Background and Structure of the Terra InvIT*' on page 94. Any losses or liabilities suffered by us in relation to the Terra InvIT Assets for which we are unable to recover under these agreements will adversely affect our results of operations, cash flows, and our ability to make distributions to the Unitholders.

### **Risks Related to the Terra InvIT's Relationships with the Sponsor and the Investment Manager**

#### **43. *The Sponsor will be able to exercise control over the Terra InvIT.***

After the completion of the Issue, the Sponsor will own an aggregate of 77.11% of the issued and outstanding Units and will be entitled to vote on all matters other than matters where it is a Related Party. Also see '*The Terra InvIT is a newly settled trust with no established operating history and no historical financial information and, as a result, investors may not be able to assess its prospects on the basis of past records.*' on page 39. The Sponsor will also exercise control over the Investment Manager, which will continue to be an associate of the Sponsor.

#### **44. *Parties to the Terra InvIT are required to maintain the eligibility conditions specified under Regulation 4 of the SEBI InvIT Regulations on an ongoing basis. The Terra InvIT may not be able to ensure such ongoing compliance by the Sponsor, the Project Manager, the Investment Manager and the Trustee, which could result in the cancellation of the registration of the Terra InvIT.***

Parties to the Terra InvIT are required to maintain the eligibility conditions specified under Regulation 4 of the SEBI InvIT Regulations on an ongoing basis. These eligibility conditions include, amongst other things, that (a) the Sponsor, Investment Manager and Trustee are separate entities, (b) the Sponsor have a net worth of not less than ₹1,000 million each and have a sound track record in the development of infrastructure or fund management in the infrastructure sector, (c) the Investment Manager has a net worth of not less than ₹100 million and has not less than five years' experience in fund management or advisory services or development in the infrastructure sector or the combined experience of the directors/key employees of the Investment Manager in fund management or advisory services or development in the infrastructure section is not less than 30 years; (d) the Trustee is registered with the SEBI under Securities and Exchange Board of India (Debenture Trustees) Regulations, 1993 and is not an associate of the Sponsor or Investment Manager; and (e) each of the Sponsor, the Project Manager, the Investment Manager and the Trustee are 'fit and proper persons' as defined under Schedule II of the SEBI Intermediaries Regulations on an ongoing basis. The Terra InvIT may not be able to ensure such ongoing compliance by the Sponsor, the Project Manager, the Investment Manager and the Trustee, which could result in the cancellation of the registration of the Terra InvIT.

#### **45. *The Investment Manager is required to comply with certain ongoing reporting and management obligations in relation to the Terra InvIT. We cannot assure you that the Investment Manager will be able to comply with such requirements.***

The Investment Manager is required to comply with certain ongoing reporting and management obligations in relation to the Terra InvIT in accordance with the SEBI InvIT Regulations. These requirements include, amongst other things, (a) making investment decisions with respect to the underlying assets or projects of the Terra InvIT, (b) overseeing the activities of the Project Manager, (c) investing and declaring distributions in accordance with the SEBI InvIT Regulations, (d) submitting reports to the Trustee and (e) ensuring the audit of the Terra InvIT's accounts. We cannot assure you that the Investment Manager will be able to comply with such requirements in a timely manner or at all, which could subject the Investment Manager, the other parties to the Terra InvIT, the Terra InvIT or any person involved in the activity of the Terra InvIT to applicable penalties under the SEBI InvIT Regulations, the SEBI Intermediaries Regulations and/or the SEBI Act. Any such failure to comply or the imposition of any penalty could have an adverse effect on our business, financial condition and results of operations. Under the SEBI InvIT Regulations, the SEBI also has the right to inspect documents, accounts and records relating to the activity of the Terra InvIT, Asset SPVs or Parties to the InvIT and may issue directions in the nature of, *inter-alia*, (i) requiring the Terra InvIT to surrender its certificate of registration; (ii) requiring the Terra InvIT to wind-up; (iii) requiring the Terra InvIT to sell its assets; (iv) requiring the Terra InvIT or Parties

to the Terra InvIT to take such action as may be in the interest of investors; or (v) prohibiting the Terra InvIT or Parties to the Terra InvIT from operating in the capital markets or from accessing the capital markets for a specified period.

## **Risks Related to India**

### **46. *Changing laws, rules and regulations, including changes in legislation or the rules relating to tax regimes, legal uncertainties and the political situation in India may adversely affect our business, financial condition and results of operations***

Our business, financial condition and results of operations could be adversely affected by any change in laws or interpretations of existing, or the promulgation of new, laws, rules and regulations applicable to us and our business. We cannot assure you that the Government or the state governments will not implement new regulations and policies which will require the Terra InvIT and Asset SPVs to obtain additional approvals and licenses from governmental and other regulatory bodies or impose onerous requirements and conditions on our operations.

Tax laws and regulations are subject to differing interpretations by tax authorities. Differing interpretations of tax and other fiscal laws and regulations may exist within governmental ministries, including tax administrations and appellate authorities, thus creating uncertainty and potential unexpected results. The degree of uncertainty in tax laws and regulations, combined with significant penalties for default and a risk of aggressive action, including by retrospective legislation, by the governmental or tax authorities, may result in tax risks in the jurisdictions in which we operate being significantly higher than expected. These events may result in an adverse effect on our business, financial condition, results of operations and prospects. Tax authorities in India may also introduce additional or new regulations applicable to our business which could adversely affect our business and profitability.

The Government has implemented two major reforms in Indian tax laws, namely the goods and services tax and provisions relating to GAAR. Given the recent implementation of these laws, we cannot assure you as to the manner in which this tax regime will be implemented, which could create uncertainty.

The right to own property in India is subject to restrictions that may be imposed by the Government. In particular, the Government under the provisions of the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 has the right to compulsorily acquire any land if such acquisition is for a “public purpose,” after providing compensation to the owner. However, the compensation paid pursuant to such acquisition may not be adequate to compensate the owner for the loss of such property. The likelihood of such acquisitions may increase as central and state governments seek to acquire land for the development of infrastructure projects such as roads, railways, airports and townships. Any delays or disputes relating to such acquisitions could lead to delays and disruptions in the execution of our projects, which would have an adverse effect on our business, financial condition and results of operations. For further details, see ‘*Regulations and Policies*’ on page 183.

### **47. *Our business is dependent on economic growth in India and financial stability in Indian markets, and any slowdown in the Indian economy or in Indian financial markets could have an adverse effect on our business.***

The Terra InvIT is registered in India, and all of our assets are located in India. As a result, we are highly dependent on the prevailing economic conditions in India and our results of operations are significantly affected by factors influencing the Indian economy. Factors that may adversely affect the Indian economy, and hence our results of operations, may include:

- any increase in interest rates or inflation in India;
- any exchange rate fluctuations;
- any scarcity of credit or other financing in India;
- prevailing income, consumption and saving conditions amongst consumers and corporations in India;
- changes in India’s tax, trade, fiscal or monetary policies;
- political instability, terrorism or military conflict in India or in countries in the region or globally, including in India’s various neighbouring countries;

- the intensification of the adverse effects of the ongoing COVID-19 pandemic or the occurrence or other epidemics or pandemics;
- prevailing regional or global economic conditions;
- the balance of trade movements, including export demand and movements in key imports, including oil and oil products; annual rainfall which affects agricultural production;
- civil unrest, riots, protests, acts of violence, terrorist attacks, regional conflicts or situations or war involving India or other countries could adversely affect the financial markets, which could impact our business; and
- other significant regulatory or economic developments in or affecting India or its infrastructure sector.

Any slowdown or perceived slowdown in the Indian economy, or in specific sectors of the Indian economy, could have an adverse effect on our business, financial condition and results of operations and the price of the Units.

Further, the Indian economy and Indian financial market are influenced by economic and market conditions in other countries, particularly in emerging market in Asian countries. Financial turmoil in Asia, Europe, the United States and elsewhere in the world in recent years has affected the Indian economy. Although economic conditions are different in each country, investors' reactions to developments in one country can have an adverse effect on the securities of companies in other countries, including India. A loss in investor confidence in the financial systems of other emerging markets may cause increased volatility in Indian financial markets and, indirectly, in the Indian economy in general. Any global financial instability, including any instability related to current relation between the United States and China, could also have a negative impact on the Indian economy. Financial disruptions may occur again and could harm our results of operations and financial condition

**48. *Any downgrading of India's sovereign debt rating by a domestic or international rating agency could adversely affect our ability to obtain financing and, in turn, our business and financial performance.***

India's sovereign debt rating could be downgraded due to various factors, including changes in tax or fiscal policy or a decline in India's foreign exchange reserves, which are outside of our control. Any adverse revisions to India's credit ratings for domestic and international debt by domestic or international rating agencies may adversely impact our ability to raise additional financing, and the interest rates and other commercial terms at which any such additional financing is available. This could have an adverse effect on our business and financial performance, ability to obtain financing for capital expenditures and the price of the Units.

**49. *Fluctuations in the exchange rate of the Indian Rupee with respect to the U.S. Dollar or other currencies will affect the foreign currency equivalent of the value of the Units and any distributions.***

Fluctuations in the exchange rates between the Indian Rupee and other currencies will affect the foreign currency equivalent of the Indian Rupee price of the Units. Such fluctuations will also affect the amount that holders of the Units will receive in foreign currency upon conversion of any cash distributions or other distributions paid in Indian Rupees by us on the Units, and any proceeds paid in Indian Rupees from any sale of the Units.

**50. *Significant differences could exist between Ind AS and other accounting principles, such as Indian GAAP and IFRS, which may affect investors' assessments of the Terra InvIT's financial condition.***

The Combined Financial Statements included in this Final Placement Memorandum have been prepared in accordance with Ind AS. The impact of Indian GAAP or IFRS on such financial information included in this Final Placement Memorandum has not been quantified and the Combined Financial Statements have been prepared without reconciliation to any other body of accounting principles. Each of Indian GAAP and IFRS differs in significant respects from Ind AS. Accordingly, the degree to which the Combined Financial Statements included in this Final Placement Memorandum will provide meaningful information is dependent on the reader's level of familiarity with the relevant accounting practices. Any reliance by persons not familiar with such accounting practices on the financial disclosures presented in this Final Placement Memorandum should accordingly be limited.

## **Risks Related to Ownership of the Units**

**51. *The sale or possible sale of a substantial number of Units by the Sponsor in the public market following the completion of its lock-in requirement as prescribed under the SEBI InvIT Regulations could adversely affect the price of Units***

Under the SEBI InvIT Regulations, the Sponsor is required to hold a minimum of 15% of our Units for a minimum period of three years from the date of listing pursuant to the Issue and the balance of its unitholding in the Terra InvIT is required to be locked in for a period of one year from the date of listing of the Units. The Units are proposed to be listed on the Stock Exchange. If the Sponsor, following the completion of either of the aforesaid lock-in periods directly or indirectly sells or is perceived as intending to sell a substantial number of its Units, or if a secondary offering of the Units is undertaken, the market price for the Units could be adversely affected.

**52. *The Issue Price of the Units may not be indicative of the market price of the Units and may decline after the Issue.***

The Units may trade at prices significantly below the Issue Price after the Issue. The Issue Price determined by the Investment Manager may not be indicative of the price of the Units upon completion of the Issue. If the price of the Units declines significantly, the Sponsor may be unable to sell its Units at or above their purchase price, if at all. We cannot assure you that the price of the Units will not fluctuate or decline significantly in the future. The trading price and value of the Units will depend on many factors, including, amongst others:

- differences between our actual financial and operating results and those expected by investors and analysts;
- changes in general economic or market conditions;
- the market value of our assets;
- the perceived attractiveness of the Units against those of other business trusts, equity or debt securities;
- the balance of buyers and sellers of the Units;
- the size and liquidity of the Indian business trusts market;
- any changes to the regulatory system, including the tax system, both generally and specifically in relation to India business trusts;
- the ability of the Investment Manager to implement successfully its investment and growth strategies;
- foreign exchange rates;
- variations in our quarterly operating results;
- additions or departures of key management personnel of the Investment Manager and/or the Asset SPVs;
- changes in the amounts of our distributions, if any, and changes in the distribution payment policy or failure to execute the existing distribution policy;
- actions by Unitholders;
- changes in market valuations of similar business entities or companies;
- announcements by us or our competitors of significant contracts, acquisitions, disposals, strategic partnerships, joint ventures or capital commitments;
- speculation in the press or investment community; and
- changes or proposed changes in laws or regulations affecting the renewable energy industry and infrastructure development in India or enforcement of these laws and regulations, or announcements relating to these matters.

For these reasons, the price of Units may fluctuate. To the extent that we retain operating cash flow for investment purposes, working capital reserves or other purposes, these retained funds, while increasing the value of our

underlying assets, may not correspondingly increase the price of the Units. Our performance with regard to future earnings and distributions may adversely affect the market price of the Units. In addition, Unitholders who do not, or are not able to, participate in a new issuance of Units may experience a dilution of their interest in the Terra InvIT. The Units are not capital-safe products and there is no guarantee that Unitholders can regain the amount invested, in full or in part. If the Terra InvIT is extinguished, it is possible that investors may lose a part or all of their investment in the Units.

**53. *Under Indian law, foreign investors are subject to restrictions that limit their ability to transfer or redeem Units, which may adversely impact the trading price of the Units.***

Under foreign exchange regulations currently in force in India, transfers of units between non-residents and residents are permitted, subject to certain exceptions, if they comply with the pricing and reporting requirements specified by RBI. If a transfer of units is not compliant with such pricing or reporting requirements and does not fall under any of the exceptions specified by RBI, then RBI's prior approval is required.

Additionally, unitholders who seek to convert Indian rupee proceeds from a sale of units in India into foreign currency and repatriate that foreign currency from India require a no-objection or a tax clearance certificate from the Indian income tax authorities.

We cannot assure you that any required approval from RBI or any other Governmental agency can be obtained on any particular terms or in a timely manner, or at all. Our Unitholders will not have the right to redeem or request the redemption of our Units while our Units are listed on the Stock Exchange. In terms of the SEBI InvIT Regulations, an infrastructure investment trust may redeem units only by way of a buyback or at the time of delisting of units and may be subject to additional conditions and restrictions under Indian regulations.

**54. *The Units have never been traded and the listing of the Units on the Stock Exchange may not result in an active or liquid market for the Units.***

There is no market for the Units prior to the Issue and an active market for the Units may not develop or be sustained after the Issue. Moreover, the listing and quotation do not guarantee that a trading market for the Units will develop or, if a market does develop, the liquidity of that market for the Units. As the Units will be sold through a private placement in a Minimum Bid Size (₹ 2,500 lakhs), there may be a lack of liquidity and a limited market for the Units. The price of the Units may be volatile, and investors may be unable to resell the Units at or above the Issue Price, or at all. Although it is currently intended that the Units will remain listed on the Stock Exchange, there is no guarantee of the continued listing of the Units. There is no assurance that the Terra InvIT will continue to satisfy the listing requirements for InvITs. Further, it may be difficult to assess the Terra InvIT's performance against domestic benchmarks.

**55. *Market and economic conditions may affect the market price and demand for the Units***

Movements in domestic and international securities markets, economic conditions, foreign exchange rates and interest rates may affect the market price of and demand for the Units. In particular, an increase in market interest rates may have an adverse impact on the market price of the Units if the annual yield on the price paid for the Units gives investors a lower return as compared to other investments.

**56. *There is no assurance that our Units will remain listed on the Stock Exchange.***

Although it is currently intended that the Units will remain listed on the Stock Exchange, there is no guarantee of the continued listing of the Units. Among other factors, we may not continue to satisfy the listing requirements of the Stock Exchange. Accordingly, Unitholders will not be able to sell their Units through trading on the Stock Exchange if the Units are no longer listed on the Stock Exchange. While the SEBI InvIT Regulations state that we must provide Unitholders with an exit prior to delisting, the specific mechanism of such delisting and related exit offer has not yet been finalised by the SEBI. Further, under the SEBI InvIT Regulations, we are required to maintain a minimum of five Unitholders (other than the Sponsor, its related parties and its associates) at all times after the listing of the Units pursuant to the Issue and certain minimum public holding requirements. Failure to maintain such minimum number of Unitholders or public holding may result in action being taken against us by the SEBI and the Stock Exchange, including the compulsory delisting of our Units.

**57. *Any future issuance of Units by us may dilute investors' Unitholding. The sale or possible sale of a substantial number of Units by the Sponsor or another significant Unitholder could adversely affect the price of the Units***

Where new Units are issued at less than the market price of the Units, the value of an investment in the Units may be affected. In addition, Unitholders who do not, or are not able to, participate in the new issuance of Units may experience a dilution of their interest in the Terra InvIT.

Further, under the SEBI InvIT Regulations, the Sponsor is required to hold a minimum of 15% of our Units for a minimum period of three years from the date of listing pursuant to the Issue and the balance of its unitholding in the Terra InvIT is required to be locked in for a period of one year from the date of listing of the Units. The Units are proposed to be listed on the Stock Exchange. If the Sponsor, following the lapse of either of the aforesaid lock-in period directly or indirectly sells or is perceived as intending to sell a substantial number of its Units, or if a significant Unitholder other than the Sponsor directly or indirectly sells or is perceived as intending to sell a substantial number of its Units, the market price for the Units could be adversely affected.

**58. *We may not be able to make distributions to Unitholders or the level of distributions may fall.***

The Terra InvIT's distributions will be based on the NDCF available for distribution and not on whether the Terra InvIT makes an accounting profit or loss. The SEBI InvIT Regulations provide that not less than 90% of NDCF of each Asset SPV generated by it to be distributed to the Terra InvIT in proportion of its holding in each of the Asset SPVs subject to applicable provisions of the Companies Act. Under the SEBI InvIT Regulations, not less than 90% of the NDCF of the Terra InvIT is required be distributed to the Unitholders not less than once a year in case of an infrastructure investment trust which has undertaken an initial offer through private placement. Such distributions are required to be made not later than fifteen days from the date of declaration. In relation to the Terra InvIT, the Asset SPVs, and the Investment Manager have adopted a distribution policy pursuant to which distributions are required to be made to the Unitholders on a quarterly basis for periods after Allotment pursuant to the Issue. For further details, see '*Distributions*' on page 190.

The Terra InvIT will rely on the receipt of interest, dividends, principal loan repayments, buy back of shares (net of applicable taxes and expenses), etc. and certain tax benefits thereon from the Asset SPVs in order to make distributions to the Unitholders. We cannot assure or guarantee that the Terra InvIT will have sufficient distributable or realised profits or surplus in any future period to make distributions quarterly or half-yearly or annually in any amount or at all. The ability of the Asset SPVs to pay dividends, make interest payments may be affected by a number of factors including, amongst other things:

- their respective businesses and financial positions;
- insufficient cash flows received from the assets;
- applicable law which may restrict the payment of dividends by the Asset SPVs;
- operating losses incurred by the Asset SPVs in any Financial Year;
- the debt service costs and other liabilities of the Asset SPVs, including terms of the financing and agreements; and
- changes in accounting standards, taxation laws and regulations, laws and regulations in respect of foreign exchange repatriation of funds, corporation laws and regulations relating thereto.

Further, the method of calculation of NDCF is subject to change. Any change in the applicable law in India or elsewhere (including, for example, tax laws and foreign exchange controls) may limit the Terra InvIT's ability to pay or maintain distributions to Unitholders. No assurance can be given that the Terra InvIT will be able to pay or maintain the levels of distributions or that the level of distributions will increase over time, or that future acquisitions will increase the Terra InvIT's distributable free cash flow to Unitholders. Any reduction in, or elimination or taxation of, payments of distributions could adversely affect the distributions made by the Terra InvIT.

**59. *The Terra InvIT may be dissolved, and the proceeds from the dissolution thereof may be less than the amount invested by the Unitholders.***

The Terra InvIT is an irrevocable trust registered under the Registration Act, 1908 and it may only be extinguished (i) if it is impossible to continue with the Terra InvIT or if the Trustee, on the advice of the Investment Manager, deems it impracticable to continue with the Terra InvIT; (ii) on the written recommendation of the Investment Manager and upon obtaining the prior written consent of such number of the Unitholders as is required under the SEBI InvIT Regulations; (iii) if the SEBI passes a direction for the winding up of the Terra InvIT or the delisting

of the Units; or (iv) in the event the Terra InvIT becomes illegal. Under the Trust Deed, in the event of dissolution, the net assets of the Terra InvIT, remaining after settlement of all debt and liabilities (including statutory dues), and the retention of any reserves which the Trustee deems to be necessary to discharge contingent or unforeseen liabilities, shall be paid to the Unitholders. Should the Terra InvIT be dissolved, depending on the circumstances and the terms upon which assets of the Terra InvIT are disposed of, a Unitholder might not recover all or any part of his investment. There may also be uncertainty around the interpretation and implementation of certain provisions in relation to the insolvency of a trust under the Insolvency and Bankruptcy Code, 2016.

**60. *Our rights and the rights of the Unitholders to recover claims against the Investment Manager or the Trustee or Project Manager are limited.***

Under the Investment Management Agreement, the Investment Manager is not liable for, amongst other things, any bonafide action by the Investment Manager, acts or things required to be done by the Investment Manager under law, acts done in good faith, suits, proceedings or claims against the Terra InvIT (except as provided in the Investment Management Agreement).

Pursuant to the Trust Deed, the Trustee is not liable for anything done or omitted to be done or suffered by the Trustee in good faith. Further, the Trustee and the Investment Manager are not liable for any action or omission that results in any depletion in the value of the trust fund and consequent losses of the Unitholder, except in situations where such depletion is a result of fraud, gross negligence or misconduct part of the Trustee or the Investment Manager as may be determined by a court of competent jurisdiction. Any costs and expenses incurred by the Trustee in connection with any legal proceedings, in relation to the Terra InvIT, shall be incurred by the Trustee from the trust funds.

Further, recourse against the Project Manager is limited under the Project Management Agreement as the aggregate maximum liability of the Project Manager in any financial year pursuant to any provision of the Project Management Agreement shall cumulatively not exceed the service fee payable to the Project Manager in such financial year in accordance with the terms of Project Management Agreement, however such aggregate maximum liability shall not be applicable in the event such liability of the Project Manager arises out of any fraud of the Project Manager. The Investment Management Agreement provides that the Investment Manager is entitled to be indemnified out of the trust funds against all claims, losses, costs, damages, liabilities, suits, proceedings and expenses, including legal fees incurred in connection with the Terra InvIT, unless arising out of gross negligence, misconduct, wilful default and fraud. As a result, the Terra InvIT's rights and the rights of the Unitholders to recover claims against the Investment Manager are limited. Further, recourse to the Trustee may be limited under the Trust Deed. The Trust Deed provides for the indemnification of the Trustee for all claims, liabilities, damages and expenses, including legal fees, except losses incurred due to any gross negligence, fraud, misconduct or violation of laws or is in material violation of the Trust Deed as may be determined by a court of competent jurisdiction.

**61. *Information and the other rights of Unitholders under Indian law may differ from such rights available to equity shareholders of an Indian company or under the laws of other jurisdictions.***

The Trust Deed and various provisions of Indian law govern our corporate affairs. Legal principles relating to these matters and the validity of corporate procedures, fiduciary duties and liabilities, and Unitholders' rights may differ from those that would apply to a company in India or a trust in another jurisdiction. Unitholders' rights and disclosure standards under Indian law may also differ from the laws of other countries or jurisdictions. Also see '*Rights of Unitholders*' on page 193.

**62. *It may not be possible for Unitholders to enforce foreign judgements.***

The Trustee and the Investment Manager are incorporated in India and the Terra InvIT is settled and registered in India. All of our assets are located in India. Where investors wish to enforce foreign judgements in India, where our assets are or will be located, they may face difficulties in enforcing such judgements. India is not a party to any international treaty in relation to the recognition or enforcement of foreign judgements. India exercises reciprocal recognition and enforcement of judgements in civil and commercial matters with a limited number of jurisdictions, including Singapore. In order to be enforceable, a judgement obtained in a jurisdiction which India recognises as a reciprocating territory must meet certain requirements of the Code of Civil Procedure, 1908 ("**Civil Code**"). Further, the Civil Code only permits enforcement of monetary decrees not being in the nature of any amounts payable in respect of taxes, or other charges of a like nature or in respect of a fine or other penalty and does not provide for the enforcement of arbitration awards even if such awards are enforceable as a decree or judgement. Judgements or decrees from jurisdictions not recognised as a reciprocating territory by India cannot

be enforced or executed in India except through a fresh suit upon judgement. Even if we or a Unitholder were to obtain a judgement in such a jurisdiction, we or it would be required to institute a fresh suit upon the judgement and would not be able to enforce such judgement by proceedings in execution. In addition, the party which has obtained such judgement must institute the new proceedings within three years of obtaining the judgement. It is unlikely that an Indian court would award damages on the same basis or to the same extent as was awarded in a judgement rendered by a foreign court if the Indian court believed that the amount of damages awarded was excessive or inconsistent with public policy in India. In addition, any person seeking to enforce a foreign judgement in India is required to obtain prior approval of the RBI to repatriate outside India any amount recovered pursuant to the execution of the judgement.

Consequently, it may not be possible to enforce in an Indian court any judgement obtained in a foreign court, or effect service of process outside of India, against Indian companies, their directors and executive officers, and any other parties resident in India. Additionally, there is no assurance that a suit brought in an Indian court in relation to a foreign judgement will be disposed of in a timely manner.

### **Risks Related to Tax**

**63. *Changes in legislation or the rules relating to various central and state government tax regimes could adversely affect our business, prospects and results of operations.***

Tax and other levies imposed by the Government and state governments may include: (i) income tax (including withholding tax and tax collection at source); (ii) wealth tax (which was withdrawn with effect from January 1, 2016); (iii) excise duty; (iv) value added tax/central sales tax/ goods and service tax; (v) service tax; (vi) stamp duty; and (vii) other special taxes and surcharges that are introduced on a temporary or permanent basis from time to time. In some cases, these taxes and other levies may be changed from year to year and the Indian courts which interpret tax legislation may apply such interpretations with retroactive effect. Also, the Government in certain situations has the authority to change tax laws retrospectively.

Additionally, there have been two recent major reforms in Indian tax laws, namely the introduction of the GST and provisions relating to GAAR.

The GST regime came into effect on July 1, 2017, combining taxes and levies by the Government and state governments in India into a unified rate structure. Given the limited availability of information in the public domain concerning the GST, we cannot assure you as to the tax regime following implementation of the GST. Further, any application of existing law or future amendments may affect our overall tax efficiency, and may result in significant additional taxes becoming payable.

The GAAR regime came into effect on April 1, 2017. The GAAR regime is a broad set of provisions which grant powers to India tax authorities to invalidate any arrangement for tax purposes in the event, the main purpose of entering into the transaction by the taxpayer is to obtain a tax benefit. Besides the “tax benefit”, the transaction should meet any one of the following specified additional tests: (i) creates rights, or obligations, which are not ordinarily created between persons dealing at arm’s length; (ii) results, directly or indirectly, in the misuse, or abuse, of the provisions of the IT Act; (iv) lacks commercial substance or is deemed to lack commercial substance as prescribed under the IT Act in whole or in part; and (v) is entered into, or carried out, by means which are, or in a manner which is, not ordinarily employed for bona fide purposes. Such transactions are declared as impermissible avoidance arrangements. The tax consequences of the GAAR provisions being applied to an arrangement could result in denial of tax benefit, amongst other consequences, including on the interest paid by the Asset SPVs on the debt from the Terra InvIT. In the absence of any precedents on the subject, the application of these provisions is uncertain. If the GAAR provisions are made applicable to the Terra InvIT, it may have an adverse effect on the Terra InvIT.

Further, other tax and levies imposed by the Government and state governments that affect our liability include: (i) income tax (including withholding tax and tax collection at source); (ii) wealth tax (which was withdrawn with effect from January 1, 2016); (iii) excise duty; (iv) value added tax/central sales tax/ goods and service tax; (v) service tax; (vi) stamp duty; and (vii) other special taxes and surcharges that are introduced on a temporary or permanent basis from time to time. In certain instances, these taxes and other levies may be changed from year to year and the Indian courts which interpret tax legislation may apply such interpretations with retroactive effect.

The Investment Manager has not determined the impact of such existing or proposed legislations on our business.



Further, the Government in certain instances has the authority to change tax laws retrospectively. Also, we may incur increased costs relating to compliance with any new requirements, which may also require management time and other resources, and any failure to comply may adversely affect our business, results of operations and prospects. Uncertainty in the applicability, interpretation or implementation of any amendment to, or change in, governing law, regulation or policy, including by reason of an absence, or a limited body, of administrative or judicial precedent, may be time consuming as well as costly for us to resolve and may impact the viability of our current business or restrict our ability to grow our business in the future.

**64. *Investors may be subject to Indian taxes arising out of capital gains on the sale of Units and on any dividend or interest component of any returns from the Units.***

Under current Indian tax laws, listed units of a business trust held for more than 36 months are considered as long term capital assets, which is subject to long term capital gains tax at a rate of 10% (plus applicable surcharge and cess) on long term capital gain exceeding ₹100,000 in hands of a unitholder, provided that the sale of Units is subject to securities transaction tax. In case the units are held for less than or up to 36 months, the same shall be regarded as short term capital asset, and is subject to short term capital gains tax at a rate of 15% (plus applicable surcharge and cess) in the hands of a unitholder, provided the sale of Units is subject to securities transaction tax. The aforesaid taxability in India is subject to tax treaty benefits in the case of a non-resident holder.

The Finance Act, 2020 amended the IT Act to abolish the DDT regime and shift the incidence of taxation of dividend (declared or distributed on or after April 1, 2020) to shareholder. Under the Finance Act, 2020, a distribution made by a business trust, being in the nature of dividend income received from a special purpose vehicle, will not be subject to tax in the hands of a unitholder, so long as the special purpose vehicle has not opted to pay corporate tax under the beneficial regime introduced under Section 115BAA of the IT Act. Similarly, a business trust (which includes an InvIT) will not be required to withhold tax on any distributions which are in the nature of dividend income received from a special purpose vehicle, so long as such special purpose vehicle has not opted to pay corporate tax under the beneficial regime introduced under Section 115BAA of the IT Act. However, where the special purpose vehicle opts to pay tax under Section 115BAA of the IT Act, dividend income distributed by the business trust would be taxed in the hands of a non-resident unitholder at 20% (plus applicable surcharge and cess) or the applicable treaty rate and at the ordinary rate for a resident unitholder. Further, the business trust would be required to withhold tax on such distributions made from dividend received from the Asset SPV. Thus, the taxability of dividends distributed by the Terra InvIT will depend on the taxation regime opted by Asset SPVs.

**65. *Tax laws are subject to changes and differing interpretations, which may adversely affect our operations***

Tax laws and regulations are subject to differing interpretations by tax authorities. Differing interpretations of tax and other fiscal laws and regulations may exist within governmental ministries, including tax administrations and appellate authorities, thus creating uncertainty and potential unexpected results. The degree of uncertainty in tax laws and regulations, combined with significant penalties for default and a risk of aggressive action, including by retrospective legislation, by the governmental or tax authorities, may result in tax risks in the jurisdictions in which we operate being significantly higher than expected. These events may result in a material, adverse effect on our business, financial condition, results of operations and prospects. Tax authorities in India may also introduce additional or new regulations applicable to our business which could adversely affect our business and profitability.

The Investment Manager intends to take measures to ensure that it is in compliance with all relevant tax laws. However, the tax authorities might take a position that differs from the position taken by us with regard to our tax treatment of various items. For instance, our Asset SPVs are subject to tax assessments and notices from time to time which if determined against us may result in an adverse impact on our financial position and prospects. For details of such actions, see ‘*Material Litigation and Regulatory Action - Taxation Proceedings*’ to page 297.

**66. *The Ministry of Finance, GoI, has constituted a task force to draft new direct tax legislation, the provisions of which may have an unfavourable implication for us.***

The Ministry of Finance, GoI, has set up a panel to review the IT Act and to draft a new direct tax legislation (“**Panel**”). The Panel has been tasked with drafting appropriate direct tax legislation aimed at (i) aligning India’s domestic direct tax regime in line with international best practices; and (ii) ensuring and encouraging compliance.

The impact of the report by the Panel, including findings and recommendations in their report and the provisions of the proposed direct tax legislation could have an unfavourable implication on us. Since the Panel and their report, including their recommendations and the draft of the new direct tax legislation has not been released yet, the possible impact on us is not clear. Any such change made may have an impact on our ability to make distributions.

**67. *Terra InvIT and the Asset SPVs may be subject to certain tax related risks under the provisions of the IT Act.***

Shortfall in the determination of fair market value of the equity shares at the time of transfer of Asset SPVs to Terra InvIT may be subject to taxation in the hands of the acquirer. Under the provisions of section 56(2)(x) of the IT Act, where purchase of shares is undertaken at a value which is lower than the fair market value of the shares, such shortfall in value is subject to be taxed as income from other sources in the hands of the acquirer. The manner of determination of fair market value as provided under the IT rules, includes the value determined by net asset method, subject to the prescribed adjustments.

There is a lack of clarity on the tax treatment that will be applicable on the Terra InvIT on the occurrence of such an event. The Terra InvIT is under an obligation to distribute to the Unitholders, the Terra InvIT's distributions will be based on the NDCF available for distribution and not on whether the Terra InvIT makes an accounting profit or loss. The provisions of the IT Act provide that the Terra InvIT should disclose the nature of the amount distributed to the Unitholders, i.e., whether from dividends received from the Asset SPVs, interest income earned, etc. However, there is lack of clarity on the method to be adopted by the Terra InvIT for the allocation of various expenses incurred towards earning each specific stream of income by the Terra InvIT which may impact the viability of our current business or restrict our ability to grow our business in the future.

### **SECTION III – INTRODUCTION**

#### **SUMMARY FINANCIAL INFORMATION OF THE TERRA INVIT**

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**Virescent Renewable Energy Trust**  
**Combined Balance Sheet**  
**All amounts are in INR lakhs unless otherwise stated**

Particulars	Notes	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>ASSETS</b>				
<b>Non-current assets</b>				
Property, plant and equipment	3	1,53,602.97	1,99,155.82	2,13,532.35
Capital work-in-progress	4	-	-	51.50
Goodwill		236.47	236.47	236.47
Intangible assets	5	0.13	0.37	0.64
Financial assets				
Investments	6	0.50	4,120.49	655.75
Others	7	136.62	2,090.57	1,079.73
Income tax assets (net)	8	445.38	554.63	690.98
Deferred tax assets (net)	9	4,968.66	4,976.60	2,501.68
Other non-current assets	10	31.36	131.22	423.45
<b>Total non-current assets</b>		<b>1,59,422.09</b>	<b>2,11,266.17</b>	<b>2,19,172.55</b>
<b>Current assets</b>				
Inventories	11	67.84	58.81	19.57
Financial assets				
Trade receivables	12	10,784.07	19,529.48	10,192.81
Cash and cash equivalents	13	12,560.78	7,865.17	9,338.73
Other bank balances	14	17,890.71	5,328.37	4,421.57
Loans	15	-	-	3,182.00
Others	7	3,893.43	2,271.72	2,666.01
Other current assets	10	176.28	232.65	167.22
<b>Total current assets</b>		<b>45,373.11</b>	<b>35,286.20</b>	<b>29,987.91</b>
<b>Assets held for sale</b>	16	3,437.87	-	-
<b>Total assets</b>		<b>2,08,233.07</b>	<b>2,46,552.37</b>	<b>2,49,160.46</b>
<b>EQUITY AND LIABILITIES</b>				
<b>Equity</b>				
Equity share capital	17	43,619.57	43,619.57	41,719.57
Instrument entirely equity in nature	18	3,929.00	3,929.00	3,929.00
Other equity	19	(56,031.36)	(6,670.86)	3,616.51
<b>Total equity</b>		<b>(8,482.79)</b>	<b>40,877.71</b>	<b>49,265.08</b>
<b>Non-controlling interest</b>		<b>322.70</b>	<b>332.18</b>	<b>350.86</b>
<b>LIABILITIES</b>				
<b>Non-current liabilities</b>				
Financial liabilities				
Borrowings	20	1,13,438.00	1,59,820.17	1,59,874.00
Lease liabilities	21	120.83	120.47	148.24
Provisions	22	31.32	25.20	13.13
Other non-current liabilities	23	2,074.94	1,672.00	-
<b>Total non-current liabilities</b>		<b>1,15,665.09</b>	<b>1,61,637.84</b>	<b>1,60,035.37</b>
<b>Current liabilities</b>				
Financial liabilities				
Borrowings	20	63,572.79	3,610.41	1,061.28
Lease liabilities	21	23.73	54.96	66.17
Trade payables	24	2,138.35	2,373.83	7,913.43
Others	25	12,899.14	17,713.87	14,369.73
Provisions	22	3.35	0.22	2.73
Income tax liabilities (net)	8	37.79	3.82	43.10
Other current liabilities	23	22,052.92	19,947.53	16,052.71
<b>Total current liabilities</b>		<b>1,00,728.07</b>	<b>43,704.64</b>	<b>39,509.15</b>
<b>Total liabilities</b>		<b>2,16,393.16</b>	<b>2,05,342.48</b>	<b>1,99,544.52</b>
<b>Total equity and liabilities</b>		<b>2,08,233.07</b>	<b>2,46,552.37</b>	<b>2,49,160.46</b>

Significant accounting policies 2

The accompanying notes form an integral part of the combined financial statements.

In terms of our report attached

**For MSKA & Associates**  
Chartered Accountants  
ICAI Firm's Registration No: 105047W

For and on behalf of the Board of Directors  
**Virescent Infrastructure Investment Manager Private Limited**  
(acting as Investment Manager to Virescent Renewable Energy Trust)

**Ananthkrishnan G**  
Partner  
Membership No: 205226

**Sanjay Grewal**  
Director  
DIN: 01971866

**Hardik Shah**  
Director  
DIN: 06648474

**Charmy Bhoot**  
Company Secretary

Place: Hyderabad  
Date: 23 July 2021

Place: New York  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

**Virescent Renewable Energy Trust**  
**Combined Statement of Profit and Loss**  
**All amounts are in INR lakhs unless otherwise stated**

Particulars	Notes	Year ended 31 March 2021	Year ended 31 March 2020	Year ended 31 March 2019
I Revenue from operations	26	34,423.98	35,134.95	32,766.51
II Other income	27	2,448.22	1,312.11	618.46
III <b>Total income (I + II)</b>		<b>36,872.20</b>	<b>36,447.06</b>	<b>33,384.97</b>
IV <b>Expenses</b>				
Operating and maintenance expenses	28	1,491.20	1,564.73	1,366.70
Employee benefits expense	29	165.32	139.69	193.20
Finance costs	30	22,243.56	20,093.22	18,669.65
Depreciation and amortization expense	31	13,660.65	14,908.46	14,296.37
Other expenses	32	6,453.00	2,311.89	4,142.11
<b>Total expenses (IV)</b>		<b>44,013.73</b>	<b>39,017.99</b>	<b>38,668.03</b>
V <b>Profit/(Loss) before exceptional items (III-IV)</b>		<b>(7,141.53)</b>	<b>(2,570.93)</b>	<b>(5,283.06)</b>
VI Exceptional items	33	33,177.48	3,445.95	2,322.64
VII <b>Profit/(Loss) before tax (V-VI)</b>		<b>(40,319.01)</b>	<b>(6,016.88)</b>	<b>(7,605.70)</b>
VIII <b>Tax Expense:</b>	34			
Current tax		465.20	503.89	49.01
Deferred tax charge/(credit)		7.94	(2,474.92)	(4,673.27)
<b>Total tax expense (VIII)</b>		<b>473.14</b>	<b>(1,971.03)</b>	<b>(4,624.26)</b>
IX <b>Profit / (loss) for the year</b>		<b>(40,792.15)</b>	<b>(4,045.85)</b>	<b>(2,981.44)</b>
X <b>Other comprehensive income</b>				
(i) Item that will not be reclassified to profit or loss		(0.10)	(0.81)	0.07
(ii) Income tax relating to item that will not be reclassified to profit or loss		-	-	-
XI <b>Total other comprehensive income</b>		<b>(0.10)</b>	<b>(0.81)</b>	<b>0.07</b>
XII <b>Total comprehensive income for the year (X+XI)</b>		<b>(40,792.25)</b>	<b>(4,046.66)</b>	<b>(2,981.37)</b>
<b>Profit / (loss) for the year</b>		<b>(40,792.15)</b>	<b>(4,045.85)</b>	<b>(2,981.44)</b>
Attributable to:				
Equity holders		(40,792.15)	(4,045.85)	(2,981.44)
<b>Total comprehensive loss for the year</b>		<b>(40,792.25)</b>	<b>(4,046.66)</b>	<b>(2,981.37)</b>
Attributable to:				
Equity holders		(40,792.25)	(4,046.66)	(2,981.37)
<b>Profit/(Loss) for the year attributable to</b>				
Owners of the company		-40,782.77	-4,027.98	-2,969.93
<b>Non Controlling interest</b>		-9.48	-18.68	-11.44
Earnings per unit - Refer note 37				

**Significant accounting policies**

2

The accompanying notes form an integral part of the combined financial statements.

In terms of our report attached

**For MSA & Associates**  
Chartered Accountants  
ICAI Firm's Registration No: 105047W

For and on behalf of the Board of Directors  
**Virescent Infrastructure Investment Manager Private Limited**  
(acting as Investment Manager to Virescent Renewable Energy Trust)

**Ananthakrishnan G**  
Partner  
Membership No: 205226

**Sanjay Grewal**  
Director  
DIN: 01971866

**Hardik Shah**  
Director  
DIN: 06648474

**Charmy Bhoot**  
Company Secretary

Place: Hyderabad  
Date: 23 July 2021

Place: New York  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

**Virescent Renewable Energy Trust**  
**Combined Cash Flow Statement**  
**All amounts are in INR lakhs unless otherwise stated**

	Year ended 31 March 2021	Year ended 31 March 2020	Year ended 31 March 2019
<b>Operating activities</b>			
Loss before tax from continuing operations	(40,319.01)	(6,016.88)	(7,605.70)
Profit/(loss) before tax from discontinued operations			
<b>Loss before tax</b>	<b>(40,319.01)</b>	<b>(6,016.88)</b>	<b>(7,605.70)</b>
<i>Adjustments to reconcile profit before tax to net cash flows:</i>			
Depreciation and amortisation expense	13,660.65	14,908.46	14,296.37
Impairment loss	32,495.61	-	2,322.64
Finance cost	22,243.56	20,093.22	18,669.65
Loss on sale of property, plant and equipment (net)	108.80	120.35	5.01
Loss on receivable written off	5.36	-	-
Bad debt Expenses	-	3,182.00	-
Impairment loss on investment	649.13	-	2,377.13
Provision for doubtful advances	-	263.95	-
Allowance for doubtful advances	-	302.97	-
Excess provisions written back	(1,276.54)	(266.50)	-
Foreign exchange loss	-	20.48	13.43
Interest income	(801.03)	(881.07)	(409.98)
Amortization of VGF receipt	(144.26)	(152.00)	-
Dividend income	-	(0.04)	(30.27)
<b>Operating profit before working capital changes and other adjustments</b>	<b>26,622.27</b>	<b>31,574.94</b>	<b>29,638.28</b>
<i>Working capital adjustments:</i>			
(Increase)/ Decrease in inventories	(9.03)	(39.24)	3.64
(Increase)/ Decrease in trade receivables	8,745.55	(9,336.67)	(2,931.76)
(Increase)/ Decrease in financial and other asset	(1,448.05)	23.48	1,338.50
Increase/ (Decrease) in trade payable	1,041.06	(5,273.10)	(12,815.21)
Increase/ (Decrease) in other financial and other liability	4,772.78	4,637.65	2,664.55
<b>Cash flow from operating activities post working capital changes</b>	<b>39,724.58</b>	<b>21,587.06</b>	<b>17,897.99</b>
Income tax paid(net)	(315.02)	(390.94)	(326.06)
<b>Net cash flows from operating activities</b>	<b>39,409.56</b>	<b>21,196.11</b>	<b>17,571.93</b>
<b>Investing activities</b>			
Purchase of property, plant and equipment (including capital work in progress)	(716.14)	(294.61)	(27,878.04)
Sale of property, plant and equipment (including capital work in progress)	4.17	2.30	78.43
Investment income recognised in profit or loss	748.65	855.60	383.31
Purchase of investments	(13,331.26)	(5,691.86)	(14,255.00)
Sale of investments	2,785.31	40.85	12,148.37
Loan given to associates	-	-	(3,182.00)
<b>Net cash flows used in investing activities</b>	<b>(10,509.27)</b>	<b>(5,087.73)</b>	<b>(32,704.93)</b>
<b>Financing activities</b>			
Proceeds from issue of equity instruments	-	1,900.00	3,922.00
Proceeds from borrowings	1,44,097.22	17,251.56	55,180.25
Transaction with owners of acquired business undertaking for the year	(3,384.94)	(6,230.43)	16,558.60
Repayment of borrowings	(1,40,856.47)	(14,012.40)	(46,591.96)
Repayment of lease liabilities	(37.10)	(44.74)	(16.07)
VGF funds received	570.00	1,900.00	-
Share issue expenses	-	(35.75)	(4.47)
Finance cost paid	(24,593.39)	(18,310.19)	(18,465.08)
<b>Net cash flows from/(used in) financing activities</b>	<b>(24,204.68)</b>	<b>(17,581.95)</b>	<b>10,583.26</b>
Net increase in cash and cash equivalents	4,695.61	(1,473.56)	(4,549.73)
Cash and cash equivalents at the beginning of the year	7,865.17	9,338.73	13,888.46
<b>Cash and cash equivalents at period/year end (Refer Note: 13)</b>	<b>12,560.78</b>	<b>7,865.17</b>	<b>9,338.73</b>

The accompanying notes form an integral part of the combined financial statements.

In terms of our report attached  
**For MSA & Associates**  
Chartered Accountants  
ICAI Firm's Registration No: 105047W

For and on behalf of the Board of Directors  
**Virescent Infrastructure Investment Manager Private Limited**  
(acting as Investment Manager to Virescent Renewable Energy Trust)

**Ananthkrishnan G**  
Partner  
Membership No: 205226

**Sanjay Grewal**  
Director  
DIN: 01971866

**Hardik Shah**  
Director  
DIN: 06648474

**Charmy Bhoot**  
Company Secretary

Place: Hyderabad  
Date: 23 July 2021

Place: New York  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

a. Equity share capital

Particulars

Equity shares of INR 10 each issued, subscribed and fully paid

As at 1 April 2018

Changes in equity share capital during the year

As at 31 March 2019

Changes in equity share capital during the year

As at 31 March 2020

Changes in equity share capital during the year

As at 31 March 2021

Amount
43,575.03
-
43,575.03
1,900.00
45,475.03
-
45,475.03

b. Instrument entirely equity in nature

Particulars

Compulsorily convertible preference shares (CCPS) of INR 10 each issued, subscribed and fully paid

As at 1 April 2018

Changes in CCPS capital during the year

As at 31 March 2019

Changes in CCPS capital during the year

As at 31 March 2020

Changes in CCPS capital during the year

As at 31 March 2021

Amount
7.00
3,922.00
3,929.00
-
3,929.00
-
3,929.00

b. Other equity

Particulars	Reserves and Surplus				Non Controlling interest	Equity of acquired business undertaking	Total
	Capital reserve	General reserve	Security premium reserve	Retained earnings			
Balance as at 1 April 2018	116.74	7.00	12,159.44	(22,845.36)	414.35	542.44	(9,605.39)
Loss for the year	-	-	-	(2,970.00)	(11.44)	-	(2,981.44)
Other comprehensive income for the year, net of income tax	-	-	-	0.07	-	-	0.07
Share issue expenses	-	-	-	(4.47)	-	-	(4.47)
Consequent to change in Groups interest	-	-	-	52.05	(52.05)	-	-
Transaction with owners of acquired business undertaking for the year	-	-	-	-	-	16,558.60	16,558.60
Balance as at 31 March 2019	116.74	7.00	12,159.44	(25,767.71)	350.86	17,101.04	3,967.37
Impact on account of change in transition date of Ind AS 116	-	-	-	6.79	-	-	6.79
Loss for the year	-	-	-	(4,027.17)	(18.68)	-	(4,045.85)
Other comprehensive income for the year, net of income tax	-	-	-	(0.81)	-	-	(0.81)
Share issue expenses	-	-	-	(35.75)	-	-	(35.75)
Transaction with owners of acquired business undertaking for the year	-	-	-	-	-	(6,230.43)	(6,230.43)
Balance as at 31 March 2020	116.74	7.00	12,159.44	(29,824.65)	332.18	10,870.61	(6,338.68)
Loss for the year	-	-	-	(40,782.67)	(9.48)	-	(40,792.15)
Other comprehensive income for the year, net of income tax	-	-	-	(0.10)	-	-	(0.10)
Share issue expenses	-	-	-	-	-	-	-
Impact of Fair valuation of Non-Convertible Debentures	-	-	-	(5,192.79)	-	-	(5,192.79)
Transaction with owners of acquired business undertaking for the year	-	-	-	-	-	(3,384.94)	(3,384.94)
Transfer to capital reserve	7,485.67	-	-	-	-	(7,485.67)	-
Balance as at 31 March 2021	7,602.41	7.00	12,159.44	(75,800.21)	322.70	-	(55,708.66)

Securities premium

Securities premium includes premium on issued of shares and issue of shares through conversion of compulsory convertible debentures. It will be utilised in accordance with the provisions of the Companies Act, 2013.

General reserve

Under the erstwhile Companies Act 1956, general reserve was created through an annual transfer of net income at a specified percentage in accordance with applicable regulations. The purpose of these transferes was to ensure that if a dividend distribution in a given year is more than 10% of the paid-up capital of the Company for that year, then the total dividend distribution is less than the total distributable results for that year. Consequent to introduction of Companies Act 2013, the requirement to mandatory transfer a specified percentage of the net profit to general reserve has been withdrawn. However, the amount previously transferred to the general reserve can be utilised only in accordance with the specific requirement of Companies Act, 2013.

The accompanying notes form an integral part of the combined financial statements.

In terms of our report attached

For MSKA & Associates

Chartered Accountants

ICAI Firm's Registration No: 105047W

For and on behalf of the Board of Directors

Virescent Infrastructure Investment Manager Private Limited

(acting as Investment Manager to Virescent Renewable Energy Trust)

Ananthakrishnan G

Partner

Membership No: 205226

Sanjay Grewal

Director

DIN: 01971866

Hardik Shah

Director

DIN: 06648474

Charmy Bhoot

Company Secretary

Place: Hyderabad

Date: 23 July 2021

Place: New York

Date: 23 July 2021

Place: Mumbai

Date: 23 July 2021

Place: Mumbai

Date: 23 July 2021

**SUMMARY FINANCIAL INFORMATION OF THE SPONSOR**

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**TERRA ASIA HOLDINGS II PTE. LTD.**

**STATEMENTS OF FINANCIAL POSITION**  
**December 31, 2020**

	<u>Note</u>	<u>2020</u> US\$
<b><u>ASSETS</u></b>		
<b>Current asset</b>		
Cash and cash equivalents	7	4,971,041.00
Other receivables	8	<u>68,905.00</u>
Total current assets		<u>5,039,946.00</u>
<b>Non-current assets</b>		
Investment at fair value through profit or loss	9	122,737,422.00
Fixed assets	11	<u>86,386.00</u>
Total non-current assets		<u>122,823,808.00</u>
<b>Total assets</b>		<u>127,863,754.00</u>
<b><u>LIABILITIES AND EQUITY</u></b>		
<b>Current liabilities</b>		
Other payables	12	242,651.00
Amount due to a related company	5	<u>3,000.00</u>
Total current liabilities		<u>245,651.00</u>
<b>Capital and reserves</b>		
Share capital	13	22,725,001.00
Capital reserves	14	111,075,000.00
Translation reserves		7,001.00
Accumulated losses		<u>(6,189,733.00)</u>
Equity attributable to owner of the company		127,617,269.00
Non-controlling interest		<u>834.00</u>
Total equity		<u>127,618,103.00</u>
<b>Total liabilities and equity</b>		<u>127,863,754.00</u>

See accompanying notes to financial statements.

**TERRA ASIA HOLDINGS II PTE. LTD.**

**CONSOLIDATED STATEMENT OF PROFIT OR LOSS AND OTHER COMPREHENSIVE INCOME**  
**For the period from January 6, 2020 (date of incorporation) to December 31, 2020**

	<u>Note</u>	For the period from January 6, 2020 (date of incorporation) to December 31, <u>2020</u> US\$
Change in fair value on financial asset at fair value through profit or loss	9	286,129.00
Other income		3,968.00
Investment transaction fee	5	(3,902,913.00)
Management fee	5	(96,393.00)
Operating expenses	15	<u>(2,480,964.00)</u>
<b>Loss before income tax</b>		(6,190,173.00)
Income tax	16	<u>–</u>
<b>Loss for the period</b>		<u>(6,190,173.00)</u>
<b>Loss attributable to:</b>		
Owner of the company		(6,189,733.00)
Non-controlling interest		<u>(440.00)</u>
		<u>(6,190,173.00)</u>
<b>Other comprehensive income</b>		
<i>Items that may be reclassified subsequently to profit or loss</i>		
Foreign exchange differences on translation of foreign operations		<u>7,001.00</u>
<b>Other comprehensive income for the period, net of tax</b>		<u>7,001.00</u>
<b>Total comprehensive loss for the period</b>		<u><u>(6,183,172.00)</u></u>
<b>Total comprehensive loss attributable to:</b>		
Owner of the company		(6,182,732.00)
Non-controlling interest		<u>(440.00)</u>
		<u>(6,183,172.00)</u>

See accompanying notes to financial statements.

**TERRA ASIA HOLDINGS II PTE. LTD.**

**STATEMENTS OF CHANGES IN EQUITY**

**For the period from January 6, 2020 (date of incorporation) to December 31, 2020**

	<u>Note</u>	<u>Share capital</u> US\$	<u>Capital reserves</u> US\$	<u>Translation reserves</u> US\$	<u>Accumulated losses</u> US\$	Equity attributable to owner of the company <u>US\$</u>	<u>Non-controlling interests</u> US\$	<u>Total</u> US\$
Total comprehensive loss for the period:								
Loss for the period		-	-	-	(6,189,733.00)	(6,189,733.00)	(440.00)	(6,190,173.00)
Other comprehensive income for the period		-	-	7,001.00	-	7,001.00	-	7,001.00
Transactions with owner, recognised directly in equity:								
Issue of share at date of incorporation	13	1.00	-	-	-	1.00	-	1.00
Issue of new shares	13	16,725,000.00	-	-	-	16,725,000.00	-	16,725,000.00
Issue of subsidiary's shares to non-controlling interest holders		-	-	-	-	-	1,274.00	1,274.00
Conversion of deemed capital contribution from immediate holding company into shares	14	6,000,000.00	(6,000,000.00)	-	-	-	-	-
Deemed capital contribution from immediate holding company	14	-	117,075,000.00	-	-	117,075,000.00	-	117,075,000.00
<b>Balance at December 31, 2020</b>		<u>22,725,001.00</u>	<u>111,075,000.00</u>	<u>7,001.00</u>	<u>(6,189,733.00)</u>	<u>127,617,269.00</u>	<u>834.00</u>	<u>127,618,103.00</u>

See accompanying notes to financial statements.

**TERRA ASIA HOLDINGS II PTE. LTD.**

**CONSOLIDATED STATEMENT OF CASH FLOWS**

**For the period from January 6, 2020 (date of incorporation) to December 31, 2020**

	<u>Note</u>	For the period from January 6, 2020 (date of incorporation) to December 31, <u>2020</u> US\$
<b>Operating activities</b>		
Loss before income tax		(6,190,173.00)
Adjustments for:		
Change in fair value on financial asset at fair value through profit or loss		(286,129.00)
Depreciation expense		<u>1,898.00</u>
Operating cash flows before movements in working capital		(6,474,404.00)
Other receivables		(68,905.00)
Other payables		242,651.00
Amount due to a related company		<u>3,000.00</u>
Cash used in operations, representing net cash used in operating activities		<u>(6,297,658.00)</u>
<b>Investing activities</b>		
Acquisition of financial asset at fair value through profit or loss	9	(122,451,293.00)
Purchase of fixed assets	11	<u>(88,284.00)</u>
Net cash used in investing activities		<u>(122,539,577.00)</u>
<b>Financing activities</b>		
Proceeds from issue of shares	13	16,725,001.00
Loan received from immediate holding company	14	117,075,000.00
Proceeds from issue of subsidiary's shares to non-controlling interest holders		<u>1,274.00</u>
Net cash generated from financing activities		<u>133,801,275.00</u>
Net effect of exchange rate changes in consolidating a subsidiary		<u>7,001.00</u>
<b>Net increase in cash and cash equivalents and cash and cash equivalents at end of the period</b>	7	<u><u>4,971,041.00</u></u>

Significant non-cash transactions during the year ended December 31, 2020

During the year, the group made partial capitalisation of its capital reserves in exchange for issuance of 6,000,000 ordinary shares for US\$6,000,000 to its immediate holding company.

See accompanying notes to financial statements.

## **SUMMARY FINANCIAL INFORMATION OF THE INVESTMENT MANAGER**

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**Virescent Infrastructure Investment Manager Private Limited**  
Consolidated Balance Sheet as at 31st March, 2021

Amounts in INR

Particulars	Note No	As at 31st March 2021
<b>ASSETS</b>		
<b>Financial Assets</b>		
Cash and Cash Equivalents	6	3,92,43,840
Receivables		
- Trade Receivables	7	14,34,18,180
Other Financial Assets	8	12,75,000
<b>Non-Financial Assets</b>		
Current Tax Assets (Net)		88,51,003
Deferred Tax Assets (Net)	9	8,00,355
Property, Plant and Equipment	10	18,10,886
Intangible Assets under development		91,56,000
Other Non-Financial Assets	11	1,25,57,855
<b>TOTAL ASSETS</b>		<b>21,71,13,119</b>
<b>LIABILITIES AND EQUITY</b>		
<b>Financial Liabilities</b>		
Payables	12	
Trade Payables		
(i) Total outstanding dues of micro enterprises and small enterprises		10,28,763
(ii) Total outstanding dues of other than micro enterprises and small enterprises		28,77,633
<b>Non-Financial Liabilities</b>		
Current Provisions	13	6,71,17,143
Non-Current Provisions	13	25,25,853
Other Non Financial Liabilities	14	2,71,72,909
<b>EQUITY</b>		
Equity Share Capital	15	11,01,00,000
Other Equity	16	62,90,818
<b>TOTAL LIABILITIES AND EQUITY</b>		<b>21,71,13,119</b>
Summary of significant accounting policies	3	

As per our report of even date

For **MSKC & Associates (Formerly known as R.K. Kumar & Co.)**  
Chartered Accountants  
ICAI Firm Registration No.: 0015955



**Tushar Kurani**  
Partner  
Membership No.: 118580

For and on behalf of the Board of Directors of  
Virescent Infrastructure Investment Manager Private Limited



**Sanjay Grewal**  
Director  
DIN: 01971866



**Hardik Shah**  
Director  
DIN: 06648474



**Charmy Bhoot**  
Company Secretary

Place: Mumbai  
Date: May 11, 2021

Place: New Delhi  
Date: May 11, 2021

Place: Mumbai  
Date: May 11, 2021

**Virescent Infrastructure Investment Manager Private Limited**  
Consolidated Statement of Profit & Loss for the period August 22, 2020 (date of incorporation) to March 31, 2021  
Amounts in INR

Particulars	Note No	For the period August 22, 2020 (date of incorporation) to March 31, 2021
<b>Revenue from operations</b>		
Management Fee Income	17	16,42,20,210
<b>Other Income</b>	18	3,40,795
<b>Total Income (I)</b>		<b>16,45,61,005</b>
<b>Expenses</b>		
Employee benefits expense	19	9,11,98,881
Depreciation and amortisation expense	20	3,05,278
Other expenses	21	6,40,75,310
<b>Total Expenses (II)</b>		<b>15,55,79,468</b>
<b>Profit/(loss) before tax (III) = (I-II)</b>		<b>89,81,536</b>
<b>Tax expenses</b>		
Current tax		34,91,073
Deferred tax Expense / (Income)		-8,00,355
<b>Total tax expense</b>		<b>26,90,718</b>
<b>Profit for the year</b>		<b>62,90,818</b>
<b>Other Comprehensive income for the year</b>		-
<b>Total Comprehensive income for the year</b>		<b>62,90,818</b>

Earnings per equity share (nominal value of share Rs.10)

- Basic	0.70
- Diluted	0.70

Summary of significant accounting policies

3

The accompanying notes are an integral part of the financial statements.

As per our report of even date

**For MSKC & Associates (Formerly known as R.K. Kumar & Co.)**

Chartered Accountants

ICAI Firm Registration No.: 0015955



**Tushar Kurani**

Partner

Membership No.: 118580

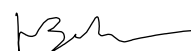
For and on behalf of the Board of Directors of  
Virescent Infrastructure Investment Manager Private Limited



**Sanjay Grewal**

Director

DIN: 01971866



**Hardik Shah**

Director

DIN: 06648474



**Chamy Bhoot**

Company Secretary

Place: Mumbai  
Date: May 11, 2021

Place: New Delhi  
Date: May 11, 2021

Place: Mumbai  
Date: May 11, 2021

**Virescent Infrastructure Investment Manager Private Limited**

Consolidated Statement of Changes in Equity for the period August 22, 2020 (date of incorporation) to March 31, 2021

**Equity Share Capital**

Amounts in INR

	Balance at the beginning of the reporting year	Changes in equity share capital during the year	Balance at the end of the reporting year
For the period August 22, 2020 (date of incorporation) to March 31, 2021	-	11,01,00,000	11,01,00,000
	<b>General Reserves</b>	<b>Retained earnings</b>	<b>Total</b>
Balance as at beginning of period	-	-	-
Profit for the period		62,90,818	-
Dividends		-	-
Dividend Distribution Tax		-	-
Balance at the end of the reporting period	-	62,90,818	62,90,818

As per our report of even date

For MSKC & Associates (Formerly known as R.K. Kumar & Co.)  
Chartered Accountants  
ICAI Firm Registration No.: 0015955



Tushar Kurani  
Partner  
Membership No.: 118580

For and on behalf of the Board of Directors of  
Virescent Infrastructure Investment Manager Private Limited



Sanjay Grewal  
Director  
DIN: 01971866



Hardik Shah  
Director  
DIN: 06648474

Place: Mumbai  
Date: May 11, 2021

Place: New Delhi  
Date: May 11, 2021



Charmy Bhoot  
Company Secretary  
Place: Mumbai  
Date: May 11, 2021



**Virescent Infrastructure Investment Manager Private Limited**  
Consolidated Cash Flow Statement for the period August 22, 2020 (date of incorporation) to March 31, 2021

Amounts in INR

Particulars	Amounts
<b>A. CASH FLOW FROM OPERATING ACTIVITIES:</b>	
Profit / (Loss) before taxation and extraordinary items	89,81,536
Adjustments for :	
Depreciation & Amortization Expenses	3,05,278
Interest on Fixed Deposits	(3,40,795)
<b>Operating Profit / (Loss) Before Working Capital Changes</b>	<b>89,46,019</b>
<b>Movements in working capital:</b>	
Increase / (Decrease) in Provisions	6,96,42,996
Increase / (Decrease) in Trade Payables	39,06,396
Increase / (Decrease) in Other Non Financial Liabilities	2,71,72,909
(Increase) / Decrease in Trade Receivables	(14,34,18,180)
(Increase) / Decrease in Other Financial and Non Financial Assets	(1,38,32,855)
<b>Cash Generated from Operations</b>	<b>(4,75,82,715)</b>
Taxes Paid ( Net of Refunds )	(1,23,42,076)
<b>Net Cash generated by Operating Activities (A)</b>	<b>(5,99,24,791)</b>
<b>B. CASH FLOW FROM INVESTING ACTIVITIES:</b>	
Purchase of Fixed Assets and Intangibles	(1,12,72,164)
Interest on Fixed Deposits	3,40,795
<b>Net cash (used in) / generated by investing activities (B)</b>	<b>(1,09,31,369)</b>
<b>C. CASH FLOW FROM FINANCING ACTIVITIES:</b>	
Equity Infusion	11,01,00,000
<b>Net Cash (used in) / generated from Financing Activities (C)</b>	<b>11,01,00,000</b>
<b>Net Increase / ( Decrease ) in Cash &amp; Cash Equivalents (A) + (B) + (C)</b>	<b>3,92,43,840</b>
Cash and Cash Equivalents As At Beginning of the Period	-
<b>Cash and Cash Equivalents As At End of the Period</b>	<b>3,92,43,840</b>

As per our report of even date

For **MSKC & Associates** (Formerly known as R.K. Kumar & Co.)  
Chartered Accountants  
ICAI Firm Registration No.: 0015955



**Tushar Kurani**  
Partner  
Membership No.: 118580

For and on behalf of the Board of Directors of  
**Virescent Infrastructure Investment Manager Private Limited**



**Sanjay Grewal**  
Director  
DIN: 01971866



**Hardik Shah**  
Director  
DIN: 06648474



**Charmy Bhoot**  
Company Secretary

Place: Mumbai  
Date: May 11, 2021

Place: New Delhi  
Date: May 11, 2021

Place: Mumbai  
Date: May 11, 2021

## THE ISSUE

*The following summarises the details of the Issue. This summary should be read in conjunction with, and is qualified in its entirety by, the detailed information appearing elsewhere in this Final Placement Memorandum.*

<b>Issue</b>	Initial offer by way of fresh issue of up to 460 lakh Units* aggregating up to ₹46,000 lakhs
<b>Issue Price</b>	₹100
<b>Minimum Bid Size</b>	₹2,500 lakhs
<b>Bid/Issue Opening Date</b>	September 27, 2021
<b>Bid/Issue Closing Date</b>	September 28, 2021
<b>Sponsor</b>	Terra Asia Holdings II Pte. Ltd.
<b>Trustee</b>	Axis Trustee Services Limited
<b>Investment Manager</b>	Virescent Infrastructure Investment Manager Private Limited
<b>Project Manager</b>	Virescent Renewable Energy Project Manager Private Limited
<b>Authority for this Issue</b>	This Issue was authorised, and approved by the Board on July 23, 2021
<b>Tenure of Terra InvIT</b>	The Terra InvIT shall stand settled until it comes to an end or is wound up in accordance with the Trust Deed. For details, please see ' <i>Parties to the Terra InvIT</i> ' on page 197.
<b>Units issued and outstanding as of the date of the Final Placement Memorandum</b>	As of the date of this Final Placement Memorandum, there are no issued and outstanding Units
<b>Units issued and outstanding immediately after this Issue</b>	20,10,00,000 Units*
<b>Distribution</b>	See ' <i>Distribution</i> ' on page 190
<b>Use of Proceeds</b>	See ' <i>Use of Proceeds</i> ' on page 73
<b>Listing</b>	Prior to this Issue, there has been no market for the Units. The Units are proposed to be listed on the Stock Exchange. In-principle approval for listing of the Units has been received from NSE on August 6, 2021. The Investment Manager shall apply to the Stock Exchange for the final listing and trading approval, after the Allotment and the credit of the Units to the demat accounts of the Allottees
<b>Trading Lot</b>	Upon listing, such number of Units, the value of which is, or exceeds, ₹ 200 lakhs
<b>Designated Stock Exchange</b>	NSE
<b>Closing Date</b>	The date on which Allotment of the Units pursuant to this Issue shall be made, i.e. on or about September 30, 2021
<b>Ranking</b>	The Units being issued shall rank <i>pari passu</i> in all respects, including rights in respect of distribution. See ' <i>Rights of Unitholders</i> ' on page 193
<b>Rights of Unitholders</b>	For details, please see the section titled ' <i>Rights of Unitholders</i> ' on page 193

*\*Subject to allotment of units by the board of directors of the Investment Manager*

The Issue is a private placement of listed Units under Regulation 14(2) of the SEBI InvIT Regulations.

The Units will be allotted only in dematerialised form, in accordance with the SEBI InvIT Regulations. Upon listing of the Units on the Stock Exchange, the Units shall be traded only on the dematerialized segment of the Stock Exchange.

In accordance with the SEBI InvIT Regulations, no Unitholder shall enjoy preferential voting or any other rights over another Unitholder. Further, there shall not be multiple classes of Units of the Terra InvIT, unless permitted by applicable law.

No person connected with the Issue, including any person connected with the distribution of this Final Placement Memorandum, shall offer any incentive, whether direct or indirect, in any manner, whether in cash or kind or services or otherwise to any person for making an application for Allotment of the Units.

## GENERAL INFORMATION

The Terra InvIT has been settled by the Investment Manager (acting as the settlor) on the instructions of the Sponsor, as an irrevocable trust under the provisions of the Trusts Act in Mumbai, India pursuant to the Trust Deed. The Terra InvIT has been registered with the SEBI as an infrastructure investment trust under the SEBI InvIT Regulations on February 25, 2021 having registration number IN/InvIT/20-21/0018.

For further details, please see '*Background and Structure of the Terra InvIT*' and '*Business*' on pages 94 and 132.

### Principal place of business and correspondence address of the Terra InvIT:

#### **Virescent Renewable Energy Trust**

2<sup>nd</sup> Floor, Piramal Tower

Peninsula Corporate Park

Lower Parel, Mumbai 400013

Maharashtra, India

**Tel:** +91 98205 50707

**E-mail:** invit@virescent.co.in

**SEBI registration number:** IN/InvIT/20-21/0018

**Date of registration with the SEBI:** February 25, 2021

### Contact Person and Compliance Officer

Ms. Charmy Bhoot has been designated by the Investment Manager as the Compliance Officer with respect to the Terra InvIT, and is the relevant contact person with respect to the Terra InvIT. The contact details are as follows:

Ms. Charmy Bhoot

10th Floor, Parinee Crescenzo

C-30, 'G' Block, Bandra Kurla Complex,

Bandra (East), Mumbai 400051,

Maharashtra, India

**Tel:** +91 98338 49735

**E-mail:** charmy.bhoot@virescent.co.in

Bidders can contact the Compliance Officer and the Lead Manager in case of any pre-Issue or post-Issue related problems such as non- credit of Allotted Units in the respective beneficiary account and non-receipt of refunds.

### Sponsor

#### **Terra Asia Holdings II Pte. Ltd.**

10 Changi Business Park, Central 2

#05-01, Hansapoint, Singapore - 486030

**Tel:** +65 6922 5800

**Email:** sgffunds@kkf.com

**Contact person:** Board of directors

### Project Manager

#### **Virescent Renewable Energy Project Manager Private Limited**

10th Floor, Parinee Crescenzo

C-30, 'G' Block, Bandra Kurla Complex,

Bandra (East), Mumbai 400051,

Maharashtra, India

**Tel:** +91 98338 49735

**Email:** Charmy.bhoot@virescent.co.in

**Contact person:** Ms. Charmy Bhoot

## **Trustee**

### **Axis Trustee Services Limited**

Axis House, Bombay Dyeing Mills Compound  
Pandurang Budhkar Marg, Worli  
Mumbai – 400025  
Maharashtra, India  
**Tel:** +91 22 6230 0451  
**Email:** debenturetrustee@axistrustee.in  
**Contact Person:** Mr. Anil Grover  
**SEBI registration number:** IND000000494

## **Trustee Correspondence Office**

### **Axis Trustee Services Limited**

The Ruby, 2<sup>nd</sup> Floor, SW  
29 Senapati Bapat Marg, Dadar West  
Mumbai – 400 028  
Maharashtra, India  
**Tel:** +91 22 6230 0431

## **Investment Manager**

### **Virescent Infrastructure Investment Manager Private Limited**

10th Floor, Parinee Crescenzo  
C-30, 'G' Block, Bandra Kurla Complex,  
Bandra (East), Mumbai 400051,  
Maharashtra, India  
**Tel:** +91 98338 49735  
**Email:** Charmy.bhoot@virescent.co.in  
**Contact person:** Ms. Charmy Bhoot

## **Lead Manager to the Issue**

### **Axis Capital Limited**

8<sup>th</sup> Floor, Axis House  
C 2 Wadia International Centre  
P. B. Marg, Worli  
Mumbai 400 025  
Maharashtra, India  
**Tel:** +91 22 4325 2183

## **Escrow Collection Bank**

### **Axis Bank Limited**

Fortune 2000, Ground Floor,  
Bandra Kurla Complex, Bandra East  
Mumbai 400 051  
Maharashtra, India  
**Tel:** +91 22 6710 5264

## **Legal Advisor to the Issue**

### **Shardul Amarchand Mangaldas & Co**

24<sup>th</sup> Floor, Express Towers,  
Nariman Point,  
Mumbai 400 021  
Maharashtra, India  
**Tel:** +91 22 4933 5555

### **Shardul Amarchand Mangaldas & Co.**

Prestige Sterling Square, Madras Bank Road,  
Off Lavelle Road, Bengaluru 560 001  
Karnataka, India  
**Tel:** +91 80 6674 9999

**Auditor****MSKA & Associates**

1101/B, Manjeera Trinity Corporate  
JNTU Hightech City Road, Kukatpally  
Telangana State  
Hyderabad – 500 072  
**Tel:** +91 80 0830 1972  
**E-mail:** ananthakrishnangovindan@bdo.in  
**ICAI Firm registration number:** 105047W

**Valuer****Mr. S. Sundararaman**

5B, “A” Block, 5th Floor, Mena Kampala Arcade  
New#18 & 20, Thiagaraya Road, T.Nagar  
Chennai – 600 017  
**IBBI Registration Number:** IBBI/RV/06/2018/10238  
**Tel:** +91 44 2815 4192  
**E-mail:** chennaissr@gmail.com

**Technical Consultant****SgurrEnergy India Private Limited**

506 Clover Metropole, Level – 4  
Next to Clover Highlands  
NIBM Road, Kondhwa, Pune - 411048  
Maharashtra, India  
**Tel:** +91 62 625 55111  
**E-mail:** nazish.shaikh@sgurrenergy.com

**Registrar and Unit Transfer Agent****Link Intime India Private Limited**

247 Park C-101, 1st Floor  
Lal Bhadur Shastri Marg  
Vikhroli (West), Mumbai 400 083  
Maharashtra, India  
**Tel:** +91 22 4918 6000  
**Email:** ajit.patankar@linkintime.co.in  
**SEBI registration number:** INR000004058  
**Contact person:** Mr. Ajit Patankar  
**Website:** www.linkintime.co.in  
**Investor Grievance Email:** bonds.helpdesk@linkintime.co.in

**Credit rating**

The Terra InvIT has received a rating of ‘AAA’ for long term bank facilities aggregating to ₹6,000 million, the rationale for which is available on the website of CRISIL.

## INFORMATION CONCERNING THE UNITS

Unit holding of the Trust

Particulars	Number of Units
Units issued and outstanding prior to this Issue	15,50,00,000
Units issued and outstanding after this Issue*	Up to 20,10,00,000

Unitholders holding more than 5% of the Units\*

Sr. No.	Name of the Unit Holders*	Pre-Issue*		Post Issue*	
		Number of Units	Percentage of holding (%)	Number of Units	Percentage of holding (%)
1.	Terra Asia Holdings II Pte. Ltd.	15,50,00,000	100.00	15,50,00,000	77.11
2.	PIP7 Mahseer S.a.r.l.	Nil	Nil	2,74,00,000	13.63

*\*Subject to allotment of units by the board of directors of the Investment Manager*

## USE OF PROCEEDS

The proceeds of the Issue will be up to ₹46,000 lakhs (the “**Issue Proceeds**”). The Issue Proceeds will be utilized towards the following objects:

- a) Providing unsecured loans to the Asset SPVs for repayment/pre-payment of their respective outstanding loans (including any accrued interest and prepayment penalty);
- b) Payment of certain amounts under the terms of Securities Acquisition Agreement- II in connection with the acquisition of the Specified SPVs;
- c) Providing cash consideration for acquisition of Sale CCPS in accordance with Securities Acquisition Agreement -II;
- d) General corporate purposes; and
- e) Issue expenses.

### Net Proceeds

The details of the proceeds from the Issue are summarised in the following table:

Particulars	Estimated Amount (in ₹ lakhs)
Gross Proceeds of the Issue	46,000.00
(Less) Issue expenses	2,170.00
Net Proceeds	43,830.00

### Requirements of Funds

The Issue Proceeds are proposed to be utilized in accordance with the details provided in the following table:

(in ₹ lakhs)	
Particulars	Estimated Amount
Providing unsecured loans to the Asset SPVs for repayment/pre-payment of their respective outstanding loans (including any accrued interest and prepayment penalty)	37,302.00
Payment of certain amounts under the terms of Securities Acquisition Agreement-II in connection with the acquisition of the Specified SPVs	1,000.00
Providing cash consideration for acquisition of Sale CCPS from TSET	1,145.00
General corporate purposes*	4,383.00
Payment of Issue expenses	2,170.00
<b>Total</b>	<b>46,000.00</b>

\* Amount utilised for general corporate purposes shall not exceed the limits as prescribed under the SEBI InvIT Regulations

The Investment Manager believes that utilizing the Issue Proceeds towards the above mentioned objects will (i) help reduce outstanding indebtedness of the Terra InvIT, on a consolidated basis; and (ii) assist the Terra InvIT optimizing the capital structure of the Terra InvIT on a consolidated basis and ensuring compliance with the SEBI InvIT Regulations. This will also enable the Terra InvIT to raise further financing to fund potential business development opportunities, growth and expansion of its business in the future.

### Details of Utilization of the Proceeds

The details of utilization of the Issue Proceeds are set forth herein below:

- a) ***Providing unsecured loans to the Asset SPVs for repayment/pre-payment of the outstanding loans of the Asset SPVs (including any accrued interest and prepayment penalty)***

As of August 31, 2021, Asset SPVs had total outstanding external borrowing of ₹93,228 lakhs. The Terra InvIT proposes to utilize an aggregate amount of ₹37,302 lakhs from the Issue Proceeds towards repayment/pre-payment of certain outstanding loans of Asset SPVs including any interest accrued and prepayment penalty thereon. The selection and extent of loans proposed to be prepaid and/or repaid from the Asset SPV's outstanding loans mentioned below, as the case may be, will be based on various commercial considerations including, amongst

others, the interest rate of the relevant loan, prepayment charges, the amount of the loan outstanding and the remaining tenor of the loan.

The below table provides the details of the borrowings of the Asset SPVs proposed to be repaid or prepaid:

Borrowings of each of the Asset SPVs	Name of lender	Outstanding amount as on August 31, 2021 (in ₹lakhs)
<b>PLG</b>		
Facility I Loan	L&T Infrastructure Debt Fund	12,065.29
Add: Interest accrued		Nil
<b>Total (A)</b>		12,065.29
<b>TSET</b>		
Facility I	L&T Infrastructure Finance Company Limited	647.84
Add: Interest accrued		Nil
Facility II	L&T Infrastructure Debt Fund	2,518.50
Add: Interest accrued		Nil
<b>Total (B)</b>		3,166.34
<b>TSEC</b>		
Facility I	L&T Infrastructure Finance Company Limited	1,223.79
Add: Interest accrued		Nil
Facility II	L&T Infrastructure Debt Fund	4,381.33
Add: Interest accrued		Nil
<b>Total (C)</b>		5605.12
<b>USUPL</b>		
Facility	Indian Renewable Energy Development Agency Limited	13,091.25
Add: Interest accrued		Nil
<b>Total (D)</b>		13,091.25
Solar Edge Facility	L&T Finance Limited	59,300.00
Add : Interest accrued		Nil
<b>Total (E)</b>		59,300.00
<b>Total (A+B+C+D+E)</b>		93,228.00

For further details, see ‘*Financial Indebtedness*’ on page 280.

The Asset SPVs will repay or pre-pay in part or in full any of the outstanding loans, as described in the table above in any combination that it deems fit. The pre-payment or repayment of term loans, in full or in part, availed by the Asset SPVs as set out above shall be based on various factors, including, (i) any conditions attached to the loans restricting our ability to pre-pay or repay the loans, in full or in part, and the time taken to fulfil any such requirements; (ii) levy of any pre-payment penalties; (iii) provisions of any laws, rules, regulations and contracts governing such borrowings; and (iv) other commercial considerations, including, the interest rate on the loan facility, the amount of the loan outstanding and the remaining tenor of the loan. The aggregate amount to be utilized from the Issue Proceeds towards repayment or pre-payment of loans (including additional loans availed, if any), in part or full, would not exceed ₹37,302 lakhs.

The Investment Manager, on behalf of the Terra InvIT, proposes to provide an estimated amount of ₹37,302 lakhs from the Issue Proceeds to the Asset SPVs, by way of unsecured loans (the “**Trust Loans**”), which shall be utilised by the Asset SPV, in accordance with indicative terms set out below. The below mentioned indicative terms have been approved by the Board on July 23, 2021 and the Terra InvIT has entered into the relevant debt documentation with the Asset SPVs on September 20, 2021.

Term	Description
Interest	a. Interest rate at 14.00% - 16.00%, to be decided by the Board of the Investment Manager, subject to detailed benchmarking study and would be at arm’s length;



Term	Description
	<ul style="list-style-type: none"> <li>b. Interest to be paid quarterly or annually by the Specified SPV (or such other interval as may be mutually agreed by and between Parties), in light of COVID-19 pandemic (“<b>Interest Period</b>”)</li> <li>c. Interest on the outstanding principal amount of loan shall accrue from day to day on a prorata basis of 365 / 366 day year (as the case may be) for the actual number of days in the relevant Interest Period.</li> </ul>
Security	Unsecured
Tenure	25 years
Repayment of scheduled repayment amounts	<ul style="list-style-type: none"> <li>a. Any cash surplus available at the end of each quarter of a financial year to the account of the borrower may be applied at the option of the borrower, to repay the Trust Loans. The borrower shall be entitled to prepay all or any part of the principal amount of the Trust Loan (together with accrued but unpaid Interest).</li> <li>b. The borrower can provide prior information about the pre-payment and the repayment timelines can be mutually agreed.</li> <li>c. No prepayment charges or penalty will be payable by the borrower in respect of such voluntary prepayment.</li> <li>d. On the maturity date, the borrower shall repay the debt in full.</li> </ul>
Use of proceeds	The proceeds of Trust Loan shall be utilised by the borrower in compliance with the provisions of Applicable Law towards the repayment or pre-payment, in full or part, from the external lenders, (including any accrued interest and any applicable penalties) or as may be mutually agreed.
Withholding tax	<p>No withholding tax is applicable as per the provisions of the Income-tax Act, 1961.</p> <p>In case, there is any change in law and withholding tax becomes applicable, then withholding tax may be deducted as per the prescribed rate and relevant withholding tax certificate to be provided by the borrower to the lender.</p>

**b) Payment of certain outstanding amounts under the acquisition agreements for the Specified SPVs**

The Master Share Purchase Agreement dated October 3, 2020 (“**Master Agreement**”), amended by way of an Amendment cum Supplemental Agreement dated April 19, 2021 (“**ASA**”), for the sale and purchase of issued share capital of the Specified SPVs was entered into amongst Sindicatum Captive Energy Singapore Pte. Limited (“**SCE Singapore**”), Sindicatum Renewable Energy Company Pte. Limited (“**SRE Singapore**”) and Sindicatum Renewable Energy India Private Limited (“**SREIPL**”) (collectively, the “**Sellers**”), the Sponsor and the Specified SPVs.

In terms of the provisions of the Master Agreement, read with the ASA, in addition to sums paid as consideration for acquisition of 100% interest (directly or indirectly) in the Specified SPVs, ₹1,950 lakhs was agreed to be payable by the Sponsor to SCE Singapore, subject to and upon completion of certain milestones as set out in the ASA (“**Holdback Amount**”).

Such conditions, included the completion of transfer of certain land parcels in connection with PLG Project, the survey and measurement of the survey numbers, obtaining certified copies of mutation entered upon the change of name of the entities of the Specified SPVs, as applicable each within specified period of time as set out under the ASA (“**Master Agreement Milestones**”). Under the terms of the ASA, such Holdback Amount is required to be paid within 15 business days of completion of the relevant Master Agreement Milestone.

In accordance with the Securities Acquisition Agreement - II, Terra InvIT to reflect the arrangement under the ASA, has agreed to pay ₹1,000 lakhs (“**SSA II Holdback Amount**”) within 10 business days of completion of specified actions under the Master Agreement Milestones (“**Holdback Completion Milestones**”). The Holdback Completion Milestones as stated in the Securities Acquisition Agreement – II include:

S. No.	Completion of actions set out in the following Paragraphs of Schedule 12 of the Master Agreement	Timeline	Amount
1	Each of Paragraphs 16 and 17	Within 150 days from May 7, 2021 or such extended period as is notified by the Transferor to the Acquirer (being the period determined by Transferor and informed to the Seller (as defined under Master Agreement) in writing in accordance with Clause 4A of the Master Agreement.)	₹50,000,000 less any applicable set-off amounts or other amounts determined under clause 9.10 of the Master Agreement in each case to the extent spent by the Acquirer or the Specified SPVs
2	Paragraphs 18 and 19	Within 180 days from May 7, 2021 or such extended period as is notified by the Transferor to the Acquirer (being the period determined by Transferor and informed to the Seller (as defined under Master Agreement) in writing in accordance with Clause 4A of the Master Agreement.)	₹35,000,000 less any applicable set-off amounts or other amounts determined under clause 9.10 of the Master Agreement in each case to the extent spent by the Acquirer or the Specified SPVs
3	Paragraph 20	Within 270 days from May 7, 2021 or such extended period as is notified by the Transferor to the Acquirer (being the period determined by Transferor and informed to the Seller (as defined under Master Agreement) in writing in accordance with Clause 4A of the Master Agreement.)	₹15,000,000 less any applicable set-off amounts or other amounts determined under clause 9.10 of the Master Agreement in each case to the extent spent by the Acquirer or the Specified SPVs

For further details, see '*Background and structure of Terra InvIT - Acquisition of the Specified SPVs by the Terra InvIT*' on page 102.

Therefore, the Terra InvIT proposes to pay the specified amount under the Securities Acquisition Agreement-II equivalent to the SSA II Holdback Amount from the Issue Proceeds in terms of the provisions of the Securities Acquisition Agreement – II and in accordance with the above mentioned terms and conditions.

**c) Providing cash consideration for acquisition of CCPS of USUPL held by TSET**

As on date of this Final Placement Memorandum, 11,45,000 CCPS constituting 6.40% of the issued, subscribed and paid-up share capital of USUPL (on a fully diluted basis) are held by TSET ("Sale CCPS"). In accordance with the Securities Acquisition Agreement – II, as consideration for acquisition of Sale CCPS, the Terra InvIT shall pay ₹1,145 lakhs to TSET. The Terra InvIT proposes to utilize such aggregate amount from the Issue Proceeds to acquire 6.40% of the issued, subscribed and paid-up share capital of USUPL on a fully diluted basis. Consequently, the Terra InvIT will hold 100% of the issued, subscribed and paid-up capital of USUPL on completion of the Formation Transactions. For details, see '*Background and structure of Terra InvIT - Acquisition of the Specified SPVs by the Terra InvIT*' on page 102.

**d) General corporate purposes**

The Investment Manager (on behalf of the Terra InvIT) proposes to deploy the balance Net Proceeds, aggregating to ₹4,383 lakhs, towards general purposes, subject to such utilization not exceeding limits as prescribed under the SEBI InvIT Regulations. The general purposes for which the Investment Manager (on behalf of the Terra InvIT) proposes to utilize the Net Proceeds include meeting expenses incurred in the ordinary course of business, meeting any exigencies that the Terra InvIT may face, or any other purposes as may be approved by the Investment Manager from time to time, subject to compliance with necessary provisions of the SEBI InvIT Regulations. Further, the Investment Manager (on behalf of the Terra InvIT), will have flexibility in utilizing surplus amounts, if any.

**e) Issue Expenses**

The Issue Expenses shall be met from the monies from the Issue Proceeds by the Terra InvIT. The total expenses of this Issue are estimated to be up to ₹2,170 lakhs. The Issue Expenses comprise stamp duties payable on issuance of units, fee payable to the Lead Manager, fee payable to the Registrar and Unit Transfer Agent, Auditors, other advisors/ arrangers and all other incidental and miscellaneous expenses.

For ease of operations, if required, the expenses in relation to the Issue as stated above, at the outset, may be borne by the Sponsor or the Investment Manager on behalf of the Terra InvIT, and the Terra InvIT (through Investment Manager) agrees that it will reimburse the Sponsor or the Investment Manager for all such expenses as may be incurred by the Sponsor or the Investment Manager on actual basis from the Issue Proceeds or from the future cash flows of the Terra InvIT.

Any changes in the utilization of Issue Proceeds, shall be made by the Investment Manager in accordance with applicable law and in compliance with SEBI InvIT Regulations.

**STATEMENT OF TAX BENEFITS**

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To,  
Virescent Renewable Energy Trust

The Board of Directors  
Axis Trustee Service Limited [As the Trustee of Trust]

The Board of Directors  
Virescent Infrastructure Investment Manager Private Limited (As the Investment Manager of the Trust)

**Sub: Statement of Possible Special Tax Benefits available to the Virescent Renewable Energy Trust (the “Terra InvIT”) and its unitholders on proposed Private Placement of units which will be listed (‘Issue’).**

1. We, MSKA & Associates (“the Firm”), Chartered Accountants, the statutory auditors of Virescent Renewable Energy Trust (the “Terra InvIT”), hereby confirm that the enclosed Statement of possible special tax benefits (“the Statement”) prepared and issued by the Terra InvIT, which provides the possible special tax benefits under direct tax laws under the provisions of the Income-tax Act, 1961 (the “Act”) presently in force in India. Several of these benefits are dependent on the Terra InvIT and its unitholders, as the case may be, fulfilling the conditions prescribed under the relevant provisions of the Act. Hence, the ability of the Terra InvIT or its unitholders to derive the possible special tax benefits is dependent upon their fulfilling such conditions, which based on business imperatives the Terra InvIT and its unitholders face in the future, the Terra InvIT and its unitholders may or may not choose to fulfil.
2. The benefits discussed in the enclosed Statement are not exhaustive and the preparation of the contents stated is the responsibility of the Investment Manager (on behalf of the Terra InvIT). We are informed that this Statement is only intended to provide general information to the investors and is neither designed nor intended to be a substitute for professional tax advice. In view of the distinct nature of the tax consequences and the changing tax laws, each investor is advised to consult their own tax consultant with respect to the specific tax implications arising out of their participation in the issue and we shall in no way be liable or responsible to any unitholder or subscriber for placing reliance upon the contents of this Statement. Also, any tax information included in this written communication was not intended or written to be used, and it cannot be used by the Terra InvIT or the investor, for the purpose of avoiding any penalties that may be imposed by any regulatory, governmental taxing authority or agency.
3. We do not express any opinion or provide any assurance whether:
  - The Terra InvIT or its unitholders will continue to obtain these benefits in future;
  - The conditions prescribed for availing the benefits have been/would be met; and
  - The revenue authorities/courts will concur with the views expressed herein.
4. The contents of the enclosed Statement are based on information, explanations and representations obtained from the Investment Manager (on behalf of the Terra InvIT) and on the basis of our understanding of the business activities and operations of the Terra InvIT. We have relied upon the information and documents of the Terra InvIT being true, correct and complete and have not audited or tested them. Our view, under no circumstances, is to be considered as an audit opinion under any regulation or law. No assurance is given that the revenue authorities/ courts will concur with the views expressed herein. Our Firm or any of partners or affiliates, shall not be responsible for any loss, penalties, surcharges, interest or additional tax or any tax or non-tax, monetary or non-monetary, effects or liabilities (consequential, indirect, punitive or incidental) before any authority / otherwise within or outside India arising from the supply of incorrect or incomplete information of the Terra InvIT.
5. The enclosed Statement is intended solely for inclusion in the Draft Placement Memorandum, Placement Memorandum and Final Placement Memorandum in connection with the proposed Issue. It should not be used by any other person or for any other purpose. Accordingly, we do not accept or assume any liability or any duty of care for any other purpose or to any other person to whom this Statement is shown or into whose hands it may come without our prior consent in writing.
6. Any subsequent amendment / modification to the provisions of the applicable laws may have an impact

on the views contained in our Statement. While reasonable care has been taken in the preparation of this Statement, we accept no responsibility for any errors or omissions therein or for any loss sustained by any person who relies on it.

7. In our opinion, the Statement prepared by the Investment Manager (on behalf of the Terra InvIT) presents, in all material respects, the possible special tax benefits available as on the date of signing of this report, to the Terra InvIT and its unitholders, in accordance with the Act.

For **MSKA & Associates**

Chartered Accountants

ICAI Firm Registration Number: 105047W

Ananthakrishnan Govindan

Partner

Membership Number: 205226

UDIN: 21205226AAAAFV7170

Hyderabad

July 23, 2021

## **ANNEXURE TO STATEMENT OF POSSIBLE TAX BENEFITS AVAILABLE TO VIRESCENT RENEWABLE ENERGY TRUST AND ITS UNITHOLDERS UNDER THE APPLICABLE LAWS IN INDIA**

*The information provided below sets out the possible tax benefits available to the unitholders in a summary manner only and is not a complete analysis or listing of all potential tax consequences of purchase, ownership and disposal of equity shares or units, under the Tax Laws presently in force in India. It is not exhaustive or comprehensive analysis and is not intended to be a substitute for professional tax advice.*

UNITHOLDERS SHOULD CONSULT THEIR OWN TAX ADVISORS CONCERNING THE INDIAN TAX IMPLICATIONS AND CONSEQUENCES OF PURCHASING, OWNING AND DISPOSING OF UNITS, INCLUDING TAX IMPLICATIONS ON ANY DISTRIBUTIONS BY/ RECEIPTS FROM VIRESCENT RENEWABLE ENERGY TRUST, IN THEIR PARTICULAR SITUATION.

### **I. UNDER THE INCOME-TAX ACT, 1961 (hereinafter referred to as ‘the Act’)**

#### **1. TAX BENEFITS AVAILABLE TO VIRESCENT RENEWABLE ENERGY TRUST (‘BUSINESS TRUST’) UNDER THE ACT**

Virescent Renewable Energy Trust is proposed as a privately placed listed Infrastructure Trust in accordance with the Securities and Exchange Board of India (Infrastructure Investment Trusts) Regulations, 2014, as amended (‘SEBI Regulations’).

The following benefits are available to the Business Trust after fulfilling conditions as per the applicable provisions of the Act and the guidelines prescribed by the Securities and Exchange Board of India (‘SEBI’) (including the Securities and Exchange Board of India (Infrastructure Investment Trusts) Regulations, 2014, as amended) (‘SEBI Regulations’). Business trust is defined under section 2(13A) of the Act to include trust registered as an Infrastructure Investment Trust under the Securities and Exchange Board of India (Infrastructure Investment Trusts) Regulations, 2014.

#### **1.1. Tax implications in the hands of the Business Trust in respect of interest and dividend income received from the Special Purpose Vehicle(s) (‘SPVs’):**

Interest and dividend received or receivable by the business trust from the Project SPVs should be exempt from tax under section 10(23FC) of the Act as tax incidence will arise at the time of distribution of such income to unit holders. For the purposes of this section, SPV means an Indian company in which the business trust holds controlling interest and any specific percentage of shareholding or interest, as may be required by the regulations under which such trust is granted registration.

With respect to interest income (as referred to in section 10(23FC) distributed by SPVs to the Business Trust, section 194A(3)(xi) exempts SPV from the provisions of tax deduction at source in respect of interest paid/payable to the business trust, provided such interest is in relation to interest other than ‘interest on securities’. Withholding tax will arise on interest distributed to unit holders of the Business Trust.

As per the provisions of section 193 of the Act, every Indian company shall withhold taxes at rates in force prescribed under the relevant Finance Act i.e. 10 percent for FY 2021-22, while making payment of any interest on unlisted securities. Accordingly, SPVs will be required to withhold taxes where interest is paid or payable on unlisted securities.

Please note that the procedural provisions regarding exemption from TDS in relation to such interest paid or payable by SPV to business trust are absent. Accordingly, where SPVs withhold taxes on interest on securities paid or payable to the Trust, the Trust shall be eligible to claim a refund for the same.

The Finance Act 2021 extends the benefit of non-withholding of tax on the dividend income credited or paid to REIT/ InvIT by specified SPV or payment of dividend income to any other person as may

be notified. This amendment shall be made effective from Financial year 2019-20. Accordingly, with respect to dividend income distributed by the SPVs to the Business Trust, SPVs may not be liable to withhold tax while making payment to the Business Trust.

The Finance Act, 2020 has abolished Dividend Distribution Tax ('DDT') and hence there shall be no DDT on profits distributed by SPVs to business trust on or after April 1, 2020. However, with the removal of DDT, dividend income would be taxable in the hands of unit holders based on whether the SPVs have opted for the old tax regime or the new tax regime. Therefore, withholding tax would need to be assessed at the time of distribution of dividend income by the Business Trust to the unit holders based on the tax regime (ie old tax regime/ new tax regime) adopted by the respective SPVs.

Where there is expenditure incurred at the Business Trust, tax deduction of the same against interest or dividend income distributed would need to be assessed based on the facts of the case.

## **1.2. Implications in the hands of the business trust in respect of income other than the income distributed by the SPVs held by the Business Trust<sup>1</sup>:**

### **1.2.1. Income by way of dividend (other than received from SPVs):**

Finance Act, 2020 has discontinued the exemption on dividend income available under section 10(34) of the Act and hence the business trust shall be liable to pay tax on dividends received on or after April 1, 2020 at maximum marginal rate.

As per section 57 of the Act, no deduction shall be allowable against the dividend income other than deduction on account of interest expense and such interest expense shall not exceed 20% of the dividend income included in the total income for that year, without deduction under section 57 of the Act.

Further, as per section 194 of the Act, the entity declaring dividend shall be liable to withhold tax at the rate of 10% on profits distributed to business trust in the form of dividends.

### **1.2.2. Section 10(35) of the Act – Income from specified units:**

The Finance Act, 2020 has discontinued the exemption available under section 10(35) and hence the Trust shall be liable to pay tax on income in respect of units received on or after 1 April 2020 at maximum marginal rate.

As per section 57 of the Act, no deduction shall be allowable against the income in respect of specified units other than deduction on account of interest expense and such interest expense shall not exceed 20% of the income in respect of units included in the total income for that year, without deduction under section 57 of the Act.

Further, as per section 194K of the Act, the entity paying any income (other than income in the nature of capital gains) in respect of units shall be liable to withhold tax at the rate of 10% on such income distributed to the Business Trust.

Further, as per the provisions of section 94(8) of the Act, if an investor purchases units within three months prior to the record date for entitlement of bonus units and is allotted bonus units without any payment on the basis of the original holding on the record date and such person sells / transfers the original units within nine months of the record date, then the loss arising from sale/ transfer of the original units will be ignored for the purpose of computing income chargeable to tax and the amount of such loss ignored shall be regarded as the cost of acquisition of the bonus units.

### **1.2.3. Section 10(34A) of the Act - Income from buy back of shares:**

The provisions of section 115QA mandate domestic companies to pay an additional tax at the rate of 20% (plus applicable surcharge and cess) of the distributed income on buy-back of shares. Distributed

<sup>1</sup> Would be relevant for treasury activities undertaken



income means the consideration paid by the company on buy-back of shares as reduced by the amount which was received by the company for issue of such shares, determined as per Rule 40BB of the Income-tax Rules, 1962.

Further, income arising from buy-back of shares as referred to in Section 115QA shall not be taxable as per section 10(34A) of the Act in the hands of the business trust being a shareholder.

#### **1.2.4. Section 115UA(2) read with section 111A, section 112 and section 112A of the Act – Taxability of business income, capital gains and income from other sources in the hands of the business trust**

In terms of section 115UA(2) of the Act, the total income of the business trust shall be chargeable to tax at the maximum marginal rates in force except for the income chargeable to tax on transfer of Short Term Capital assets under section 111A and Long Terms Capital assets under section 112 and section 112A of the Act and income referred to in section 10(23FC) of the Act. Section 112A is not explicitly mentioned in section 115UA(2) and hence an ambiguity exists on the tax rate to be applied on the gains earned by the business trust referred to in section 112A of the Act.

If the period of holding of a security (other than a unit) listed on a recognized stock exchange in India or a unit of the Unit Trust of India or a unit of an equity oriented fund or a zero coupon bond is more than 12 months, it will be considered a long term capital asset as per section 2(29AA) read with section 2(42A) of the Act. With respect to shares of a company not being listed on a recognized stock exchange in India or immovable property, being land, building, or both, the determinative period of holding shall be more than 24 months for it to be regarded as long term capital asset. With respect to other assets including a unit of a mutual fund other than equity oriented mutual fund or unit of a business trust, the determinative period of holding is more than 36 months for it to be regarded as long-term capital asset.

As per the provisions of section 111A of the Act, any income arising from transfer of short term capital asset being an equity share in a company or a unit of an equity oriented fund or a unit of a business trust, transacted through a recognized stock exchange and subject to STT, will be taxable at a concessional rate of 15.00% (plus applicable surcharge and cess)

As per the provisions of section 112(1)(d) of the Act, gains arising on the transfer of long-term capital assets shall be chargeable to tax in the hands of the Trust at the rate of 20% (plus applicable surcharge and cess). However, as per the proviso to section 112 of the Act, the tax on long term capital gains on transfer of listed securities (other than units) or Zero-Coupon Bonds shall be at the rate of 10% (plus applicable surcharge and cess) without indexation benefit.

Further, as per section 112A, with effect from FY 2018-19, gains exceeding one lakh rupees arising on the transfer of long term capital asset, being an equity share in a company or a unit of an equity oriented fund or a unit of a business trust, transacted through a recognized stock exchange and subject to STT, shall be chargeable to tax in the hands of the Trust at the rate of 10% (plus applicable surcharge and cess) without indexation benefit.

For non-resident Unit Holders, the applicable tax treaty would also need to be analysed on taxability of income streams, if it is more beneficial to the non-resident unit holder and they are eligible for tax treaty benefit.

Section 48 of the Act prescribes the mode of computation of Capital Gains and provides for deduction of cost of acquisition/ improvement and expenses incurred in connection with the transfer of a capital asset, from the sale consideration to arrive at the amount of Capital Gains. However, in respect of long-term capital gains, section 48 provides for substitution of cost of acquisition/ improvement with indexed cost of acquisition/ improvement, which adjusts the cost of acquisition/ improvement by a cost inflation index as prescribed from time to time. Such indexation benefit would not be available on bonds, debentures, listed equity shares in a company or units of equity-oriented funds or units of a business trust referred to in section 112A of the Act.

In accordance with, and subject to the conditions, including the limit of investment of ₹ 50 lakhs, capital gains arising on transfer of a long term capital asset, being land or building or both, shall be

exempt from capital gains under section 54EC if the gains are invested within 6 months from the date of transfer in purchase of specified bonds (redeemable after five years and issued on or after 1 April 2018) issued by National Highways Authority of India (NHAI) or Rural Electrification Corporation Ltd (RECL) or any other bond notified by the Central Government, if permitted to be invested by an Investment trust as per the extant governing regulations. In case the whole of the gains is not so invested, the exemption shall be allowed on a pro rata basis.

In accordance with, and subject to the conditions, including the limit of investment of ₹50 lakhs, capital gains arising on transfer of a long term capital asset shall be exempt from capital gains tax under section 54EE if the gains are invested within 6 months from the date of transfer in the purchase of long-term specified assets if permitted to be invested by an Investment trust as per the extant governing regulations. In case the whole of the gains is not so invested, the exemption shall be allowed on a pro rata basis.

As per section 70 read with section 74 of the Act, short term capital loss arising during a year is allowed to be set-off against short term capital gains as well as long term capital gains. Balance loss, if any, shall be carried forward and set-off against any capital gains arising during subsequent eight assessment years. Also, as per section 70 of the Act, long term capital loss arising during a year is allowed to be set-off only against long term capital gains. Balance loss, if any, shall be carried forward and set-off against long term capital gains arising during subsequent eight assessment years.

Further, as per Section 71 of the Act, short term/ long term capital loss for the year cannot be set-off against income under any other head for the same year.

## **2. TAX IMPLICATIONS FOR UNIT-HOLDERS OF THE BUSINESS TRUST**

### **2.1. Special Benefits available to the Unitholders of the business trust**

Following tax benefit is specifically available to the unitholders of the business trust subject to the fulfilment of the conditions specified in the Act and SEBI Regulations:

#### **2.1.1. Section 10(23FD) of the Act - Tax exemption in respect of income distributed by the business trust (except interest and dividend received from SPV by the trust provided dividend is received from SPV exercising option under section 115BAA of the Act):**

As per the provisions of section 115UA(1) of the Act, the income distributed by the Trust shall be deemed to be of the same nature and in the same proportion in the hands of the Unitholder as such income was received by or accrued to the Trust.

As per the provisions of section 10(23FD), any income referred to in section 115UA(1) of the Act and distributed by the business trust shall not be included in the total income of the unit- holders except for the following income:

- Interest referred to in Section 10(23FC); and
- Specified dividend i.e. dividend income received in cases where SPV has exercised the option under Section 115BAA of the Act.

SPV have the option, subject to certain condition, to choose a concessional tax rate of 22 percent under section 115BAA of the Act. In case, SPV has exercised the option under section 115BAA of the Act, any dividend distributed by the Trust out of the dividend paid by such SPV shall be taxable in the hands of unitholder. In other cases, the dividend distributed by Trust out of the dividend paid by SPV which has not exercised the option under section 115BAA of the Act, shall be exempt in the hands of unitholders under section 10(23FC) of the Act.

Where there is expenditure incurred at the Business Trust, tax deduction of the same against interest or dividend income distributed would need to be assessed based on the facts of the case.

#### **2.1.2. Swap of shares of the SPVs for units of the Business Trust:**

According to section 47(xvii) of the Act, any transfer of a capital asset, being share of a special purpose vehicle to a business trust in exchange of units allotted by that trust to the transferor shall not be regarded as transfer and accordingly not be liable to capital gains tax.

According to section 49(2AC) of the Act, the cost of units acquired in lieu of shares in SPV shall be deemed to be cost of acquisition of shares in SPV.

As per clause (hc) of explanation 1 of sec. 2(42A), for ascertaining the period of holding of such units, the period of holding of shares in SPV shall also be included.

Please note that any notional gain or loss arising on transfer of shares of SPV to business trust in exchange of units allotted by the trust (as referred u/s 47(xvii) are to be excluded while calculating book profits for the purpose of Minimum Alternate Tax ('MAT') u/s 115JB. Similarly, any notional gain or loss arising upon change in carrying amount of the units held by Unitholder are to be excluded in calculating book profits for the levy of MAT u/s 115JB. *(clause (iie)/(fc) to explanation 1 to section 115JB)*

Further, actual gain or loss on disposal of units held by the Unitholder as referred to in section 47(xvii) are considered for the purpose of MAT u/s 115JB. *(clause (iif)/(k) to explanation 1 to section 115JB)*

However, if the Unitholder opts for concessional tax regime u/s 115BAA/ 115BAB then provisions of MAT u/s 115JB shall not be applicable for the Unitholder and it shall forego its entire MAT credit available at the time of exercising concessional tax-regime.

## **2.2. General Benefits available to all Unitholders of the business trust**

### **2.2.1. For resident Unitholder:**

- Long Term Capital Gains (exceeding one lakh rupees) arising on transfer of units of the business trust through a recognized stock exchange, on which STT is paid, shall be chargeable to tax in the hands of the unit holders at a rate of 10% without indexation benefit (plus applicable surcharge and cess) under section 112A of the Act if the said units are long-term capital assets. The determinative period of holding for such units to qualify as long-term capital asset is more than 36 months.

Income arising on transfer of units of the business trust that are long term capital assets, which is not through a recognized stock exchange and not subject to STT, shall be chargeable to tax at 20%, with indexation benefit (plus applicable surcharge and cess) under section 112 of the Act.

- Short-term capital gains arising on transfer of the units of the Trust will be chargeable to tax at the rate of 15% (plus applicable surcharge and cess) as per the provisions of section 111A of the Act provided such transaction is subject to STT and through a recognized stock exchange. In case of a Unit-holder being an individual or HUF, where the total taxable income as reduced by short-term capital gains is below the basic exemption limit, the short-term capital gains will be reduced to the extent of the shortfall and only the balance short-term capital gains will be subjected to such tax in accordance with the proviso to sub-section (1) of section 111A of the Act. Short term capital gains on transfer of units of the business trust, not transacted through a recognized stock exchange and not subject to STT shall be taxable at the applicable rate of tax for respective unit holders.
- Short Term Capital Loss computed for the given year is allowed to be set-off against Short Term/ Long Term Capital Gains computed for the said year under section 70 of the Act. Further, as per Section 71 of the Act, short term capital loss for the year cannot be set-off against income under any other heads for the same year. Balance loss, if any, shall be carried forward and set-off against any capital gains arising during subsequent eight assessment years. Also, as per section 70 of the Act, long term capital loss arising during a year is allowed to be set-off only against long term capital gains. Balance loss, if any, shall be carried forward and set-off against long term capital gains arising during subsequent eight assessment years.

- Where the gains arising on the transfer of the units of the Trust are included in the business income of an assessee assessable under the head “Profits and Gains from Business or Profession” and on which securities transaction tax has been charged, such securities transaction tax shall be a deductible expense from business income as per the provisions of section 36(1)(xv) of the Act. The characterization of gains/ losses, arising from sale of shares, as capital gains or business income would depend on the nature of holding in the hands of the unitholder and various other factors.

### **2.2.2. For non-resident Unitholder:**

- Long Term Capital Gains (exceeding one lakh rupees) arising on transfer of units of the business trust, shall be chargeable to tax in the hands of the unit holders at a rate of 10% without indexation benefit (plus applicable surcharge and cess) under section 112A of the Act if the said units are long-term capital assets and transfer is through a recognized stock exchange and subject to STT. These assets turn long term if they are held for more than 36 months. Income arising on transfer of units of the business trust that are long term capital assets, which is not through a recognized stock exchange and not subject to STT, shall be chargeable to tax at 20%, with any applicable indexation benefit (plus applicable surcharge and cess), under section 112 of the Act.
- Short-term capital gains arising on transfer of the units of the business trust will be chargeable to tax at the rate of 15% (plus applicable surcharge and cess) as per the provisions of section 111A of the Act if such transaction is chargeable to STT. Short term capital gains on transfer of units of the business trust, not transacted through a recognized stock exchange and not subject to STT shall be taxable at the applicable rates for respective unit holders.
- Short Term Capital Loss computed for the given year is allowed to be set-off against Short Term/ Long Term Capital Gains computed for the said year under section 70 of the Act. Further, as per Section 71 of the Act, short term capital loss for the year cannot be set-off against income under any other heads for the same year. Balance loss, if any, shall be carried forward and set-off against any capital gains arising during subsequent eight assessment years. Also, as per section 70 of the Act, long term capital loss arising during a year is allowed to be set-off only against long term capital gains. Balance loss, if any, shall be carried forward and set-off against long term capital gains arising during subsequent eight assessment years.
- Where the gains arising on the transfer of shares of the company are included in the business income of an assessee assessable under the head “Profits and Gains from Business or Profession” and on which securities transaction tax has been charged, such securities transaction tax shall be a deductible expense from business income as per the provisions of section 36(1)(xv) of the Act.
- Under the provisions of section 90(2) of the Act, a non-resident will be governed by the provisions of the Double Tax Avoidance Agreement (DTAA) between India and the country of tax residence of the non-resident and the provisions of the Act apply to the extent they are more beneficial to the assessee.
- As per explanation 4 to section 115JB(2), the provisions of section 115JB shall not be applicable to a foreign company if the foreign company is a resident of a country having DTAA with India and such foreign company does not have a permanent establishment within the definition of the term in the relevant DTAA, or the foreign company is a resident of a country which does not have a DTAA with India and such foreign company is not required to seek registration under section 592 of the Companies Act 1956 or section 380 of the Companies Act 2013.

### **2.2.3. For unitholders who are Foreign Portfolio Investors (‘FPIs’)/ Foreign Institutional Investors (‘FIIs’):**

- As per section 2(14) of the Act, transfer of any shares/ securities being invested in accordance with the regulations made under the Securities and Exchange Board of India Act, 1992 shall be deemed to be treated as Capital Gains.

- As per section 196D, no tax is to be deducted from any income, by way of capital gains arising from the transfer of units to Foreign Institutional Investor. In respect of non-residents, the tax rates and consequent taxation mentioned above will be further subject to any benefits available under the Tax Treaty, if any, between India and the country in which the FII is a tax resident. As per the provisions of section 90(2) of the Act, the provisions of the Act would prevail over the provisions of the Tax Treaty to the extent they are more beneficial to the FII. As per the Finance Act, 2021 as per section 196D of the IT Act whereby tax shall be withheld at lower of 20% or the rates provided in the DTAA, subject to the following conditions:
  - DTAA exists between India and the respective jurisdiction of the FPI; and
  - FPI has furnished a TRC to the payer.

This amendment shall be made effective from Financial Year 2020-21.

- Pursuant to Central Board of Direct Tax press release dated 24 September 2015, the Government has clarified the inapplicability of Minimum Alternate Tax provisions to FIIs/FPIs.

#### **2.2.4. For unitholders who are Mutual Funds:**

- Under section 10(23D) of the Act, any income earned by a Mutual Fund registered under the Securities and Exchange Board of India Act, 1992, or a Mutual Fund set up by a public sector bank or a public financial institution, or a Mutual Fund authorized by the Reserve Bank of India would be exempt from income-tax, subject to such conditions as the Central Government may by notification in the Official Gazette specify in this behalf.
- As per section 196 of the Act, the business trust is not required to withhold tax on interest or dividend payment or any other payment to Mutual Fund set up under section 10(23D) of the Act

#### **2.2.5. For Venture Capital Companies/Funds:**

##### **For VCF/VCC registered prior to 21 May 2012**

- Under Section 10(23FB) of the Act, any income of Venture Capital Company to whom the certificate of registration is granted before 21/05/2012 under SEBI (Venture Capital Funds) Regulations, 1996 or of a company which has been granted a certificate of registration as Venture Capital Fund as a subcategory of Category I Alternative Investment Fund and is regulated under SEBI (Alternative Investment Funds Regulations) under the SEBI Act, 1992, would be exempt from income tax, subject to conditions specified therein.
- As per Section 115U of the Act, any income derived by a person from his investment in Venture Capital Company/Venture Capital Fund would be taxable in the hands of the person making an investment in the same manner as if it were the income accruing or arising to or received by such person had the investments been made directly in the venture capital undertaking.

##### **For VCF/VCC registered post 21 May 2012**

- VCF/VCC registered post 21 May 2012 shall be classified as a Category 1 Alternate Investment Fund which shall be governed by the SEBI (AIF) Regulations 2012. For such funds benefit of section 10(23FB) and section 115U shall not be applicable and shall be governed by section 115UB read with section 10(23FBA) and 10(23FBB) which states that business income earned by such fund shall be taxable in the hands of the Fund and exempt in the hands of the unit holders, and other income earned viz. capital gains, income from other sources shall be exempt in the hands of the fund and taxable in the hands of unit holder.

#### **2.2.6. Section 10(23FE): Income of a specified person in the nature of dividend, interest or long-term capital gains arising from an investment made by it in India.**

As per section 10(23FE) of the Act, dividend, interest and long-term capital gains arising from investments made by 'specified person' in India, whether in the form of debt or share capital or unit, shall be exempt, if such investment is:

- (i) made on or after the 01 April 2020 but on or before the 31 March 2024
- (ii) is held for at least 3 years
- (iii) inter alia, is in a business trust

Further, such specified person (subject to certain conditions prescribed in section 10(23FE)) shall include:

- (i) Wholly owned subsidiary of Abu Dhabi Investment Authority (ADIA)
- (ii) Sovereign Wealth Funds (SWF)
- (iii) Pension funds

*In this regard, please note that there are no amendments in the withholding tax provisions under the Act providing for exemption from withholding taxes on above mentioned income accruing to specified persons.*

### **3. UNDER THE WEALTH TAX ACT, 1957**

The Wealth Tax Act, 1957 has now been abolished from FY 2015-16 and is not applicable from AY 2016-17 onwards.

## **4. TAX DEDUCTION AT SOURCE**

### **4.1. Section 194LBA – Certain income from units of the business trust:**

Where any distributed income referred in section 115UA, is in the nature referred to in sub clause (a) of clause (23FC) of section 10 i.e. interest payable by the business trust to its unit holder being a resident or dividend payable by business trust to its unit holder being a resident where such dividend is received from SPV which has exercised the option under section 115BAA of the Act, shall at the time of credit of such payment to the account of the payee or at the time of payment, whichever is earlier, deduct tax at the rate of 10%.

In case payment referred to above is made to a non-resident unit holder, then the same shall be subjected to the tax deduction at the rate of 5% (plus applicable surcharge and cess) in case of interest referred to in clause (a) of sub clause (23FC) of Section 10 and 10% (plus applicable surcharge and cess) in case of dividend payable by a business trust where such dividend is received from SPV which has exercised the option under section 115BAA of the Act.

Additionally, in view of section 90(2) of the Act, a non-resident will be governed by the provisions of the Double Taxation Avoidance Agreement (DTAA) between India and the country of tax residence of the non-resident and the provisions of the Act apply to the extent they are more beneficial to the assessee

### **4.2. Applicability of other provisions**

No income tax is deductible at source from income by way of capital gains arising to a resident shareholder under the present provisions of the Act. However, as per the provisions of Section 195 of the Act, any income by way of capital gains payable to non-residents may be subject to withholding of tax at the rate under the domestic tax laws or under the tax laws or under the Double Tax Avoidance Agreement (DTAA), whichever is beneficial to the assessee, unless a lower withholding tax certificate is obtained from the tax authorities (other than FPIs/ FIIs which are subject to provisions of section 196D(2) of the Act)

However, the non-resident investor will have to furnish a certificate of his being a tax resident in a country outside India and a suitable declaration for not having a fixed base/permanent establishment in India, to get the benefit of the applicable DTAA and such other document as may be prescribed as per the provision of section 90(4) of Act.

#### **Section 206AA of the Act – Where PAN details are not furnished by the unitholder**

As per Section 206AA of the Act, where a taxpayer does not have a Permanent Account Number ('PAN'), taxes have to be withheld on payment of income to the taxpayer (where chargeable to tax) at higher of the following:

- at the rate specified in the Act; or
- at the rate or rates in force; or
- at the rate of 20 percent

Pursuant to amendment in section 206AA vide notification 53/2016 dated 24 June 2016 introducing Rule 37BC, requirement of quoting permanent account number (PAN) in case of certain specified income is dispensed by maintaining specified documents as mentioned in the said notification.

#### **Section 206AB of the Act (introduced vide the Finance Act, 2021) – Where the return of income has not been furnished by the unitholder**

As per Section 206AB of the Act, where taxes are required to be deducted on any sum (other than those referred to in section 192, 192A, 194B, 194BB, 194LBC or 194N) paid/ payable/ credited to a specified person, the taxes have to be withheld at higher of the following:

- at twice the rate specified in the Act; or
- at twice the rate or rates in force; or
- at the rate of 5 percent

Wherein the specified person means a person, who –

- has not filed the return of income for two assessment years relevant to two previous years immediately preceding the previous year in which the tax is required to be deducted, for which time-limit of filing u/s 139(1) has expired; and
- the aggregate of tax deducted at source and tax collected at source is INR 50,000 or more in each of the two previous years

The above provisions shall not be applicable in case of non-resident not having a permanent establishment in India.

Further, in cases where both Section 206AA and Section 206AB of the Act are applicable, TDS shall be deducted at higher of the rate prescribed under both these sections.

Note1: Please note that the rate prescribed under section 206AB of the Act shall not be increased by any surcharge and cess

Note2: Please note that the proposed section shall come into force with effect from 01 July 2021

## **5. TAX COLLECTION AT SOURCE**

### **Section 206C(1H) – Tax collection on source**

As per clause 1H of section 206C of the Act, every seller, who receives any amount as consideration for sale of any goods for value exceeding fifty lakh rupees shall at the time of receipt of such amount, collect from the buyer, a sum equal to 0.1 per cent of the sale consideration exceeding fifty lakh rupees as income-tax.

Further, it has been provided that the Seller would be required to collect such tax only if his total sales, gross receipts or turnover from his business exceeds INR 100 million during the financial year immediately preceding the financial year in which the sale of goods is carried out.

For this purpose, “buyer” means a person who purchases any goods, but does not include: (a) the Central Government, a State Government, an embassy, a High Commission, legation, commission, consulate and the trade representation of a foreign State; or (b) a local authority as defined in the Explanation to clause (20) of section 10; or (c) a person importing goods into India or any other person as the Central Government may, by notification in the Official Gazette, specify for this purpose, subject to such conditions as may be specified therein.

Further, in case buyer fails to furnish PAN or Aadhar to the seller, in such case seller is required to collect tax at the rate of 1 percent.

In addition, the section provides that the provisions of this section shall not be applicable if the buyer is liable to deduct TDS under other provisions of the Act on the goods purchased by him from the seller and has deducted such amount.

### **Section 206CC of the Act – Where PAN details are not furnished by the unitholder**

As per Section 206CC of the Act, where a buyer does not possess a Permanent Account Number (‘PAN’), taxes have to be collected by the seller (where tax is required to be collected) at higher of the following:

- at twice the rate specified in the relevant provision of this Act; or
- at the rate of 5 percent



The above provisions shall not be applicable in case of non-resident not having a permanent establishment in India.

**Section 206CCA of the Act – Where the return of income has not been furnished by the unitholder**

As per Section 206CCA of the Act, where tax is required to be collected at source under the provisions of the Act on any sum or amount received by a person from a specified person, the taxes have to be collected at higher of the following two rates:

- at twice the rate specified in the relevant provision of this Act; or
- at the rate of 5 percent

Wherein the specified person means a person, who –

- (i) has not filed the return of income for two assessment years relevant to two previous years immediately preceding the previous year in which the tax is required to be collected, for which time-limit of filing u/s 139(1) has expired; and
- (ii) the aggregate of tax deducted at source and tax collected at source is INR 50,000 or more in each of the two previous years

The above provisions shall not be applicable in case of non-resident not having a permanent establishment in India.

Further, in cases where both Section 206CC and Section 206CCA of the Act are applicable, TCS shall be collected at higher of the rate prescribed under both these sections.

Note1: Please note that the rate prescribed under section 206CCA of the Act shall not be increased by any surcharge and cess

Note2: Please note that the proposed section shall come into force with effect from 01 July 2021

**Notes:**

- i. Business trust is compulsorily required to file Income-tax return as per section 139(4E) of the Act.
- ii. The income-tax rates specified in this note are as applicable for the financial year 2021-22, and are exclusive of surcharge and cess, if any. Rate of surcharge and cess are provided below:

**Surcharge:****Domestic companies (not opting for Section 115BAA):**

If the net income does not exceed INR 10 million – Nil

If the net income exceeds INR 10 million but does not exceed INR 100 million - 7 per cent

If the net income exceeds INR 100 million - 12 per cent

**Domestic companies (opting for Section 115BAA) – 10%****Foreign companies:**

If the net income does not exceed INR 10 million - Nil

If the net income exceeds INR 10 million but does not exceed INR 100 million - 2 per cent

If the net income exceeds INR 100 million - 5 per cent

**For Individuals**

	<b>Taxable Income</b>	<b>Surcharge (%)</b>
<b>1</b>	If total income (including capital gains on specified securities and dividend income) is above Rs 50 Lakhs & upto Rs 1 Cr	<b>10%</b>
<b>2</b>	If total income (including capital gains on specified securities and dividend income) is above Rs 1 Cr. & upto Rs 2 Crs.	<b>15%</b>
<b>3</b>	If total income (excluding capital gains on specified securities and dividend income) is above Rs 2 Crs. & upto Rs 5 Crs.	<b>25%</b>
<b>4</b>	If total income (excluding capital gains on specified securities and dividend income) is above Rs 5 Crs.	<b>37%</b>
<b>5</b>	If total income is above 2 Crs. (including capital gains on specified securities and dividend income) but is not covered under 3 and 4 above. Provided surcharge not to exceed 15 per cent in case of capital gains on specified securities and dividend income included in such total income	<b>15%</b>

Specified security mean equity shares, units of equity oriented mutual funds, units of business Trust taxed under section 111A or section 112A of the Act

**For FPIs (AOP and BOI)**

	<b>Taxable Income</b>	<b>Surcharge (%)</b>
<b>1</b>	If total income (including capital gains on all securities) is above Rs 50 Lakhs & upto Rs 1 Cr	<b>10%</b>
<b>2</b>	If total income (including capital gains on all securities) is above Rs 1 Cr. & upto Rs 2 Crs.	<b>15%</b>
<b>3</b>	If total income (excluding capital gains on all securities) is above Rs 2 Crs. & upto Rs 5 Crs.	<b>25%</b>
<b>4</b>	If total income (excluding capital gains on all securities) is above Rs 5 Crs.	<b>37%</b>
<b>5</b>	If total income is above 2 Crs. (including capital gains on all securities) but is not covered under 3 and 4 above. Provided surcharge not to exceed 15 per cent in case of capital gains on specified securities included in such total income	<b>15%</b>

**Health and Education Cess**

In all cases, Health and Education cess will be levied at the rate of 4 per cent of income-tax and surcharge.

- iii. The above statement of possible direct tax benefits sets out the provisions of law in a summary manner only and is not a complete analysis or listing of all potential tax consequences of the purchase, ownership and disposal of shares and units.
- iv. The stated benefits will be available only to the sole/ first named holder in case the units are held by joint holders.
- v. In respect of non-residents, the tax rates and the consequent taxation mentioned above shall be further subject to any benefits available under the applicable DTAA, if any, between India and the country in which the non-resident has fiscal domicile.
- vi. This statement is intended only to provide general information to the investors and is neither designed nor intended to be substituted for professional tax advice. In view of the individual nature of tax consequences, each investor is advised to consult his/her own tax advisor with respect to specific tax consequences of his/her participation in the scheme.
- vii. No assurance is given that the revenue authorities/courts will concur with the views expressed herein. Our views are based on the existing provisions of law and its interpretation, which are subject to changes from time to time. We do not assume responsibility to update the views consequent to such changes. We shall not be liable to any claims, liabilities or expenses relating to this assignment except to the extent of fees relating to this assignment, as finally judicially determined to have resulted primarily from bad faith or intentional misconduct. We will not be liable to any other person in respect of this statement.
- viii. This statement of possible direct tax benefits enumerated above is as per the Act as amended by the Finance Act, 2021. The above statement of possible Direct-tax Benefits sets out the possible tax benefits available to the Trust and its unit holders under the current tax laws presently in force in India. Several of these benefits available are dependent on the Company or its shareholders fulfilling the conditions prescribed under the relevant tax laws.
- ix. The information provided above sets out the possible tax benefits available to the unit holders in a summary manner only and is not a complete analysis or listing of all potential tax consequences of the purchase, ownership and disposal of equity shares and units, under the current tax laws presently in force in India. It is not exhaustive or comprehensive and is not intended to be a substitute for professional advice. Investors are advised to consult their own tax consultant with respect to the tax implications of an investment in the equity shares and units particularly in view of the fact that certain recently enacted legislation may not have a direct legal precedent or may have a different interpretation impacting the benefits, which an investor can avail

## SECTION IV – ABOUT THE TERRA INVIT

### BACKGROUND AND STRUCTURE OF THE TERRA INVIT

*The following overview is qualified in its entirety by, and is subject to, the more detailed information contained in, or referred to elsewhere in this Final Placement Memorandum. Under no circumstances should the inclusion of such information herein be regarded as a representation, warranty or prediction of the accuracy of the underlying assumptions by the Terra InvIT or the Parties to the Terra InvIT or any other person or that these results will be achieved or are likely to be achieved.*

#### Structure and description the Terra InvIT

The Terra InvIT has been settled by the Investment Manager (acting as the settlor) on the instructions of the Sponsor, as an irrevocable trust under the provisions of the Trusts Act in Mumbai, India pursuant to the Trust Deed. The Terra InvIT has been registered with the SEBI as an infrastructure investment trust under the SEBI InvIT Regulations on February 25, 2021 having registration number IN/InvIT/20-21/0018. The Investment Manager irrevocably transferred to the Trustee an amount of ₹10,000 towards the initial corpus of the Terra InvIT, with an intention to settle and establish the Terra InvIT. The initial sum of Terra InvIT shall in no event be distributed to the Investment Manager.

For details of the principal place of business and contact person of the Sponsor, please see '**General Information**' on page 69.

Further, Virescent Infrastructure Investment Manager Private Limited has been appointed as the Investment Manager, and Virescent Renewable Energy Project Manager Private Limited has been appointed as the Project Manager. For further details, please see '**General Information**' and '**Parties to the Terra InvIT**' on pages 69 and 197, respectively.

#### Investment Objectives

The object and purpose of the Terra InvIT, as described in the Trust Deed, is to carry on the activity of an infrastructure investment trust as permissible under the SEBI InvIT Regulations to raise funds through the Terra InvIT, to make investments in accordance with the SEBI InvIT Regulations and the investment strategy and to carry on the activities as may be required for operating the Terra InvIT, including incidental and ancillary matters thereto. The objective and purpose of the Terra InvIT includes the following:

- (a) to raise funds in accordance with applicable law, for the purpose of attaining the object and purpose of the Terra InvIT;
- (b) to make investments or re-investments in accordance with the Terra InvIT Documents and applicable law;
- (c) to park amounts held by the Terra InvIT pending investment or distribution, or as a reserve of the Terra InvIT's anticipated obligations, as permitted under the SEBI InvIT Regulations;
- (d) to make regular distributions to the Unitholders in the manner prescribed in the Trust Deed;
- (e) to do all other things necessary and conducive to the attainment of the investment objective of the Terra InvIT, through agents or other delegates (including the Investment Manager); and
- (f) to carry on generally such other activities as may be permitted under applicable laws.

For further details in relation to the business and investment strategy of the Terra InvIT, see '**Business**' on page 132.

The Terra InvIT is required to make distributions to the Unitholders in accordance with the SEBI InvIT Regulations and the Distribution Policy. For details in relation to the distribution policy of the Terra InvIT, see '**Distributions**' on page 190.

## Fees and expenses

The expenses in relation to the Terra InvIT, other than such expenses incurred in relation to operations of the Asset SPVs would broadly include fee payable to: (i) the Trustee; (ii) the Investment Manager; (iii) the Project Manager; (iv) the Auditors, (v) the Valuer; and (vi) other intermediaries and consultants.

The estimated recurring expenses on an annual basis (exclusive of out of pocket expenses, taxes and escalations) including but not limited to, are as follows:

Payable by the Terra InvIT	Estimated Expenses
Fee payable to the Trustee	₹ 9.00 lakhs
Fee payable to the Valuer	₹ 6.89 lakhs
Fee payable to the Auditor	₹ 5.00 lakhs
Fee payable to the Investment Manager	Investment Manager shall charge a fee equivalent to 110% of the costs incurred by the Investment Manager in providing such services to the Terra InvIT
Fee payable to the Project Manager	Project Manager shall charge a fee equivalent to 110% of the costs incurred by the Project Manager in providing such services to the Terra InvIT
Fee payable to the Registrar	₹1.20 lakhs
Fee payable to the Stock Exchange and Depositories	Stock Exchange: ₹10.00 lakhs NSDL: ₹0.75 lakhs CDSL: ₹0.75 lakhs
Fee payable to credit rating agencies	₹ 21.50 lakhs

## Set-up costs

In connection with the establishment and registration of the Terra InvIT, the Investment Manager has incurred/ may incur approximately ₹469 lakhs in expenses which forms part of the Issue Expenses. Such expenses may be reimbursed by the Terra InvIT to the Investment Manager in the future as agreed between the Investment Manager and the Terra InvIT in terms of the Investment Management Agreement.

## Parties to the Terra InvIT

In accordance with the SEBI InvIT Regulations, the Parties to the Terra InvIT are (i) the Sponsor; (ii) the Investment Manager; (iii) the Trustee; and (iv) the Project Manager. For details, see '*Parties to the Terra InvIT*' on page 197.

The following diagram illustrates the shareholding structure of the Asset SPVs post the transfer of Asset SPV pursuant Securities Acquisition Agreements and prior to the Allotment:



*\*TSEC and USUPL shall be considered as HoldCos in accordance with the SEBI InvIT Regulations and shall also hold the respective assets.*

### **Details of the Asset SPVs**

The details of Solar Edge, Terralight Kanji, TN Solar, UMD, Terralight Rajapalayam, PLG, TSET, TSEC and USUPL as of the date of this Final Placement Memorandum are provided below:

#### **1. Solar Edge Power and Energy Private Limited (“Solar Edge”)**

##### **Corporate Information**

Solar Edge was incorporated on June 29, 2015 under the Companies Act, 2013 at Mumbai, Maharashtra. The registered office of Solar Edge is at 10th Floor, Parinee Crescenzo, C-30, ‘G’ Block, Bandra Kurla Complex, Bandra (East), Mumbai 400051, Maharashtra, India. Its CIN is U74900MH2015PTC266093. Solar Edge owns and operates a 169 MW DC solar project spread across three locations of Maharashtra, India two in Beed district and one in Jalgaon district.

##### **Capital Structure**

The capital structure of Solar Edge is as follows:

Particulars	Amount (in ₹)
Authorised capital	1,50,00,00,000
Issued, subscribed and paid-up capital	1,49,00,00,000

##### **Shareholding Pattern**

The equity shareholding pattern of Solar Edge is as follows:

Sr. No.	Name of the shareholder	Number of equity shares of ₹10 each	Percentage of the Issued, subscribed and paid-up capital
1.	Sponsor	14,89,99,999	99.99
2.	Terra I <sup>#</sup>	1	Negligible
	<b>Total</b>	<b>14,90,00,000</b>	<b>100</b>

<sup>#</sup>Nominee of Sponsor.

Our Sponsor holds 12,15,32,667, unrated, unlisted, unsecured CCDs issued by Solar Edge to the Sponsor at ₹10 each aggregating to ₹12,153.27 lakhs. Solar Edge has also issued NCDs. For details of NCDs, please see, ‘**Financial Indebtedness**’ on page 280.

#### **2. Terralight Kanji Solar Private Limited (“Terralight Kanji”) (previously known as Solar PV)**

Terralight Kanji was incorporated on May 6, 2010 under the Companies Act, 1956 at Mumbai, Maharashtra. The registered office of Terralight Kanji is at 10th Floor, Parinee Crescenzo, C-30, ‘G’ Block, Bandra Kurla Complex, Bandra (East), Mumbai 400051, Maharashtra, India. Its CIN is U40300MH2010PTC202812. Terralight Kanji owns and operates a 36 MW DC solar project located in Thiruvannamalai district of Tamil Nadu, India.

##### **Capital Structure**

The capital structure of Terralight Kanji is as follows:

Particulars	Amount (in ₹)
Authorised capital	85,10,00,000
Issued, subscribed and paid-up capital	40,57,08,000

##### **Shareholding Pattern**

The equity shareholding pattern of Terralight Kanji is as follows:

Sr. No.	Name of the shareholder	Number of equity Shares of ₹10 each	Percentage of the Issued, subscribed and paid-up capital
1.	Sponsor	4,05,00,799	99.83
2.	Terra I <sup>#</sup>	1	Negligible
	<b>Total</b>	<b>4,05,00,800</b>	<b>99.83</b>

<sup>#</sup> Nominee of Sponsor

The preference shareholding pattern of Terralight Kanji is as follows:

Sr. No.	Name of the shareholder	Number of compulsorily convertible preference shares of face value ₹10 each	Percentage of the Issued, subscribed and paid-up capital
1.	Sponsor	70,000	0.17

Our Sponsor holds 24,18,22,113 unrated, unlisted, unsecured CCDs issued by Terralight Kanji to the Sponsor at ₹10 each aggregating to ₹24,182.21 lakhs. Terralight Kanji has also issued NCDs. For details of NCDs, please see, '*Financial Indebtedness*' on page 280.

### 3. TN Solar Power Energy Private Limited ("TN Solar")

TN Solar was incorporated on October 14, 2013 under the Companies Act, 1956 at Chennai, Tamil Nadu. The registered office of TN Solar is at "Sreyas Virat", 1<sup>st</sup> Floor, 3<sup>rd</sup> Cross Road, Raja Annamalaipuram, Chennai 600028, Tamil Nadu, India. Its CIN is U40103TN2013PTC093340. TN Solar owns and operates a 28 MW DC project spread across 3 (three) locations of Tamil Nadu, India (Vidrudhunagar, Thuthookudi and Dindigul districts).

#### Capital Structure

The capital structure of TN Solar is as follows:

Particulars	Amount (in ₹)
Authorised capital	75,00,00,000
Issued, subscribed and paid-up capital	62,62,00,000

#### Shareholding Pattern

The equity shareholding pattern of TN Solar is as follows:

Sr. No.	Name of the shareholder	Number of equity shares of ₹10 each	Percentage of the Issued, subscribed and paid-up capital
1.	Sponsor	4,34,99,999	69.47
2.	Terra I <sup>#</sup>	1	Negligible
	<b>Total</b>	<b>4,35,00,000</b>	<b>69.47</b>

<sup>#</sup> Nominee of Sponsor

The preference shareholding pattern of TN Solar is as follows:

Sr. No.	Name of the shareholder	Number of compulsorily convertible preference shares of face value ₹10 each	Percentage of the Issued, subscribed and paid-up capital
1.	Sponsor	1,91,20,000	30.53

Our Sponsor holds 13,44,58,559 unrated, unlisted, unsecured CCDs issued by TN Solar to the Sponsor at ₹10 each aggregating to ₹13,445.86 lakhs. TN Solar has also issued NCDs. For details of NCDs, please see, '*Financial Indebtedness*' on page 280.

### 4. Universal Mine Developers and Service Providers Private Limited ("UMD")

UMD was incorporated on July 11, 2008 under the Companies Act, 1956 at Mumbai, Maharashtra as SP Research Laboratories Private Limited. Subsequently, its name was changed to Universal Mine Developers and Service

Providers Private Limited and a fresh certificate of incorporation consequent upon change of name of the company dated March 18, 2010 was issued by Registrar of Companies, Mumbai at Maharashtra. The registered office of UMD is at 10th Floor, Parinee Crescenzo, C-30, 'G' Block, Bandra Kurla Complex, Bandra (East), Mumbai 400051, Maharashtra, India. Its CIN is U10100MH2008PTC184554. UMD owns and operates a 30 MW DC project spread across 2 (two) locations of Tamil Nadu, India (Virudunagar and Thuthookudi (*earlier known as Tuticorin*) districts).

### Capital Structure

The capital structure of UMD is as follows:

Particulars	Amount (in ₹)
Authorised capital	80,00,00,000
Issued, subscribed and paid-up capital	67,00,10,000

### Shareholding Pattern

The equity shareholding pattern of UMD is as follows:

Sr. No.	Name of the shareholder	Number of equity shares of ₹10 each	Percentage of the Issued, subscribed and paid-up capital
1.	Sponsor	4,69,00,999*	70.00
2.	Terra I <sup>#</sup>	1	Negligible
	<b>Total</b>	<b>4,69,01,000</b>	<b>70.00</b>

<sup>#</sup> Nominee of Sponsor.

The preference shareholding pattern of UMD is as follows:

Sr. No.	Name of the shareholder	Number of compulsorily convertible preference shares of face value ₹10 each	Percentage of the Issued, subscribed and paid-up capital
1.	Sponsor	20,100,000	30.00

Our Sponsor holds 15,06,58,705 unrated, unlisted, unsecured CCDs issued by UMD to the Sponsor at ₹10 each aggregating to ₹15,065.87 lakhs. UMD has also issued NCDs. For details of NCDs, please see, '*Financial Indebtedness*' on page 280.

### 5. Terralight Rajapalayam Solar Private Limited ("Terralight Rajapalayam") (previously known as SP Suryaprakash)

Terralight Rajapalayam was incorporated on October 9, 2018 under the Companies Act, 2013 at Mumbai, Maharashtra. The registered office of Terralight Rajapalayam is at 10th Floor, Parinee Crescenzo, C-30, 'G' Block, Bandra Kurla Complex, Bandra (East), Mumbai 400051, Maharashtra, India. Its CIN is U40100MH2018PTC315556. Terralight Rajapalayam owns and operates a 54 MW DC solar project located in Rajapalayam, Tamil Nadu, India.

### Capital Structure

The capital structure of Terralight Rajapalayam is as follows:

Particulars	Amount (in ₹)
Authorised capital	50,00,000
Issued, subscribed and paid-up capital	11,00,000

### Shareholding Pattern

The equity shareholding pattern of Terralight Rajapalayam is as follows:



Sr. No.	Name of the shareholder	Number of equity shares of ₹10 each	Percentage of the Issued, subscribed and paid-up capital
1.	Sponsor	1,09,999	99.99
2.	Terra I <sup>#</sup>	1	Negligible
	<b>Total</b>	<b>1,10,000</b>	<b>100</b>

<sup>#</sup> Nominee of Sponsor

Our Sponsor holds 18,53,33,277 unrated, unlisted, unsecured CCDs issued by Terralight Rajapalayam to the Sponsor at ₹10 each aggregating to ₹18,533.33 lakhs.

## 6. PLG Photovoltaic Private Limited (“PLG”)

PLG was incorporated on June 11, 2007 under the Companies Act, 1956 at Kolkata, India as public limited company. Subsequently, it was converted into private limited company and fresh certificate of incorporation dated June 8, 2019 consequent upon conversion from public limited to private limited Company was issued by Registrar of Companies, Kolkata. The registered office of PLG is at Kalika Dham, P- 4/B, C.I.T. Road Sch. No. 55 Kolkata-700014, West Bengal, India. Its CIN is U30004WB2007PTC116408. PLG owns and operates a 20 MW DC solar power project located in Dahisar, Patan district of Gujarat, India.

### Capital Structure

The capital structure of PLG is as follows:

Particulars	Amount (in Rs.)
Authorised capital	43,00,00,000
Issued, subscribed and paid-up capital	41,23,71,570

### Shareholding Pattern

The equity shareholding pattern of PLG is as follows:

Sr. No.	Name of the shareholder	Number of equity shares of Rs. 10 each	Percentage of the Issued, subscribed and paid-up capital
1.	Sponsor	10,89,447	2.64%
2.	USUPL	4,01,47,710	97.36%
	<b>Total</b>	<b>4,12,371,57</b>	<b>100</b>

## 7. Terralight Solar Energy Tinwari Private Limited (“TSET”)

TSET was incorporated on June 17, 2008 under the Companies Act, 1956 at New Delhi, India as AES Solar Energy Private Limited. Subsequently its name was changed to Sindicatum Solar Energy Private Limited and fresh certificate of incorporation dated January 23, 2017, consequent upon change of name of the company was issued by Registrar of Companies, New Delhi. Further, its name was changed from Sindicatum Solar Energy Private Limited to Terralight Solar Energy Tinwari Private Limited and fresh certificate of incorporation dated July 16, 2021, consequent upon change of name of the company was issued by Registrar of Companies, New Delhi. The registered office of TSET is at B-93, Basement Defence Colony, New Delhi (South) – 110024, India. Its CIN is U40106DL2008PTC333444. TSET owns and operates a 5.75 MW DC solar project located at Tinwari in Jodhpur district, Rajasthan, India.

### Capital Structure

The capital structure of TSET is as follows:

Particulars	Amount (in Rs.)
Authorised capital	26,50,00,000
Issued, subscribed and paid-up capital	18,55,46,120

### Shareholding Pattern

The equity shareholding pattern of TSET is as follows:

Sr. No.	Name of the shareholder	Number of equity shares of Rs. 10 each	Percentage of the Issued, subscribed and paid-up capital
1.	TSEC	1,85,54,611	99.99%
2.	TN Solar #	1	Negligible
	<b>Total</b>	<b>1,85,546,12</b>	<b>100</b>

# Nominee of TSEC

#### 8. Terralight Solar Energy Charanka Private Limited (“TSEC”)

TSEC was incorporated on May 12, 2010 under the Companies Act, 1956 at New Delhi, India as AES Solar Energy Gujarat Private Limited. Subsequently its name was changed to Sindicatum Solar Energy Gujarat Private Limited and fresh certificate of incorporation dated January 23, 2017, consequent upon change of name the company was issued by Registrar of Companies, New Delhi. Further, its name was changed from Sindicatum Solar Energy Gujarat Private Limited to Terralight Solar Energy Charanka Private Limited, and fresh certificate of incorporation dated July 16, 2021, consequent upon change of name of the company was issued by Registrar of Companies, New Delhi. The registered office of TSEC is at B-93, Basement Defence Colony, New Delhi (South) – 110024, India. Its CIN is U40107DL2010PTC333963. TSEC owns and operates a 15 MW DC solar power project located in Gujarat Solar Park, Gujarat, India.

##### Capital Structure

The capital structure of TSEC is as follows:

Particulars	Amount (in Rs.)
Authorised capital	99,00,00,000
Issued, subscribed and paid-up capital	98,32,27,410

##### Shareholding Pattern

The equity shareholding pattern of TSEC is as follows:

Sr. No.	Name of the shareholder	Number of equity shares of Rs. 10 each	Percentage of the Issued, subscribed and paid-up capital
1.	Sponsor	9,83,22,740	99.99%
2.	TN Solar #	1	Negligible
	<b>Total</b>	<b>9,83,22,741</b>	<b>100</b>

# Nominee of the Sponsor

#### 9. Universal Saur Urja Private Limited (“USUPL”)

USUPL was incorporated on January 30, 2015 under the Companies Act, 2013 at Punjab, India. The registered office of USUPL is at a 274 A, New Adarsh Nagar, Mandi Guru Harsahai Jalalabad, Firozpur, Punjab -152022, India. Its CIN is U40101PB2015PTC039220. USUPL owns and operates a 35.21 MW DC solar photovoltaic power project located in Kankua Village in Mahoba, Uttar Pradesh, India.

##### Capital Structure

The capital structure of USUPL is as follows:

Particulars	Amount (in Rs.)
Authorised capital	35,00,00,000
Issued, subscribed and paid-up capital	17,87,89,850

##### Shareholding Pattern

The equity shareholding pattern of USUPL is as follows:

Sr. No.	Name of the shareholder	Number of equity shares of Rs. 10 each	Percentage of the Issued, subscribed and paid-up capital
1.	Sponsor	1,67,33,984	93.60%
2.	TN Solar #	1	Negligible

Sr. No.	Name of the shareholder	Number of equity shares of Rs. 10 each	Percentage of the Issued, subscribed and paid-up capital
<b>Total</b>		<b>1,67,33,985</b>	<b>100</b>

# Nominee of the Sponsor

The preference shareholding pattern of USUPL is as follows:

Sr. No.	Name of the shareholder	Number of compulsorily convertible preference shares of face value ₹10 each	Percentage of the Issued, subscribed and paid-up capital
1	TSET	11,45,000	6.40

### Acquisition of the Project SPVs by the Terra InvIT

Prior to the Allotment and in accordance with Regulation 14(1) of the SEBI InvIT Regulations, the Terra InvIT, acting through its Trustee, proposes to acquire 100% of the issued and paid-up share capital including CCPS and equity shares of each of Solar Edge, Terralight Kanji, TN Solar, UMD, Terralight Rajapalayam (“**SAA-I Sale Shares**”) and Sale CCDs from the Sponsor pursuant to the Securities Acquisition Agreement - I. As consideration for the acquisition of the SAA –I Sale Shares and Sale CCDs of the Project SPVs, the Terra InvIT will issue such number of Units as mutually agreed in writing between the Sponsor and the Terra InvIT.

### Key terms of the Securities Acquisition Agreement - I (“SAA-I”)

- Sale and Purchase of Share Capital:** Under the terms of the SAA-I, Sponsor has agreed to sell the SAA-I Sale Shares and Sale CCDs to the Terra InvIT, together with all legal and beneficial interest and free and clear of all encumbrances (other than Permitted Encumbrances (as defined in the SAA-I)), by way of a swap arrangement, on the terms and conditions set out the SAA-I.
- Consideration:** Terra InvIT has agreed to issue and allot such number of Units as mutually agreed in writing between the Sponsor and the Terra InvIT as consideration for the SAA-I Sale Shares and Sale CCDs.
- Conditions Precedent:** The SAA-I Sale Shares and Sale CCDs will stand transferred to the Terra InvIT subject to the satisfaction of the condition precedent as set out in the SAA-I by the Sponsor to the satisfaction of the Terra InvIT such that the Fundamental Warranties (as defined in the SAA-I) provided by the Sponsor under the SAA-I are true, accurate, correct, and complete in all material respects as on SAA-I Closing Date, other than as disclosed in this Final Placement Memorandum.
- Closing:** Closing shall occur within 7 (seven) business days of the Terra InvIT issuing a certificate confirming satisfaction of the conditions precedent or on such other date, as may be mutually agreed between the parties to the Securities Acquisition Agreement (such date “**SAA-I Closing Date**”). On the SAA-I Closing Date, the Sponsor and the Terra InvIT shall deliver relevant instructions for the transfer of the respective SAA-I Sale Shares and Sale CCDs from the Sponsor to the Terra InvIT. Further, each Project SPV shall approve and take note of the transfer of the relevant SAA-I Sale Shares and Sale CCDs in its meeting of the board of directors.
- Post-Closing Actions:** On or after the SAA-I Closing Date, amongst other things, Terra InvIT shall take all necessary steps to ensure that necessary filings with the relevant governmental authorities are duly made in relation to the acquisition of the SAA-I sale Shares and Sale CCDs by the Terra InvIT including to record the name of Terra InvIT as the true, legal and beneficial owner of the SAA-I Sale Shares and Sale CCDs.
- Representations and Warranties:** The representations and warranties provided by the Sponsor, the Terra InvIT, the Investment Manager and Project SPVs, include:
  - due incorporation and valid existence;
  - due authorisation for the consummation of the SAA-I;
  - execution of the SAA-I and transactions contemplated in the SAA-I does not violate its charter documents, or material breach or violation of material contract or applicable law; and

- (iv) representations in relation to solvency.

Further, the Sponsor represents and warrants to the knowledge of the Sponsor that it is the sole, legal and beneficial owner having good, valid and marketable title of the SAA-I Sale Shares and the SAA-I Sale Shares are fully paid up, free and clear of all encumbrances (other than Permitted Encumbrance (as defined in the SAA-I)), subject to terms and conditions contained in the SAA-I).

The Sponsor has also extended the benefit of all the SP Warranties (as specified in the SAA-I) provided under the Specified Agreements (as specified in the SAA-I) to the Terra InvIT, and the Terra InvIT shall be entitled to make an indemnity claim in relation to a breach of such SP Warranties, in the manner specified in Paragraph 7 below.

7. **Indemnity:** The Sponsor has agreed to indemnify the Terra InvIT (acting through its Trustee) and the Project SPVs (if the Terra InvIT so requires) and their respective directors and employees from and against any and all losses resulting from (i) any misrepresentation in or breach of any Fundamental Warranties (as defined in the SAA-I) of the Indemnifying Party; (ii) any breach of any covenant or obligation of the Project SPV and/ or the Sponsor contained in the SAA-I which occurs on or prior to the SAA-I Closing Date; (iii) any Project SPV Specific Indemnity Items (as defined in the SAA-I); or (iv) any misrepresentation in or breach of the SP Warranties (as defined in the SAA-I). The indemnification obligations of the Sponsor will be the exclusive monetary remedy available to the indemnified parties for any loss that they may suffer on account of any of the Indemnification Events (as defined in the SAA-I). The liability for any loss actually suffered or incurred is subject to a de-minimis amount, basket thresholds and financial limitations (as specified in the SAA-I).

The Sponsor has the right to assign all its rights and obligations (including the right to make indemnity claims) under the Specified Agreements (as defined in the SAA-I) to the Terra InvIT. In the event the Sponsor has assigned all its rights and obligations under the Specified Agreements to the Terra InvIT, then the Terra InvIT shall make all indemnity claims in relation to a breach of the SP Warranties (as defined in the SAA-I) and/or any of the Project SPV Specific Indemnity Items (as defined in the SAA-I) directly against the SP Indemnifying Parties (as defined in the SAA-I) under the Specified Agreements and will not have any recourse against the Sponsor in relation to indemnity claims arising from a breach of the SP Warranties (as defined in the SAA-I) and/or any Project SPV Specific Indemnity Items (as defined in the SAA-I). However, in the event the Sponsor does not assign its rights and obligations under the Specified Agreements to the Terra InvIT, then the Terra InvIT shall be entitled to make indemnity claims (including in relation to a breach of any SP Warranties and/or any Project SPV Specific Indemnity Items) under the SAA-I against the Sponsor in the manner and subject to limitations set out in the SAA-I.

If the Sponsor has assigned its rights and obligations under the Specified Agreements to the Terra InvIT, and (i) the Sponsor ceases to own at least 50% of the share capital (on a fully diluted basis) of the investment manager of the Terra InvIT, and control (by itself or jointly) such investment manager; and (ii) neither the co-sponsor or the sponsor of the Terra InvIT is the Sponsor or its Affiliate, then the Sponsor's rights and obligations under the Specified Agreements as assigned to the Terra InvIT, shall be assigned back by the Terra InvIT to the Sponsor. In such event, the Terra InvIT shall be entitled to make all indemnity claims (including in relation to a breach of SP Warranties and/or the Project SPV Specific Indemnities) against the Sponsor in the manner and subject to limitations set out in the SAA.

8. **Termination:** The SAA-I shall stand terminated by either of the parties to the SAA-I by (i) by mutual consent of the parties, (ii) by a notice in writing if Closing does not take place by the Long Stop Date (as specified in the SAA-I); or; (iii) automatically, in the event SEBI revokes the registration granted to the Terra InvIT.

#### **Acquisition of the Specified SPVs by the Terra InvIT**

Prior to the Allotment and in accordance with Regulation 14(1) of the SEBI InvIT Regulations, the Terra InvIT, acting through its Trustee, proposes to acquire the shareholding of the Sponsor in the issued and paid-up equity share capital of each of PLG, TSEC and USUPL ("**SAA-II Sale Shares**") from the Sponsor and outstanding CCPS of USUPL from TSET ("**Sale CCPS**") pursuant to the Securities Acquisition Agreement-II. Pursuant to the Completion under the Securities Acquisition Agreement-II, the Terra InvIT will acquire 100% interest (directly or indirectly) in the Specified SPVs. As consideration for the acquisition of the SAA-II Sale Shares, the Terra InvIT will allot such number of Units as mutually agreed in writing between the Sponsor and the Terra InvIT and

pay the Sponsor ₹1,000 lakhs on completion of certain milestones as set out in the SAA-II. Further, as consideration of the Sale CCPS, Terra InvIT shall pay ₹1,145 lakhs to TSET or such other amount as may be agreed between Terra InvIT and TSET after obtaining valuation reports prepared in accordance with the Income-Tax Rules, 1962.

**Key terms of the Securities Acquisition Agreement - II (“SAA-II”)**

1. **Sale and Purchase of Share Capital:** Under the terms of the SAA-II, Sponsor has agreed to sell the SAA-II Sale Shares and TSET has agreed to sell the Sale CCPS to the Terra InvIT, together with all legal and beneficial interest and free and clear of all encumbrances (other than Permitted Encumbrances (as defined in the SAA-II)), by way of a swap arrangement and for a cash consideration, on the terms and conditions set out the SAA-II.
2. **Consideration:** Terra InvIT has agreed to issue and allot such number of Units as mutually agreed in writing between the Sponsor and the Terra InvIT and ₹1,145 lakhs as consideration amount for the Sale CCPS. In addition, on completion of certain milestones the Terra InvIT will pay the Sponsor ₹1,000 lakhs, as set out in the SAA-II.
3. **Conditions Precedent:** The SAA-II Sale Shares and Sale CCPS will stand transferred to the Terra InvIT subject to the satisfaction of the condition precedent as set out in the SAA-II by the Sponsor and Specified SPVs to the satisfaction of the Terra InvIT, such as that the Fundamental Warranties (as defined in the SAA-II) provided by the Sponsor and Specified SPVs under the SAA-II are true, accurate, correct, and complete in all material respects as on SAA-II Closing Date, other than as disclosed in this Final Placement Memorandum.
4. **Closing:** Closing shall occur within seven business days of the Terra InvIT issuing a certificate confirming satisfaction of the conditions precedent or on such other date, as may be mutually agreed between the parties to the Securities Acquisition Agreement-II (such date “**SAA-II Closing Date**”). On the SAA-II Closing Date, the Sponsor, TSET and the Terra InvIT shall deliver relevant instructions for the transfer of the respective SAA-II Sale Shares and Sale CCPS as stated in the SAA-II. Further, each Specified SPV shall approve and take note of the transfer of the relevant SAA-II Sale Shares and/or Sale CCPS in its meeting of the board of directors.
5. **Post-Closing Actions:** On or after the SAA-II Closing Date, amongst other things, Terra InvIT shall take all necessary steps to ensure that necessary filings with the relevant governmental authorities are duly made in relation to the acquisition of the SAA-II Sale Shares and Sale CCPS by the Terra InvIT including to record the name of Terra InvIT as the true, legal and beneficial owner of the SAA-II Sale Shares and Sale CCPS.
6. **Representations and Warranties:** The representations and warranties provided by the Sponsor, the Terra InvIT, the Investment Manager and Specified SPVs, include:
  - (i) due incorporation and valid existence;
  - (ii) due authorisation for the consummation of the SAA-II;
  - (iii) execution of the SAA-II and transactions contemplated in the SAA-II does not violate its charter documents, or material breach or violation of material contract or applicable law; and
  - (iv) representations in relation to solvency.

Further, the Sponsor represents and warrants that to its knowledge that all the SAA – II Sale Shares and Sale CCPS are duly authorised and validly issued, it is the sole, legal and beneficial owners having good, valid and marketable title of their respective number of the SAA –II Sale Shares and Sale CCPS, their respective SAA-II Sale Shares and Sale CCPS were fully paid up, and the SAA-II Sale Shares are free and clear of all encumbrances (other than Permitted Indebtedness Encumbrances (as defined in the SAA-II)).

The Sponsor has also extended the benefit of all the Sindicatum Warranties (as specified in the SAA-II) under the Master Agreement (as defined in the SAA-II) to the Terra InvIT, and the Terra InvIT shall be entitled (on account of being an ‘Affiliate’ as per the Master Agreement (as defined in the SAA-II)) to

make an indemnity claim in relation to a breach of any such Sindicatum Warranties, in the manner specified in Paragraph 7 below.

7. **Indemnity: Sponsor Indemnity** - The Sponsor has agreed to indemnify the Terra InvIT (acting through its Trustee) and the Specified SPVs (if the Terra InvIT so requires) and their respective directors and employees from and against any and all losses resulting from (i) any misrepresentation in or breach of any Fundamental Warranties (as defined in the SAA-II) of the Indemnifying Party; (ii) any breach of any covenant or obligation of the Specified SPV and/ or the Sponsor contained in the SAA-II which occurs on or prior to the SAA-II Closing Date; (iii) any Specific Indemnity Items (as defined in the SAA-II); or (iv) any misrepresentation in or breach of the Sindicatum Warranties (as defined in the SAA-II). The indemnification obligations of the Sponsor will be the exclusive monetary remedy available to the indemnified parties for any loss that they may suffer on account of any of the Indemnification Events (as defined in the SAA-II). The liability for any loss actually suffered or incurred is subject to a de-minimis amount, basket thresholds and financial limitations (as specified in the SAA-II).

The Sponsor has the right to assign all its rights (including the right to make indemnity claims) under the Master Agreement (as defined in the SAA-II) to the Terra InvIT. In the event the Sponsor has assigned all its rights under the Master Agreement to the Terra InvIT, then the Terra InvIT shall make all indemnity claims in relation to a breach of the Sindicatum Warranties (as defined in the SAA-II) and/or any of the Specific Indemnity Items (as defined in the SAA-II) directly against the Sindicatum Indemnifying Parties (as defined in the SAA-II) under the Master Agreement and will not have any recourse against the Sponsor in relation to indemnity claims arising from a breach of the Sindicatum Warranties (as specified in the SAA-II) and/or any Specific Indemnity Items (as defined in the SAA-I). However, in the event the Sponsor does not assign its rights under the Master Agreement to the Terra InvIT, then the Terra InvIT shall make the indemnity claims (in relation to a breach of any Sindicatum Warranties and/or any Specific Indemnity Items) under the SAA-II against the Sindicatum Sellers (as defined in the SAA – II) in the manner set out in the Master Agreement as an ‘affiliate’ of the Sponsor. The Sponsor shall cooperate and provide assistance, as may be reasonably necessary, to enable the Indemnified Parties to make an Indemnity Claim against the Sindicatum Sellers, subject to limitations set out in the SAA-II and no recourse to the Sponsor.

**Terra InvIT Indemnity** - The Terra InvIT has agreed to indemnify Sponsor, against Losses (as defined in the SAA-II), the Sponsor actually suffers on account of a claim made by the Sindicatum Sellers (as defined in SAA-II) under the Master Agreement as a result of (i) a breach by Terra InvIT, and/or any of the Specified SPVs of any of the terms, conditions and/or covenants of the Master Agreement; or (ii) any action performed by the Terra InvIT, the Specified SPVs or by the Transferor Indemnified Parties (as defined in SAA-II) at the request of Terra InvIT, in each case under the terms of the Master Agreement.

8. **Termination:** The SAA-II shall stand terminated by either of the parties to the SAA-II by (i) by mutual consent of the parties, (ii) by a notice in writing if Closing does not take place by the Long Stop Date (as specified in the SAA-II); or; (iii) automatically, in the event SEBI revokes the registration granted to Terra InvIT.

## INDUSTRY OVERVIEW

Unless otherwise specified, all of the information contained in this section is derived from a report issued by CRISIL, titled 'Renewable Power Market in India' dated July, 2021, prepared by CRISIL Limited ("CRISIL Report"). Neither we, nor the Sponsor, Investment Manager, the Trustee, the Project Manager nor any other person connected with the Issue has independently verified this information. The data may have been re-classified by us for the purposes of presentation. Industry sources and publications generally state that the information contained therein has been obtained from sources generally believed to be reliable, but their accuracy, completeness and underlying assumptions are not guaranteed and their reliability cannot be assured. Industry publications are also prepared based on information as of specific dates and may no longer be current or reflect current trends.

For further details, see 'Risk Factors – This Final Placement Memorandum contains information from the CRISIL Report which have been commissioned by the Investment Manager from CRISIL in relation to the Issue. The Investment Manager cannot assure you that the statistical, financial and other industry information in the CRISIL Report is either complete or accurate' on page 42.

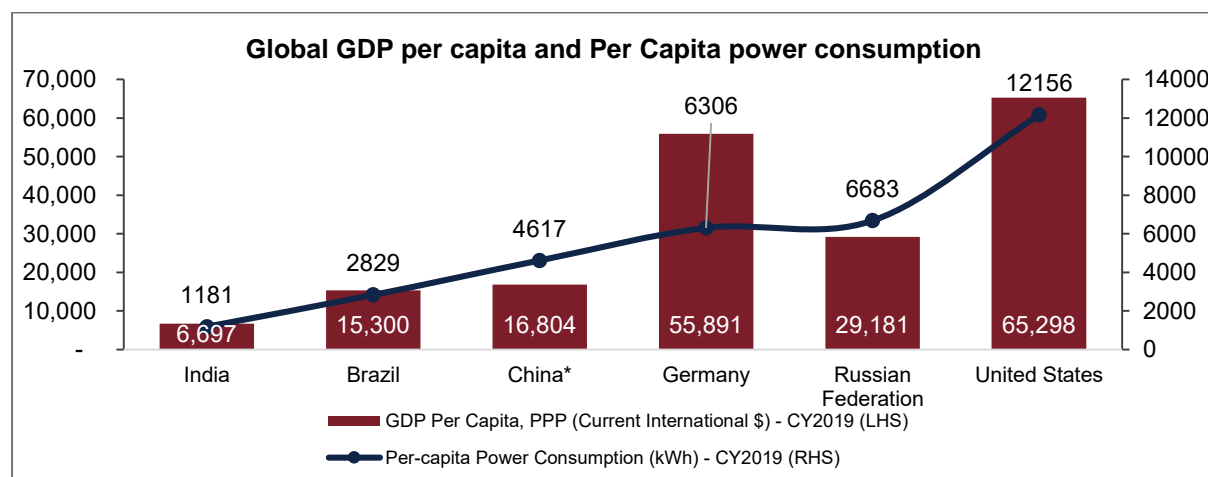
Industry sources and publications may also base their information on estimates, projections, forecasts and assumptions that may prove to be incorrect. Accordingly, investors must rely on their independent examination of, and should not place undue reliance on, or base their investment decision solely on this information. The recipient should not construe any of the contents in this section as advice relating to business, financial, legal, taxation or investment matters and are advised to consult their own business, financial, legal, taxation, and other advisors concerning the Issue and the Units.

### 1. The Power Sector in India

The power industry is a core sector, fulfilling the energy requirement of several other industries and having a multiplier effect on the economy. Electricity consumption in India at ~1614 TWh was the third highest after China (6453 TWh) and the US (~3990 TWh), with a 7% global share in the year 2019

Despite being amongst the top three power consumers in the world, the per-capita electricity consumption in India is only 1,181 kWh in 2019 (Source: CEA). This is lowest amongst the BRICS (Brazil, Russia, India, China and South Africa) nations. This indicates the strong growth potential of the Indian power sector.

India's per-capita power consumption was almost half of the world's average 2019 (Jan-Dec)



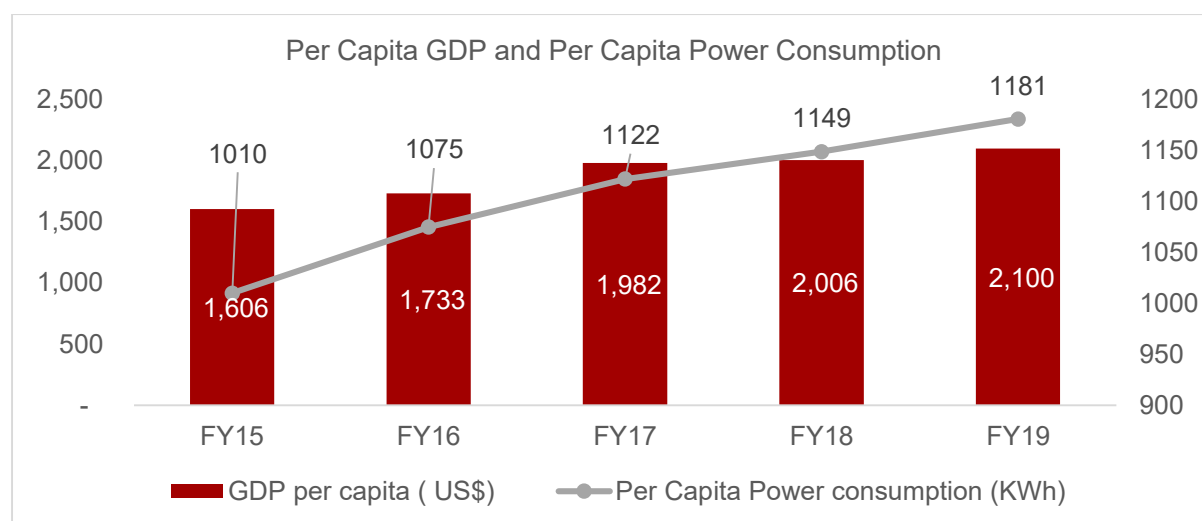
Note 1:\*\* Per capita power consumption is calculated by dividing the Total electricity consumption (From EIA) with total population (available from World Bank)

Per capita electricity consumption for India is taken from CEA(FY2019)

Total electricity consumption for China is as per CY 2018 data

Source: World Bank, CEA, EIA, CRISIL Report

Growth in per capita power consumption in India rising at CAGR~3.2% and is in sync with per capita GDP growing at CAGR 5.5%



Source: International Monetary Fund (IMF), CEA, CRISIL Report

## 1.1 Overview of regulatory authorities within the power sector in India

The power sector in India involves governance by the central and state regulatory agencies. The sector is highly regulated with various functions being distributed between multiple implementing agencies.

### 1.1.1 Functions of regulatory authority in India

Regulatory Authority	Functions/Powers
Appellate Tribunals	<ul style="list-style-type: none"> <li>Discovery and production of documents</li> <li>Receive evidence on affidavits</li> <li>Set up commissions for the examination of witnesses or documents and reviews its decisions</li> </ul>
CERCs	<ul style="list-style-type: none"> <li>Regulates tariff of generating companies owned/controlled by the Central government</li> <li>Regulates inter-state transmission (including granting of license) of energy including tariff of the transmission utilities;</li> <li>Advises the Central government in formulation of National Electricity Policy and Tariff Policy</li> </ul>
SERCs	<ul style="list-style-type: none"> <li>Determine tariffs for generation, supply, transmission and wheeling of electricity, wholesale, bulk or retail sale within the state</li> <li>Issue licenses for intra-state transmission, distribution and trading; to promote generation of electricity from renewable sources of energy, etc.</li> </ul>
CTUs and STUs	<ul style="list-style-type: none"> <li>Undertakes the transmission of energy through inter-state transmission system</li> <li>Planning and coordination of inter-state transmission systems</li> </ul>
NLDC	<ul style="list-style-type: none"> <li>Apex body to ensure integrated power system in each region;</li> <li>Responsible for the dispatch of electricity within the regions, monitoring grid operations, etc.</li> </ul>
SLDC	<ul style="list-style-type: none"> <li>Ensures integrated power system in intra state</li> <li>Responsible for dispatch of electricity within the state, monitoring intra-grid operations etc.</li> </ul>

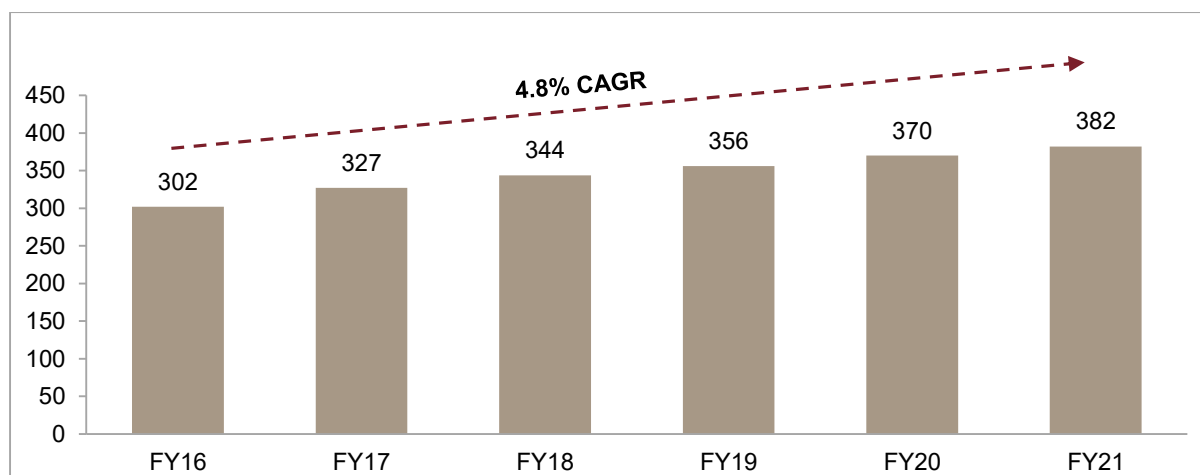
## 1.2 Demand-Supply Review

### 1.2.1 Generation segment witnessed robust capacity growth of 4.8% over Fiscals 2016-21

The total installed generation capacity at the end of March 2021 was 382 GW, of which approximately 80 GW of capacity was added over Fiscals 2016-21. Coal and lignite-based installed power generation capacity has maintained its dominant position over the years and accounts for 55% as on March 2021. However, renewable energy installations have more than tripled to ~94.4 GW capacity as on March 2021, compared with 25 GW as on March 2012 (Source: MNRE), constituting ~25% of total installed generation capacity as of date. In particular,

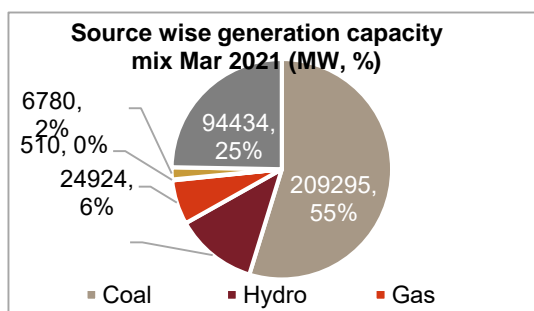


this growth has been led by solar power, which grew at breakneck speed to ~40 GW from 0.9 GW over the period. Evolution of installed generation capacity

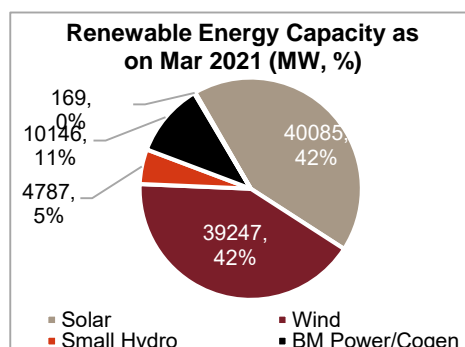


Note: 4.8% CAGR is for capacity additions growth between Fiscal 2016-Fiscal 2021

Source: CEA, CRISIL Report



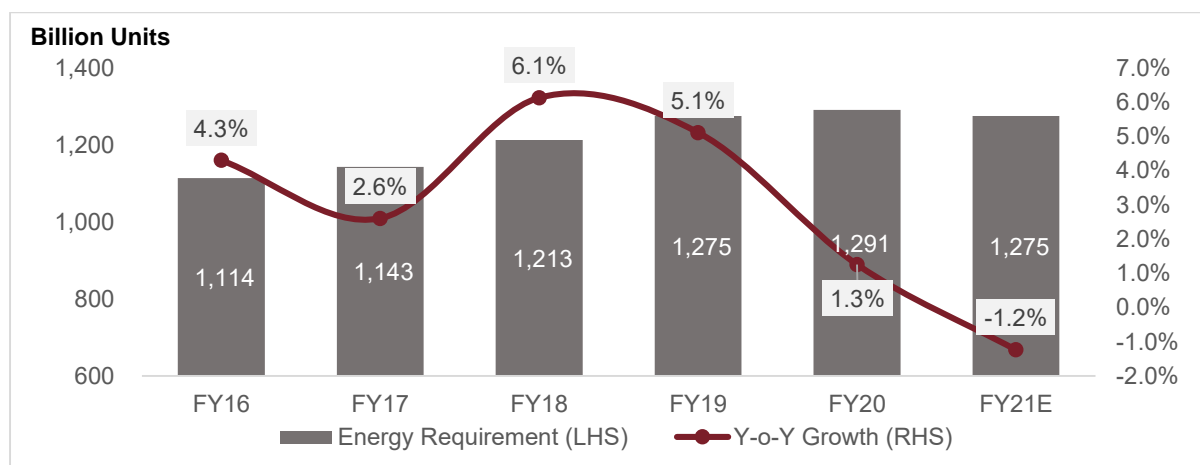
Source: CEA, CRISIL Report



Source: CEA, CRISIL Report

The Electricity Act, 2003 coupled with competitive bidding for power procurement, implemented in 2006, encouraged the participation of private players who had announced large capacity additions. Moreover, the strong government thrust on renewable energy coupled with reducing tariffs (with falling capital costs and improving efficiency) also supported renewable energy capacity additions. Tepid rise in demand growth coupled with rising supply led to drop in power deficit.

Trend in energy requirement -.



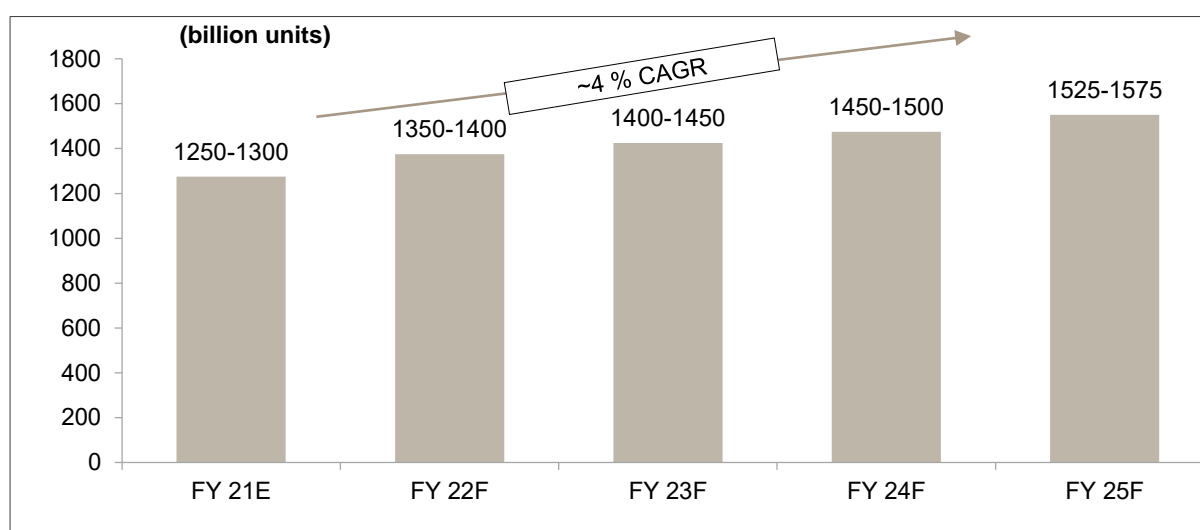
Source: CEA, CRISIL Report

The growth stood at 4.3% during Fiscal 2016 and 2.6% in Fiscal 2017 owing to slowdown in manufacturing activity. It improved to 6.2% in Fiscal 2018, mainly driven by rising electrical connections under the rural electrification and Saubhagya schemes. Power demand growth was subdued at 1.3% on-year in Fiscal 2020 owing to a slowing economy, with an extended monsoon till October 2019 further dampening demand. The extended monsoon resulted in lower cooling demand from domestic consumers as well as reducing irrigation demand from agricultural consumers. Demand recovered slightly in January-February 2020 with the onset of summer, but the pandemic downed the shutters on economic activity in March 2020, thereby pulling power demand growth into negative territory. Power consumption is expected to be on the higher side in March on the back of healthy economic activity and lower base of March 2020, leading to 7-8% y-o-y growth in fourth quarter. Consequently, power demand is expected to post a decline by (1-2) % in Fiscal 2021.

### 1.3 Demand-Supply Outlook

#### 1.3.1 Energy requirement to rise at ~4% CAGR over 2021-25

##### Energy requirement growth over next five years



Source: CRISIL Report

CRISIL Report expects energy requirement to grow at ~4% CAGR over Fiscals 2021 to 2025. The beginning of Fiscal 2021 has seen power demand slip as the nation went into lockdown to tackle the COVID-19 pandemic, bringing all economic activity to a screeching halt. With industries shuttered, offices locked up, and services such as retail, hospitality, and entertainment closed as a part of the containment measures, power demand continued its downward trajectory, registering a 16% on-year decline in March 2021. With relaxations now being allowed, the economy is slowly starting to open up, but economic activity is likely to remain sluggish for the rest of the Fiscal with a mild recovery likely towards the end of the year as relief measures announced by the government begin to take effect.

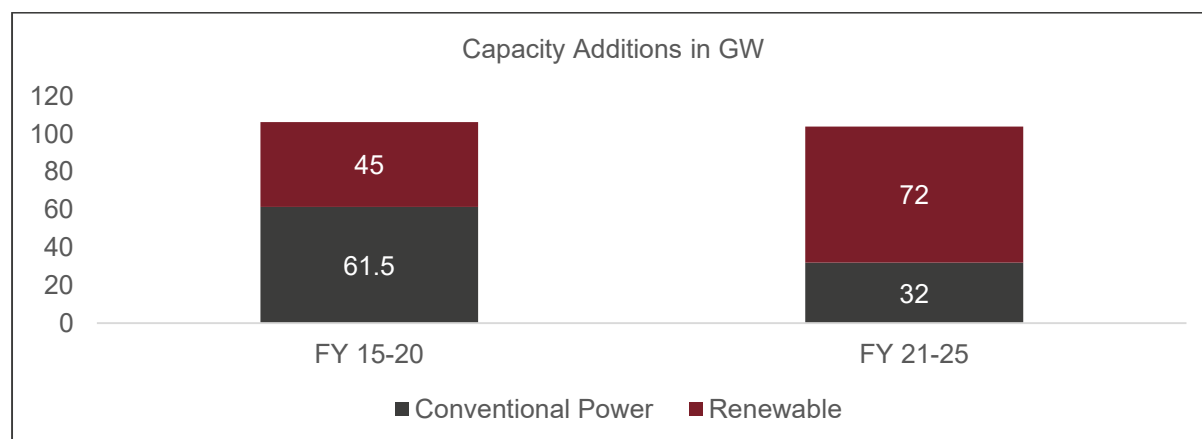
Economic growth is expected to make a healthy comeback in Fiscal 2022 coupled with a low base effect as well as government spending on infrastructure. Consequently, the power demand is expected to return to positive territory during the year, growing at 7-8%. Subsequently, demand is expected to gradually pick up on the back of healthy recovery in economic growth, expansion in reach via strengthening of T&D infrastructure, and improved power quality, thereby registering ~4% CAGR over Fiscals 2022 to 2025, aided by lower base of fiscal 2021. Capacity additions are likely to have fallen to ~4 GW in Fiscal 2021, as construction activity was halted by the lockdown imposed in the first quarter, and picked up pace only in the second half of the Fiscal as supply chain and labour issues were gradually ironed out. Beyond Fiscal 2021, yearly conventional capacity additions are expected to slow down gradually as against a high of 23-24 GW witnessed between Fiscals 2015 and 2016.

#### 1.3.2 Strong growth in renewable capacity additions to continue

CRISIL Report expects ~70-74 GW of renewable power generation capacities to be added between Fiscals 2021-25 of which around 55-57 GW are estimated from solar followed by ~15-17 GW through wind. Capacity additions in the renewable energy segment are expected to witness robust growth. Additions in both wind and solar power

are expected to be driven by strong government focus, which is evident from the Fiscal and regulatory incentives, VGF and execution support in terms of land and evacuation infrastructure. Improved availability of low-cost finance through various instruments/ sources would also support renewable energy capacity additions. In solar power, in particular, a further drop in capital costs, and consequently tariffs, are expected to drive capacity additions.

#### Expected trend in power generation capacity addition



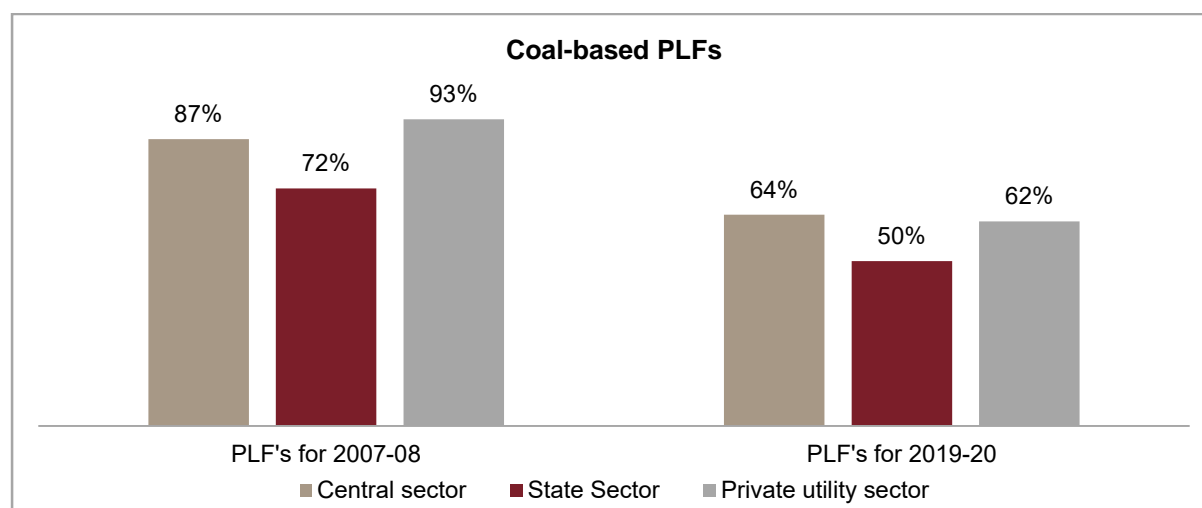
*Note: Renewables consists of solar and wind power capacities only.*

*Source: CEA, CRISIL Report*

### **1.3.3 Rising renewable capacity additions resulted in fall of thermal PLFs**

Power demand is estimated to have grown at a CAGR of 2.5-3.0% between Fiscals 2016 and 2021, while conventional and renewable installed generation capacities are estimated to have grown at a CAGR of 2.0-2.5% and 15-16% respectively. As a result, average plant load factors (PLFs) of coal based power plants declined from 62% in Fiscal 2016 to 55-56% in Fiscal 2021 while PLFs of gas based plants continued to trend at 22-25% levels. In particular, the PLFs of the private sector generators were even lower in Fiscal 2020 due to lack of PPAs.

#### Coal-based PLFs



*Source: CEA; CRISIL Report*

This has resulted in operational inefficiencies for many coal-based plants as they were designed to operate at minimum ~55% PLF and have to be retrofitted for increased ramping requirements in order to integrate more renewable energy sources. Further, continued ramp-up in the renewable energy supplied on account of reducing grid constraints, rising renewable purchaser obligations and improvement in technology have resulted in decline of PLFs of coal-based power plants.

### 1.3.4 Key policy frameworks

Under the Paris Agreement, the Indian government has committed to a target of generating 40% of electricity from non-fossil fuels sources by the year 2030. The country also has a target of setting up 450 GW of renewable energy by 2030.

#### *UDAY Scheme and Atmanirbhar Package*

To alleviate the financial stress in the power distribution sector, the government announced the UDAY scheme. The states opting for this scheme will take over 75% of the total debt outstanding on Discoms' books as on September 30, 2015, while the remaining 25% debt will be converted into longer-tenure loans or bonds backed by state government guarantee. Around, 32 states / union territories have signed a memorandum of understanding to implement the UDAY scheme. Lower debt burden and subsequently lower interest outgo, reduction in power purchase cost and gradual decline in AT&C losses are expected to improve the financial health of Discoms. This, in turn, will not only improve power offtake but also lead to more timely payment to generators by Discoms.

#### *Synopsis of UDAY scheme*

UDAY Scheme			
Reduction in power purchase cost	Reduction in interest expense	Improvement in operational efficiencies	Other key provisions
<ul style="list-style-type: none"> <li>Additional supply of domestic coal</li> <li>Coal linkage rationalization through swap agreements</li> <li>Allocation of cheaper power from CPSU's like NTPC</li> <li>Supply of washed and crushed coal</li> </ul>	<ul style="list-style-type: none"> <li>States to take over 75% discom debt as on Sept 15</li> <li>25% to be converted by lender into state guaranteed discom bond</li> </ul>	<ul style="list-style-type: none"> <li>Installation of smart meters</li> <li>Upgrade transformers</li> <li>Use of energy efficient LED's</li> <li>Additional funding from IPDS and DDUGJY</li> </ul>	<ul style="list-style-type: none"> <li>Hard budget constraints on states as discom losses post FY18 will have to be taken over by state government in phased/manner</li> <li>Restrictions on banks for funding operational losses</li> <li>Monthly monitoring of progress</li> </ul>

As of February 2021, Gujarat, Karnataka and Maharashtra were amongst the top performing states, followed by Telangana, Himachal Pradesh and Haryana.

#### • *Deendayal Upadhyaya Gram Jyoti Yojana ("DDUGJY")*

Rural electrification, segregation of agricultural and non-agricultural feeders, strengthening and augmentation of T&D infrastructure in rural areas and metering of transformers, feeders and consumers are expected to boost power demand in the agriculture sector over the next five years.

#### *Snapshot of progress of DDUGJY (as of December 2018)*

Particulars	Scope	Achievement	Percentage
Un-electrified villages	1,29,274	1,29,274	100%
Intensive electrification of villages	7,80,337	6,09,468	78%
Household electrification (in ₹ million)	179	179	100%
BPL households covered (in ₹ million)	39	33	84%

Source: DDUGJY portal, CRISIL Report

While 100% rural electrification has been achieved as of April 2018, 22% villages are yet to be intensively electrified. Thus, there exists strong potential for growth in electricity consumption in rural areas, which would be achieved under DDUGJY during Fiscals 2019 to 2023.

- **Introduction of Renewable Energy Act**

The central government has released the draft Renewable Energy Act in July 2015 to address various issues limiting the growth potential of renewable energy sector. The Act is in the consultation stage and would be proposed in the parliament once other amendments and legislations (Under National Tariff Policy 2006 and Electricity Act 2003) to facilitate the implementation of the Act are also identified and implemented.

The Act aims to boost demand for renewable energy by creating a mandatory national level RPO targets with provision for penalties on Discoms/states in case of non/under compliance. In addition, it envisages timely provisioning of infrastructure, payment security mechanisms and other steps to improve operations for developers.

While, most of the reforms suggested by the government are positive / neutral and are targeted towards solving long term issues plaguing the sector, implementation remains key for materialisation of the improvements envisaged. Few of the proposals also need to be spelled out before their impact can be ascertained fully.

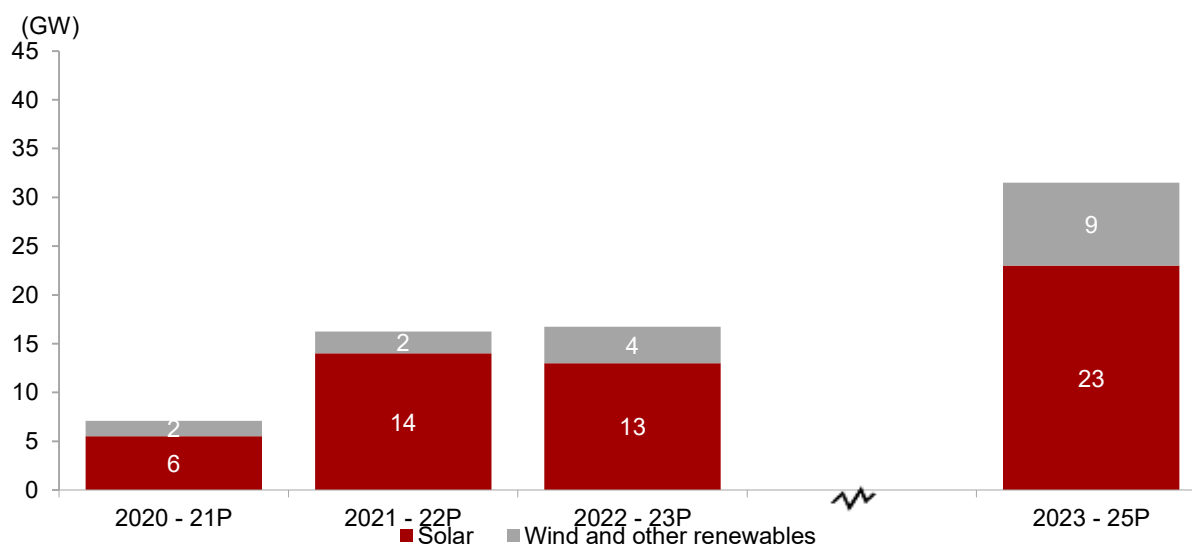
## 2. Overview for renewable energy sector in India

Renewable sources of energy form a cleaner source of energy than conventional ones as they do not burn like fossil fuels, thus preventing release of pollutants in the air. Increasing use of renewable energy would aid in reducing carbon emissions and thereby reduce global warming in the world. Further, the wide availability of these resources makes them less susceptible to depletion unlike conventional sources of energy. Solar and wind remain the key sources that are used in place of conventional sources.

The renewable energy market of India is one of the most attractive markets globally on account of large capacity additions, strong government support and a favorable policy regime. Further, India is the fourth largest in terms of installed wind energy capacity.

The renewable energy installations have more than tripled to ~94.47 GW as on March 2021, compared with 25 GW as on March 2012 (source: MNRE) led by various central and state level incentives. As on March 2021, installed grid connected renewable energy generation capacity in India constituted ~25% of the total installed generation base in India. In particular, this growth has been led by solar power, which has grown to ~40.4 GW from ~0.09 GW over the discussed time period.

Strong government support, falling tariffs and easing transmission constraints to drive renewable energy capacity addition

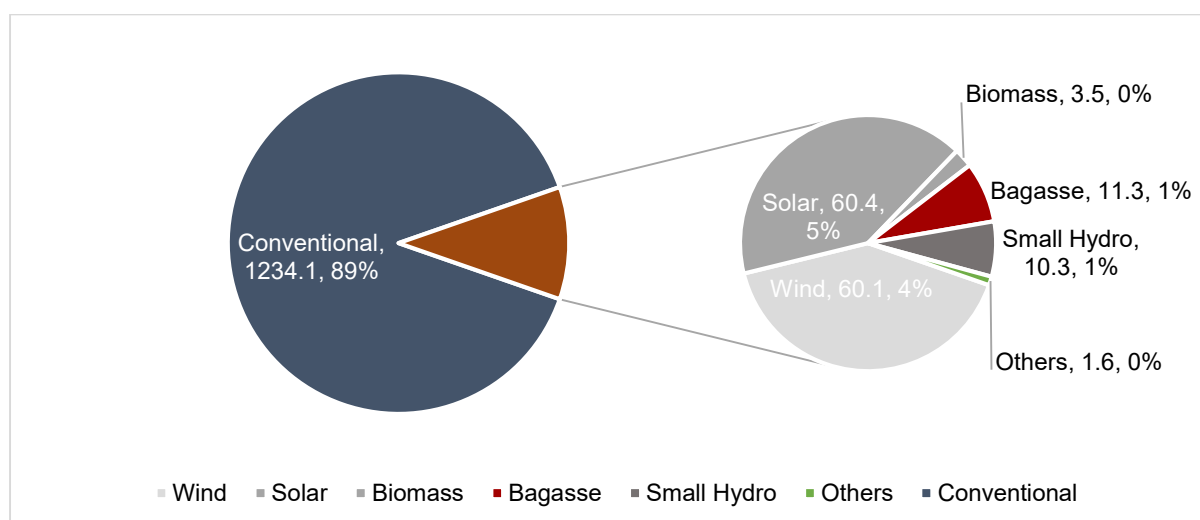


*Note: P-Projected*

*Capacity additions for solar includes both solar ground mounted and solar rooftop capacity additions. It does not includes the outlook on the off-grid/captive power.*

*Source: MNRE; CEA, CRISIL Report*

Renewable energy penetration is ~11% in India at the end of Fiscal 2020-21



*Note: Latest available generation data from renewable sources available till March 21*

*Source: MNRE; CEA, CRISIL Research*

#### Potential and cumulative capacity of RE (technology wise)

Technology	Potential	Cumulative capacity as on May 2019	Untapped Potential
Wind	302 GW (100 m hub height)	38.26 GW	263.74 GW
Solar ground mounted	750 GW	31.38 GW	718.62 GW
Bio-energy	25 GW	10.31 GW	14.69 GW
Small Hydro	20 GW	4.74 GW	15.26 GW
Waste to Energy	NA	0.14 GW	NA

*Source: MNRE; NITI Aayog; CRISIL Report*

Solar energy potential is highest in India amongst all commercially available renewable energy sources. As per an assessment done by the NISE and a report by the MNRE, the top five states with the highest solar PV potential are Rajasthan, Jammu & Kashmir, Maharashtra, Madhya Pradesh and Andhra Pradesh.

Solar generation capacity in India is expected to rise at a CAGR of ~19% to 95-97 GW in Fiscal 2025 from ~40 GW in Fiscal 2021. Overall, renewable energy generation capacity is expected to grow by 70-74 GW over the next five years, largely driven by solar additions of 55-57 GW. In addition to this, 15-17 GW of wind and other renewables capacity is expected to be added till Fiscal 2025.

#### Distribution reforms planned by the government to revive the sector

The government plans to implement several policies to resolve the issues of the ailing distribution segment, as it impacts the entire value chain. Key announcements pertaining to the same are:

- Fresh trajectory for reduction of AT&C losses to below 15%. Possible cumulation of targets and funds under DDUGJY and IPDS;
- Privatisation of distribution circles - separation of content and carriage. Distribution system remains with utilities and they will get wheeling charges. However, make available power in wholesale to the supply licensee (private sector) who services the end consumers. Tata Power has won the bid to service five circles within Odisha - roughly a consumer base of 2.5 million;
- Letter of credit (LC) mechanism was also implemented in August 2019. This order mandated discoms to issue LCs or provide payments upfront before purchase of power. However, success of this scheme has been limited so far, due to various loopholes utilised by the discoms and the lower bargaining power of private IPPs;

- Ensuring 24x7 power supply on a sustainable basis across India; and
- A revised tariff policy to make tariff revisions more effective and cost encompassing but at the same time not passing on costs due to discom inefficiencies.

Apart from the above, the central government also introduced a Rs 900 billion stimulus for state distribution utilities within the economic relief package announced by the government in relation to COVID-19 related negative impact, which was further enhanced to Rs 1.2 trillion. The relief package will help discoms clear a significant portion of their outstanding dues to power generators. The latter is expected to be provided in the form of concessional loans (moratorium, lower interest rates) to the state distribution utilities, secured by discom receivables and state guarantees. Power Finance Corporation (PFC) / Rural Electrification Corporation (REC) have been identified as key lenders for this package. From the total package worth Rs 1.2 trillion, Rs ~1.35 trillion has been sanctioned and Rs ~463 billion has been disbursed as of January 2021.

### 3. Indian Solar Power Market

#### 3.1 Evolution of Solar Power in India

In the renewable energy basket as of March 2021, solar energy accounted for a share of 42.4%. Growth in the solar power sector over the last five years has been robust. As much as 27.8 GW capacity was added in the segment over Fiscals 2017-2021 registering a CAGR of ~26.7%, although on a low base. However, in Fiscal 2021 the solar capacity added was lower at 5.46 GW (6.45 GW in Fiscal 2020). ). The sector missed its capacity addition targets for the fourth year in a row. The slowdown in capacity addition during H2 of 2021 was mainly due to continued localized restrictions, extension to timelines and a rise in solar module pricing stemming from shortage of upstream components (glass and polysilicon). This was coupled with Covid pandemic led restriction which halted on-ground project execution amidst labor unavailability and supply chain constraints during H1 2021. In FY20, additional taxation in form of safeguard, higher GST rate led to the slowdown in capacity additions.

#### 3.2 Growth drivers for the solar sector in India



Source: CRISIL Report

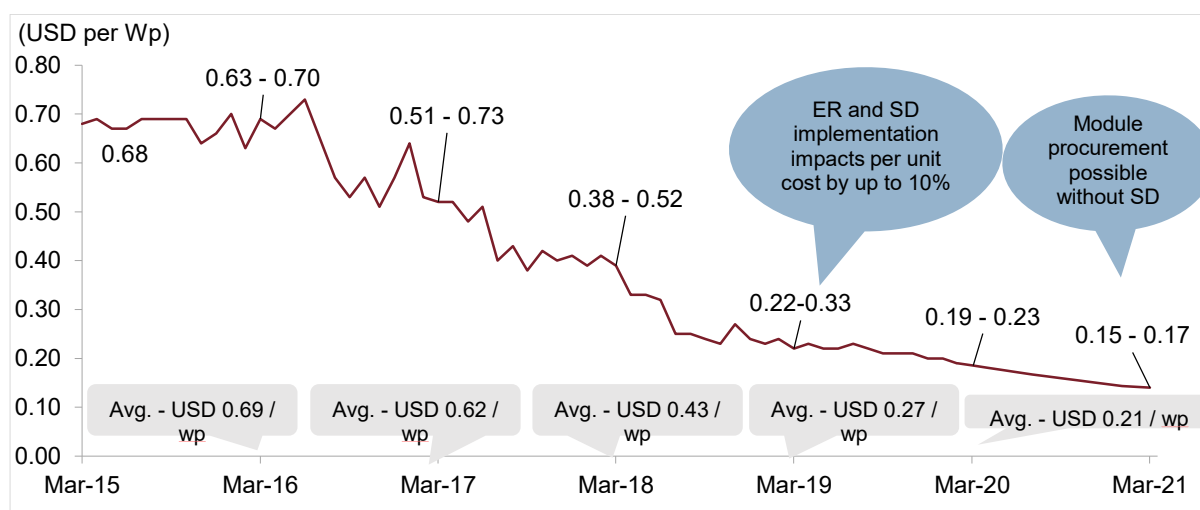
Each of the growth factors for the solar energy in India is as detailed below:

##### 3.2.1 Sharp decline in module price

Innovation in the manufacturing processes has reduced cost, putting downward pressure on module prices. Further, declining inverter prices (6-7% of the capital cost), which fell to USD 21/watt by March 2020, reduced system costs. Module prices reached to USD 0.22 per wattpeak level in Fiscal 2021.



### Module prices declined over 86% from 2010 to Fiscal 2021



Source: Industry, CRISIL Report

Technological advancements, economies of scale and mostly a slowdown in the Chinese market due to policy changes and halt in business activity amidst the COVID pandemic resulted in prices of silicon wafers (used to make solar PV cells) rising by ~55 per cent from April 2020 to April 2021. But since China remains the largest market for solar capacity additions, any weakening in demand there hugely impacts the fortunes of solar equipment makers. Hence, even though solar component manufacturing has at all stages seen over capacities in the system causing a supply glut, this being coupled with Chinese demand weakening in the Fiscal, caused much downward pressure on prices.

### 3.2.2 Fiscal and Regulatory Initiatives

The government has laid significant thrust on climate change for which it provided a framework, NAPCC in 2008, where it proposed an eight-pronged strategy – NSM, energy efficiency, sustainable habitat, water planning, Himalayan ecosystem, afforestation, sustainable agriculture and strategic knowledge on climate change.

In order to facilitate growth of renewable energy and in particular the solar power sector, the government has provided several Fiscal and regulatory incentives to developers, as enumerated below:

- Accelerated depreciation (AD):** The government provided AD of 80% (till 2016-17) in the first year of operations, however in the budget for Fiscal 2017, the government halved the A.D. benefit to 40% for projects getting commissioned post April 2017, i.e. from Fiscal 2018 onwards. Also, the 40% A.D. benefit reduces the tariff required for earning healthy equity IRRs by INR 0.6-0.8/unit (assuming a capital cost INR 40 Mn/MW).
- Generation based incentives (GBI):** This incentive was introduced on December 2009, for ~4 MW capacities wherein the wind energy developers were provided 50 paise per unit over and above FiTs provided by the state for wind energy projects. The incentive amount was capped at ₹ 10 million/MW that needs to be claimed within first 10 years of the registration of the project and there was an annual ceiling of ~₹1.5 million/ MW p.a. in the first 4 years of registration. The scheme ended on March 2017 and government has not provided any indications on renewing the scheme as the wind energy sector has become a matured market.
- Tax holiday under section 80IA:** Section 80 IA of the IT Act has allowed developers to avail a tax waiver on the profits for 10 assessment years. The 80 IA benefit in the absence of A.D. benefit helped in improving the project IRR by 100-110 bps. However, this provision has lapsed effective 1st April 2017, and developers will not be able to avail this benefit going forward.
- Regulatory incentives:** Under central level allocations, government is providing various incentives to renewable energy projects such as must-run status of renewable and deemed generation for projects. Under must-run status (as per regulation 5.2 (u) of the Grid code) there is provision of no backing down of renewable power. Under state solar policies, there are several incentives for solar players like



concessional wheeling and banking charges, concessional transmission charges and transmission losses, cross subsidy surcharges, reactive charges etc.

- Subsidy/VGF: VGF is a form of capital subsidy provided by SECI for signing PPAs at pre-determined tariffs. VGF available is INR 1 crore/MW for open category (where source of cells/modules is not mentioned) projects. Players are expected to bid on expectation of VGF to set-up the project. It is available for developers setting up projects under various schemes (Phase II Batch II, III, IV and VI) to be awarded by SECI.
- Infrastructure support from Government - In line with the NAPCC, the government launched the JNNSM, in Fiscal 2010, under which it has undertaken several initiatives to promote low cost solar power in the country. The government has appointed NVVN to buy competitively bid solar power and bundle it with cheaper thermal power to sell it to Discoms. The objective was to reduce the average power purchase cost of solar power. Under the NSM, NTPC has committed to add 10 GW of solar power by Fiscal 2022. The government is incentivising the central public sector undertakings to install solar power under the VGF mechanism. Under the batch V of NSM it has already allocated ~1 GW.

Apart from providing incentives, the government has lent significant support to the solar power sector for execution of projects.

- Solar parks: One of the most important initiatives by the government has been setting up of solar parks in the country. This is critical given the land intensive nature (~5 acres required per MW of solar PV) of solar projects coupled with low average holding (1.16 hectare) per person in India. Under the Solar Park Policy released in September 2014, the government planned to prepare land banks for 20,000 MW of solar projects spread across 25 states. Further, the capacity of the scheme was doubled from 20,000 MW to 40,000 MW on March 21, 2017, to set up at least 50 solar parks by Fiscal 2022. Such parks significantly reduce construction/ execution risk as it includes contiguous parcel of land, evacuation infrastructure (HV/EHV substation evacuating to state grid substation) and other ancillary infrastructure and utilities such as road, water and drainage, etc. Currently, 21 states, including Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, Karnataka, Telangana, West Bengal, Chhattisgarh, Tamil Nadu, Jammu and Kashmir and a few north-eastern states have started preparing land banks for solar parks, either through their own implementing agencies or through joint ventures with SECI. As on December 2020, 42 solar parks with aggregate capacity of 26.8 GW have been approved in 15 states.
- Availability of contiguous parcels of land: With rapid capacity additions and stiff competition, it becomes imperative for developers to acquire land at competitive costs and in areas with high levels of solar irradiance. Land acquisition is difficult, considering that average land holding in India is small at 1.16 hectares (National Bank for Agricultural and Rural Development 2014). To acquire large tracts of land in a single location, many stakeholders have to be involved which slows down the pace of project execution. The government plans to prepare land banks for 40,000 MW (doubled from 20,000 MW in March 2017) of solar projects spread across 25 states in India, under its Solar Park Policy released in September 2014. Under this policy, a state designated nodal agency (SNA) will construct solar parks of 500-1,000 MW size each in association with either SECI or a public sector undertaking or in a joint venture with a private developer under the public-private partnership model. The central government will provide budgetary support of INR 20 lakh/MW to the entity undertaking the solar park projects with all necessary infrastructure. The Government of India and World Bank have signed a USD 98 million loan agreement and USD 2 million grant agreement in November 2017. The said funds will be used to fund solar park infrastructure in various states via the Indian Renewable Energy Agency (IREDA) under MNRE's solar park implementation scheme. The first two solar parks to be supported were in the Rewa (750 MW) and Mandsaur (250 MW) districts of Madhya Pradesh. The agency is also looking at other solar parks in various parts of the country such as Odisha, Haryana and Chhattisgarh. Previously, the World Bank had also provided USD 25 million to develop the transmission infrastructure for REWA solar park at concessional loan terms.

The grid capacity additions will come under two main schemes, namely the Green Energy Corridor Scheme and Renewable Energy Zones (REZ), both of which are to be implemented by Fiscal 2022. This would add ~80 GW of transmission grid capacity to an existing ~24 GW, taking grid capacity planned for renewable energy integration to ~100 GW.

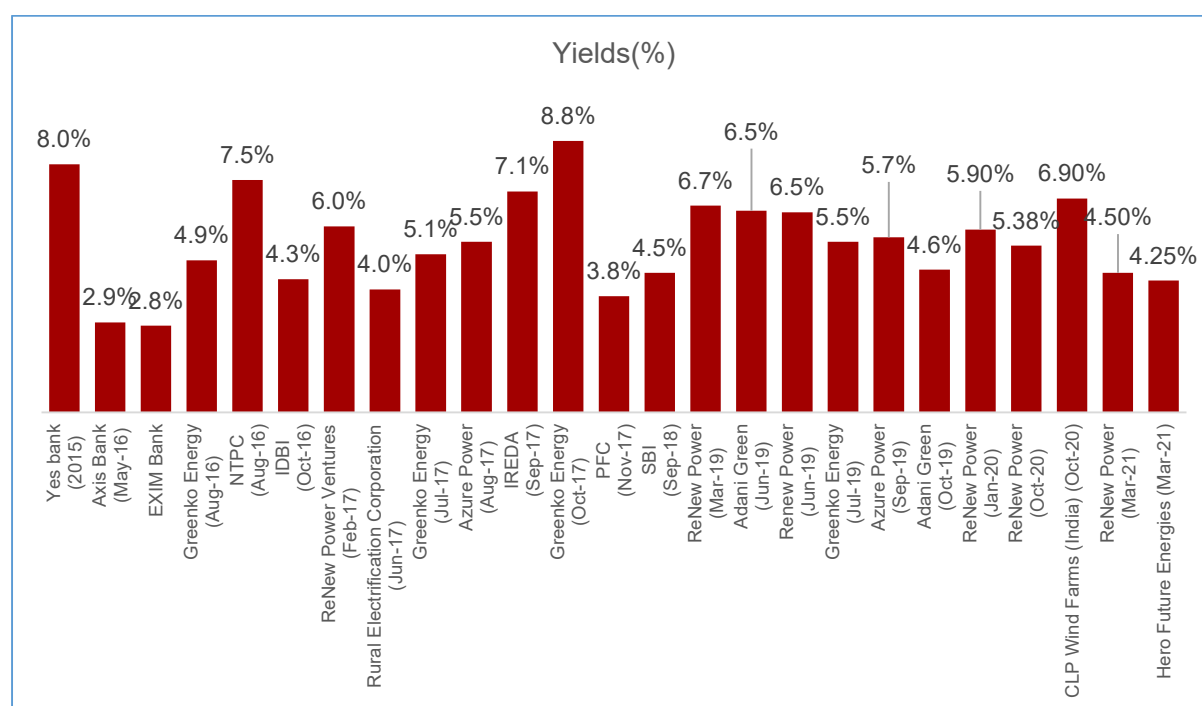
- Improving availability of finance at low cost - Given the capital-intensive nature of the solar power sector, availability of finance and that too at a low cost is critical. On the one hand, the government has

undertaken several steps to ensure availability of low cost finance, on the other developers are exploring several instruments/sources to raise finance as elaborated below. This has lent significant support to growth in the solar power sector. In fact, the companies that are backed by large private equity firms or have raised domestic/offshore bonds at cheaper rate of interest to repay expensive domestic debt have outstripped the growth rate at which renewable energy sector in India is growing.

Some of the steps taken by the government to ensure availability of low cost finance is as given below:

- **Funding from lending institutions such as IREDA and PFS:** Government financial institutions such as PTC India Financial Services Limited (“**PTC**”), Rural Electrification Corporation (“**REC**”) and IREDA are also financing many solar projects. As of March 2019, the cumulative debt sanctioned by PFS to renewable energy projects stood at ₹216.4 billion. Further, IREDA, under its IREDA-NCEF refinance scheme, re-finances 30% of total loan disbursed by the scheduled commercial banks/financial institutions, to the project developer at concessional rate of interest.
- **Green bond/Masala bond market:** Green bonds are like any other bond that invests the proceeds to support green energy or renewable energy projects. The tenure of the bonds typically range from 18 months to 30 months period and are issued for 1-10 year tenure. India is the second country after China to have a national-level guidelines published by SEBI. The green bonds may be issued by the Government, multilateral organisations like Asian development bank (ADB), World Bank (WB) or by the export-import (EXIM) bank of the country, financial institutions and corporations. Some of the recent instances of green bond issuance in India are given below:

#### Yields of recent green bond issuances



Source: Industry; CRISIL Report

- **Pension Funds/ Endowment Funds:** The pension funds/endowment funds are expected to play key role in financing solar projects. The Canadian funds like Brookfield Asset Management and Caisse de Dépôt et Placement du Québec have already announced to invest ~USD 2 billion in the country.
- **Private equity investments and debt investments:** Apart from the traditional funding channels available from banks, non-banking financial companies and private equity, developers are also exploring other options to ensure availability of low cost finance. CRISIL Report believes that this will support solar power capacity additions given the capital intensive nature of projects.

- **Funding from Multilateral banks and International Solar alliance (ISA):** Further government channelises the funds available from multilateral banks and financing institutes like World Bank, kfw etc. The ISA, an association of solar resource rich countries that has been launched by the Government and France, aims at mobilising USD 1000 billion in funds by 2030. The alliance intends to make joint efforts through various policy measures such as international credit enhancement mechanism that is expected to de-risk investments and reduce cost of financing for solar projects. The ISA member countries in collaboration with United Nations, the green climate fund, multilateral development banks, investors, insurers, private financial institution and other interested stakeholder will finance solar projects.
- **Favourable technology:** Power generation in India typically takes place via various technologies, which includes conventional fossil fuels (like coal, lignite and gas), large hydro power plants, nuclear power and renewable energy sources. In the below table, we have highlighted the key advantages and disadvantages across fuels and as we can see that solar power is favourable on most counts.

The comparison across various power generation technologies depicts solar as one of the most favorable technology.

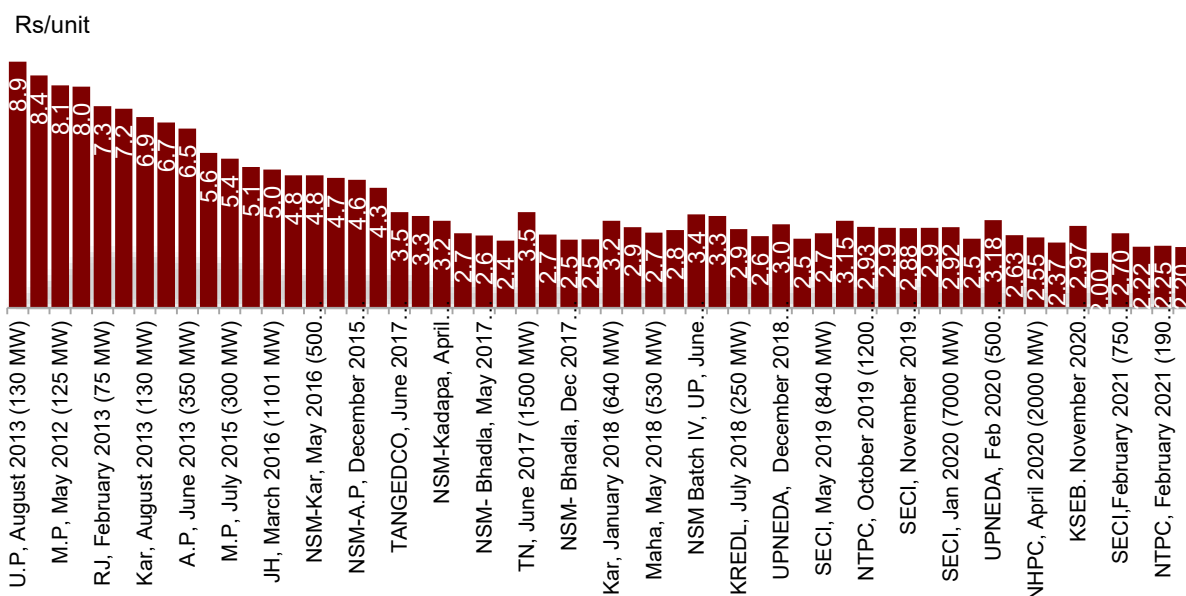
Parameter Type of power generation	Input/fuel risk	Technology risk	O&M cost (Rs lakhs/MW)	Resource risk/ potential in India (GW)	Environmental risk	Levelised tariff (Rs/KWh)
Coal-based power plant	Domestic coal availability has been an issue historically. There are logistical hurdles for coal supply. Low calorific value of domestic coal	Minimal risks due to matured technology	19.24*	CEA estimates no potential additions over Fiscals 2018-2022	Pollutants such as SO <sub>2</sub> , NO <sub>x</sub> , CO <sub>2</sub> released in the atmosphere due to combustion	Domestic coal: 3.78 Imported coal: 4.23
Solar power	PV Limited variation in annual irradiation level. About 55% of annual generation spread across six months. However, rising temperature can adversely impact generation	Not all the modules are of the same output. Issues in modules connected in series impact generation of the entire string	3 - 7	749	PV manufacturing involves usage of hazardous chemicals, Minor environmental impact over lifetime of PV power plant	1.99-4.15 (based on the recent competitive bidding)

Note: \*averaged O&M cost for 600 MW series and 800 MW series of coal based and lignite fired generating station

Source: CERC benchmark tariffs; CRISIL Report

- **Sale of Power to Discoms:** Discoms in India are buying renewable power from developers at either FiTs or, in most cases on the basis of the reverse e-auctions conducted by the state. Many states of India have come out with their solar and wind policies respectively and provide incentives (such as concessional wheeling and banking charges, nil cross subsidy surcharge, no electricity duty etc.) for setting up renewable energy projects in their respective states.
- **Tariff trends in past bids:** Competitive bidding for solar projects started in Fiscal 2011 with the allocation of capacities under JNNSM phase I and this trend of allocating capacities continued for the solar energy sector in India. However, each year has witnessed new lows. With declining solar module prices, rising project size, stiff competition and lower interest rates, bid tariffs have plummeted over the years. Awarding of projects in solar parks coupled with offtake from high credit worthy procurers has also contributed to drop in tariffs.

## Trend in Bid Tariffs

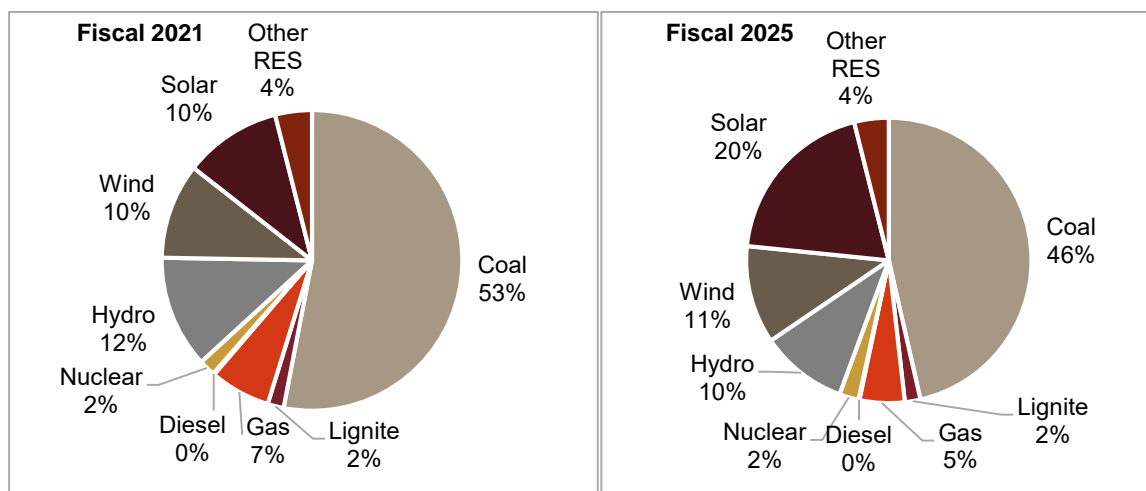


Note: \*Wind solar hybrid capacity

Source: CRISIL Report

### 3.2.3 Outlook for solar

#### Renewable energy penetration in the Grid Fiscal 2021



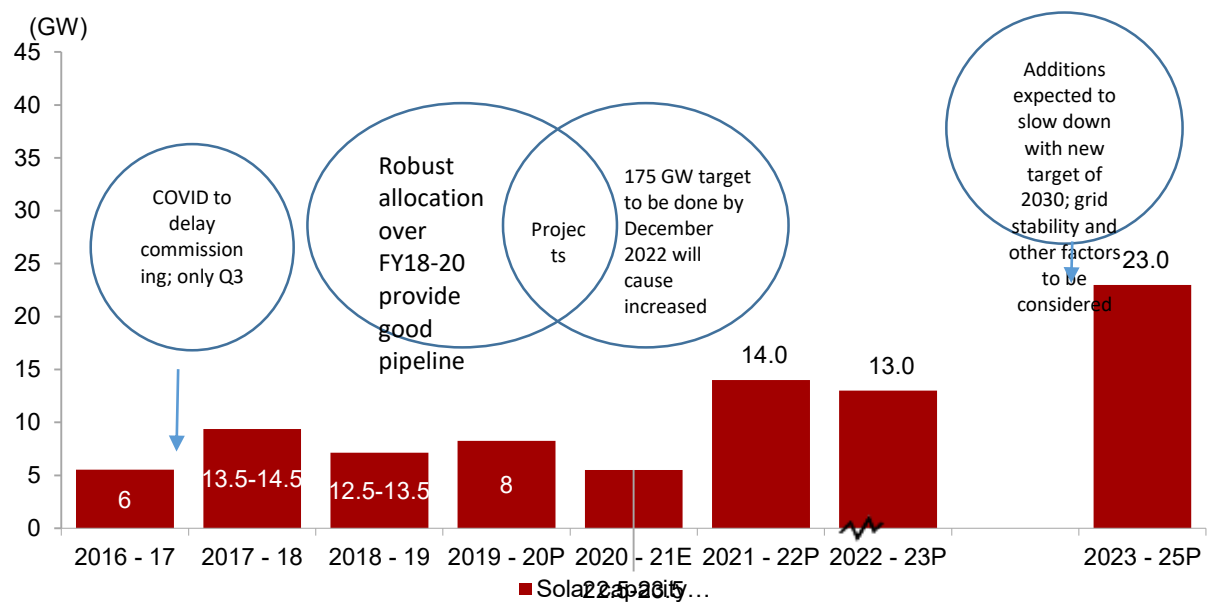
Note: Renewables consists of solar and wind power capacities only.

Source: CEA, CRISIL Report

States like Maharashtra, Gujarat, Madhya Pradesh, Rajasthan, Karnataka, Andhra Pradesh, Telangana and Tamil Nadu have a high potential of renewable energy generation as compared to other states in India. Hence most of the renewable energy capacities would be planned in these states, leading to high penetration levels.

CRISIL Report expects solar power capacity additions of 55-57 GW over the next five years (FY 2021-25), as compared to 32 GW added over the last five years (FY 2016-20). Growth in capacity additions will be driven by government support with an aggressive tendering roadmap outlined and being followed by the government so far. Few external factors such as improvement in technology (floating solar, module efficiency) and low capital costs is also key to enabling additions. However, the additional taxation to increase capital costs and consequent willingness of state discoms to offtake.

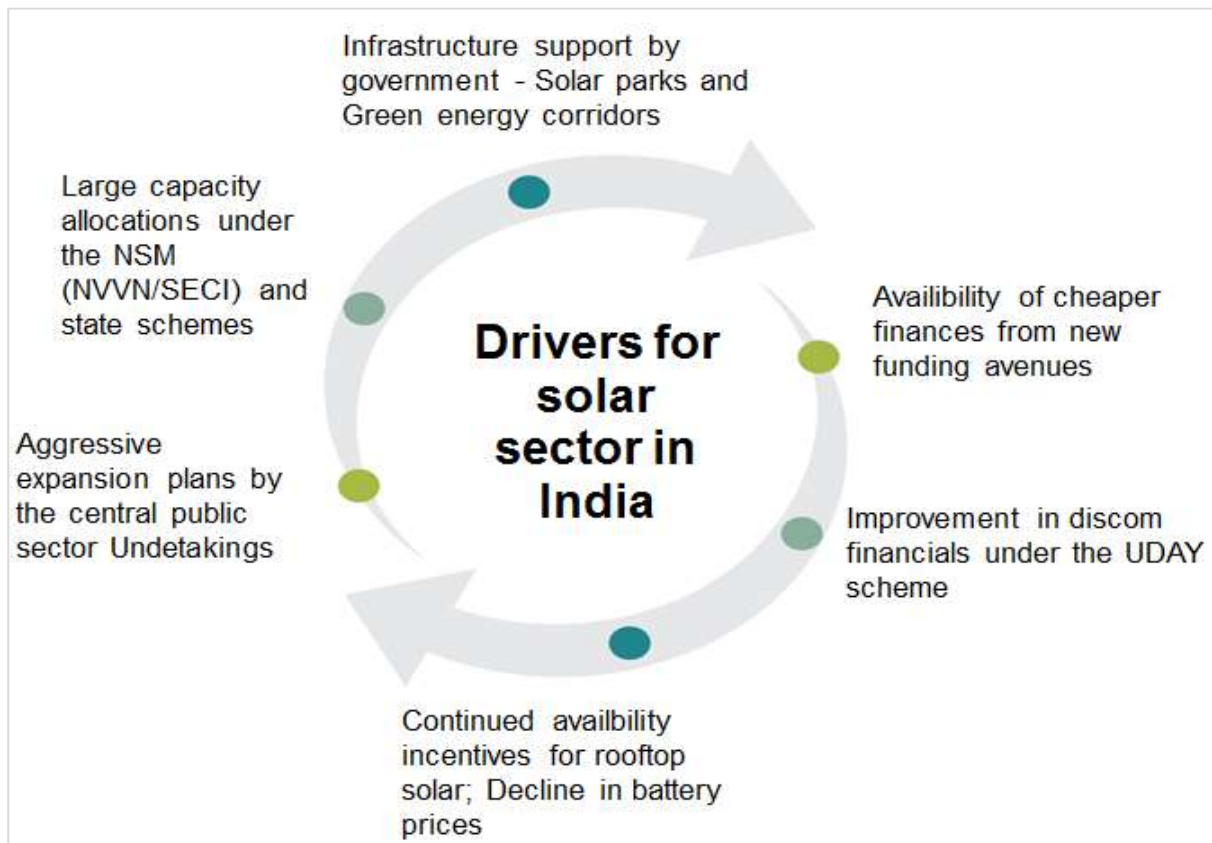
### Solar capacity additions over Fiscals 2021-2025



P- Projected

Source: MNRE, CRISIL Report

### The key drivers that are likely to boost the growth in the solar capacity additions



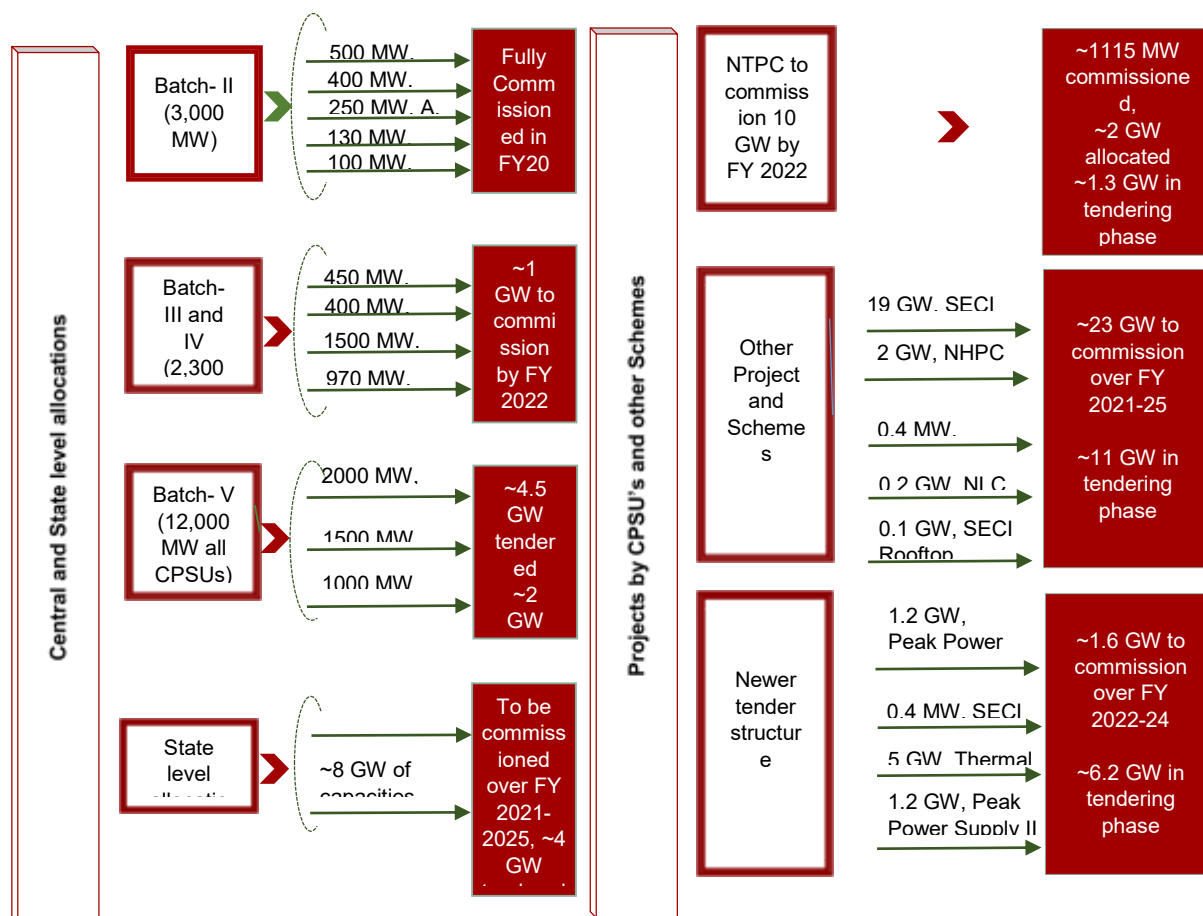
Source; CRISIL Research

## Key factors for growth of solar sector

- Large capacity allocations under the central and state level schemes

In line with the government target of installing 175 GW by December 2022, large-scale central allocations are planned under the NSM. CRISIL Report believes that the offtake and payment security under central allocations will be key drivers for additions under this scheme. Moreover, strategies to reduce tariffs through bundling with thermal power (by NVVN) and VGF or VGF (SECI state-specific VGF schemes) will support additions. NVVN, through its bundling scheme (2 units of solar bundled with one unit of thermal power), is expected to allocate ~12 GW under Tranche II and III of the NSM. Also, SECI has planned to set up 12 GW of projects over Fiscals 2020 to 2023 under the VGF scheme, which is also expected to boost capacity additions going forward.

### The various central and state level allocations

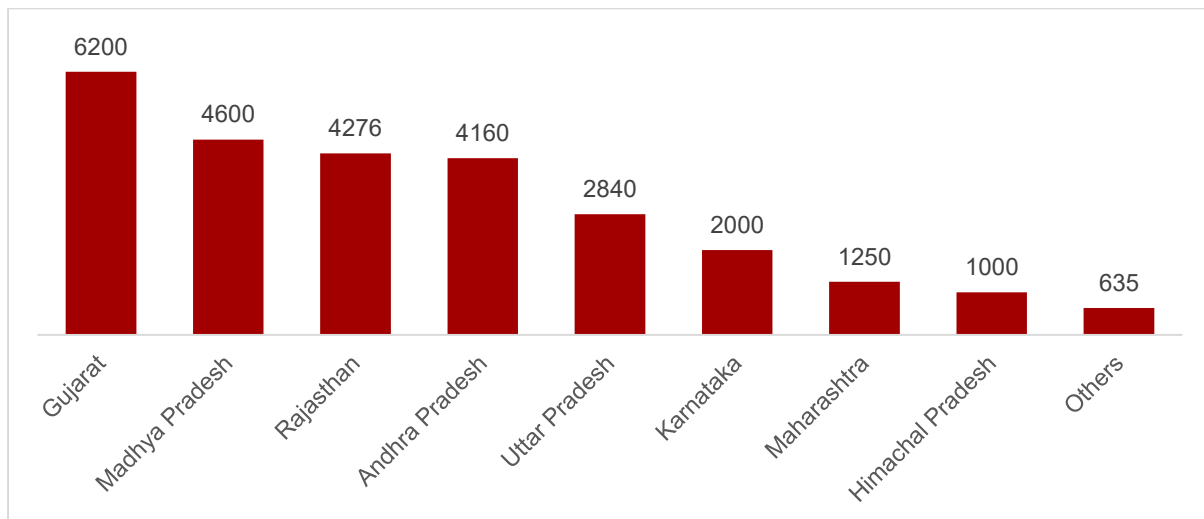


Source: CRISIL Report

- States driving capacity additions

Government plans to double solar park capacity to 40 GW to largely resolve any potential land issues. As on December 2020, solar parks of ~8.1 GW capacity are ready while others are under different stages of construction.

### List of approved solar parks (MW)

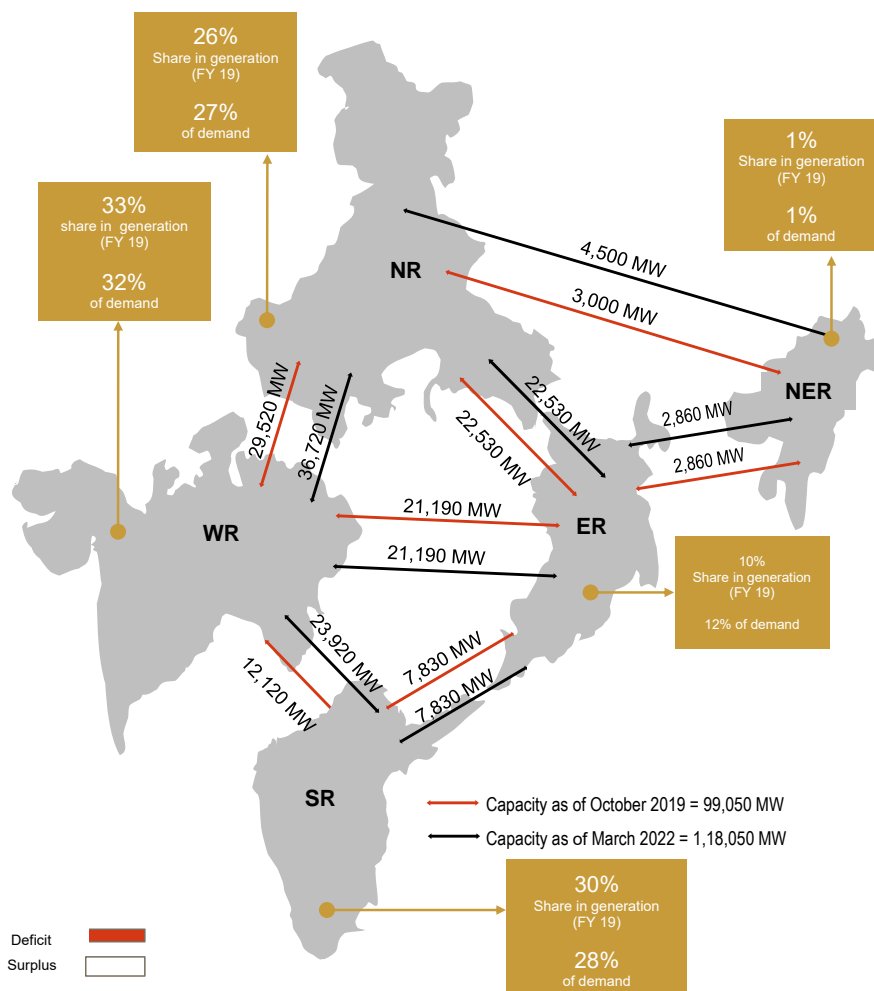


Source: SECI; CRISIL Report

### • Rise in the Inter-regional transmission capacity

The government has planned to increase the Inter regional transmission capacity in India to 118 GW by Fiscal 2022 which is expected to boost interstate/regional transactions.

### Inter-regional capacity scale up plan



- Improving transmission under Green Energy corridors

The government has already tendered out ₹63 billion of transmission lines and substation projects under the green energy corridor scheme. Further MNRE has envisaged large renewable energy capacity additions across 6 complexes in India by Fiscal 2030, it has commenced the transmission planning for these complexes. MNRE expects 200 GW of renewable energy capacity by 2030 for which transmission corridors would be constructed utilising the concessional loans from foreign funding agencies. These corridors would help in building lower cost transmission system for evacuating renewable power.

- Extension of timelines for solar projects:

The government vide an office memorandum dated August 19, 2020, offered extensions to the solar parks for which land has been acquired by the developer. However, the balance capacity can be cancelled for which the land has not been allocated. The extensions are subject to the parks meeting certain conditions such as developer and the land allotment have to be completed by before March 31, 2021. These parks will be eligible to an additional one year of extension for completion. In April 2020, MNRE had granted a 30- day extension beyond the lockdown period for renewable energy projects and has now decided that all renewable energy implementing agencies will treat lockdown due to COVID-19 as 'Force Majeure' and all renewable energy projects under implementation as on the date of lockdown i.e. March 25, 2020 will be given the five month time extension.

- Availability of low cost finance from the new funding avenues

Apart from the traditional funding channels available from banks, non-banking financial companies and private equity, developers are also exploring other options to ensure availability of low cost finance. CRISIL Report believe that this will support solar power capacity additions given the capital intensive nature of projects.

Some of these funding sources that are expected to support the overall financing market are as below:

- Funding from Asian Infrastructure Investment Bank ("AIIB"): The China led investment bank, has plans to lend USD 500 million for renewable projects in India. The interest rate will be 2-2.5% floating Libor, with a tenure of 15 years. Hence even with hedging cost of 6-7%, the overall interest rate to borrower would be ~9%, which is cheaper than the interest rates provided by the domestic banks.
- Issuance of Masala bonds and Green bonds: Masala bonds are liquid financial instruments just like any other bonds, however, the offshore investor buys the bond in Rupee terms and takes on the currency risk. Masala bond have advantages of lower interest rate and wide range of maturity issuances of 3, 5, 7 year. Further the yields of these bonds are ~300-400 bps lower than the interest rates charged by domestic banks. Also, such kind of issuances are helpful for raising large sized funds as it provides greater access to the large global investor base.
- Creation of Investment trusts: SEBI has allowed creation of infrastructure investment trusts in 2014, under which developers can create an investment trust for renewable energy projects which have long term PPAs and are generating revenues. By listing the trust, the developer can get the equity invested in these project and can use it for repaying debt or investing in other (under construction/New) renewable energy project.
- Aggressive expansion plans by the central public sector undertakings

The government while allocating the 100 GW of solar capacity addition target, envisaged that central public sector undertakings would contribute around 10 GW of grid connected solar power by Fiscal 2022. However NTPC, India's largest thermal power company has alone targeted to add ~10 GW over the same time period. In fact as on March 2021, the company has already commissioned ~1115MW of solar projects, while ~2GW solar capacity is under construction.

- States such as Telangana, Karnataka, Rajasthan, Andhra Pradesh and Tamil Nadu to drive solar capacity additions

Telangana, Karnataka, Rajasthan, Andhra Pradesh and Madhya Pradesh together comprise ~65% of the installed solar capacity in India. CRISIL Report believes that the states will continue driving capacity additions going forward, given large allocations under central schemes, presence of green energy



corridors and relatively better financial health in most of these states. These states have allocated large capacities under various central and state schemes which are expected to be commissioned over the coming years. States where large solar parks are already allocated and construction process has started are most likely to be the drivers for capacity additions.

### **3.2.4 Floating Solar**

Although the Government has approved 40 GW of solar parks across various states of India, there still remains huge potential in other forms of solar PV generation such as roof top solar and floating solar projects. As India has large water bodies and reservoirs, the same can be utilised by solar power developers to set up floating solar PV projects as it eliminates huge land requirement and legal hassles associated with projects to be located outside the solar parks. While some of the other benefits for installing floating solar projects are:

- Reduction in evaporation of water from the water body
- Reduction in algal growth in the water body
- Reduction in the temperature of solar panels, which increases the generations
- Reduction in soiling losses as lesser dust accumulation on the water bodies
- Reduction in the construction time for the projects vis-à-vis land based installations (Source: Industry)

SECI in December 2017 has floated an expression of interest (“**EoI**”) for inviting players interested in setting up floating solar projects of 10 GW capacity outside India. The power generated by such projects would be purchased by SECI and will be sold to Discoms under the power sales agreement. While apart from the large EoI released by SECI, there are also multiple floating solar PV projects EoI/tenders or have been planned.

### **3.2.5 Risks**

Solar power projects face risks that are unique such as radiation variation, technology, solar panel quality, and counterparty payment etc. Since electricity generation is primarily dependent on solar radiation, the business is exposed to nature’s vagaries too. Given below we have taken into account various risks, that impact the project returns and the risk mitigating initiatives. Rapid innovation and rise in the global scale of production have helped lower the prices of battery storage systems with prices gradually falling 2011 onwards. Falling cost of energy storage and rise of distributed energy sources are expected to bring a paradigm shift in the way electricity is generated and consumed.

### **Outlook 2021-2022: Global solar capacity additions of ~300 GW expected from 2021-22**

Globally, 127 GW of solar PV capacity was added in 2020 taking installed capacity to 707 GW which is a 22 per cent increase over the previous year. China continued to be the market leader with a total cumulative capacity of 254 GW where USA is second with total cumulative solar capacity of 76 GW followed by Japan with an installed capacity of 67 GW.

## **4. Indian Wind Power Market**

### **4.1 Review of India Wind Energy sector**

#### **4.1.1.Covid-19 led disruption impacted capacity additions in H1 of Fiscal 2021; recovery seen in H2**

Capacity additions slowed down ~25% y-o-y in Fiscal 2021. This was mainly due to supply chain disruption and workforce unavailability amidst restrictions imposed to prevent the spread of Coronavirus in India which severely impacted capacity additions in Q1 and Q2. With almost nil capacity addition in April 2020, overall only 136 MW and 294 MW of wind capacity was added in Q1 and Q2 of Fiscal 2021 as compared to the 742.5 MW and 562 MW capacity added last year in Q1 and Q2 respectively. Overall ~1553 MW was added in Fiscal 2021 lower from the ~2,068 MW added during Fiscal 2020.

This comes on the back of a pickup in additions in Fiscal 2020 from subdued Fiscals 2019 and 2018, post the FiT regime change. Capacity additions had picked up to at ~2,068 MW in fiscal 2020 compared to the 1,580 MW and

1,766 MW added in Fiscals 2019 and 2018 respectively. This increase in Fiscal 2020 was largely attributed to the commissioning of delayed projects under SECI Tranche I, II and III as well as state auctions of Tamil Nadu, Maharashtra and Gujarat.

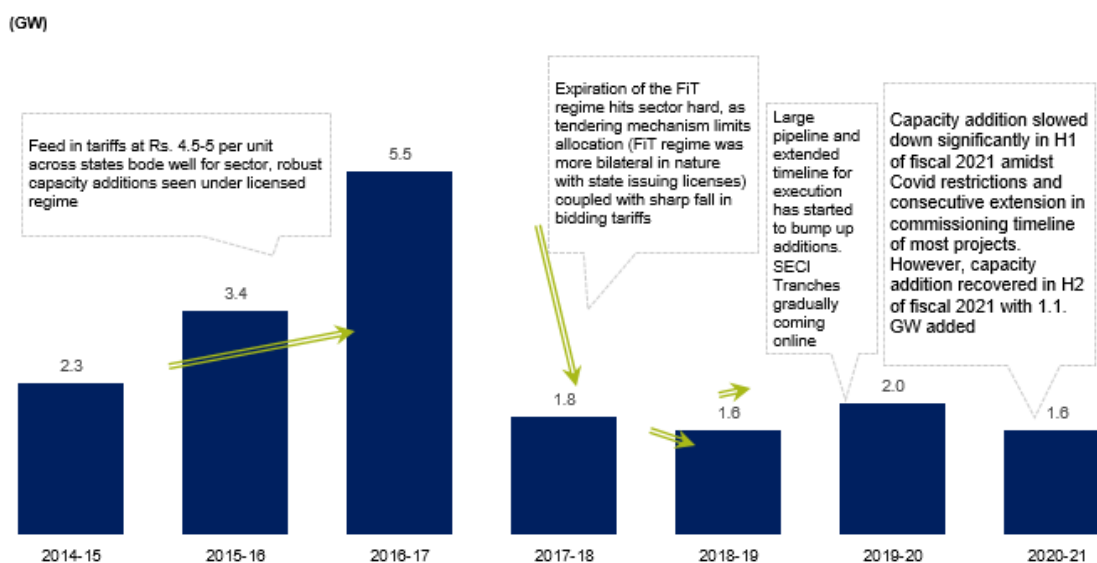
MNRE has granted time extension for renewable energy projects which have their scheduled commissioning date on or after April 1, 2021. However, the actual quantum of time-extension is yet to be decided depending on the COVID-19 related developments in the country. Last year in FY 2021, MNRE also provided an extension of five months in addition to its initial blanket extension of lockdown plus 30 days amidst the covid-19 related lockdown, apart from clarifying that any delays from constraints related to the virus outbreak will be treated as force majeure. The latter can be applied for via petitions in front of the respective state regulatory commissions.

In February 2017, the government conducted the first reverse e-auction for wind power, which led to tariffs falling to ₹3.46/unit. This was in fact 17% lower than lowest wind FiT of ₹4.16/unit in the state of Tamil Nadu. With such sharp drop in tariffs, several state Discoms like Gujarat, Andhra Pradesh, Rajasthan and Karnataka expressed their unwillingness to buy power under the FiT regime even for approved and under- construction projects as PPAs were not signed.

Wind power tariffs have since fallen to the Rs 2.5 per unit level with the tariffs as low as Rs 2.43 per unit witnessed in December 2017 in Gujarat state wind auctions of 500 MW. However, tariffs have since inched back to ~2.7-2.8 per unit range with the weighted average tariff for Fiscal 2019 and Fiscal 2020 at ₹2.7 per unit and ₹2.8 per unit respectively.

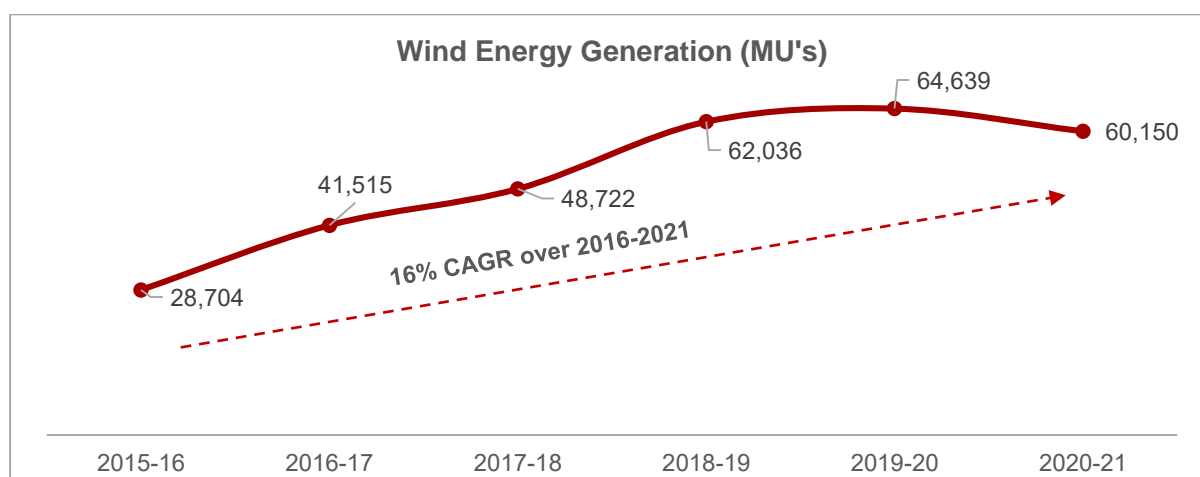
#### 4.1.1 Capacity additions in wind sector

##### Capacity addition slowdown continued to fall Fiscal 2021



Source: MNRE; CRISIL Report

## Wind Energy Generation (MU's)



Source: CEA; CRISIL Report

CRISIL Research estimates that non-solar RPO compliance was ~70% per cent in 2019-20 based on the RPO target (weighted average of ~8.5% per cent) set by the respective states. However, as per the notification provided by Ministry of power in June 2018, it had set the Non-Solar RPO target of 10.5% by Fiscal 2022 and 10.25% for Fiscal 2020.

**4.1.2** The RPO compliance in 2019-20 was mostly driven by a few states, namely – Karnataka, Tamil Nadu, Andhra Pradesh, Rajasthan, Maharashtra and Gujarat. This was due to their large installed capacity base, set up on account of attractive wind FiTs, high industrial tariffs and favorable state policies towards renewable energy. On the other hand, despite high renewable energy potential, large states like Punjab, Haryana and West Bengal are significantly lagging in terms of RPO achievement owing to low installed base and poor financial health of the discoms (except MP). **Tariff trends in past auctions**

In 2016-17, the government introduced competitive bidding in the wind sector to bring in efficiency, reduce tariffs (currently, wind power FiTs are 14-30% higher than the average power purchase cost across states) and increase transparency. This is a step away from the existing ‘feed-in-tariff’ (FiT) regime where tariff would be determined on a cost-plus basis by the respective State Electricity Regulatory Commission.

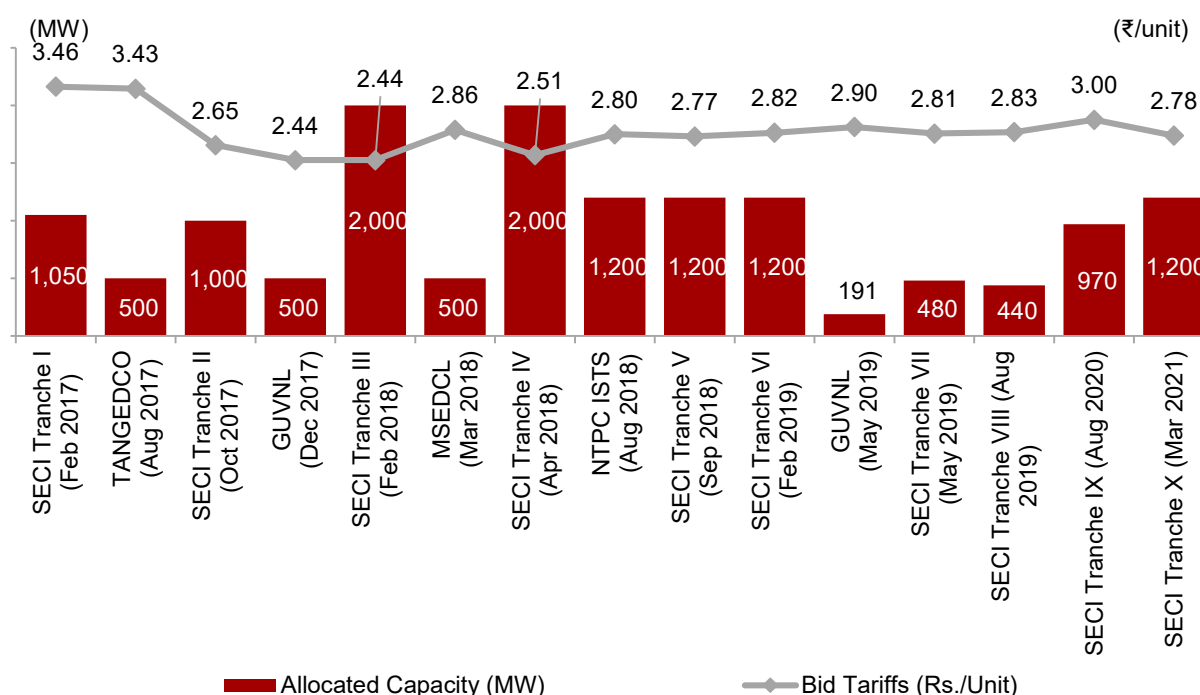
The wind power auction, which was conducted over February 2017 – February 2018 witnessed strong response. CRISIL Report believes that the keen participation was on account of issues such as slowdown in signing PPAs by states, evacuation constraints as well as payment delays plaguing the sector (PPAs to be signed with SECI and PTC India Ltd; ‘AAA’ rated agency).

The discovered tariff for the auctioned capacity ranged between ₹3.46-2.51/unit. CRISIL Report believes that the returns for the awarded for these projects to be significantly lower than the CERC benchmark return rate of 15-17% in equity IRR. CRISIL Report believes that the project viability will be mainly reliant on PLFs. Thus, micro siting and in-depth analysis of generation scenarios would help developers in improving IRR. Further attaining financial closure at low interest rates (~9-9.5% per annum) would be a monitorable.

### Shift in project allocation methodology

Auctioning has been slow since Fiscal 2019 owing to tepid bid response from developers in several large tenders with the most recent being the SECI Tranche IX, 2.5 GW tender. Developers have been raising concerns regarding lack of adequate grid infrastructure, either due to delay in construction or lack of connectivity due to congestion. Further lower availability of Type I wind sites in suitable locations is also a cause for concern. Consecutively, projects bid out at low tariffs earlier, are now facing execution challenges as project returns get impacted at increased costs due to delays.

### The list of projects auctioned and the tariffs arrived



Source: SECI; Industry; CRISIL Research

With the FiT regime ceasing to exist discovered prices for wind energy fell as low as Rs. 2.43/unit (in 500 MW wind energy auctions for GUVNL). Relevant stakeholders from the states' electricity sector also conveyed all wind-based energy procurement to be through the competitive bidding route.

This has caused realizations to fall across the value chain with both developers and OEMs reeling under the increased pressure to execute projects at such tariffs. This is caused by firstly, a correction in capital costs which had fallen in FY'18 (due to an inventory buildup with OEMs). Secondly, developers are facing increasing difficulties in tying up adequate quality wind sites coupled with connectivity, prior to bidding. CRISIL Research estimates that developers currently require tariffs near Rs 3 per unit and PLFs in the range of 32-35% for projects to be viable at current capital costs of Rs 68-70 million per MW. This should be in conjunction with developers tying up adequate land, with prior wind resource assessment, to ensure rationality while bidding.

Additionally, transmission constraints have hit the sector far more than solar, which has caused bid response to be lower for recent auctions. Adequate grid infrastructure remains a key monitorable for wind power.

11.5 GW of ISTS connected wind capacities over past 3 years. With 70% of allocated capacity in pipeline and commissioning timelines of 18-24 months, capacities are expected to commission in FY'22 onwards, albeit significant delays are being seen in old schemes due to delay in receiving regulatory approvals, land acquisition, transmission LTA, to name a few. This coupled with localized lockdowns, mobility restrictions due to second wave of COVID-19 is expected to push commissioning to second half of Fiscal 2022.

Apart from this, MNRE has granted time extension for renewable energy projects which have their scheduled commissioning date on or after April 1, 2021. The quantum of extension is yet to be decided. This is expected to provide some relief to the bunched up pipeline for the wind sector.

## **4.2 Outlook for wind**

### **4.2.1 Capacity Additions**

CRISIL Research expects capacity additions of ~15-17 GW over the next 5 years (FY 21-25) entailing investments of ~Rs. 1 trillion over the period. Capacity additions will be driven by central government (SECI) allocations under relatively stronger off takers like SECI, NTPC and PTC, which also reduces risk as compared to direct exposure to state discoms. State auctioning, on the other hand, has slowed as several have instead signed power

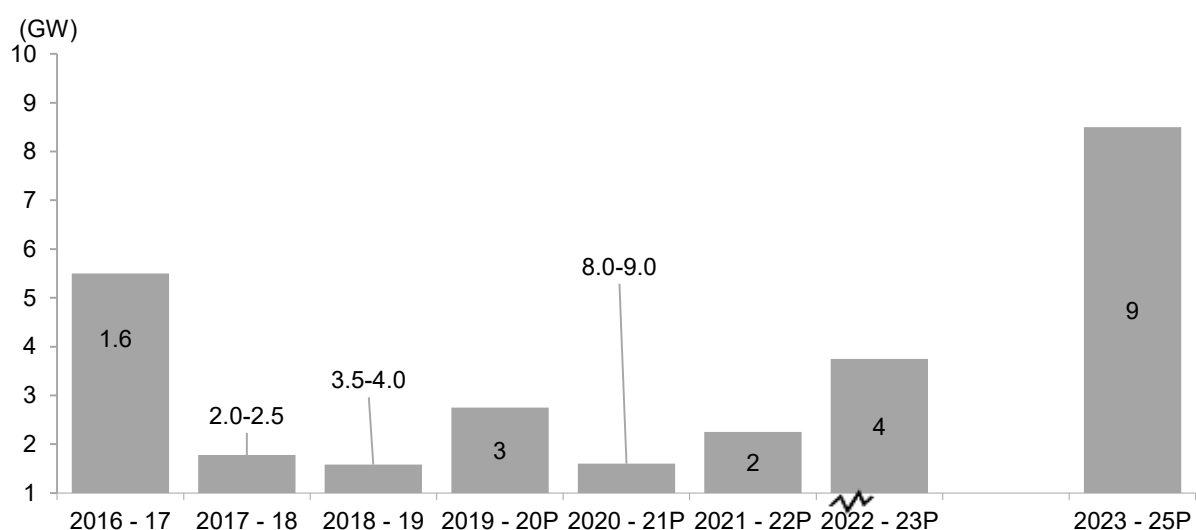
sale agreements (PSAs) with PTC and SECI for procurement of wind power under the schemes auctioned by it, to help fulfil their non-RPO targets.

Fiscal 2020 witnessed a reversal of the slowdown in capacity additions seen over Fiscals 2018 and 2019, with ~2 GW of additions in the year. This was mainly driven by additions under previously delayed schemes.

There remain almost 9 tranches of SECI led wind only allocations which have been auctioned but are currently under construction. Most of the capacities were expected to come online over FY'21/22. However, they continue to face bottle-necks in the form of delay in receiving regulatory approvals, land acquisition, transmission LTA, etc. This is coupled with supply chain disruption and work-force unavailability stemming from the Covid-19 related lockdown which significantly impacted commissioning with Fiscal 2021

As a result, only 431 MW was added during H1 of Fiscal 2021. MNRE also allowed an extension of five months in commissioning timeline with provision for further extension under the force majeure clause. This led to further push back in commissioning of capacities leading to higher commissioning of 1132 MW in H2 of the Fiscal. With second wave of Covid-19 causing localized restrictions and workforce availability issues, commissioning in first half of Fiscal 2022 is likely to be similarly weak. However, capacity pipelines are expected to be bunched up H2 of Fiscal 2022 onwards.

#### Capacity additions over Fiscals 2021-2025



Source: CRISIL Report

#### **4.2.2 Major drivers in the wind sector**

- MNRE's removal of tariff ceiling:** MNRE in March 2020, notified the removal of a tariff cap from all future tenders, including wind. This bodes well for the segment especially in light of low viability of projects previously bid at tariff below Rs 2.8 per unit and the increasing execution hurdles being faced by developer (as detailed above). Consequently, the removal of the tariff cap would help developers price in the additional risk/cost associated to these challenges, which is also expected to improve subscription rates in the sector. As per CRISIL's analysis, this could provide a fillip of up to 2 GW over the medium term, though post the impact from covid-19 related constraints subside.
- Improved technology:** Newer wind turbines are being launched which have higher rated capacity and higher hub height (over 100 m), which can be set up at low quality wind sites, otherwise considered economically unattractive. However, PLFs and subsequent viability would vary. Technological advancements have allowed players to set up wind mills in states / sites with lower wind density. Based on our estimates for every 100-bps change in PLFs, equity IRRs improve by 100-150 bps.
- Large scale allocations under the central level competitive bidding:** Post competitive bidding of 1 GW by SECI in February 2017, SECI has further allocated ~10.3 GW of capacities over March 2017 – September 2020. MNRE has outlined further plans to bid out ~5-6 GW of capacities each year, of which

majority portion should be expected from SECI/PTC. This bodes well as central sector PPAs have lower counter party risk as compared to PPAs directly with Discoms. The latter are known for delayed payments to developers and have poor financial ratings while SECI/PTC are better rated and provide various payment security mechanisms (LCs, payment security fund and SECI being part to the tripartite agreement).

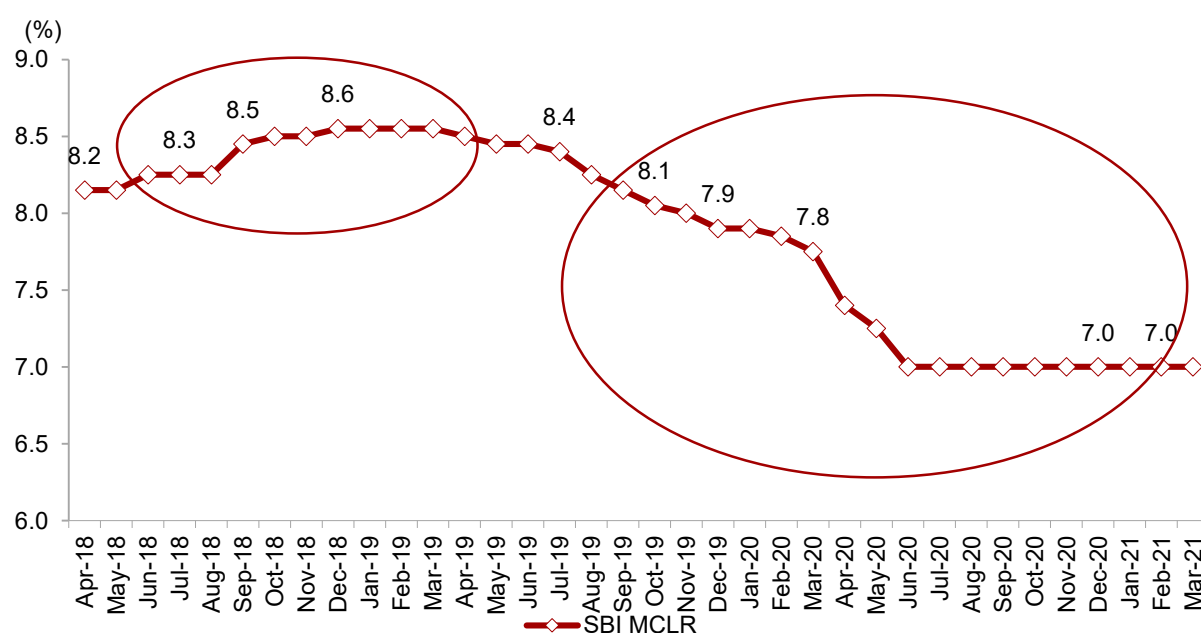
- **High industrial tariffs:** In states such as Maharashtra, Karnataka, Tamil Nadu and West Bengal where industrial tariffs are high in the range of ₹6-6.5 per unit, wind power is an attractive option since generation costs are about ₹4.2-4.4 per unit. Capacities can be set-up via the open access mode i.e. bilateral agreement directly with consumers such as commercial/industrial entities.

Wind power execution model changed due to the change in bidding mechanism OEMs, which had dominated the execution of wind power projects, were able to charge a premium for bundled services such as finding a suitable wind farm site, arranging licenses, undertaking liasoning, ensuring grid connectivity, constructing, and even maintaining the plant. With larger IPPs participating in the sector over the three -four years, business model has witnessed a shift.

OEMs, which had dominated the execution of wind power projects, were able to charge a premium for bundled services such as finding a suitable wind farm site, arranging licenses, undertaking liasoning, ensuring grid connectivity, constructing, and even maintaining the plant. With larger IPPs participating in the sector over the past 3-4 years, business model has witnessed a shift.

- **Accelerated depreciation:** Historically, particularly in Fiscals 2015 and 2016, accelerated depreciation (AD) has been a key driver for capacity additions. However going forward we expect the capacity additions under this mode to be restricted only to the large conglomerates in the unrelated business, seeking tax breaks and also those who have the financial wherewithal to competitively bid for the large wind capacities. However accelerated depreciation is 40 percent since April 2017, coupled with competitive bidding, this reduces the prospects of higher returns for accelerated depreciation based players, which has led to a shift in investment focus to other avenues.
- **Typical interest rates and debt-to-equity ratio for financing in India:** Given the capital-intensive nature of wind power projects, cost of capital plays an important role. In the past, high domestic interest rates, lower re- payment tenure and inadequate and delayed capital subsidy increased the minimum tariffs required to achieve healthy IRR. But the recent reduction in the marginal cost of funds-based lending rate (MCLR), coupled with the opening up of other financing avenues, has helped players reduce their cost of capital.

#### Interest rates remain unchanged



*Note: Data is for 1-year MCLR Source: SBI MCLR, CRISIL Report*

The above graph shows the SBI marginal cost lending rates (MCLR). Fiscals 2017 and 2018 were a period of relatively lower interest rate regime, which reversed in FY'19, following the trend globally. However, with the recent cuts in repo rates by RBI, these are again on the downtrend, being significantly lower than the Fiscals 2017-2018 levels, as can be seen above.

Despite that, lenders have become cautious in lending to the segment due to a pileup of stressed assets in the conventional power sector. Additionally, the recent re-negotiations incidents in Andhra Pradesh have also dented investor confidence to an extent where the incident also appeared to be more targeted towards wind, especially older projects from the FiT regime.

#### **4.2.3 Risks**

- Power generation risk - Power generation from wind power plants is dependent on wind speeds which vary over inter-annual and intra-annual durations and cannot be forecasted with high accuracy. Power generation from wind energy varies significantly from season to season (intra-annual). The generation performance of a wind turbine degrades with age.
- Grid variability risk - Power generation from wind energy projects is not uniform and has high variability since it is affected by natural factors such as wind speed, weather conditions etc. which are not controllable. Further, limited accuracy of forecasting and scheduling of renewable power, may lead to the grid being unable to manage fluctuations arising from variability in generation in the event where penetration of renewable power is high. Higher grid variability leads to fluctuation in grid operating parameters (such as voltage and frequency), which may result in grid imbalance and lower grid availability.
- Off-take risk - Wind energy is infirm in nature and demand from consumers is also variable, hence large quantities of unscheduled wind power in the grid can lead to a demand-supply mismatch, which may in turn lead to blackouts. This may lead to Discoms/SLDCs issuing back down instructions to wind developers.
- Counter party risk - Counter party risk pertains to payment delays and defaults to developers by state distribution utilities, which not only puts pressure on cash flows but also sends a negative signal to developers and investors in the sector. Weak financial position of Discoms is a major concern for the power sector, with project developers wary of payment delays from distribution utilities.

#### **4.2.4 Key initiatives to boost capacity additions**

In order to boost wind based capacity additions, the central government is in the process of formulating certain policies and initiatives which are as discussed below. However, CRISIL Research believes that the impact of each of these steps is expected to have an influence on the market only over the medium-term.

##### **• National Wind-Solar Hybrid Policy**

MNRE issued the National Wind-Solar Hybrid Policy in May 2018 (“**Policy**”). The Policy provides a framework for promotion of large grid connected wind-solar PV hybrid system for efficient utilisation of transmission infrastructure and land. The Policy also focuses at reducing the variability in renewable power generation and achieving better grid stability. Moreover, it aims to encourage new technologies, methods and way outs involving combined operation of wind and solar PV plants.

The Policy provides for procurement of power from a hybrid project on tariff based transparent bidding process. It stipulates that all Fiscal and financial incentives available to wind and solar power projects would also be made available to such projects. Further the policy allows addition of battery storage in hybrid projects so as to reduce variability of output power and provide higher energy output.

Based on the natural resource assessment conducted by MNRE, it has been found out that most of the renewable energy rich states in India have moderate to high potential for both wind and solar energy. Further, studies have revealed that generation from wind and solar technology is complementary to each other and generating power from both the technologies in unison would help in generating more firm power as compared to standalone wind and solar units. Hence, in order to ensure optimum utilisation of infrastructure including land and transmission systems and to minimise variability in generation from renewable energy projects, MNRE aims to promote such

hybrid projects. This would entail better utilisation of such sites where solar plants have been set up, however, wind potential also exists in addition to more interest from developers' due to the complementary benefits of the two resources.

In the recent years, with significant capacity additions in renewables and with the Hybrid Policy aiming at better utilisation of resources, it is envisaged that the new policy will open-up a new area for availability of renewable power at competitive prices. Moreover, a scheme for new hybrid projects under the policy is also expected shortly.

Further hybridisation of existing wind and solar parks are also allowed and following incentives are provided for the same under the policy:

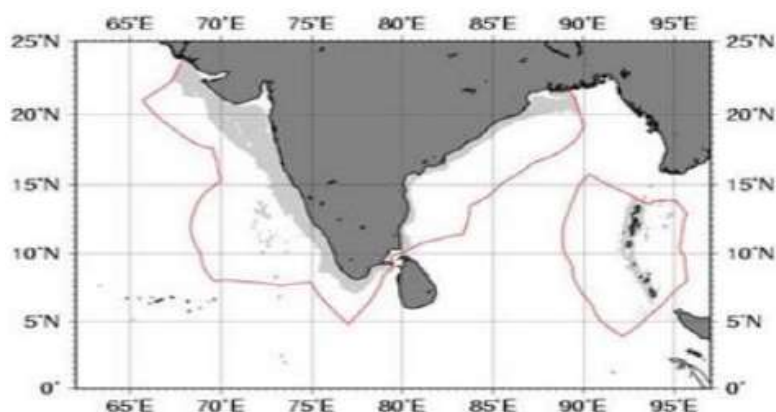
- (i) No additional transmission charges to be levied for projects having existing transmission connectivity. However normal charges may apply for additional transmission capacities to be augmented/granted.
- (ii) Additional transmission capacity can be added provided there is adequate capacity margin available at the receiving end substation. However transmission capacity augmentation is the responsibility of the developer.
- (iii) Further as there are no standards and regulations currently for DC metering of hybrid systems, hence till the time regulations are framed only AC side integration will be permitted.
- (iv) Additional wind and solar procured under the hybrid mode can be utilised for fulfilment of Solar and Non-Solar RPO targets.
- (v) Further the policy allows use of battery storage to meet the objectives like:
  - a. Reducing variability of output power from wind-solar hybrid plant
  - b. Providing higher energy output for a given capacity (sanctioned) at the delivery point Ensuring availability of firm power for a particular period.

#### • **Setting up capacities under off shore wind energy model**

In 2014, MNRE has signed a memorandum of understanding for setting up a joint venture company, for first demonstration off shore wind energy project. The company would be a joint venture of public sector undertakings ranging from MNRE, NTPC, PGCIL, IREDA, PFC, PTC India limited and GPCL. MNRE has set 30 GW of targets for commissioning of offshore wind energy under the National offshore wind energy policy.

MNRE has released the National off shore wind policy, after its cabinet approval in October 2015, considering the long coastline of India (~7500 km), high of shore wind energy potential and for the development of Indian Exclusive Economic Zone ("EEZ"). Under the policy MNRE has been authorised for the use of off shore areas within the EEZ region, while NIWE has been authorised and made the Nodal agency for carrying out the allocation of wind energy blocks, coordination and allied functions with various ministries.

#### India's exclusive economic zone for setting up off shore wind turbines



Source: MNRE



### **4.3 Wind-Solar Hybrid Model**

Wind-solar hybrid (“**WSH**”) is fast becoming the preferred renewable energy option in India. Although the MNRE has not yet set a generation target for the nascent sector, WSH has received strong support from the central public sector undertaking SECI and several state governments.

There are two types of WSH projects – pure-play ones and those with storage. There are also projects that may come up under the government’s round-the-clock power scheme, which has a mandatory 51:49 blend of renewable energy and thermal.

#### **4.3.1 Outlook on wind-solar hybrid market in India**

CRISIL Research estimates ~15 GW of WSH power to come up in the country over the next five years (Fiscals 2021 to 2025) out of the total 70 - 74 GW of overall renewable capacity.

- Of this, ~10 GW is already in the works – either under construction or being tendered.
- SECI invited bids for 1.2 GW WSH capacity, in January 2020, under its tranche-III tender for renewable energy projects
- While the biggest beneficiaries of the WSH policy will be major windy states such as Madhya Pradesh, Karnataka, Gujarat, Tamil Nadu and Andhra Pradesh, under-penetrated windy states such as Maharashtra and Chhattisgarh are also expected to see some traction.

## BUSINESS

Prospective investors should read this section together with the sections ‘Industry Overview’, ‘Risk Factors’, ‘Combined Financial Statements’, ‘Management’s Discussion and Analysis of Financial Condition and Results of Operations’ and ‘Summary of Power Purchase Agreements’ on pages 105, 19, 214, 265 and 154, respectively, as well as the other information contained in this Final Placement Memorandum.

In this section, unless the context otherwise requires, a reference to “we”, “us” and “our” refers collectively to the Terra InvIT and the Asset SPVs as managed by the Investment Manager. Further, unless the context otherwise requires, the financial information used in this section is derived from the Combined Financial Statements.

### Overview

We are an infrastructure investment trust established under the SEBI InvIT Regulations to invest, acquire, manage and operate renewable energy projects in India.

We were established by our Sponsor, Terra Asia Holdings II Pte. Ltd, an affiliate of the funds, vehicles and/or entities managed and/or advised by affiliates of KKR. The Sponsor is a 100% subsidiary of Terra Asia Holdings I Pte. Ltd., which is in turn controlled by KKR Asia Pacific Infrastructure Holdings Pte. Ltd. Founded in 1976, KKR is a leading global investment firm that offers alternative asset management and capital markets and insurance solutions with approximately US\$428.9 billion of assets under management as of June 30, 2021. KKR sponsors investment funds that invest in private equity, credit and real assets and has strategic partners that manage hedge funds. KKR’s insurance subsidiaries offer retirement, life and reinsurance products under the management of the Global Atlantic Financial Group LLC (“**Global Atlantic**”). KKR aims to generate attractive investment returns by following a patient and disciplined investment approach, employing world-class people, and supporting growth in its portfolio companies and communities. In 2008, KKR established a dedicated infrastructure team and strategy focused on global investment opportunities. KKR has been one of the more active infrastructure investors globally over the past several years, having committed more than \$30 billion across over 50 infrastructure investments. Currently, KKR’s infrastructure platform has expanded to include over 60 dedicated investment professionals across 10 offices covering a broad spectrum of investment opportunities in various infrastructure subsectors, including: midstream energy, renewables, power & utilities, water and wastewater, waste, telecommunications and transportation, among others. KKR continually monitors infrastructure sectors and infrastructure-related investments for emerging trends, and may identify and prioritize investments in other sectors as conditions change or cycles evolve. KKR has invested or committed \$6.2 billion of equity in private equity deals in India since 2010 with 20 investments made and 10 active portfolio companies currently. For details in relation to the Sponsor, see ‘Parties to the Terra InvIT’ on page 197.

Our portfolio, which are currently wholly-owned subsidiaries of the Sponsor, consisting of nine Asset SPVs spread across states of Tamil Nadu, Maharashtra, Uttar Pradesh, Rajasthan and Gujarat will be acquired by the Terra InvIT, pursuant to consummation of the Formation Transactions. Our portfolio comprises off-takers, being SECI, TANGEDCO, NVVN, GUVNL and UPPCL. As of March 31, 2021, the following solar power projects, comprise the Terra InvIT Assets generating approximately 316.6 MW of DC power / 258 MW of AC power and subsequently in May 2021, we further acquired 77.73 MW of DC power / 68 MW of AC power:

Project Name	State	Commercial Operation Date*	Contract ed Capacity (MW AC)	Capacit y (MW DC)	Tariff (₹ per unit)	Off taker	Duratio n of PPA (years)
Solar Edge Project	Maharashtra	April, 2018	130.0	169.0	4.43	SECI	25
Terralight Kanji Project	Tamil Nadu	March, 2016	30.0	36.0	7.01	TANGEDCO	25
TN Solar Project	Tamil Nadu	November, 2015	23.0	27.6	7.01	TANGEDCO	25
UMD Project	Tamil Nadu	January, 2016	25.0	30.0	7.01	TANGEDCO	25
Terralight Rajapalayam Project	Tamil Nadu	September, 2018	50.0	54.0	3.47	TANGEDCO	25
PLG Project	Gujarat	January, 2012	20.0	20.0	₹ 15/kWh for the first 12 years and	GUVNL	25

Project Name	State	Commercial Operation Date*	Contracted Capacity (MW AC)	Capacity (MW DC)	Tariff (₹ per unit)	Off taker	Duration of PPA (years)
					₹ 5/kWh thereafter		
TSET Project	Rajasthan	October, 2011	5.0	5.75	₹ 17.91/kWh	NVVN	25
TSEC Project	Gujarat	March, 2012	13.0	15.0	In accordance with the tariff structure specified in the TSEC PPA <sup>1</sup>	GUVNL	25
USUPL Project	Uttar Pradesh	September, 2016	30.0	36.98	₹ 9.33/kWh for the first 12 years and from the 13th year, tariff will be as determined in accordance with the USUPL PPA.	UPPCL	25

\*Weighted average commercial operation date based on commissioned capacity

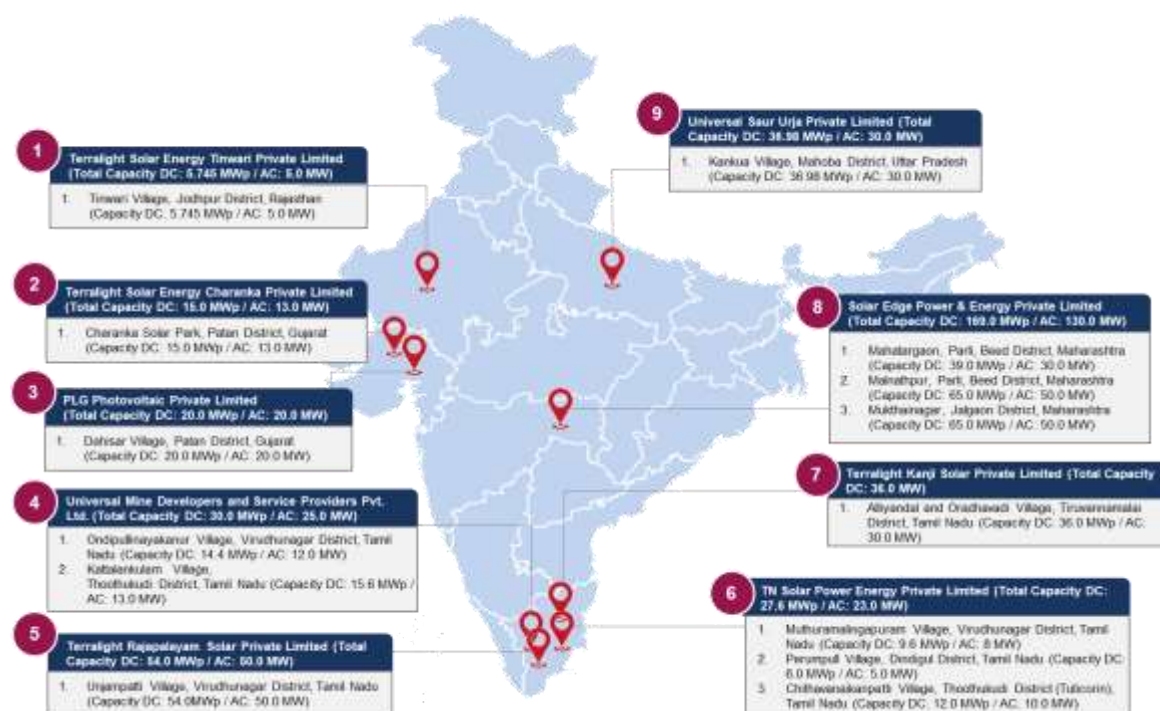
<sup>1</sup> Tariff structure for TSEC Project is as stated below:

Capacity	Tariff 1 (₹ / kWh)	Tariff 1 End Date	Tariff 2 (₹ / kWh)	Tariff 2 End Date
4.0	15.00	March 3, 2024	5.00	March 3, 2037
6.0	9.98	March 30, 2024	7.00	March 30, 2037
4.9	9.98	October 30, 2024	7.00	April 11, 2037
0.1	9.98	October 30, 2024	7.00	October 30, 2037

For details of the Terra InvIT Assets and the PPAs entered into by the Asset SPVs, see ‘- *Details of the Asset SPVs and the Terra InvIT Assets*’ and ‘*Summary of Power Purchase Agreements*’ on pages 139 and 154.

The revenue from operations of the Asset SPVs on a combined basis for the Financial Years ending March 31, 2021, March 31, 2020, and March 31, 2019 was ₹34,423.98 lakhs, ₹35,134.95 lakhs, and ₹32,766.51 lakhs respectively. The EBITDA and EBITDA Margin of the Asset SPVs on a combined basis for the Financial Years ending March 31, 2021, March 31, 2020, and March 31, 2019 was ₹26,314.46 lakhs and 76.44%, ₹31,118.64lakhs and 88.57%, and ₹27,064.50 lakhs and 82.60% respectively. For more information about the Combined Financial Statements of the Asset SPVs, see ‘*Combined Financial Statements*’ on page 214.

The following map shows the locations of our Asset SPVs:



Pursuant to the consummation of the Formation Transactions, the Terra InvIT intends to acquire, directly or indirectly, 100% of the equity shares, outstanding CCPS and CCDs of each of the Asset SPVs, as applicable, from the Sponsor and certain transferors, for which the Terra InvIT will issue Units and pay consideration, as applicable in the manner described in *'Background and Structure of the Terra InvIT – Acquisition of the Project SPVs by the Terra InvIT'* and *'Background and Structure of the Terra InvIT – Acquisition of the Specified SPVs by the Terra InvIT'* on pages 101 and 102.

The Sponsor has appointed Axis Trustee Services Limited to act as the sole Trustee of the Terra InvIT. The Trustee is registered with SEBI as a debenture trustee under the Securities and Exchange Board of India (Debenture Trustees) Regulations, 1993 and is eligible to act as the trustee to the Terra InvIT in accordance with the SEBI InvIT Regulations. For details in relation to the Trustee, see *'Parties to the Terra InvIT – The Trustee'* on page 198.

Virescent Infrastructure Investment Manager Private Limited has been appointed as the Investment Manager. The Investment Manager, which is a wholly owned subsidiary of the Sponsor, has been newly set up to manage the assets and investments of the Terra InvIT, with its key managerial personnel having several years of experience in the infrastructure sector and more particularly, the renewable and power sector. For details in relation to the Investment Manager, see *'Parties to the Terra InvIT – The Investment Manager'* on page 201.

The Trustee, the Investment Manager and the respective Asset SPVs have appointed Virescent Renewable Energy Project Manager Private Limited, a wholly owned subsidiary of the Investment Manager to act as the Project Manager for each Project SPV. For details in relation to the Project Manager, see *'Parties to the Terra InvIT – The Project Manager'* on page 206.

Our Asset SPVs and the Project Manager have entered into the O&M Agreements with O&M Contractors in order to set out the terms for operation and maintenance of the Terra InvIT Assets and performing certain specified services, under the supervision of the Project Manager such as (i) submission of daily, monthly, quarterly and annual reports on the performance of the solar power projects to the respective Project SPVs; (ii) periodic cleaning of the PV and solar modules, housekeeping services, vegetation abatement and project upkeep; (iii) civil and mechanical maintenance within the premises of the solar power project along with preventive maintenance of the solar power project; and (iv) providing security services at the solar power project, etc., in accordance with specified operating standards and specifications, including health, safety, and environment standards. For more information about the O&M arrangement, see *'-- Operation and Maintenance Services'* on page 150.

## Competitive Strengths

We believe that our key competitive strengths are as follows:

- *Stable revenue generating operational assets with no construction risk and long-term predictable cash flows*

Our portfolio of Terra InvIT Assets comprises of 100% operational assets, which have no construction risk and are capable of generating stable revenue and predictable cash flows from specified contracted tariffs under long term PPAs and have an average operating history of more than 6 years as of March 31, 2021. The pre-determined tariff structure (except for USUPL, the tariffs for which from the 13th to 25th year will be decided by the state commission determined by the Electricity Act, 2003 at the appropriate time taking into account various factors) and the long term nature of the PPAs ensure predictable and stable generation of revenue and long-term predictable cash flows. For details in relation to the PPAs entered by our Asset SPVs, see '*Summary of Power Purchase Agreements*' on page 154. Our revenue from the sale of electricity based on tariffs specified in the respective PPAs amounted to ₹34,413.95 lakhs, ₹35,133.35 lakhs, and ₹32,764.04 lakhs for the Financial Years ending March 31, 2021, March 31, 2020 and March 31, 2019 respectively. As the tariffs are pre-determined for the entire duration of our PPAs, we have both stable and predictable stream of revenue from our projects.

Generation of solar energy does not typically vary much year on year with limited variation in annual radiation levels. As a result, our solar power projects have maintained an average DC PLF of 16.62%, 16.99% and 16.58% during Financial Years ending March 31, 2021, March 31, 2020 and March 31, 2019, thus allowing us to maintain stable cash flows from our Terra InvIT Assets. In accordance with the SEBI InvIT Regulations, not less than 90% of NDCF of the Terra InvIT shall be distributed to the Unitholders. We believe that stable generation of revenue and predictable cash flows from our Asset SPVs will provide stable returns to the Unitholders.

- *Projects spread across states and off-takers*

Our portfolio of Terra InvIT Assets is spread across geographies and off-takers. Our off-takers include both central government entities such as SECI and NRVN and state government entities such as GUVNL, UPPCL and TANGEDCO. We have entered into PPAs with these off-takers for a term of 25 years. Our states include Maharashtra, Tamil Nadu, Gujarat, Uttar Pradesh and Rajasthan with an aggregate operational capacity of 394.3 MW DC/ 326 MW AC and total operating revenue of ₹34,423.98 lakhs as of March 31, 2021. Within these states, the projects are spread across 14 locations. This diversification across multiple locations mitigates operational volatility due to seasonal weather conditions, and enables us to spread our revenue realisations across weather patterns, climates, and local demand schedules.

- *Low leverage for the overall portfolio thus leading to better creditworthiness and credit rating*

As of March 31, 2021, we had a total external outstanding indebtedness of ₹94,499.73 lakhs, which pertains to Solar Edge, PLG, TSET, TSEC and USUPL, with Net Debt to AUM ratio of 26.4%. On completion of the Issue, the Net Debt to AUM ratio would be less than 10%. We believe that our low leverage provides us with the ability to pursue our inorganic growth strategies funded through an optimum combination of equity and additional leverage, thus leading to greater value creation. The SEBI InvIT Regulations provide that the aggregate consolidated borrowings of the InvIT shall not exceed 25% of the value of the InvIT assets without obtaining unit holder approval in the manner specified under the SEBI InvIT Regulations and shall not exceed 70% of the value of the Terra InvIT Assets in any case. Our low leverage will also result in better credit rating for our InvIT, thus allowing us favourable financing terms and cost. CRISIL has assigned a provisional 'AAA/Stable' rating for the bank loan facilities of the Terra InvIT, in February, 2021, taking into account the Project SPVs and the proposed acquisition of the Specified SPVs, subject to the terms set out therein. The Terra InvIT is the first renewable energy InvIT in India to be assigned a provisional "AAA" rating from CRISIL and it is amongst the few infrastructure companies in India which have been assigned a "AAA" rating. The 'AAA' rating reflects our healthy revenue visibility due to long-term PPAs at pre-determined tariffs, in addition to the track record of enhanced generation capabilities, our healthy financial risk profile, and low leverage. Further, the Union Budget 2021-2022 has provided for debt financing of InvITs by FPIs to be enabled by making suitable amendments in the SEBI InvIT Regulations. Implementation of this initiative, will allow us more efficient capital structuring, as we will have the ability to finance future acquisitions partly/ entirely through fresh borrowings. Further, we believe that our low leverage will

provide us with a significant advantage over our competitors in acquiring projects that meet our investment objectives.

- *Strong Sponsor support with extensive experience in renewable energy space*

We intend to leverage the experience and expertise of our Sponsor and its affiliates, to gain a competitive advantage within the renewable energy industry. Our Sponsor is engaged in investment activities primarily with an objective of generating stable returns and earning long term capital appreciation. Our Sponsor is an affiliate of the funds, vehicles and/or entities managed and/or advised by affiliates of KKR which is a leading global investment firm that offers alternative asset management and capital markets and insurance solutions with approximately US\$428.9 billion of assets under management, as of June 30, 2021. KKR sponsors investment funds that invest in private equity, credit and real assets and has strategic partners that manage hedge funds. KKR's insurance subsidiaries offer retirement, life and reinsurance products under the management of Global Atlantic. KKR aims to generate attractive investment returns by following a patient and disciplined investment approach, employing world-class people, and supporting growth in its portfolio companies and communities. In 2008, KKR established a dedicated infrastructure team and strategy focused on global investment opportunities. KKR has been one of the more active infrastructure investors globally over the past several years, having committed more than \$30 billion across over 50 infrastructure investments. Currently, KKR's infrastructure platform has expanded to include over 60 dedicated investment professionals across 10 offices covering a broad spectrum of investment opportunities in various infrastructure subsectors, including: midstream energy, renewables, power & utilities, water and wastewater, waste, telecommunications and transportation, among others. KKR continually monitors infrastructure sectors and infrastructure-related investments for emerging trends, and may identify and prioritize investments in other sectors as conditions change or cycles evolve. KKR has invested or committed \$6.2 billion of equity in private equity deals in India since 2010 with 20 investments made and 10 active portfolio companies currently. KKR's Asia Pacific infrastructure portfolio other than Terra InvIT, includes India Grid Trust, TSK Corporation, Eco Solutions Group, First Gen, and Pinnacle Towers. KKR's experienced team is well positioned to capture compelling opportunities and add value to its portfolio to generate attractive, risk adjusted returns for its investors. Drawing upon this depth of experience, our Sponsor has established a strong track record of operating and managing large-scale projects, which will benefit us across all stages of project operations and acquisitions within India's complex regulatory framework (including, for example, strategic acquisition, O&M, and receivables management). Our Sponsor also provides us the ability to leverage its parentage and long-term industry relationships with stakeholders to gain cost-efficient access to financing from institutions and capital markets. Further, our Investment Manager and Project Manager are also affiliates of the Sponsor. We believe our affiliation to KKR will allow us to pursue marquee and high quality renewable assets, and engage effectively with regulators and central and state off-takers.

- *Experienced management team with a focus on corporate governance*

We have a strong management team with extensive experience in the infrastructure sector, in-depth understanding of managing renewable energy projects and proven track record of performance. Our senior management team, led by our Board of Directors, has an average of more than two decades of experience in the Indian renewable energy industry. We draw on the knowledge of our Board of Directors, who bring us expertise in the areas of corporate governance, business strategy and operational and financial capabilities, amongst others. We believe this will be key to the execution of our growth strategies. Our core management team, consisting of three personnel as on date of this Final Placement Memorandum, has an average experience of more than two decades in the infrastructure sector, thus providing us an ability to pursue our growth strategies in a seamless manner.

We believe that the experience of our management team will contribute to our growth and success and ensure that the Terra InvIT Assets and Terra InvIT are operated and managed in an efficient manner. The team is supported by other qualified operational personnel who have an in-depth understanding of the regions in which we operate. We have employed a significant number of qualified technical personnel who are engaged in operating and managing our projects as on the date of this Final Placement Memorandum. It is with the aim of enshrining principles of good corporate governance and effective management and operations of the Terra InvIT, the Investment Manager has constituted various committees and adopted policies such as board governance policy, vigil mechanism policy and anti-corruption policy to manage the activities of Terra InvIT which are in line with global policies adopted by KKR. In accordance with the SEBI InvIT Regulations, the Investment Manager has also adopted the

(a) distributions policy pursuant to which distributions are required to be made to the Unitholders at least once a year for periods after Allotment and (b) borrowing policy which aims to outline the borrowing thresholds and process in relation to Terra InvIT. Further, the Investment Manager has also adopted appointment of auditor and valuer policy which aims at formulating a structure for ensuring compliance by the Terra InvIT in appointment of its auditor and the auditing standards followed and the appointment of its valuer, in accordance with applicable law including the SEBI InvIT Regulations and code of conduct policy which aims at formulating a framework for ensuring interest of the Unitholders and proper conduct in carrying out the business and affairs of the Terra InvIT in accordance with SEBI InvIT Regulations. For details in relation to the corporate governance framework of the Investment Manager, see '*Corporate Governance*' on page 180. We believe that our governance process will ensure adherence and enforcement of principles of sound corporate governance with the objectives of fairness, transparency, professionalism, trusteeship and accountability, while facilitating effective management of the businesses and efficiency in operations.

- *Renewable energy focused firm in a fast growing industry backed by government initiatives*

Our existing presence in the renewable energy sector provides us with an ability to benefit from the growth opportunities associated with alternative sources of energy as compared to conventional fuel sources, such as coal and gas. Improving unit economics of renewable energy sources such as wind and solar power due to declining capital costs and higher cost of coal based power has resulted in renewable energy tariffs becoming not only competitive, but more attractive and sustainable.

Growth in the renewable power sector over the last five years has been robust, according to CRISIL Research. Further renewable energy installations have more than tripled to approx. 94.4 GW as on March 2021, compared with 25 GW as on March 2012 (*Source: MNRE*), with solar power in particular, growing to about 40 GW from 0.9 GW over the same period.

In addition, the Indian renewable power industry also receives extensive support from the Government, both in terms of broad policy frameworks such as the National Action Plan on Climate Change, as well as in the creation of specific central and state level renewable energy purchase obligations or RPOs which require obligated entities to necessarily fulfil a prescribed percentage as specified by their respective state regulatory commissions of their energy needs from renewable energy sources. The Government has set a target of achieving 175 GW of renewable energy by 2022, with a solar capacity of 100 GW and 60 GW of wind capacity, and by 2030 is aiming to source about 40% of its cumulative electric power installed capacity from non-fossil fuel based energy resources. The Electricity Act, 2003 coupled with competitive bidding for power procurement, implemented in 2006, encouraged the participation of private players who had announced large capacity additions. Moreover, the strong government thrust on renewable energy coupled with reducing tariffs (with falling capital costs and improving efficiency) also supported renewable energy capacity additions. The Government is focusing on building charging infrastructure and creating a conducive policy environment for faster adoption of electric vehicles so as to reduce dependence on fossil fuels for transportation. India aims to increase the share of electric vehicles to 30% by 2030 (*Source: CRISIL Report*).

We believe we are well placed within a growing industry to leverage the macroeconomic factors to grow our business.

## **Business Strategies**

Our primary objective is to maximise total returns for our Unitholders through a combination of growth and value creation at the portfolio level supported by highly predictable and stable cash flows. Specifically, we intend to pursue the following strategies to achieve our objective:

- *Continue to pursue accretive growth through acquisitions*

We intend to pursue acquisition opportunities in the renewable energy sector by actively sourcing and acquiring quality assets that provide long-term, predictable cash flows, help us maintain or improve returns for our Unitholders in line with our investment criteria. We intend to assess such opportunities based on our investment criteria such as the energy source, credit profile of the off-takers, size of the project (in terms of installed capacity), operating history of the project, existing tenure of the PPA, tariff rates and background and credit profile of the selling entity, etc. For instance, the Sponsor has entered into Sponsor SPA for acquisition of one hundred percent equity of four entities owning and operating

solar assets located in Rajasthan, Punjab and Madhya Pradesh with long term power purchase agreements with a mix of state and central off-takers. The aggregated portfolio size is 49 MW (AC) / 55.4 MW (DC). The consummation of the transaction is subject to various conditions precedents including approval from lenders. The Sponsor SPA contains standard representations and warranties and indemnities (including specific indemnities) from the counter party that are customary and appropriate for a transaction of this type and nature. The Sponsor may make available these solar projects for acquisition to Terra InvIT in future. We may on an opportunistic basis, examine investment opportunities in high quality eligible projects of select marquee developers which are yet to achieve COD, subject to applicable provisions of the SEBI InvIT Regulations. Additionally, we may evaluate opportunities to invest in other eligible infrastructure projects (as defined under the SEBI InvIT Regulations) and enter into appropriate framework agreements / strategic partnerships with suitable experienced project developers to explore opportunities to invest in early stage / under construction projects, subject to applicable provisions of the SEBI InvIT Regulations.

- *Pursue diversification for our portfolio while ensuring stable cash flows*

Our current portfolio comprise of five off-takers including central off-takers, SECI and NVVN and state off-takers, GUVNL, UPPCL and TANGEDCO providing us revenue visibility and stability. We intend to further our growth with a focus on retaining a healthy mix of central and state off-takers. The Terra InvIT Assets currently comprise of solar power projects spread across states of Maharashtra, Tamil Nadu, Gujarat, Uttar Pradesh and Rajasthan. We intend to improve this mix by further adding diversification of geography and off-takers going forward as well and consider states in India which can provide suitable stable off-takers, weather conditions and tariff rates. We intend to pursue diversified growth and expand our portfolio to other sources of renewable energy such as wind energy projects and target expansion by acquiring projects with synergies as our existing projects to increase our economies of scale. Our overall objective is to ensure that there is substantial balance life remaining in the portfolio, so as to ensure long term predictable and stable cash flows. We will evaluate opportunities based on our targeted returns, operational scale and diversification criteria.

- *Maintain optimum capital structure to maximise distributions to Unitholders*

We focus on achieving an optimal capital structure for our projects and will continue to draw upon the experience, relationship and expertise of our Sponsor and its affiliates in sourcing funds from multiple sources, including from domestic and international markets. Immediately upon completion of the Issue, our consolidated external borrowings and deferred payments (net of cash and cash equivalents) will be below 25% of the total AUM. According to CRISIL Report, typically, the debt to equity ratio for operating power projects is approximately 70:30. However, it can go up to a maximum of 80:20 depending on the project economics. We also intend to optimise our leverage to retain enough flexibility to provide sustainable and predictable cash flows while also evaluating potential acquisition opportunities in the future. After the completion of the Issue, we believe that we will have sufficient equity capital and ability to add additional debt to support acquisition of additional assets while maintaining an optimum capital structure. We will seek to employ appropriate financing policies and also diversify our funding sources with an objective of minimising our overall cost of capital. We will seek to optimise our debt and equity mix in such a manner that the aggregate consolidated borrowings and deferred payments of the Terra InvIT, net of cash and cash equivalents does not exceed 70% of the value of the Terra InvIT Assets at any time subject to the approval of the unitholders as provided in accordance with the SEBI InvIT Regulations. Further, any additional debt beyond 49% of the value of the Terra InvIT Assets will be raised only upon compliance with the conditions set out in the SEBI InvIT Regulations. In accordance with the Trust Deed, any additional debt will be raised only with consent of 51% of the Unitholders of our InvIT. If it is in the interests of the Unitholders, the Investment Manager may also pursue growth opportunities that require raising additional capital through the issuance of new Units.

- *Continue to achieve operational excellence through efficient management processes, information technology infrastructure and long term O&M arrangements*

We have appointed the Project Manager to undertake operations and management of the Project SPVs in furtherance of which the Project Manager and the Project SPVs has entered into O&M Agreements with O&M Contractors to provide comprehensive operation and maintenance services in respect of the Terra InvIT Assets on a 24x7x365 days basis. For details in relation to the O&M Agreements and Project



Management Agreement, see ‘-- *Operation and Maintenance Services*’ and ‘*Parties to the Terra InvIT – Key terms of the Project Management Agreement*’ on pages 150 and 207 respectively.

We have also adopted comprehensive procedures for (i) business management, including revenue management, operations and maintenance and corporate governance; (ii) financial management including budgeting, reporting, treasury and banking support; and (iii) human resource management with an objective of incorporating industry best practices. Our aim is to employ both preventive and corrective measures in order to optimise the long term performance of each Terra InvIT Asset and ensure timely and effective management focus and attention.

Further, in order to seamlessly grow our operations and our portfolio of renewable energy assets, we intend to invest extensively on our internal processes. We are in the process of implementing a central monitoring system, which will enable us to improve performance and efficiency of the projects through data analytics along with real-time monitoring of the projects; enterprise resource planning system which will assist in tracking and managing core business processes by consolidating data across all the Asset SPVs; and data management system, for storing physical copies as well as soft copies on the cloud to ensure safety and confidentiality of all critical documents. We believe that having established procedures in place help reduce the overall operational costs, which will in turn improve our financial performance.

We intend to set up a computerised maintenance management system to ensure that the operation of Terra InvIT Assets is systematically and correctly scheduled, carried out and recorded. In addition, it is aimed at ensuring effective planning, control and monitoring of each maintenance activity. We intend to regularly review maintenance methodologies and system performance and examine for optimisation of resource deployment through the infrastructure.

#### **Details of the Asset SPVs and the Terra InvIT Assets**

The Terra InvIT Assets comprise of nine Asset SPVs in the states of Tamil Nadu, Maharashtra, Uttar Pradesh, Gujarat and Rajasthan.

See ‘*Summary of the Power Purchase Agreements*’ on page 154 for a summary of the key terms of the PPAs entered into by the SPVs in relation to their respective businesses.

The table below sets forth the details of the Asset SPVs and Terra InvIT Assets:

Asset SPV	State and Location	Off-taker	Commercial Operation Date (“COD”)		Tenure of the PPA	Tariff (₹ per unit)	Operational Capacity as on March 31, 2021 (in MW DC)	PLF for Financial Year ending March 31, 2020 (in %)	PLF for the Financial Year ended March 31, 2021	Net billed units for Financial Year ending March 31, 2020 (million units)	Net billed units for the Financial Year ended March 31, 2021 (million units)	Revenue for Financial Year ending March 31, 2020 (in ₹ lakhs)	Revenue for the Financial Year ended March 31, 2021 (in ₹ lakhs)	EBITDA for Financial Year ending March 31, 2020	EBITDA for the Financial Year ended March 31, 2021	O&M Contractor <sup>1</sup>
Solar Edge																
	(a)	Parli, Maharashtra	SECI	April 22, 2018	25 years from COD	4.43	169.00	16.78	16.80	249.15	248.69	11,261.56	11,233.16	10,148.49	7,853.94	Param Renewable Energy Private Limited
	(b)	Parli, Maharashtra	SECI	April 8, 2018	25 years from COD	4.43										
	(c)	Muktainagar Maharashtra	SECI	April 26, 2018	25 years from COD	4.43										
Terralight Kanji		Thiruvannamalai, Tamil Nadu	TANGEDC O	March 2016	25 years from COD	7.01	36.00	17.44	16.11	55.16	50.82	3,840.89	3,534.21	3,613.26	2,698.88	AVI Solar Energy Private Limited
Terralight Rajapalayam		Rajapalayam, Tamil Nadu	TANGEDC O	September 26, 2018	25 years from COD	3.47	54.00	17.57	16.60	83.36	78.52	2,872.49	2,702.82	2,619.17	2,047.39	AVI Solar Energy Private Limited
TN Solar																
	(a)	Vilathikulam, Tamil Nadu	TANGEDC O	November 2, 2015	25 years from COD	7.01	27.60	16.94	16.34	41.08	39.51	2,858.92	2,767.35	2,612.70	2,084.90	AVI Solar Energy Private Limited
	(b)	Dindigul, Tamil Nadu	TANGEDC O	December 28, 2015	25 years from COD	7.01										
	(c)	Virudhunagar, Tamil Nadu	TANGEDC O	September 28, 2015	25 years from COD	7.01										
UMD																
	(a)	Virudhunagar, Tamil Nadu	TANGEDC O	November 16, 2015	25 years from COD	7.01	30.00	16.99	15.71	44.77	41.29	3,113.01	2,889.66	2,882.55	2,180.26	AVI Solar Energy Private Limited
	(b)	Kovilpatti, Tamil Nadu	TANGEDC O	March 2016	25 years from COD	7.01										
PLG		Patan, Gujarat	GUVNL	January 2012	25 years from COD	₹15/kWh for the first 12 years and	20.00	17.91	17.65	31.47	30.93	3,116.73	3,064.36	2,618.60	2,514.58	Mitarsh Energy Private Limited

<sup>1</sup> The O&M Agreement each dated February 1, 2021 for each of Terralight Kanji, TN Solar, UMD, and Terralight Rajapalayam, dated August 20, 2021 for Solar Edge has been entered for a period of 5 years and the O&M Agreement each dated June 25, 2021 has been entered for a period of 3 years for Specified SPVs to provide comprehensive operation and maintenance services in respect of the Terra InvIT Assets on a 24x7x365 days basis

Asset SPV	State and Location	Off-taker	Commercial Operation Date (“COD”)	Tenure of the PPA	Tariff (₹ per unit)	Operational Capacity as on March 31, 2021 (in MW DC)	PLF for Financial Year ending March 31, 2020 (in %)	PLF for the Financial Year ended March 31, 2021	Net billed units for Financial Year ending March 31, 2020 (million units)	Net billed units for the Financial Year ended March 31, 2021 (million units)	Revenue for Financial Year ending March 31, 2020 (in ₹ lakhs)	Revenue for the Financial Year ended March 31, 2021 (in ₹ lakhs)	EBITDA for Financial Year ending March 31, 2020	EBITDA for the Financial Year ended March 31, 2021	O&M Contractor <sup>1</sup>	
					5/kwh thereafter											
TSET	Jodhpur, Rajasthan	NVVN	October 15, 2011	25 years from COD	₹17.91/k Wh	5.75	17.65	17.69	8.90	8.90	1,562.15	1,562.81	956.17	1,284.23	Meera Corporation	
TSEC	Kutchh, Gujarat	GUVNL	The plant was commissioned in a phased manner <sup>2</sup>	25 years from COD	In accordance with the tariff structure specified in the TSEC PPA <sup>2</sup>	15.00	16.23	16.04	21.30	21.07	1,841.72	1,812.62	1,424.32	1,240.06	Mitarsh Energy Private Limited	
USUPL	Mahoba, Pradesh	Uttar UP	UPPCL	September 15, 2016	25 years from COD	₹ 9.33/kWh for the first 12 years and from the 13th year will be determined in accordance with USUPL PPA	36.98	16.33	16.77	50.50	52.45	4,667.48	4,857.00	4,243.38	4,410.23	Meera Corporation

<sup>2</sup> Tariff structure for TSEC Project is as stated below:

Capacity	COD	Tariff 1 (₹ / kWh)	Tariff 1 End Date	Tariff 2 (₹/ kWh)	Tariff 2 End Date
4.0	March 4, 2012	15.00	March 3, 2024	5.00	March 3, 2037
6.0	March 31, 2012	9.98	March 30, 2024	7.00	March 30, 2037
4.9	April 12 2012	9.98	October 30, 2024	7.00	April 11, 2037
0.1	October 31, 2012	9.98	October 30, 2024	7.00	October 30, 2037

A summary of each of the Terra InvIT Assets is as stated below:

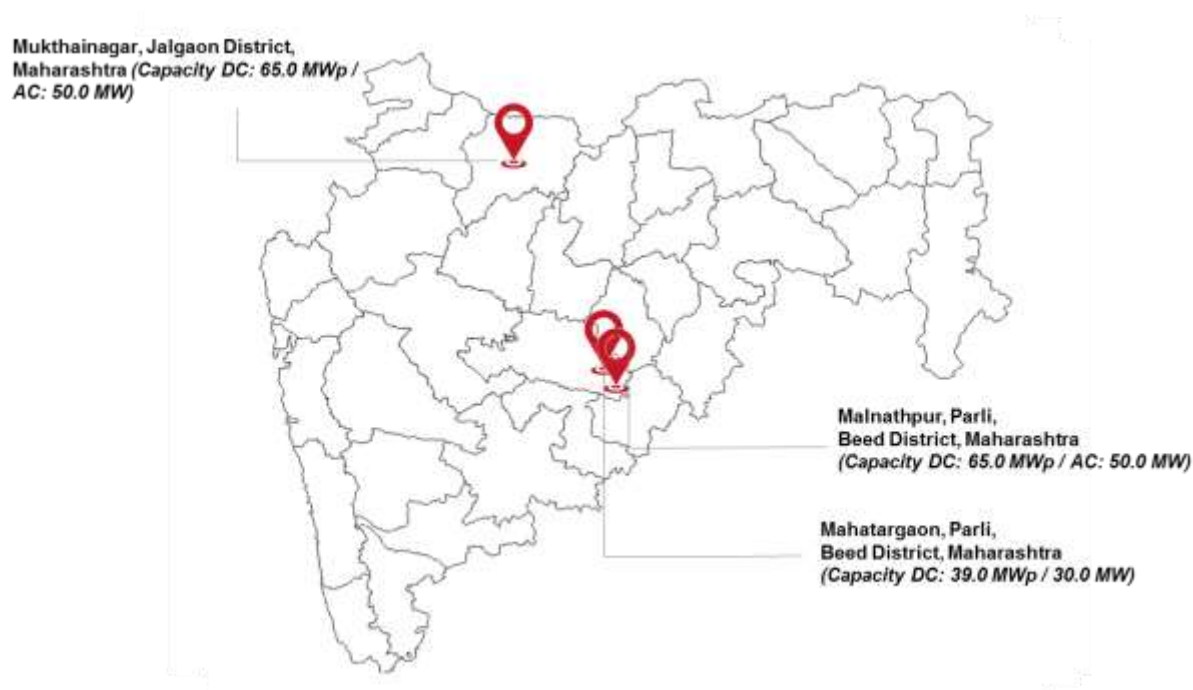
## 1. Solar Edge Project

### *Power Purchase Agreement*

On February 10, 2017, SECI and Solar Edge entered into the Solar Edge PPA wherein SECI agreed to procure 130 MW AC power from Solar Edge power generation facilities at pre-determined tariff of ₹4.43 per unit for the entire term of the agreement i.e. 25 years effective from April 22, 2018.

For further details on the Solar Edge PPA, see '*Summary of the Power Purchase Agreements – Power Purchase Agreements, dated February 10, 2017 between Solar Edge and SECI*' on page 154.

The following map illustrates the location of the Solar Edge Project located in the state of Maharashtra:



### *Financing*

As of March 31, 2021, the total external outstanding debt with respect to Solar Edge was ₹59,301.85 lakhs. Pursuant to Solar Edge Refinancing, as of June 30, 2021, the total external debt with respect to Solar Edge was ₹59,300.00 lakhs. Further, Solar Edge has also issued certain NCDs to third parties. For further details in relation to outstanding debt and terms of the NCDs issued, see '*Financial Indebtedness*' on page 280.

### *Land*

Solar Edge owns the land on which this project is situated.

### *Evacuation facilities*

As per the Solar Edge PPA, the responsibility of getting connectivity with the transmission system owned by the state transmission utility or central transmission utility or any other utility, as may be required, is with Solar Edge. In relation to the 80 MW AC / 104 MW DC, solar power project at Parli, Maharashtra, in accordance with the terms of the Solar Edge PPA, the power generated from the units is evacuated through 132KV line (11 KM) owned by Solar Edge and operated by MSEDCL connected at Pangari government sub-station (33/132KV). In relation to the 50 MW AC / 65 MW DC solar power project at Mukthainagar, Maharashtra in accordance with the terms of the PPA, the power generated from the unit is evacuated through 132KV line (10 KM) owned by Solar Edge and operated by MSEDCL connected at Mukthainagar government sub-station (33/132KV).

## 2. Terralight Kanji Project

### *Energy Purchase Agreement*

On September 19, 2015, TANGEDCO and Terralight Kanji (previously known as Solar PV) entered into the Terralight Kanji PPA wherein TANGEDCO agreed to procure 30 MW AC power from Terralight Kanji at pre-determined tariff of ₹7.01 per unit, without AD Benefits for the entire term of the agreement i.e. 25 years effective from March 26, 2016.

For further details on the Terralight Kanji PPA, see '*Summary of the Power Purchase Agreements – Energy Purchase Agreement dated September 19, 2015 between Terralight Kanji (previously known as Solar PV) and TANGEDCO*' on page 159.

The following map illustrates the location of the Terralight Kanji Project located in the state of Tamil Nadu:



### *Financing*

As of March 31, 2021, there is no external outstanding debt with respect to Terralight Kanji save for certain NCDs issued to third parties. For further details in relation to terms of the NCDs issued, see '*Financial Indebtedness*' on page 280.

### *Land*

Terralight Kanji owns the land on which this project is situated.

### *Evacuation facilities*

As per the Terralight Kanji PPA, evacuation facilities from the point of generation to the interconnection point including the required metering, protection arrangement, and related other equipment and the entire interface line shall be provided by Terralight Kanji at its cost, as per the applicable regulations. In accordance with the terms of Terralight Kanji PPA, the power generated from the unit is evacuated through 110KV line (5.5 KM) owned by Terralight Kanji and operated by TANGEDCO connected at Kanji government sub-station (11/33/110KV).

### 3. Terralight Rajapalayam Project

#### *Power Purchase Agreement*

On September 27, 2017, TANGEDCO and SPICCL entered into the Rajapalayam PPA wherein TANGEDCO agreed to procure 50 MW AC power from SPICCL at pre-determined tariff of ₹3.47 per unit, for the entire term of the agreement i.e. 25 years effective from September 26, 2018. An addendum to Rajapalayam PPA was executed between SPICCL and TANGEDCO dated October 27, 2020 wherein Rajapalayam PPA was assigned to Terralight Rajapalayam (previously known as SP Suryaprakash).

For further details on the Rajapalayam PPA and addendum agreement, see ‘*Summary of the Power Purchase Agreements – Power Purchase Agreement dated September 27, 2017 between SPICCL and TANGEDCO read with addendum dated October 27, 2020 amongst SPICCL and TANGEDCO pursuant to which the power purchase agreement was assigned to Terralight Rajapalayam (previously known as SP Suryaprakash)*’ on page 160.

The following map illustrates the location of the Terralight Rajapalayam Project located in the state of Tamil Nadu:



#### *Financing*

As of March 31, 2021, there is no external outstanding debt with respect to Terralight Rajapalayam. Terralight Rajapalayam has extended short fall undertaking in connection with Solar Edge Refinancing.

#### *Land*

Terralight Rajapalayam has entered into lease deed for the land on which this project is situated.

#### *Evacuation facilities*

As per the Rajapalayam PPA, evacuation facilities from the point of generation to the interconnection point including the required metering, protection arrangement, and related other equipment and the entire interface line shall be provided by Terralight Rajapalayam at its cost, as per the applicable regulations. In accordance with the terms of Rajapalayam PPA, the power generated from the unit is evacuated through 110KV line (9.9 km) owned

by Terralight Rajapalayam and operated by TANGEDCO connected at Nallamanaickenpatti government sub-station (110/230KV).

#### 4. TN Solar Project

##### *Energy Purchase Agreement*

On March 5, 2015, March 17, 2015, and May 20, 2015, TANGEDCO and TN Solar entered into the TN Solar PPA wherein TANGEDCO agreed to procure 23 MW AC power from TN Solar at pre-determined tariff of ₹7.01 per unit, without AD Benefits for the entire term of the agreement i.e. 25 years effective from November 11, 2015.

For further details on the TN Solar PPA, see '*Summary of the Power Purchase Agreements – Energy Purchase Agreements dated March 5, 2015, March 17, 2015 and May 20, 2015 between TN Solar and TANGEDCO*' on page 161.

The following map illustrates the location of the TN Solar Project located in the state of Tamil Nadu:



##### *Financing*

As of March 31, 2021, there is no external outstanding debt with respect to TN Solar save for certain NCDs issued to third parties. For further details in relation to terms of the NCDs issued, see '*Financial Indebtedness*' on page 280.

##### *Land*

TN Solar owns majority of land and has entered into lease deeds for the remaining portion of land that on which this project is situated.

##### *Evacuation facilities*

As per the TN Solar PPA, evacuation facilities from the point of generation to the interconnection point including the required metering, protection arrangement, and related other equipment and the entire interface line shall be provided by TN Solar at its cost, as per the applicable regulations. In relation to the 5 MW AC/ 6 MW DC solar power project at Dindigul, Tamil Nadu, in accordance with the terms of the TN Solar PPA, the power generated from the unit is evacuated through 11KV line (1.9 km) owned by TN Solar and operated by TANGEDCO connected at Eriyodu government sub-station (11/33/110KV). In relation to the 8MW AC / 9.6 MW DC solar power project at Aruppukkotai, Tamil Nadu, in accordance with the terms of TN Solar PPA, the power generated from the unit to be evacuated through 33KV line (6.5 km) owned by TN Solar and operated by TANGEDCO connected at Muthuramalingapuram government sub-station (33/110KV). Further, in relation to the 10 MW AC / 12 MW DC solar power project at Vilathikulam, Tamil Nadu, in accordance with the terms of TN Solar PPA,

the power generated from the unit is evacuated through 33KV line (7.2 km) owned by TN Solar and operated by TANGEDCO connected at Vilathikulam Government sub-station (33/110KV).

## 5. UMD Project

### *Energy Purchase Agreement*

On March 25, 2015 and May 20, 2015, TANGEDCO and UMD entered into the UMD PPA wherein TANGEDCO agreed to procure 25 MW AC power from UMD at pre-determined tariff of ₹7.01 per unit, without AD Benefits for the entire term of the agreement i.e. 25 years effective from November 16, 2015.

For further details on the UMD PPA, see '**Summary of the Power Purchase Agreements –Energy Purchase Agreements dated March 25, 2015 and May 20, 2015 between UMD and TANGEDCO**' on page 162.

The following map illustrates the location of the UMD Project located in the state of Tamil Nadu:



### *Financing*

As of March 31, 2021, there is external no outstanding debt with respect to UMD save for certain NCDs issued to third parties. For further details in relation to terms of the NCDs issued, see '**Financial Indebtedness**' on page 280.

### *Land*

UMD owns certain portion and has entered into lease deed for the remaining portion of land on which this project is situated.

### *Evacuation facilities*

As per the UMD PPA, evacuation facilities from the point of generation to the interconnection point including the required metering, protection arrangement, and related other equipment and the entire interface line shall be provided by UMD at its cost, as per the applicable regulations. In relation to 12 MW AC/ 14.4 MW DC solar power project at Amattur, Tamil Nadu, in accordance with the terms of UMD PPA, the power generated from the unit is evacuated through 33KV line (5.5 km) owned by UMD and operated by TANGEDCO connected at GN Patti government sub-station (11/33KV). Further in relation to 13MW AC / 15.6 MW DC solar power project at Kovilpatti, Tamil Nadu, in accordance with the terms of UMD PPA, the power generated from the unit is



evacuated through 33KV line (8.75 km) owned by UMD and operated by TANGEDCO connected at M.Duraisampuram Government sub-station (11/33KV).

## 6. PLG Project

### *Power Purchase Agreement*

On May 7, 2010, GUVNL and PLG entered into the PLG PPA wherein GUVNL agreed, effective from January 26, 2012 to procure 20 MW power from PLG at pre-determined tariff of ₹15 per unit for the first 12 years and ₹ 5 per unit for the remaining 13 years. For further details on the PLG PPA, see '**Summary of the Power Purchase Agreements – Power Purchase Agreement dated May 7, 2010 between PLG and GUVNL**' on page 163.

The following map illustrates the location of the PLG Power Project located in the state of Gujarat:



### *Financing*

As of March 31, 2021, the outstanding debt with respect to PLG was ₹ 12,193.94 lakhs. For further details, see '**Financial Indebtedness**' on page 280.

### *Land*

The project is situated over land parcels leased from ZNA Infra Private Limited (earlier known as Zamil New Delhi Infrastructure Private Limited) for a period of 30 years under an irrevocable lease. Further, in terms of the Master Share Purchase Agreement dated October 3, 2020, amended by way of an Amendment cum Supplemental Agreement dated April 19, 2021 entered into amongst Sindicatum Captive Energy Singapore Pte. Limited, Sindicatum Renewable Energy Company Pte. Limited and Sindicatum Renewable Energy India Private Limited, the Sponsor and the Specified SPVs, PLG is in the process of acquiring the entire land where PLG Project is operating. For further details, see '**Risk Factors - Land title in India can be uncertain and there is no assurance that we receive a clean title on the land on which our projects are situated**' on page 36.

### *Evacuation facilities*

In accordance with the terms of PLG PPA, the power generated from the unit is evacuated through 66KV line (0.5 KM) owned and operated by GETCO connected at government sub-station (66/11 KV).

## 7. TSET Project

### *Power Purchase Agreement*

On October 15, 2010, NVVN and TSET (formerly known as Sindicatum Solar Energy Private Limited and AES Solar Energy Private Limited) entered into the TSET PPA wherein NVVN agreed to procure 5 MW power from AES at pre-determined tariff of ₹17.91 per unit, for the entire term of the agreement i.e. 25 years effective from October 15, 2011. Additionally, three supplemental agreements were executed *inter alia* for recording its name change from AES Solar Energy Private Limited to Sindicatum Solar Energy Private Limited and change in registered office and subsequent amendment of relevant information in its articles of association.

For further details on the TSET PPA and supplemental agreements, see '*Summary of the Power Purchase Agreements –Power Purchase Agreement dated October 15, 2010 between TSET and NVVN*' on page 167.

The following map illustrates the location of the TSET Project located in the state of Rajasthan:



### *Financing*

As of March 31, 2021, the outstanding debt with respect to TSET was ₹3,363.15 lakhs. For further details, see '*Financial Indebtedness*' on page 280.

### *Land*

TSET has entered into a lease deed for the land on which this project is situated.

### *Evacuation facilities*

In accordance with the terms of TSET PPA, the power generated from the unit is evacuated through 33KV line (5.5 KM) owned and operated by JDVVNL connected at Tinwari Jodhpur government sub-station (33/132/220 KV).

## 8. TSEC Project

### *Power Purchase Agreement*

On May 29, 2010, GUVNL and TSEC (formerly known as Sindicatum Solar Energy Gujarat Private Limited and AES Solar Energy Gujarat Private Limited) entered into the TSEC PPA wherein GUVNL agreed to procure 15

MW power from AESG at pre-determined tariff as set out in the TSEC PPA and the supplementary agreements. TSEC has entered into supplementary agreements with GUVNL *inter alia* for determination tariff and recording change of name of from AESG to Sindicatum Solar Energy Gujarat Private Limited and subsequent amendment to its articles of association.

For further details on the TSEC PPA, see '*Summary of the Power Purchase Agreements –Power Purchase Agreement dated May 29, 2010 between TSEC and GUVNL*' on page 171.

The following map illustrates the location of the TSEC Project located in the state of Gujarat:



#### *Financing*

As of March 31, 2021, the outstanding debt with respect to TSEC was ₹5,908.35 lakhs. For further details, see '*Financial Indebtedness*' on page 280.

#### *Land*

TSEC has entered into a lease deed for the land on which this project is situated.

#### *Evacuation facilities*

In accordance with the terms of TSEC PPA, the power generated from the unit is evacuated through underground 66KV line (2.2 KM) owned and operated by GETCO connected at Charanka solar park government sub-station (66/132/220 KV).

### **9. USUPL Project**

#### *Power Purchase Agreement*

On April 6, 2015, UPPCL and USUPL entered into the USUPL PPA wherein UPPCL agreed to procure 30 MW power from USUPL at pre-determined tariff of ₹9.33 per unit for the 12 years and from 13th year to 25th year at the tariff as will be determined in accordance with USUPL PPA. UPPCL or USUPL can approach the state commission before the end of 11<sup>th</sup> year for determination of tariff for the remaining 13 years.

For further details on the USUPL PPA, see '*Summary of the Power Purchase Agreements – Power Purchase Agreement dated April 6, 2015 between USUPL and UPPCL*' on page 175.

The following map illustrates the location of the USUPL Project located in the state of Uttar Pradesh:



#### *Financing*

As of March 31, 2021, the outstanding debt with respect to USUPL was ₹13,732.43 lakhs. For further details, see '**Financial Indebtedness**' on page 280.

#### *Land*

USUPL owns the land on which this project is situated.

#### *Evacuation facilities*

In accordance with the terms of USUPL PPA, the power generated from the unit is evacuated through 132KV line (12 KM) owned and operated by UPPCL connected at Panwari government sub-station.

#### **Operation and Maintenance Services**

Our key operational activity will be the operation and maintenance of the renewable energy assets pursuant to, and in accordance with, the provisions of the PPAs, as applicable. The Project SPVs are required to operate and maintain the Terra InvIT Assets in accordance with the PPAs. In particular, each of the PPAs require the Project SPV to maintain Terra InvIT Assets in accordance with certain standards during its operation period.

Within the scope of such operation and maintenance obligations, the Project SPV may be required to undertake routine and periodic maintenance for, amongst others, evacuation of solar power generated, adequate filtering mechanism to limit the harmonics, minimising drawal of reactive power, automatic safety devices. After the completion of the Formation Transactions, the activities of the Project SPVs will be managed and supervised by the Project Manager pursuant to the Project Management Agreement.

The Project Manager shall manage the critical day-to-day operation and maintenance of the Terra InvIT Assets. The Project Manager, through the Project Management Agreement, undertakes to (i) provide operations and management support, either directly or through the appointment and supervision of agents and/or contractors; (ii) oversee the progress of development, approval status and other aspects of any expansion of the projects, or, of any new project proposed to be executed by the Project SPVs. For details in relation to the Project Manager and the Project Management Agreement, see '**Parties to the Terra InvIT – Project Manager**' on page 206.

In furtherance of its duties and obligations as a project manager under the SEBI InvIT Regulations, the Project Manager and our Asset SPVs have entered into O&M Agreements with O&M Contractors in order to set out the terms for operation and maintenance of the Terra InvIT Assets. The O&M Contractors have agreed to perform certain specified services for the operation and maintenance of the Terra InvIT Assets in accordance with specified operating standards and specifications, including health, safety, and environment standards. The O&M Contractors are responsible for operations, maintenance and other services for the Terra InvIT Assets required for a period of 5 years for Project SPVs and 3 years for the Specified SPVs. The scope of the O&M arrangement includes amongst other things, (i) submission daily, monthly, quarterly and annual reports on the performance of the solar power project to the respective Project SPVs; (ii) periodic cleaning of the PV modules and housekeeping services and project upkeep; (iii) civil and mechanical maintenance within the premises of the solar power project; (iv) providing security services at the solar power project; (v) co-coordinating with the QCA, the SLDC, distribution licensees and other government authorities for load forecasting and for carrying out joint meter reading, as applicable; (vi) providing and maintaining all tools, tackles and equipment, including safety and personal protection equipment required for providing its services; and (vii) deploying sufficient manpower at all times to ensure the performance of its services.

The O&M Contractors are entitled to fixed annual contract sum for the performance of its respective obligations which are payable in quarterly installments and are subject to escalation upto 5% as per the terms of the O&M Agreements. Certain O&M Contractors have also provided appropriate performance security in form of unconditional and irrevocable performance bank guarantees or retention amounts for securing the due performance of its obligations under the O&M Agreements. Further, the O&M Contractors are entitled to engage sub-contractors to provide the services under the O&M Agreements, subject to prior written consent by the Project SPVs. Pursuant to consummation of the Formation Transaction, the O&M Contractors shall be supervised by the Project Manager.

## **Employees**

Our employees contribute significantly to the business operations of the Asset SPVs. As of April 30, 2021, the Asset SPVs, Project Manager and Investment Manager had an aggregate of 43 employees in various departments including administration, finance, human resources, legal and compliance, operations and technology. In addition, we along with our Project Manager, as part of O&M Agreement, have arrangements with the O&M Contractors for the supply of manpower at the premises of certain of our Project SPVs for complete operation and maintenance of the Terra InvIT Assets on a 24x7x365 basis during the term of the O&M Agreements. The number of personnel deployed on this basis varies from time to time based on the nature and extent of work contracted.

Our human resource department continuously focuses on employee engagement and motivation, which further helps in achieving the strategic objectives of the organisation. Our human resource practices are aimed at recruiting talented individuals, ensuring continuous development and addressing their grievances, if any, in a timely manner. The employees at the Investment Manager are provided with insurance benefits such as group mediclaim policy and group personal accident policy. Further, the retirement benefits provided to employees include the provident fund scheme, gratuity and national pension scheme. Apart from this, benefits such as annual health care checkup and reimbursement of telephone expenses are provided to the employees of the Investment Manager.

## **Health, safety and environment**

We believe that we are in compliance, in all material respects, with applicable central, state and local statutory requirements concerning health, safety and environment and social sustainability and other requirements in their operations in the jurisdictions in which we operate.

Additionally, in order to integrate our health and environment safety performance into the overall business plan and strategy, we have adopted the health, safety and environment policy (“**HSE Policy**”), dated October 1, 2020, and as amended from time to time. The HSE Policy lays down various objectives to embrace highest standards of health and environmental safety in our workplaces. The health and safety objectives include, amongst others, to continuously strive towards prevention of accidents, injuries and occupational illnesses at all our sites and offices, to lay down procedures to be followed in the case of mishaps and to put in place health and safety metrics in order to monitor progress and continually improve performance. The environment safety objectives include, amongst others, to ensure minimal impact on the environment and take necessary steps to reduce carbon footprint, to control usage and dispose of pollutants by good environmental management practices and to create awareness and enhance skill and competency of our employees, through participation and consultation, to enable them to demonstrate involvement, responsibility and accountability towards protection of environment.

Further, the HSE Policy ensures the availability of appropriate resources at all times to fully implement and communicate the policy to all stakeholders and provides for reporting of incidents and escalation of the matter, if not resolved in a timely manner. Additionally, the HSE Policy ensures adequate protection against retaliation for individuals who make good faith report of inappropriate conduct.

### **Corporate Governance Structure and Framework**

For details in relation to the corporate governance structure and framework, see '*Corporate Governance*' on page 180.

### **IT Infrastructure**

Information technology has emerged as a key business enabler and our comprehensive information technology infrastructure plays an important role in improving our relationship with our employees, contractors and external users. The primary business functions in our information technology infrastructure include operations and maintenance (power generation, asset management and contract monitoring system), procurement and contracts (supply chain management, land and asset leasing and O&M contracts), environment and safety compliance and liaisons with Discoms. The support functions performed by our IT infrastructure include, amongst others, accounting, billing and collections, human resource operations, learning and development, monitoring for policy compliances, intellectual property protection and documents storage management. Further, we intend to enhance our information technology infrastructure by setting up a computerised maintenance management system to ensure that the operations of Terra InvIT Assets are systematically and correctly scheduled, carried out and recorded.

### **Property**

Our projects are located on freehold lands, except some of our projects which are located on leased land and for which we have entered into lease and possession agreements with the landowners, for developing, installing, commissioning, operating and maintaining a solar power project.

With respect to our power projects in the state of Tamil Nadu, the terms of our lease and possession agreements are generally for 26 years and contain common termination provisions which provides for expiry of the lease period or the termination on expiry of the energy/power purchase agreement entered into between the relevant Project SPV and TANGEDCO. The lease rentals under such agreements are generally paid in advance on an annual basis. With respect to the TSET Project, the land was allotted on leasehold basis under the Rajasthan Land Revenue (Allotment of Land for Setting up of Power Plant based on Renewable Energy Sources) Rules, 2007 for a period of 30 years with the option to renew the lease for a further period of 10 years after the expiry of the present term. The annual rent is subject to revision after every ten years. In relation to the TSEC Project, the land was allotted by Gujarat Power Corporation Limited, as part of its functions to facilitate setting up of power projects within the state of Gujarat for a period of 30 years with the option to renew the lease for a further period of 30 years. The rent is required to be paid on an annual basis. In relation to PLG Project, the lease deed for the land is valid for a period of 30 years and the parties have the option to renew the lease deed after the expiry of its term for such further period and on such terms and conditions as may be mutually agreed between the parties. Further, PLG is required to pay annual rent and rent is subject to revision after 5 years. Further, in terms of the Master Share Purchase Agreement dated October 3, 2020, amended by way of an Amendment cum Supplemental Agreement dated April 19, 2021 entered into amongst Sindicatum Captive Energy Singapore Pte. Limited, Sindicatum Renewable Energy Company Pte. Limited and Sindicatum Renewable Energy India Private Limited, the Sponsor and the Specified SPVs, PLG is in the process of acquiring the entire land where PLG Project is operating. For further details, see '*Risk Factors - Land title in India can be uncertain and there is no assurance that we receive a clean title on the land on which our projects are situated*' on page 36.

### **Seasonality**

Operating results for renewable energy projects vary significantly depending on natural variations from season to season and from year to year and may also change permanently because of climate change or other factors. The power generation in the renewable energy projects are dependent upon various seasonal factors and natural calamities. Renewable power generation is highly dependent on weather conditions and the profitability of our operations depends not only on observed weather conditions at the project site but also on the consistency of those weather conditions. The shorter daylight hours during the winter months will reduce the irradiation and consequently will have an adverse impact on the power generation through solar power projects. Additionally, our Terra InvIT Assets may be affected by the monsoon season. While the northern and western parts of India

experience monsoon rains during the period from June or July until September every year, the southern parts of India, experience monsoon rains even during the months of October to December.

The monsoon and winter seasons and threat of natural calamities such as cyclone may affect power generation and infrastructure of power projects. This may result in delays in periodic maintenance and reduce productivity, thereby adversely affect our business, financial condition and results of operations. For further details on the risk associated with seasonality, see '*Risk Factors – Our business will be subject to seasonal fluctuations and natural calamities that could have a material adverse effect on our business, financial condition and results of operations.*' on page 22.

## **Insurance**

The Asset SPVs' operations are subject to hazards inherent in operating solar power projects and other renewable energy projects, such as risk of third party bodily injury or property damage arising from solar power project operations, injury to an employee resulting from an accident or occupational disease, risk of damage to property from perils such as earthquake, floods, cyclone and fire, business interruption and third party liability from cyber related event, and theft or fraud by any employee or third party. The Asset SPVs' principal types of insurance coverage typically include industrial all risk policy, burglary and standalone terrorism policy. Further, certain PPAs require the Asset SPVs to effect and maintain insurances against such risks which prudent utility practises would ordinarily merit maintenance of and as required under the relevant agreements and applicable laws. The Investment Manager and the Trustee confirm that such insurances have been effected and maintained in accordance with the PPAs and are valid as on date. Further, the Investment Manager and the Trustee confirm that the amount of insurance that we presently maintain represents an appropriate level of coverage required to insure the Asset SPVs' business and operations and all the infrastructure assets held by the Asset SPVs, and is in accordance with industry standards in India and will perform regular assessment on the adequacy of its insurance coverage on a regular basis.

## **Competition**

Our primary competitors may include domestic and foreign operators and investors which intend to invest in the renewable energy industry in India, who may have different levels of access to financial, operational, marketing, personnel and other resources than us. We may compete on a number of factors, including the sourcing of renewable energy opportunities, reputation and track record, relationship with government authorities, access to low cost capital and control over quality, access to project land, efficiency and reliability in project operations.

Competitive conditions may be substantially affected by various forms of energy legislation and regulations. Such laws and regulations may substantially increase the costs of acquiring and operating projects.

## SUMMARY OF POWER PURCHASE AGREEMENTS

*Set out below are summaries of the power purchase agreements entered into by the Asset SPVs in relation to their respective businesses. The descriptions and summaries of the agreements below are indicative and are not and nor do they purport to be complete descriptions or summaries of all terms of such agreements. Certain terms used in this section have the meaning as assigned to such terms in the respective power purchase agreements. Copies of these power purchase agreements have been made available for inspection at the office of the Terra InvIT at Mumbai. For further details, please see 'Material Contracts and Documents for Inspection' on page 320.*

### 1. Power Purchase Agreements, all dated February 10, 2017 between Solar Edge and SECI

Power purchase agreements, all dated February 10, 2017 have been executed between Solar Edge and SECI wherein SECI agreed to procure power from Solar Edge up to 30 MW (AC) from solar power generation facility located at Village Mhatargaon, Tehsil Dharur, District Beed, Maharashtra, India, up to 50 MW (AC) from solar power generation facility located at Village Mhatargaon, Tehsil Dharur, District Beed, Maharashtra, India and up to 50 MW (AC) from solar power generation facility located at Village Mauje Wadhawe, Tehsil Muktainagar, District Jalgaon, Maharashtra, India at pre-determined tariff of ₹4.43/kWh for the entire term of the agreement effective from COD (“**Solar Edge PPA**”).

**COD:** The date 30 days subsequent to the actual date of commissioning of full capacity of the project as declared by SECI. The declaration of commercial operation dated August 1, 2018 issued by SECI, declared commercial operation date of 30 MW (AC) solar power project (Beed) of Solar Edge on April 22, 2018. The declaration of commercial operation dated August 1, 2018 issued by SECI, declared commercial operation date of 50 MW (AC) solar power project (Beed) of Solar Edge on April 8, 2018. The declaration of commercial operation dated August 1, 2018 issued by SECI, declared commercial operation date of 50 MW (AC) solar power project (Jalgaon) of Solar Edge on April 26, 2018.

**Scheduled Commissioning Date:** In relation to Solar Edge PPA, December 23, 2017, SECI extended the scheduled commissioning date of the project vide its letter dated January 3, 2019 on account of the disruptions faced by the projects due to implementation of GST in the state of Maharashtra.

**Term of Agreement:** The Solar Edge PPA shall come into effect from December 23, 2016 and shall be valid for a term from the effective date until the Solar Edge Expiry Date. It may be extended for a further period, at least 180 days prior to the Solar Edge Expiry Date on agreed terms and conditions between Solar Edge, SECI and the Buying Utilities. Solar Edge is free to operate their projects beyond the Solar Edge Expiry Date if other conditions like land lease, permits, approvals and clearances etc., allow.

Further, Solar Edge PPA shall be terminated early before Solar Edge Expiry Date if either SECI or Solar Edge terminates pursuant to the terms specified.

#### **Construction and Development of the Project:**

**Solar Edge's Obligation:** Solar Edge undertakes to be responsible, at their own cost and risk, for certain activities including the following:

- (a) obtaining all consents, clearances and permits and maintaining all consents, clearances and permits in full force and effect during the Term of Agreement;
- (b) owing the Power Project throughout the Term of Agreement free and clear of encumbrances, except those expressly permitted.

Further, Solar Edge PPA contains provisions with respect to interconnection facilities.

**Purchase and sale of Contracted Capacity:** Subject to the terms and conditions of the Solar Edge PPA, Solar Edge undertakes to sell to SECI and SECI undertakes to pay tariff for all the energy supplied at the delivery point corresponding to the Solar Edge Contracted Capacity.

**Applicable Tariff:** Solar Edge shall be entitled to tariff of ₹4.43/kWh fixed for the entire term of Solar Edge PPA, with effect from the COD, subject to certain conditions. Change in tariff due to delay with respect to commissioning and sale of excess generation of power shall be as specified in Solar Edge PPA.

**Billing and Payment:** Subject to funds being made available by Ministry of New and Renewable Energy, SECI



shall set up a payment security mechanism in order to ensure timely payment to Solar Edge. This fund will have a corpus to cover three months payment. From the commencement of supply of power, SECI shall pay to Solar Edge the monthly Tariff payments subject to the adjustments, such as deductions required by law and amount set off, as per provisions of Solar Edge PPA.

**Right to Contracted Capacity and Energy:** For 30 MW (AC) (Beed) project, SECI, at any time during a contract year, shall not be obliged to purchase any additional energy from Solar Edge beyond 66.488 million kWh (MU). If for any contract year, it is found that Solar Edge has not been able to generate minimum energy of 51.377 million kWh (MU) till the end of 10 years from the COD and 48.355 million kWh (MU) for the rest of the term, on account of reasons solely attributable to Solar Edge, the non-compliance shall make Solar Edge liable to pay the compensation provided in the power sale agreement as payable to Buying Utilities, subject to certain conditions specified.

For 50 MW (AC) (Beed) project and 50 MW(AC) (Jalgaon) project, SECI, at any time during a contract year, shall not be obliged to purchase any additional energy from Solar Edge beyond 110.814 million kWh (MU). If for any contract year, it is found that Solar Edge has not been able to generate minimum energy of 85.629 million kWh (MU) till the end of 10 years from the COD and 80.592 million kWh (MU) for the rest of the term, on account of reasons solely attributable to Solar Edge, the non-compliance shall make Solar Edge liable to pay the compensation provided in the power sale agreement as payable to Buying Utilities, subject to certain conditions specified.

Further, any excess generation over and above the specified quantity will be purchased by SECI at a tariff specified, provided that SECI is able to get buyer for such excess generation. Solar Edge will not be allowed to sell any excess power to any other entity other than SECI (unless refused by SECI).

Additionally, prior to synchronization, Solar Edge shall be required to get the Solar Edge Project certified for the requisite acceptance/performance test. Further, Solar Edge shall be required to provide entry at all times during term of agreement to third party nominated by SECI for inspection and verification of the works being carried out.

**Dispatch and Scheduling:** Solar Edge shall be required to schedule its power as per the applicable regulations, issued by the relevant authorities from time to time. Any deviation will attract the provision of applicable regulation and any financial implication on account of this shall be on the account of Solar Edge.

**Metering:** Installation of meters, meter testing, meter calibration and meter reading shall follow the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006 and grid code, as revised from time to time. Further, Solar Edge shall bear all costs pertaining to meters at Solar Edge's side of delivery point. Reporting of metered data and parameters for the same are also specified in the Solar Edge PPA.

**Insurances:** Solar Edge shall effect and maintain or cause to be effected and maintained, at its own cost and expense, throughout the term of agreement, insurances against such risks, with such deductibles and with such endorsements and co-insured(s), which the prudent utility practices would ordinarily merit maintenance of and as required under the financing agreements and VGF Securitization Agreement and under applicable laws. Application of insurance proceeds and effect on liability of SECI shall be as specified in Solar Edge PPA.

#### **Events of Default and Termination:**

**Solar Edge Event of Default:** The occurrence and/ or continuation of any of the events, subject to VGF Securitization Agreement or/ and following events, unless any event occurs as a result of a Force Majeure event or breach by SECI or Buying Utilities of its obligation under Solar Edge PPA, shall constitute event of default for Solar Edge ("**Solar Edge Event of Default**"):

- (a) the failure to commence supply of power to SECI up to the Solar Edge Contracted Capacity, by the end of the period specified in Solar Edge PPA;
- (b) Solar Edge mortgages or charges or purports to assign, mortgage or charge any of its assets or rights related to the Solar Edge Project in contravention of Solar Edge PPA or VGF Securitization Agreement or Solar Edge transfers or novates any of its rights and/ or obligations under Solar Edge PPA in a manner contrary to the provisions of Solar Edge PPA and VGF Securitization Agreement, except in certain specified situations;
- (c) Solar Edge becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding

up proceedings and such proceedings remain uncontested for a period of 30 days or any winding up or bankruptcy or insolvency order is passed against Solar Edge or Solar Edge goes into liquidation or dissolution or has a receiver appointed to manage its affairs, provided that a dissolution or liquidation of Solar Edge will not be Solar Edge Event of Default if such dissolution or liquidation is for the purpose of a merger, consolidation or reorganisation and where the resulting company retains creditworthiness similar to Solar Edge and expressly assumes all obligations of Solar Edge under Solar Edge PPA and is in a position to perform them;

- (d) Solar Edge repudiates Solar Edge PPA and does not rectify such breach within a period of 30 days from a notice from SECI in this regard;
- (e) change in controlling shareholding before the specified time frame as mentioned in Solar Edge PPA;
- (f) Occurrence of any other event which is specified in Solar Edge PPA to be a material breach/ default of Solar Edge.

*SECI Event of Default:* The occurrence and/ or continuation of any of the following events unless any such event occurs a result of a Force Majeure or a breach by Solar Edge of its obligations under Solar Edge PPA shall constitute event of default for SECI (“**SECI Event of Default**”):

- (a) SECI fails to pay monthly bill or supplementary bill, subject to certain specified conditions, for a period of 90 days after the due date and Solar Edge is unable to recover the amount outstanding to Solar Edge through letter of credit/ default escrow account;
- (b) SECI repudiates Solar Edge PPA and does not rectify such breach even within a period of 30 days from a notice from Solar Edge in this regard;
- (c) except where due to any Solar Edge failure to comply with its obligations, SECI is in material breach of any of its obligations pursuant to Solar Edge PPA, and such material breach is not rectified within 30 days of receipt of notice in this regard from Solar Edge to SECI;
- (d) SECI becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding up proceedings and such proceedings remain uncontested for a period of 30 days or any winding up or bankruptcy or insolvency order is passed against SECI or SECI goes into liquidation or dissolution or a receiver or any similar officer is appointed over all or substantially all of its assets or official liquidator is appointed to manage its affairs pursuant to law provided that it shall not constitute an SECI Event of Default where such dissolution or liquidation of SECI is for the purpose of a merger, consolidation or reorganisation where the resulting entity has the financial standing to perform its obligations under Solar Edge PPA and has creditworthiness similar to SECI and expressly assumes all obligations of SECI and is in a position to perform them;
- (e) if Buying Utilities are subject to any of the above defaults and SECI does not designate another or other Buying Utilities for purchase of power;
- (f) occurrence of any other events which is specified in Solar Edge PPA to be a material breach or default of SECI.

*Procedure in cases of Solar Edge Event of Default:* Upon the occurrence and continuation of any Solar Edge Event of Default, SECI shall have the right to deliver to Solar Edge, with a copy to the representative of the lenders to Solar Edge with whom Solar Edge has executed Financing Agreements, a notice stating its intention to terminate Solar Edge PPA which shall specify in reasonable details, the circumstances giving rise to the issue of such notice. Within a period of seven days following the consultation period of 60 days unless the parties have otherwise agreed to the contrary or the Solar Edge Event of Default giving rise to the consultation period shall have ceased to exist or shall have been remedied, SECI may terminate Solar Edge PPA by giving a written termination notice of 30 days to Solar Edge. The lenders in consultation with SECI may exercise their rights, if any, under Financing Agreements, to seek substitutions of Solar Edge by a selectee for the residual period of Solar Edge PPA in the manner specified.

*Procedure in cases of SECI Event of Default:* Upon the occurrence and continuation of any SECI Event of Default, Solar Edge shall have the right to preliminary deliver to SECI default notice which notice shall specify in reasonable detail the circumstances giving rise to its issue.

Following the issue preliminary default notice, the consultation period of 60 days or such longer period as the parties may agree, shall apply and it shall be the responsibility of the parties to discuss as to what steps shall be taken with a view to mitigate the consequences of the relevant event of default having regard to all the circumstances. During the consultation period, the parties shall continue to perform their respective obligations under Solar Edge PPA. After a period of seven days following the expiry of the consultation period and unless the parties shall have otherwise agreed to the contrary or SECI Event of Default giving rise to the consultation period shall have ceased to exist or shall have been remedied, Solar Edge shall be free to sell the Contracted Capacity to any third party of Solar Edge's choice.

Provided further that at the end of 3 months period from this period, Solar Edge PPA may be terminated by Solar Edge.

**Termination due to Force Majeure:** If force majeure event or its effects continue to be present beyond the period as specified, either party shall have the right to cause termination of Solar Edge PPA. In such an event, Solar Edge PPA shall terminate on the date of such termination notice.

**Indemnity:** Solar Edge shall indemnify, defend and hold SECI harmless against:

- (a) any and all third party claims against SECI for any loss of or damage to property of such third party or death or injury to such third party arising out of a breach by Solar Edge of any of its obligations under Solar Edge PPA; and
- (b) any and all losses, damages, costs and expenses including legal costs, fines, penalties and interest actually suffered or incurred by SECI from third party claims arising by reason of a breach by Solar Edge of any of its obligations under Solar Edge PPA, subject to certain conditions;

SECI shall cause the Buying Utilities to indemnify, defend and hold Solar Edge harmless against:

- (a) any and all third party claims against Solar Edge for any loss of or damage to property of such third party or death or injury to such third party arising out of a breach by Buying Utilities of any of its obligations under Solar Edge PPA and;
- (b) any and all losses, damages, costs and expenses including legal costs, fines, penalties and interests actually suffered or incurred by Solar Edge from third party claims by reason of a breach of Buying Utilities of any its obligations. SECI shall incorporate appropriate covenants in the PSAs for the above obligations of Buying Utilities. In so far as indemnity to Solar Edge is concerned, Buying Utilities shall be the indemnifying party and not SECI.

Further, the non-payment of losses shall constitute an event of default under Solar Edge PPA.

Additionally, except as provided above, neither Solar Edge nor Buying Utilities shall be responsible for any damages.

**Assignment and Charges:** Solar Edge PPA shall not be assigned by any party other than by mutual consent between the parties to be evidenced in writing. In the event of change in shareholding/ substitution of promoters triggered by the financial institutions leading to signing of fresh power purchase agreement with new entity, an amount of ₹10 lakh per transaction as facilitation fee (non-refundable) shall be deposited by Solar Edge to SECI.

Further, Solar Edge shall not create or permit to subsist any encumbrance over all or any of its rights and benefits under Solar Edge PPA other than permitted under Solar Edge PPA, the NSM guidelines and the VGF Securitization Agreement.

#### **1.1 VGF Securitization Agreements, all dated February 10, 2017 between Solar Edge and SECI**

VGF Securitization Agreements, all dated February 10, 2017 have been executed between Solar Edge and SECI with respect to the Solar Edge Project. For 30 MW (AC) (Beed), the VGF Securitization Agreement stipulates that pursuant to the issuance of letter of intent and signing of Solar Edge PPA and upon successful commissioning of the Project, Solar Edge would be eligible to receive VGF support amounting to maximum ₹5,70,00,000/- which shall be released by SECI. For 50 MW (AC) (Beed) and 50 MW (AC) (Jalgaon), VGF Securitization Agreement stipulates that pursuant to the issuance of letter of intent and signing of Solar Edge PPA and upon successful commissioning of the Project, Solar Edge would be eligible to receive VGF support amounting to maximum ₹9,50,00,000/- each which shall be released by SECI for each project. 100% of the indicated VGF amount will be

released on submission of bank guarantee of an amount as specified in the VGF Securitization Agreement in the manner prescribed. The entire VGF amount for all three projects was disbursed to Solar Edge on fulfilling the conditions specified.

Further, the conditions to be fulfilled for disbursement of VGF include:

- (a) Declaration of COD of the full capacity of the project;
- (b) Creation of charge as prescribed, including registration of the same with the registrar of companies;
- (c) Furnish financing documents to SECI;
- (d) Demonstration/infusion of cumulative capital in the form of equity for an amount of at least ₹1.00 crores/ MW;
- (e) Obtain all consents, clearances and permits for operation and supply of power to SECI.

The creation of charge to securitise VGF shall be in the manner prescribed which includes:

- (a) Lending institutions (if any) will have first charge on the project assets and Solar Edge shall create second charge (along with the first charge of lending institutions) on the same project assets by way of mortgage and hypothecation in favor of SECI;
- (b) In the absence of any charge in favor of lending institution, SECI will have first charge on the project assets;
- (c) Mortgage and hypothecation and all other securities/ charges shall rank the charges created/ to be created in favor of SECI subordinate to lending institutions;
- (d) Solar Edge shall make out a good title to its immovable properties and comply with all such formalities as may be necessary for the said purposes.

The VGF Securitization Agreement stipulates certain events of default which includes:

- (a) Project fails to generate power continuously for one year;
- (b) Project is dismantled and/ or its major assets are sold by Solar Edge except as specified;
- (c) Solar Edge misrepresented facts/ information to meet eligibility conditions stipulated;
- (d) Solar Edge defaults in any terms of the loan documents and lender takes steps for recovery including winding up of Solar Edge;
- (e) Any voluntary or involuntary bankruptcy or insolvency proceedings against Solar Edge or Solar Edge goes into liquidation or has receiver appointed to manage its affairs;
- (f) Except as permitted, Solar Edge fails to maintain its controlling shareholding up to a period of one year after COD;
- (g) Any attachment or distraint is levied on the mortgaged/ charged property and or/ proceedings are taken for recovery of any dues from Solar Edge;
- (h) Solar Edge fails to comply with the applicable law in relation to the Project and such non-compliance results in revocation of any consent or approval obtained in relation to the Project;

In cases of such events of default, SECI shall have the right to refund of VGF and if not paid by Solar Edge, then a claim on the Project assets equal to the value of VGF released on pro-rata basis as specified. Further, in case the lending institution exercises its right to take over the Solar Edge Project, SECI will also have right to step in along with lending institutions to reclaim VGF or handover the Solar Edge Project to another party in the manner prescribed.

Upon the occurrence of event of default and continuation for a period of 30 days, SECI with the consent of lending institutions, shall have the right to deliver a notice, in the manner specified, stating its intention to terminate the

agreement. Within a period of seven days following the consultation period, unless parties have otherwise agreed to contrary or event of default has been remedied, SECI may terminate the agreement by giving written notice of 30 days to Solar Edge.

Further, upon the occurrence of event of default, SECI will declare a percentage of the amount of VGF released to Solar Edge as prescribed and the same shall become due and payable to SECI by Solar Edge within the period prescribed. Upon failure of Solar Edge to pay the entire declared amount, SECI shall enforce the charge created for the entire amount so declared. The VGF amount to be released by SECI, if any, shall automatically stand cancelled.

The VGF Securitization Agreement shall be co-terminus with Solar Edge PPA.

## **2. Energy Purchase Agreement dated September 19, 2015 between Terralight Kanji (previously known as Solar PV) and TANGEDCO**

An energy purchase agreement dated September 19, 2015 has been executed between Terralight Kanji (previously known as Solar PV) and TANGEDCO wherein TANGEDCO agreed to buy solar energy from Terralight Kanji generated from its 30 MW (AC) solar power project at Aliyandhal Village, Tiruvannamalai District, Tamil Nadu, India at tariff of ₹7.01 per unit, without AD benefits (“**Terralight Kanji PPA**”).

**Date of Commercial Operation:** Means COD as defined in 2(m) of the Tamil Nadu Electricity Regulatory Commission (Terms and Conditions for the Determination of Tariff) Regulations, 2005. The commissioning certificate dated March 29, 2016 issued by TANGEDCO, certified successful commission of 30 MW (AC) solar power project of Terralight Kanji on March 26, 2016.

**Interfacing and Evacuation Facilities:** Terralight Kanji PPA requires compliance with the relevant provisions contained in the Indian Electricity Grid Code, Tamil Nadu Electricity Grid Code, the Electricity Act, 2003 and other codes and regulations issued by the Tamil Nadu Electricity Regulatory Commission or Central Electricity Authority, as amended from time to time.

**Operation and Maintenance:** Terralight Kanji PPA specifies certain operation and maintenance conditions amongst others, with respect to evacuation of solar power generated, adequate filtering mechanism to limit the harmonics, minimise drawal of reactive power, suitable automatic safety devices.

**Metering Arrangements:** Terralight Kanji PPA requires compliance with certain metering arrangements, including accordance with the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006, Commission’s Grid Connectivity and Intra State Open Access Regulations, 2014, Tamil Nadu Electricity Distribution Code, 2004 and the Tamil Nadu Grid Code.

**Tariff and other charges:** The solar power tariff for Terralight Kanji commissioned during the control period of Order No. 7 of 2014, dated September 12, 2014 shall be of ₹7.01 per unit without AD benefit. Further, the reactive power charges shall be specified in the order on Open Access by the Commission, as amended from time to time. Additionally, in drawal of energy by Terralight Kanji from TANGEDCO shall be adjusted against the exported energy and in case drawal of power is in excess over the exported power in a month, such excess drawal shall be billed under applicable temporary supply tariff as per the Commission’s Tariff Order, as amended from time to time.

**Billing and payment:** Terralight Kanji shall raise a monthly bill along with supporting documents every month to TANGEDCO for the net energy sold/ exported. TANGEDCO shall make payment to Terralight Kanji for the solar energy purchased/ exported within 60 days from the date following the date of receipt of the bill. Any delay beyond sixty days shall attract interest at the rate of 1% per month. Further, stand-by letter of credit shall be opened by TANGEDCO for an estimated value of one month bill, which shall be valid for a period up to one year.

**Assignment:** Terralight Kanji PPA shall not be assigned by any party other than by mutual consent between the parties to be evidenced in writing.

**Term of Agreement:** Terralight Kanji PPA shall come into effect from Terralight Kanji Effective Date i.e. September 19, 2015. The actual period of sale/purchase of power by TANGEDCO shall be valid for 25 years subject to COD and Terralight Kanji Expiry Date. Further, parties to the agreement shall have the option to terminate the agreement for violation of any of the clauses of the agreement after serving a notice of three months to the other party.

**CDM:** The CDM benefits accrued shall be shared between the parties on gross basis starting from 100% to Terralight Kanji in the first year and thereafter reducing by 10% every year till the sharing becomes equal between Terralight Kanji and TANGEDCO in the sixth year. Thereafter, the sharing of CDM benefits shall remain equal till such time the benefits accrue, provided that sharing shall take place only after actual receipt of benefit by Terralight Kanji.

**Force Majeure:** No party shall be liable for any claim for any loss or damage whatsoever arising out of failure to carry out the terms of Terralight Kanji PPA to the extent that such failure is due to force majeure events, as defined in Terralight Kanji PPA. Any party claiming the benefit of force majeure shall satisfy the other party of the existence of such events by giving notice to the other party in writing within 15 days from the occurrence of such event.

**3. Power Purchase Agreement dated September 27, 2017 between SPICCP and TANGEDCO read with addendum dated October 27, 2020 amongst SPICCP and TANGEDCO pursuant to which the power purchase agreement was assigned to Terralight Rajapalayam (formerly known as SP Suryaprakash).**

A power purchase agreement dated September 27, 2017 has been executed between SPICCP and TANGEDCO wherein TANGEDCO agreed to buy solar energy from SPICCP generated from its 50 MW (AC) solar power project at Thenkarai Village, Rajapalayam Taluk, Virudhunagar District, Tamil Nadu, India at a tariff ₹3.47 per unit for period of 25 years from the Commercial Operation Date and pursuant to addendum agreement dated October 27, 2020, the power purchase agreement was assigned to Terralight Rajapalayam (“**Terralight Rajapalayam PPA**”). As per the addendum, wherever the expression ‘SPICCP’ occur in the power purchase agreement, the expression ‘SP Suryaprakash’ shall be substituted (which is currently known as Terralight Rajapalayam).

**Interfacing and Evacuation Facilities:** Terralight Rajapalayam PPA requires compliance with the relevant provisions contained in the Indian Electricity Grid Code, Tamil Nadu Electricity Grid Code, the Electricity Act, 2003 and other codes and regulations issued by the Tamil Nadu Electricity Regulatory Commission or Central Electricity Authority, as amended from time to time.

**Operation and Maintenance:** Terralight Rajapalayam PPA specifies certain operation and maintenance conditions amongst others, with respect to evacuation of solar power generated, adequate filtering mechanism to limit the harmonics, minimise drawal of reactive power, suitable automatic safety devices.

**Metering Arrangements:** Terralight Rajapalayam PPA requires compliance with certain metering arrangements, including accordance with the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006, Commission’s Grid Connectivity and Intra State Open Access Regulations, 2014, Tamil Nadu Electricity Distribution Code, 2004 and the Tamil Nadu Grid Code.

**Tariff and other charges:** The solar power tariff of ₹3.47 per unit shall be applicable for Terralight Rajapalayam for the agreement period of 25 years from COD. Further, the reactive power charges shall be specified in the order on Open Access by the Commission, as amended from time to time. Additionally, in drawal of energy by Terralight Rajapalayam from TANGEDCO shall be adjusted against the exported energy and in case drawal of power is in excess over the exported power in a month, such excess drawal shall be billed as per the Commission’s Tariff Order, in force.

**CUF:** The CUF shall be 17% to 19% calculated on yearly basis. In case the availability is more than the maximum CUF, TANGEDCO will purchase the excess generation at average pooled purchase cost or the Terralight Rajapalayam PPA tariff or the applicable preferential tariff, whichever is less. In case the availability is less than the minimum CUF, Terralight Rajapalayam shall pay TANGEDCO for the actual shortfall in terms specified.

**Billing and payment:** The due date for payment of energy bill will be 60 days from the date of receipt of bill from generator. TANGEDCO shall provide unconditional revolving and irrevocable letter of credit which shall be drawn upon by Terralight Rajapalayam, on non-payment.

**Termination Compensation:** TANGEDCO and Terralight Rajapalayam are restricted from unilateral termination or amendment of Terralight Rajapalayam PPA. There shall be termination compensation for following scenarios:

- (a) *Termination of Rajapalayam PPA solely attributable to Terralight Rajapalayam* – TANGEDCO shall not be liable to pay any termination compensation. The lenders may take over the project and manage it or bring in new promoters. Save as otherwise provided in the applicable guidelines, Terralight

Rajapalayam cannot terminate Terralight Rajapalayam PPA to supply power to third party.

- (b) *For all other cases* – Save as otherwise excluded, balance debt or actual debt, whichever is less, minus insurance coverage on the project shall be provided by TANGEDCO to Terralight Rajapalayam. The project shall be handed over to TANGEDCO. Notwithstanding this, Terralight Rajapalayam may choose not to take the termination compensation and retain the project with the consent of lenders.

**Assignment:** Terralight Rajapalayam PPA shall not be assigned by any party other than by mutual consent between the parties to be evidenced in writing.

**Term of Agreement:** Terralight Rajapalayam PPA shall come into effect from Terralight Rajapalayam Effective Date i.e. September 27, 2017. The actual period of sale/purchase of power by TANGEDCO shall be valid for 25 years subject to COD and Terralight Rajapalayam Expiry Date. After execution of Terralight Rajapalayam PPA, the controlling shareholding in Terralight Rajapalayam shall be maintained for a period of 3 months after commencement of supply of power. Thereafter, any change can be undertaken under the intimation to TANGEDCO. This condition would not apply to cases where substitution of promoter or controlling shareholder is necessitated by lender.

**CDM:** The CDM benefits accrued shall be shared between the parties in the manner namely 100% of the gross proceeds to be retained by Terralight Rajapalayam in the first year and in second year, the share of TANGEDCO shall be 10% progressively increased by 10% every year till it reaches 50%.

**Commercial Operation Date:** The COD shall be considered 30 days from the actual date of commissioning of the first part capacity. The tenure of Terralight Rajapalayam PPA shall commence from COD of the first part commissioning of the project. Commissioning certificate dated October 24, 2018 issued by TANGEDCO, certified successful commission of 50 MW (AC) solar power project on September 26, 2018.

**Force Majeure:** No party shall be liable for any claim for any loss or damage whatsoever arising out of failure to carry out the terms of Terralight Rajapalayam PPA to the extent that such failure is due to force majeure events, as defined in Terralight Rajapalayam PPA. Any party claiming the benefit of force majeure shall satisfy the other party of the existence of such events by giving notice to the other party in writing within 15 days from the occurrence of such event.

#### **4. Energy Purchase Agreements dated March 5, 2015, March 17, 2015 and May 20, 2015 between TN Solar and TANGEDCO**

Energy purchase agreements dated March 5, 2015, March 17, 2015 and May 20, 2015 have been executed between TN Solar and TANGEDCO wherein TANGEDCO agreed to buy solar energy from TN Solar generated from its 8 MW (AC) solar power project at Muthuramalingam Village, Virudhunagar District, Tamil Nadu, India, 10 MW (AC) solar power project at Chithavanayakanpatti Village, Vilathikulam Taluk, Tuticorin District, Tamil Nadu, India and 5 MW (AC) solar power project at Perumpalli Village, Veda sandur Taluk, Dindigul District, Tamil Nadu, India at tariff of ₹7.01 per unit, without AD Benefits (“**TN Solar PPA**”).

**Date of Commercial Operation:** COD as defined in 2(m) of the Tamil Nadu Electricity Regulatory Commission (Terms and Conditions for the Determination of Tariff) Regulations, 2005. Letter dated May 30, 2016 issued by TANGEDCO, certified successful synchronization of 5 MW (AC) solar power project of TN Solar on December 28, 2015. Commissioning certificate dated October 19, 2015 issued by TANGEDCO, certified successful commission of 8 MW(AC) solar power project of TN Solar on September 28, 2015. Letter dated December 28, 2015 issued by TANGEDCO, certified successful synchronization of 10 MW (AC) solar power project of TN Solar on November 2, 2015.

**Interfacing and Evacuation Facilities:** TN Solar PPA requires compliance with the relevant provisions contained in the Indian Electricity Grid Code, Tamil Nadu Electricity Grid Code, the Electricity Act, 2003 and other codes and regulations issued by the Tamil Nadu Electricity Regulatory Commission or Central Electricity Authority, as amended from time to time.

**Operation and Maintenance:** TN Solar PPA specifies certain operation and maintenance conditions amongst others, with respect to evacuation of solar power generated, adequate filtering mechanism to limit the harmonics, minimise drawal of reactive power, suitable automatic safety devices.

**Metering Arrangements:** TN Solar PPA requires compliance with certain metering arrangements, including accordance with the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006,

Commission's Grid Connectivity and Intra State Open Access Regulations, 2014, Tamil Nadu Electricity Distribution Code, 2004 and the Tamil Nadu Grid Code.

**Tariff and other charges:** The solar power tariff for TN Solar commissioned during the control period of Order No. 7 of 2014, dated September 12, 2014 shall be of ₹7.01 per unit without AD benefit. Further, the reactive power charges shall be specified in the order on Open Access by the Commission, as amended from time to time. Additionally, in drawal of energy by TN Solar from TANGEDCO shall be adjusted against the exported energy and in case drawal of power is in excess over the exported power in a month, such excess drawal shall be billed under applicable temporary supply tariff as per the Commission's Tariff Order, as amended from time to time.

**Billing and payment:** TN Solar shall raise a monthly bill along with supporting documents every month to TANGEDCO for the net energy sold/ exported. TANGEDCO shall make payment to TN Solar for the solar energy purchased/ exported within 60 days from the date following the date of receipt of the bill. Any delay beyond sixty days shall attract interest at the rate of 1% per month. Further, stand-by letter of credit shall be opened by TANGEDCO for an estimated value of one month bill, which shall be valid for a period up to one year.

**Assignment:** TN Solar PPA shall not be assigned by any party other than by mutual consent between the parties to be evidenced in writing.

**Term of Agreement:** TN Solar PPA shall come into effect from TN Solar Effective Date i.e. March 5, 2015, March 17, 2015 and May 20, 2015 for the respective projects. The actual period of sale/purchase of power shall be valid for 25 years subject to COD and TN Solar Expiry Date. Further, parties to the agreement shall have the option to terminate the agreement for violation of any of the clauses of the agreement after serving a notice of three months to the other party.

**CDM:** The CDM benefits accrued shall be shared between the parties on gross basis starting from 100% to TN Solar in the first year and thereafter reducing by 10% every year till the sharing becomes equal between TN Solar and TANGEDCO in the sixth year. Thereafter, the sharing of CDM benefits shall remain equal till such time the benefits accrue, provided that sharing shall take place only after actual receipt of benefit by TN Solar.

**Force Majeure:** No party shall be liable for any claim for any loss or damage whatsoever arising out of failure to carry out the terms of TN Solar PPA to the extent that such failure is due to force majeure events, as defined in TN Solar PPA. Any party claiming the benefit of force majeure shall satisfy the other party of the existence of such events by giving notice to the other party in writing within 15 days from the occurrence of such event.

## **5. Energy Purchase Agreements, dated March 25, 2015 and May 20, 2015 between UMD and TANGEDCO**

Energy purchase agreements dated March 25, 2015 and May 20, 2015 have been executed between UMD and TANGEDCO wherein TANGEDCO agreed to buy solar energy from UMD generated from its 12 MW (AC) solar power project at Ondipulinayakanoor Village, Aruppukottai Taluk, Virudunagar District, Tamil Nadu, India and 13 MW (AC) solar power project at Kattarakulam Village, Tuticorin District, Tamil Nadu, India at tariff of ₹7.01 per unit, without AD benefits ("UMD PPA").

**Date of Commercial Operation:** COD as defined in 2(m) of the Tamil Nadu Electricity Regulatory Commission (Terms and Conditions for the Determination of Tariff) Regulations, 2005. Commissioning certificate dated December 2, 2015 issued by TANGEDCO, certified successful commission of 12 MW (AC) solar power project of UMD on November 16, 2015. Letter dated May 7, 2016 issued by TANGEDCO, certified successful synchronisation of 13 MW (AC) solar power project of UMD on March 21, 2016.

**Interfacing and Evacuation Facilities:** UMD PPA requires compliance with the relevant provisions contained in the Indian Electricity Grid Code, Tamil Nadu Electricity Grid Code, the Electricity Act, 2003 and other codes and regulations issued by the Tamil Nadu Electricity Regulatory Commission or Central Electricity Authority, as amended from time to time.

**Operation and Maintenance:** UMD PPA specifies certain operation and maintenance conditions amongst others, with respect to evacuation of solar power generated, adequate filtering mechanism to limit the harmonics, minimise drawal of reactive power, and suitable automatic safety devices.

**Metering Arrangements:** UMD PPA requires compliance with certain metering arrangements, including accordance with the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006, Commission's Grid Connectivity and Intra State Open Access Regulations, 2014, Tamil Nadu Electricity



Distribution Code, 2004 and the Tamil Nadu Grid Code.

**Tariff and other charges:** The solar power tariff for UMD commissioned during the control period of Order No. 7 of 2014, dated September 12, 2014 shall be of ₹7.01 per unit without AD benefit. Further, the reactive power charges shall be specified in the order on Open Access by the Commission, as amended from time to time. Additionally, in drawal of energy by UMD from TANGEDCO shall be adjusted against the exported energy and in case drawal of power is in excess over the exported power in a month, such excess drawal shall be billed under applicable temporary supply tariff as per the Commission's Tariff Order, as amended from time to time.

**Billing and payment:** UMD shall raise a monthly bill along with supporting documents every month to TANGEDCO for the net energy sold/ exported. TANGEDCO shall make payment to UMD for the solar energy purchased/ exported within 60 days from the date following the date of receipt of the bill. Any delay beyond sixty days shall attract interest at the rate of 1% per month. Further, stand-by letter of credit shall be opened by TANGEDCO for an estimated value of one-month bill, which shall be valid for a period up to one year.

**Assignment:** UMD PPA shall not be assigned by any party other than by mutual consent between the parties to be evidenced in writing.

**Term of Agreement:** UMD PPA shall come into effect from UMD Effective Date i.e. March 25, 2015 and May 20, 2015 for the respective projects. The actual period of sale/purchase of power shall be valid for 25 years subject to COD and UMD Expiry Date. Further, parties to the agreement shall have the option to terminate the agreement for violation of any of the clauses of the agreement after serving a notice of three months to the other party.

**CDM:** The CDM benefits accrued shall be shared between the parties on gross basis starting from 100% to UMD in the first year and thereafter reducing by 10% every year till the sharing becomes equal between UMD and TANGEDCO in the sixth year. Thereafter, the sharing of CDM benefits shall remain equal till such time the benefits accrue, provided that sharing shall take place only after actual receipt of benefit by UMD.

**Force Majeure:** No party shall be liable for any claim for any loss or damage whatsoever arising out of failure to carry out the terms of UMD PPA to the extent that such failure is due to force majeure events, as defined in UMD PPA. Any party claiming the benefit of force majeure shall satisfy the other party of the existence of such events by giving notice to the other party in writing within 15 days from the occurrence of such event.

## **6. Power Purchase Agreement dated May 7, 2010 between PLG and GUVNL**

A power purchase agreement dated May 7, 2010 has been executed between PLG Power Limited ("PPL") and GUVNL wherein GUVNL agreed to purchase power from PPL, with Discom wise share to be decided from time to time ("Original PLG PPA"), comprising of a total installed capacity of 40 MW at a tariff of ₹15/KWh for the first 12 years and thereafter ₹5/KWh from 13th year to 25th year. Vide a supplemental power purchase agreement dated January 6, 2011, executed amongst PPL, PLG and GUVNL, 20 MW was agreed to be developed by PLG (together with the Original PLG PPA the "PLG PPA"). PLG entered into an additional supplemental PPA with GUVNL on June 9, 2011 for identifying the appropriate project site and the revised scheduled operation date for the project.

**Commercial Operation Date:** The date on which the power plant is available for commercial operation (certified by GEDA) and such date as specified in written notice given at least ten days in advance by PLG to GUVNL; Commissioning certificate dated February 23, 2012 issued by GEDA, certified successful commission of 20 MW solar power project of PLG on January 26, 2012.

**Scheduled Commercial Operation Date:** For (a) 10 MW plant – May 31, 2011; and (b) 10 MW plant – June 30, 2011.

**Licenses, Permits and Conditions Precedent:** PLG, at its sole cost and expense, shall acquire and maintain in effect all clearances, permits, licenses and approvals required from time to time by all regulatory/statutory authorities in order to enable it to perform its obligations under the PLG PPA. GUVNL will render all reasonable assistance to PLG to enable to obtain such clearances without any legal obligation on the part of GUVNL.

PLG will be allowed to migrate to GoI's Jawaharlal Nehru National Solar Mission. However, if such migration is not allowed, PLG shall have to ensure commencement of supply of power on Scheduled Commercial Operation Date as per the terms and conditions of PLG PPA. In case PLG fails to commence the supply of power on Scheduled Commercial Operation Date, it shall be liable to pay liquidated damage as specified in PLG PPA.

**Construction and Operation:** If PLG commits an O&M default other than due to force majeure event, GUVNL shall give notice of 90 days in writing to PLG, calling upon PLG to remedy such default and if PLG fails to take steps to remedy such default within the period, PLG PPA shall stand terminated as specified in the PLG PPA.

Upon occurrence of an emergency (*as specified in PLG PPA*) GETCO or Discom's evacuation systems for safe operation of its grid, GUVNL/GETCO/Discom reserves the right to shut down the line and has no obligation to evacuate the electricity nor to pay any compensation during such period. PLG shall suitably back down their generation. GUVNL/GETCO/Discom will however, make reasonable endeavors to remedy such emergency and bring back normalcy at the earliest.

PLG shall be required to submit bi-monthly progress report to GUVNL beginning with signing of PLG PPA till the project gets fully commissioned.

**Undertakings:**

*The obligations of PLG:*

- (a) Obtain all statutory approvals, clearances and permits necessary at their own cost in addition to the specified approvals;
- (b) Construct, operate and maintain the project during the term of PLG PPA at their cost and risk including interconnection facilities;
- (c) Sell all available capacity from the solar photovoltaic grid interactive power plants to the extent of contracted capacity on first priority basis to GUVNL and not sell to any third party;
- (d) Seek approval of GETCO in respect of interconnection facilities;
- (e) Approach GETCO for laying transmission line from switchyard to nearest substation of GETCO. Further, PLG shall ensure the injection of power at not lower than 66 KV level. PLG shall also install RTUs to enable SLDC to monitor injection of power;
- (f) Undertake at its own cost maintenance of the interconnection facilities as per the specifications and requirements of GETCO, as notified to PLG in accordance with prudent utility practices;
- (g) Operate and maintain the project in accordance with prudent utility practices. Further, PLG shall submit forecast for availability of power to SLDC as per regulations of GERC / CERC;
- (h) Be responsible for all payments on account of any taxes, cesses, duties or levies imposed by government or its statutory authority on land, equipment, material or works of the project or on the electricity generated or consumed by the project or by itself or on the income or assets owned by it;
- (i) Procure start-up power required for the plant from respective Discom;
- (j) Fulfilling all other obligations under PLG PPA; and
- (k) Ensure that no fossil fuel viz. coal, gas, lignite, naphtha, wood etc. shall be used except during barring gear operation.

*Obligations of GUVNL:*

- (a) To allow PLG to extent possible to operate the project as a base load generating station; and
- (b) Pay to PLG for month energy bills for scheduled energy as certified by SLDC in SEA.

**Rates and Charges:** GUVNL shall pay the fixed tariff mentioned for the period of 25 years for all scheduled energy/energy injected as certified by the monthly SEA by SLDC. The tariff is determined by Commission vide Tariff Order for Solar Based Power Projects dated January 30, 2010.

In case commissioning is delayed beyond December 31, 2011, GUVNL shall pay the tariff as determined by GERC for solar projects effective on the date of commissioning or above mentioned Tariff, whichever is lower.

For each kVArh drawn from the grid, PLG shall pay the rate as determined by the Commission payable to GETCO

from time to time. Upon implementation of Intra-State Availability Based Tariff in the state, the provisions of such regulations shall become applicable automatically if not permitted otherwise.

**Billing and Payment:** PLG shall prepare invoices on a monthly basis and shall submit the same to GUVNL along with the copy of SEA on the second business day of the following month, in the manner specified in PLG PPA. GUVNL shall make payment of the amounts within 30 days from the date of receipt of the tariff invoice by the designated office of GUVNL.

PLG PPA also specifies provisions for late payment and payment of rebate and the calculation of the same.

**Letter of Credit:** GUVNL shall establish and maintain irrevocable and unconditional revolving letter of credit in favor and for the sole benefit of PLG for the contracted capacity of 40 MW and above. The conditions for drawal under letter of credit in respect of tariff invoice is specified in the PLG PPA.

Additionally, PLG PPA contains provisions in the event of a dispute as to the amount of any tariff invoice.

**Metering and Communication:** The reading and correction of meters, sealing and maintenance of meters and maintenance of records at the power plant shall be followed, and as prescribed in the PLG PPA.

**Force Majeure:** Neither party shall be responsible or liable for or deemed in breach because of any delay or failure in the performance of its obligations or failure to meet milestone dates due to any circumstance beyond the reasonable control of the party experiencing such delay or failure and such events are specified in the PLG PPA. Further, the PLG PPA specifies certain force majeure event exclusions and the available relief for a force majeure event.

**Term, Termination and Default:** PLG PPA shall become effective upon the execution and delivery thereof by the parties hereto and unless terminated pursuant to other provisions, shall continue to be in force for such time until the completion of a period of 25 years from the COD.

*Events of Default:*

**PLG's Default:** The occurrence of any of the following events at any time during the Term of PLG PPA shall constitute event of default by PLG ("**PLG Event of Default**"):

- (a) O&M default on part of PLG;
- (b) Failure or refusal by PLG to perform any of its material obligations;
- (c) PLG fails to make any payment required to be made to GUVNL under PLG PPA within three months after due date of a valid invoice raised by GUVNL;
- (d) If PLG (a) assigns or purports to assign its assets or rights in violation of PLG PPA; or (b) transfers or novates any of its rights and/ or obligations under PLG PPA;
- (e) PLG becomes voluntarily or involuntarily the subject of proceeding under any bankruptcy or insolvency laws or goes into liquidation or dissolution or has receiver appointed over it or liquidator appointed, pursuant to law, except where such dissolution of PLG is for the purpose of a merger, consolidation or reorganisation and where the resulting entity has the financial standing to perform its obligations under PLG PPA and creditworthiness similar to PLG and expressly assumes all obligations under PLG PPA and is in a position to perform them;
- (f) Not operating the plant as per GERCs grid code, SLDC instruction and prudent practices of industries;
- (g) Disinvestment of equity below minimum percentage holding during lock in period as specified; and
- (h) PLG repudiates PLG PPA.

**GUVNL's Default:** The occurrence of any of the following events at any time during the Term of PLG PPA shall constitute event of default by GUVNL ("**GUVNL Event of Default**"):

- (a) Failure or refusal by GUVNL to pay any portion of undisputed monthly bill for a period of 90 days after due date;

- (b) GUVNL repudiates PLG PPA;
- (c) GUVNL becomes voluntarily or involuntarily the subject of proceeding under any bankruptcy or insolvency laws or goes into liquidation or dissolution or has receiver appointed over it or liquidator appointed, pursuant to law, except where such dissolution of GUVNL is for the purpose of a merger, consolidation or reorganisation and where the resulting entity has the financial standing to perform its obligations under PLG PPA and creditworthiness similar to GUVNL and expressly assumes all obligations under PLG PPA and is in a position to perform them.

**Termination:**

*Termination for PLG Event of Default:* Upon the occurrence of PLG Event of Default, GUVNL may deliver a default notice to PLG in writing as specified in PLG PPA. After the expiry of 30 days from the delivery of notice and unless the parties have agreed otherwise or PLG Event of Default has been remedied, GUVNL may deliver termination notice to PLG. GUVNL may terminate PLG PPA by delivering such a termination notice to PLG and intimate the same to the Commission. Upon delivery of termination notice, PLG PPA shall stand terminated and GUVNL shall stand discharged of all its obligations. PLG shall have liability to make payment within 30 days from the date of termination notice towards compensation to GUVNL equivalent to three years billing based on first year tariff considered on normative PLF while determining the tariff by Hon'ble GERC.

*Termination for GUVNL Event of Default:* Upon occurrence of a GUVNL Event of Default, PLG may deliver a default notice to GUVNL as specified in the PLG PPA. After expiry of 30 days from the delivery of the default notice and unless the parties have agreed otherwise or the GUVNL Event Default has been remedied, PLG may serve suspension notice to GUVNL for a duration not exceeding one year.

During suspension period, GUVNL shall allow PLG to sell power from the project to any HT consumers of the State in the open market either by finding the said consumers on its own or through Central/State power trading utilities. In case of wheeling of power to such third parties, the transmission charges, transmission losses, wheeling charges and losses, SLDC charges and cross subsidy, surcharges etc. shall be applicable as per GERC's regulations in force from time to time and paid directly to respective agencies by third party. No banking facility shall be allowed to PLG and third parties.

On expiry of the Suspension Period, GUVNL will be entitled to cure its default and buy power from PLG. In the event GUVNL fails to cure the default, PLG may terminate PLG PPA by delivering a termination notice to GUVNL and GUVNL shall have liability to make payment within 30 days from the date of termination notice towards compensation to PLG equivalent to three years billing based on first year tariff considered on normative PLF while determining the tariff by Hon'ble GERC.

**Indemnity:**

*PLG's Indemnity:* PLG agrees to defend, indemnify and hold harmless GUVNL, its officers, directors, agents, employees and affiliates from and against any and all claims, liabilities, actions, demands, judgements, losses, costs, expenses, suits, actions and damage arising by reason of bodily injury death or damage to property sustained by third parties that are caused by an act of negligence or the willful misconduct of PLG or by an officer, director, subcontractor, agent, or employee of PLG except to the extent such injury, death or damage as is attributable to the willful misconduct or negligence of or breach of PLG PPA by GUVNL or by an officer, director, sub-contractor, agent or employee of GUVNL.

*GUVNL's Indemnity:* GUVNL agrees to defend, indemnify and hold harmless PLG, its officers, directors, agents, employees and affiliates from and against any and all claims, liabilities, actions, demands, judgements, losses, costs, expenses, suits, actions and damage arising by reason of bodily injury, death or damage to property sustained by third parties that are caused by an act of negligence or the willful misconduct of GUVNL or by an officer, director, subcontractor, agent or employee of GUVNL except to the extent such injury, death or damage as is attributable to the willful misconduct or negligence of or breach of PLG PPA by PLG or by an officer, director, sub-contractor, agent or employee of PLG.

**Miscellaneous Provisions:**

*Assignment:* Neither party shall assign PLG PPA or any portion hereof without the prior written consent of the other party provided further that any assignee shall expressly assume the assignor's obligations thereafter arising under PLG PPA pursuant to documentation satisfactory to such other party. In furtherance of the foregoing, GUVNL acknowledges that the financing documents may provide that upon an event of default by PLG under the

financing documents, the financing parties may cause the PLG to assign to a third party the interest, rights and obligations of PLG thereafter arising under PLG PPA. GUVNL further acknowledges that the financing parties may in addition to the exercise of their rights as set forth, cause PLG to sell or lease the project and cause any new lessee or purchaser of the project to assume all of the interests, rights and obligations of PLG thereafter arising under PLG PPA.

*Sharing of benefits CDM:* PLG shall share CDM benefits with GUVNL on gross basis starting from 100% to PLG in the first year after commissioning and thereafter reducing by 10% every year till the sharing becomes equal between PLG and GUVNL in the sixth year. Thereafter, sharing of CDM benefit shall remain equal till the time that benefit accrues.

## **7. Power Purchase Agreement dated October 15, 2010 between TSET and NVVN**

A power purchase agreement dated October 15, 2010 has been executed between TSET (*formerly known as AES Solar Energy Private Limited and Sindicatum Solar Energy Private Limited*) and NVVN wherein NVVN has agreed to purchase solar power from TSET as an intermediary seller and sell it to Discom after bundling it with the unallocated power procured from the central unallocated quota of coal based power projects of NTPC, holding company of NVVN as per the provisions of the National Solar Mission ("**TSET PPA**"). NVVN agreed to procure power from TSET up to 5 MW from power generation facility at Tinwari in Jodhpur District, Rajasthan at a tariff of ₹17.91 /kWh from Scheduled Commissioning date.

**Commercial Operation Date:** The actual commissioning date of respective units of the power project where upon TSET starts injecting power from the power project to delivery point.

**Scheduled Commissioning Date:** Means October 15, 2011. Commissioning certificate dated October 21, 2011 issued by RRECL, certified successful commission of 5 MW solar power project of TSET on October 15, 2011.

**Term of agreement:** The TSET PPA shall come into effect from October 15, 2010 and shall be valid for a term from the effective date until the date occurring 25 years from the Commercial Operation Date. It may be extended for a further period, on mutually agreed terms at least 180 days prior to the expiry date.

Further, TSET PPA shall be terminated early before expiry date if either NVVN or TSET terminates pursuant to the terms specified.

### **Construction and Development of the Project:**

**TSET's Obligation:** TSET undertakes to be responsible, at their own cost and risk, for certain activities including the following:

- (a) obtaining all consents, clearances and permits and maintaining all consents, clearances and permits in full force and effect during the Term of Agreement;
- (b) designing, constructing, erecting, commissioning, completing and testing the power project in accordance with applicable laws, the grid code specified by Central Electricity Regulatory Commission or State Commission under the Electricity Act, 2003, terms and conditions of TSET PPA and prudent utility practices;
- (c) continuance of the supply of power to NVVN;
- (d) owing the power project throughout the term of agreement free and clear of encumbrances, except those expressly permitted;

**Purchase and sale of Contracted Capacity:** Subject to the terms and conditions of the TSET PPA, TSET undertakes to sell to NVVN and NVVN undertakes to pay Tariff for all the energy supplied at the delivery point, corresponding to the contracted capacity.

**Right to Contracted Capacity and Energy:** NVVN, at any time during a contract year, shall not be obliged to purchase any additional energy from TSET beyond 9.198 million kWh (MU). If for any contract year, it is found that TSET has not been able to generate minimum energy of 5.256 million kWh (MU), on account of reasons solely attributable to TSET, the non-compliance shall make TSET liable to pay the compensation provided in the power sale agreement as payable to Discom, subject to certain conditions specified.

Further, TSET is free to sell such power to any third party prior to Scheduled Commissioning Date and any capacity which is in excess of the quantum of power agreed to be supplied under the TSET PPA from Scheduled Commissioning Date. Provided that TSET shall not be entitled to claim benefit of bundling of power provided in TSET PPA in any manner on such sale of infirm power or power in excess of contracted capacity.

**Applicable Tariff:** TSET shall be entitled to receive the tariff ₹17.91 /kWh from Scheduled Commissioning Date.

**Billing and Payment:** From the commencement of supply of power, NVVN shall pay to TSET the monthly tariff payments on or before the due date. The manner for delivery and contents of the monthly bills, supplementary bills, payment of monthly bills, late payment surcharges and rebate is specified in the TSET PPA.

Further, NVVN shall provide to TSET a monthly, unconditional, revolving and irrevocable letter of credit which may be drawn upon by TSET in the manner as specified in the TSET PPA.

Additionally, as a further support for the NVVN's obligations, on or prior to the effective date of the agreement, TSET and NVVN shall execute default escrow agreement for the establishment and operation of the default escrow account in favor of TSET, through which the incremental receivables of NVVN shall be routed and used as per the terms of the default escrow agreement. Further, TSET and NVVN shall contemporaneously with the default escrow agreement enter into the agreement to hypothecate cum deed of hypothecation, whereby NVVN shall agree to hypothecate incremental receivables to the extent as required for the letter of credit, as specified in the TSET PPA. Incremental receivables are the money received by NVVN on account of sale of bundled power under the NVVN-Discom power sale agreement.

TSET shall be required to provide entry to the site at all times during term of agreement to NVVN and a third party nominated by Governmental instrumentality for inspection and verification of the works being carried out. The third party may carry out checks for testing the CUF of the power project and non-fulfillment of its obligations may attract liability as specified in the TSET PPA.

**Dispatch:** TSET shall be required to maintain compliance to the applicable grid code requirements and directions, as specified by concerned State Load Dispatch Centre /Regional Load Dispatch Centre from time to time.

**Metering:** Installation of meters, meter testing, meter calibration and meter reading shall follow the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006 and grid code, as revised from time to time. Further, TSET shall bear all costs pertaining to meters at TSET's side of delivery point. Reporting of metered data and parameters for the same are also specified in the TSET PPA.

**Insurances:** TSET shall effect and maintain or cause to be effected and maintained, at its own cost and expense, throughout the term of agreement, insurances against such risks, with such deductibles and with such endorsements and co-insured(s), which the prudent utility practices would ordinarily merit maintenance of and as required under the financing agreements. Application of insurance proceeds and effect on liability of NVVN shall be as specified in TSET PPA.

**Force Majeure:** Force majeure means any event or circumstances or combination of events specified in TSET PPA, that wholly or partly prevents or unavoidably delays the parties in the performance of its obligations under TSET PPA, but only if and to the extent that such events or circumstances are not within the reasonable control, directly or indirectly, of the party and could not have been avoided if the party had taken reasonable care or complied with prudent utility practices. Further, the TSET PPA specifies certain force majeure exclusions, manner of notification of force majeure event, duty to perform and duty to mitigate of the parties and the available relief for a force majeure event.

#### **Change in Law:**

Change in law means the occurrence of any of the events specified in the TSET PPA after the effective date of the agreement resulting into any additional recurring/ non-recurring expenditure by TSET or any income to TSET. TSET PPA specifies that the aggrieved party shall be required to approach the central commission for seeking approval of change in law.

#### **Events of Default and Termination:**

**TSET Event of Default:** The occurrence and/ or continuation of any of the events, unless any event occurs as a result of a force majeure event or breach by NVVN or Discoms of its obligation under TSET PPA, shall constitute event of default for TSET ("TSET Event of Default"):

- (a) the failure to commence supply of power to NVVN up to the contracted capacity, by the end of the period specified in TSET PPA;
- (b) TSET mortgages or charges or purports to assign, mortgage or charge any of its assets or rights related to the power project in contravention of TSET PPA or TSET transfers or novates any of its rights and/or obligations under TSET PPA in a manner contrary to the provisions of TSET PPA, except in certain specified situations;
- (c) TSET becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding up proceedings and such proceedings remain uncontested for a period of 30 days or any winding up or bankruptcy or insolvency order is passed against TSET or TSET goes into liquidation or dissolution or has a receiver appointed to manage its affairs, provided that a dissolution or liquidation of TSET will not be TSET Event of Default if such dissolution or liquidation is for the purpose of a merger, consolidation or reorganisation and where the resulting company retains creditworthiness similar to TSET and expressly assumes all obligations of TSET under TSET PPA and is in a position to perform them;
- (d) TSET repudiates TSET PPA and does not rectify such breach within a period of 30 days from a notice from NVVN in this regard;
- (e) change in controlling shareholding before the specified time frame as mentioned in TSET PPA;
- (f) occurrence of any other event which is specified in TSET PPA to be a material breach/ default of TSET.

*NVVN Event of Default:* The occurrence and continuation of any of the following events unless any such event occurs a result of a force majeure or a breach by TSET of its obligations under TSET PPA shall constitute event of default for NVVN (“**NVVN Event of Default**”):

- (a) NVVN fails to pay monthly bill or supplementary bill, subject to certain specified conditions, for a period of 90 days after the due date and TSET is unable to recover the amount outstanding to TSET through letter of credit/ default escrow account;
- (b) NVVN repudiates TSET PPA and does not rectify such breach even within a period of 30 days from a notice from TSET in this regard;
- (c) except where due to any TSET failure to comply with its obligations, NVVN is in material breach of any of its obligations pursuant to TSET PPA, and such material breach is not rectified within 30 days of receipt of notice in this regard from TSET to NVVN;
- (d) NVVN becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding up proceedings and such proceedings remain uncontested for a period of 30 days or any winding up or bankruptcy or insolvency order is passed against NVVN or NVVN goes into liquidation or dissolution or a receiver or any similar officer is appointed over all or substantially all of its assets or official liquidator is appointed to manage its affairs pursuant to law provided that it shall not constitute an NVVN Event of Default where such dissolution or liquidation of NVVN is for the purpose of a merger, consolidation or reorganisation where the resulting entity has the financial standing to perform its obligations under TSET PPA and has creditworthiness similar to NVVN and expressly assumes all obligations of NVVN and is in a position to perform them;
- (e) if Discoms are subject to any of the above defaults and NVVN does not designate another or other Discoms for purchase of power;
- (f) occurrence of any other events which is specified in TSET PPA to be a material breach or default of NVVN.

*Procedure in cases of TSET Event of Default:* Upon the occurrence and continuation of any TSET Event of Default, NVVN shall have the right to deliver to TSET, a notice stating its intention to terminate TSET PPA which shall specify in reasonable details, the circumstances giving rise to the issue of such notice.

Within a period of seven days following the consultation period of 60 days unless the parties have otherwise agreed to the contrary or the TSET Event of Default giving rise to the consultation period shall have ceased to exist or shall have been remedied, NVVN may terminate TSET PPA by giving a written termination notice of 30 days to TSET.

*Procedure in cases of NVVN Event of Default:* Upon the occurrence and continuation of any NVVN Event of Default, TSET shall have the right to preliminary deliver to NVVN default notice which notice shall specify in reasonable detail the circumstances giving rise to its issue.

Following the issue of preliminary default notice, the consultation period of 60 days or such longer period as the parties may agree, shall apply and it shall be the responsibility of the parties to discuss as to what steps shall be taken with a view to mitigate the consequences of the relevant event of default having regard to all the circumstances. During the consultation period, the parties shall continue to perform their respective obligations under TSET PPA. After a period of seven days following the expiry of the consultation period and unless the parties shall have otherwise agreed to the contrary or NVVN Event of Default giving rise to the consultation period shall have ceased to exist or shall have been remedied, TSET shall be free to sell the contracted capacity to any third party of TSET's choice.

Provided further that at the end of three months' period from this period, TSET PPA may be terminated by TSET.

*Termination due to Force Majeure:* If force majeure event or its effects continue to be present beyond the period as specified, either party shall have the right to cause termination of TSET PPA. In such an event, TSET PPA shall terminate on the date of such termination notice.

**Indemnity:** TSET shall indemnify, defend and hold NVVN harmless against:

- (a) any and all third party claims against NVVN for any loss of or damage to property of such third party or death or injury to such third party arising out of a breach by TSET of any of its obligations under TSET PPA; and
- (b) any and all losses, damages, costs and expenses including legal costs, fines, penalties and interest actually suffered or incurred by NVVN from third party claims arising by reason of a breach by TSET of any of its obligations under TSET PPA, subject to certain conditions;

NVVN shall cause the Discoms to indemnify, defend and hold TSET harmless against:

- (a) any and all third party claims against TSET for any loss of or damage to property of such third party or death or injury to such third party arising out of a breach by Discoms of any of its obligations under TSET PPA and;
- (b) any and all losses, damages, costs and expenses including legal costs, fines, penalties and interests actually suffered or incurred by TSET from third party claims by reason of a breach of Discoms of any its obligations. NVVN shall incorporate appropriate covenants in the PSAs for the above obligations of Discoms. In so far as indemnity to TSET is concerned, Discoms shall be the indemnifying party and not NVVN.

Further, the non-payment of losses shall constitute an event of default under TSET PPA.

Additionally, except as provided in TSET PPA, neither TSET nor buying Discoms nor its respective officers, directors, agents, employees or affiliates shall be liable or responsible to the other party or its affiliates, officers, directors, agents, employees, successors or permitted assigns or their respective insurers for incidental, indirect, or consequential damages connected with or resulting from performance or non-performance of TSET PPA, including claims in the nature of lost revenues, income or profits, any increased expense, reduction in or loss of power generation or equipment used, irrespective of whether such claims are based on breach of warranty, tort, strict liability, contract, breach of statutory duty, operation of law or otherwise. Further, NVVN shall have no recourse against any officer, director, or shareholder of TSET or any affiliate for such claims. TSET shall have no recourse against any officer, director or shareholder of NVVN or Discoms or any affiliates for such claims.

**Assignment and Charges:** TSET PPA shall not be assigned by any party other than by mutual consent between the parties to be evidenced in writing. Further, TSET shall not create or permit to subsist any encumbrance over all or any of its rights and benefits under TSET PPA.

#### **7.1 Supplemental Power Purchase Agreements between TSET and NVVN dated October 15, 2010, May 12, 2011 and May 30, 2017**

Supplemental power purchase agreements were entered into between TSET and NVVN wherein, amongst others, amendments were made to TSET PPA clauses with respect to third party verifications, delivery point, rights of



lenders in case of event of default, assignment in favor of lenders, permitted charges and sharing of clean development mechanism benefits.

Further, AES Solar Energy Private Limited (AES) changed its name to Sindicatum Solar Energy Private Limited along with change in registered office. The existing articles of TSET PPA was amended in order to make such changes to the preamble paragraph and article concerning the address. Further, consequent to name change from Sindicatum Solar Energy Private Limited to TSET, TSET is in the process of intimating NVVN to record change in name.

## 8. Power Purchase Agreement dated May 29, 2010 between TSEC and GUVNL

A power purchase agreement dated May 29, 2010 has been executed between TSEC (formerly known as AES Solar Energy Gujarat Private Limited and Sindicatum Solar Energy Gujarat Private Limited) and GUVNL wherein GUVNL agreed to purchase power from TSEC, with Discom wise share to be decided from time to time (“**TSEC GUVNL PPA**”), generated from its power station at Village Bandhdi, Taluka Bhachau, District Kutchh, Gujarat State comprising of total installed capacity of 15 MW, at a tariff of ₹15/KWh for the first 12 years and thereafter ₹5/KWh from 13<sup>th</sup> year to 25<sup>th</sup> year. The current Tariff for the project is as follows:

Capacity	Tariff 1 (INR / kWh)	Tariff 1 End Date	Tariff 2 (INR / kWh)	Tariff 2 End Date
4.0	15.00	March 3, 2024	5.00	March 3, 2037
6.0	9.98	March 30, 2024	7.00	March 30, 2037
4.9	9.98	October 30, 2024	7.00	April 11, 2037
0.1	9.98	October 30, 2024	7.00	October 30, 2037

**Commercial Operation Date:** The date on which the power plant is available for commercial operation certified by GEDA and such date as specified in written notice given at least ten days in advance by TSEC to GUVNL; Commissioning certificate dated April 17, 2012 issued by GEDA, certified successful commission of solar power project, 4 MW (DC) plant on March 4, 2012, 6 MW (DC) plant on March 31, 2012, 4.92 MW (DC) plant on April 12, 2012. Further, commissioning certificate dated November 7, 2012 issued by GEDA, certified successful commission of 0.08 MW solar power plant on October 31, 2012

**Scheduled Commercial Operation Date:** For (a) 3 MW plant – June 30, 2011; (b) 12 MW plant – December 31, 2011.

**Licenses, Permits and Conditions Precedent:** TSEC, at its sole cost and expense, shall acquire and maintain in effect all clearances, permits, licenses and approvals required from time to time by all regulatory/statutory authorities in order to enable it to perform its obligations under the TSEC GUVNL PPA. GUVNL will render all reasonable assistance to TSEC to enable to obtain such clearances without any legal obligation on the part of GUVNL.

TSEC will be allowed to migrate to GoI’s Jawaharlal Nehru National Solar Mission. However, if such migration is not allowed, TSEC shall have to ensure commencement of supply of power on Scheduled Commercial Operation Date as per the terms and conditions of TSEC GUVNL PPA. In case TSEC fails to commence the supply of power on Scheduled Commercial Operation Date, it shall be liable to pay liquidated damage as specified in TSEC GUVNL PPA.

**Construction and Operation:** If TSEC commits an O&M default other than due to force majeure Event, GUVNL shall give notice of 90 days in writing to TSEC, calling upon TSEC to remedy such default and if TSEC fails to take steps to remedy such default within the period, TSEC GUVNL PPA shall stand terminated.

Upon occurrence of an emergency (*as specified in TSEC GUVNL PPA*) in GETCOs or Discom’s evacuation systems for safe operation of its grid, GUVNL/GETCO/Discom reserves the right to shut down the line and has no obligation to evacuate the electricity nor to pay any compensation during such period. TSEC shall suitably back down their generation. GUVNL/GETCO/Discom will however, make reasonable endeavors to remedy such Emergency and bring back normalcy at the earliest.

TSEC shall be required to submit bi-monthly progress report to GUVNL beginning with signing of TSEC GUVNL PPA till the project gets fully commissioned.

### ***Undertakings:***

#### ***The obligations of TSEC:***

- (a) obtain all statutory approvals, clearances and permits necessary at their own cost in addition to the specified approvals;
- (b) construct, operate and maintain the project during the term of TSEC GUVNL PPA at their cost and risk including interconnection facilities;
- (c) sell all available capacity from the solar photovoltaic grid interactive power plants to the extent of contracted capacity on first priority basis to GUVNL and not sell to any third party;
- (d) seek approval of GETCO in respect of interconnection facilities;
- (e) approach GETCO for laying transmission line from switchyard to nearest substation of GETCO. Further, TSEC shall ensure the injection of power at not lower than 66 KV level. TSEC shall also install RTUs to enable SLDC to monitor injection of power;
- (f) undertake at its own cost maintenance of the interconnection facilities as per the specifications and requirements of GETCO, as notified to TSEC in accordance with prudent utility practices;
- (g) operate and maintain the project in accordance with prudent utility practices. Further, TSEC shall submit forecast for availability of power to SLDC as per regulations of GERC/CERC;
- (h) be responsible for all payments on account of any taxes, cesses, duties or levies imposed by government or its statutory authority on land, equipment, material or works of the project or on the electricity generated or consumed by the project or by itself or on the income or assets owned by it;
- (i) procure start-up power required for the plant from respective Discom;
- (j) fulfilling all other obligations under TSEC GUVNL PPA; and
- (k) ensure that no fossil fuel viz. coal, gas, lignite, naphtha, wood etc. shall be used except during barring gear operation.

#### ***Obligations of GUVNL:***

- (a) to allow TSEC to extent possible to operate the project as a base load generating station; and
- (b) pay to TSEC for month energy bills for scheduled energy as certified by SLDC in SEA.

***Rates and Charges:*** GUVNL shall pay the fixed tariff mentioned for the period of 25 years for all scheduled energy/energy injected as certified by the monthly SEA by SLDC. The Tariff is determined by Hon'ble Commission vide Tariff Order for Solar based Power Projects dated January 30, 2010.

In case commissioning is delayed beyond December 31, 2011, GUVNL shall pay the tariff as determined by GERC for solar projects effective on the date of commissioning or above mentioned tariff, whichever is lower.

For each kVArh drawn from the grid, TSEC shall pay the rate as determined by the Hon'ble Commission payable to GETCO from time to time. Upon implementation of Intra-State Availability Based Tariff in the state, the provisions of such regulations shall become applicable automatically if not permitted otherwise.

***Billing and Payment:*** TSEC shall prepare invoices on a monthly basis and shall submit the same to GUVNL along with the copy of SEA on the second business day of the following month, in the manner specified in TSEC GUVNL PPA. GUVNL shall make payment of the amounts within 30 days from the date of receipt of the tariff invoice by the designated office of GUVNL.

TSEC GUVNL PPA also specifies provisions for late payment and payment of rebate and the calculation of the same.

***Letter of Credit:*** GUVNL shall establish and maintain irrevocable and unconditional revolving letter of credit in favor and for the sole benefit of TSEC for the contracted capacity of 15 MW and above. The conditions for drawal

under letter of credit in respect of tariff invoice is specified in the TSEC GUVNL PPA.

Additionally, TSEC GUVNL PPA contains provisions in the event of a dispute as to the amount of any tariff invoice.

***Metering and Communication:*** The TSEC GUVNL PPA contains provisions with respect to reading and correction of meters, sealing and maintenance of meters and maintenance of records at the power plant.

***Force Majeure:*** Neither party shall be responsible or liable for or deemed in breach because of any delay or failure in the performance of its obligations or failure to meet milestone dates due to any circumstance beyond the reasonable control of the party experiencing such delay or failure and such events are specified in the TSEC GUVNL PPA. Further, the TSEC GUVNL PPA specifies certain force majeure event exclusions and the available relief for a force majeure event.

***Term, Termination and Default:*** TSEC GUVNL PPA shall become effective upon the execution and delivery thereof by the parties hereto and unless terminated pursuant to other provisions, shall continue to be in force for such time until the completion of a period of 25 years from the Commercial Operation Date.

*Events of Default:*

***TSEC's Default:*** The occurrence of any of the following events at any time during the term of TSEC GUVNL PPA shall constitute event of default by TSEC ("**TSEC Event of Default**"):

- (a) O&M default on part of TSEC;
- (b) Failure or refusal by TSEC to perform any of its material obligations;
- (c) TSEC fails to make any payment required to be made to GUVNL under TSEC GUVNL PPA within three months after due date of a valid invoice raised by GUVNL;
- (d) If TSEC (a) assigns or purports to assign its assets or rights in violation of TSEC GUVNL PPA; or (b) transfers or novates any of its rights and/ or obligations under TSEC GUVNL PPA;
- (e) TSEC becomes voluntarily or involuntarily the subject of proceeding under any bankruptcy or insolvency laws or goes into liquidation or dissolution or has receiver appointed over it or liquidator appointed, pursuant to law, except where such dissolution of TSEC is for the purpose of a merger, consolidation or reorganisation and where the resulting entity has the financial standing to perform its obligations under TSEC GUVNL PPA and creditworthiness similar to TSEC and expressly assumes all obligations under TSEC GUVNL PPA and is in a position to perform them;
- (f) Not operating the plant as per GERCs grid code, SLDC instruction and prudent practices of industries;
- (g) Disinvestment of equity below minimum percentage holding during lock in period as specified; and
- (h) TSEC repudiates TSEC GUVNL PPA.

***GUVNL's Default:*** The occurrence of any of the following events at any time during the term of TSEC GUVNL PPA shall constitute event of default by GUVNL ("**GUVNL Event of Default**"):

- (a) Failure or refusal by GUVNL to pay any portion of undisputed monthly bill for a period of 90 days after due date;
- (b) GUVNL repudiates TSEC GUVNL PPA;
- (c) GUVNL becomes voluntarily or involuntarily the subject of proceeding under any bankruptcy or insolvency laws or goes into liquidation or dissolution or has receiver appointed over it or liquidator appointed, pursuant to law, except where such dissolution of GUVNL is for the purpose of a merger, consolidation or reorganisation and where the resulting entity has the financial standing to perform its obligations under TSEC GUVNL PPA and creditworthiness similar to GUVNL and expressly assumes all obligations under TSEC GUVNL PPA and is in a position to perform them.

#### *Termination:*

*Termination for TSEC Event of Default:* Upon the occurrence of TSEC Event of Default, GUVNL may deliver a default notice to TSEC in writing as specified in TSEC GUVNL PPA. After the expiry of 30 days from the delivery of notice and unless the parties have agreed otherwise or TSEC Event of Default has been remedied, GUVNL may deliver termination notice to TSEC. GUVNL may terminate TSEC GUVNL PPA by delivering such a termination notice to TSEC and intimate the same to the Commission. Upon delivery of termination notice, TSEC GUVNL PPA shall stand terminated and GUVNL shall stand discharged of all its obligations. TSEC shall have liability to make payment within 30 days from the date of termination notice towards compensation to GUVNL equivalent to three years billing based on first year tariff considered on normative PLF while determining the tariff by GERC.

*Termination for GUVNL Event of Default:* Upon occurrence of a GUVNL Event of Default, TSEC may deliver a default notice to GUVNL as specified in the TSEC GUVNL PPA. After expiry of 30 days from the delivery of the default notice and unless the parties have agreed otherwise or the GUVNL Event Default has been remedied, TSEC may serve suspension notice to GUVNL for a duration not exceeding one year.

During suspension period, GUVNL shall allow TSEC to sell power from the project to any HT consumers of the State in the open market either by finding the said consumers on its own or through Central/State power trading utilities. In case of wheeling of power to such third parties, the transmission charges, transmission losses, wheeling charges and losses, SLDC charges and cross subsidy, surcharges etc. shall be applicable as per GERC's regulations in force from time to time and paid directly to respective agencies by third party. No banking facility shall be allowed to TSEC and third parties.

On expiry of the suspension period, GUVNL will be entitled to cure its default and buy power from TSEC. In the event GUVNL fails to cure the default, TSEC may terminate TSEC GUVNL PPA by delivering a termination notice to GUVNL and GUVNL shall have liability to make payment within 30 days from the date of termination notice towards compensation to TSEC equivalent to three years billing based on first year tariff considered on normative PLF while determining the tariff by GERC.

#### *Indemnity:*

*TSEC's Indemnity:* TSEC agrees to defend, indemnify and hold harmless GUVNL, its officers, directors, agents, employees and affiliates from and against any and all claims, liabilities, actions, demands, judgements, losses, costs, expenses, suits, actions and damage arising by reason of bodily injury death or damage to property sustained by third parties that are caused by an act of negligence or the willful misconduct of TSEC or by an officer, director, subcontractor, agent, or employee of TSEC except to the extent such injury, death or damage as is attributable to the willful misconduct or negligence of or breach of TSEC GUVNL PPA by GUVNL or by an officer, director, sub-contractor, agent or employee of GUVNL.

*GUVNL's Indemnity:* GUVNL agrees to defend, indemnify and hold harmless TSEC, its officers, directors, agents, employees and affiliates from and against any and all claims, liabilities, actions, demands, judgements, losses, costs, expenses, suits, actions and damage arising by reason of bodily injury, death or damage to property sustained by third parties that are caused by an act of negligence or the willful misconduct of GUVNL or by an officer, director, subcontractor, agent or employee of GUVNL except to the extent such injury, death or damage as is attributable to the willful misconduct or negligence of or breach of TSEC GUVNL PPA by TSEC or by an officer, director, sub-contractor, agent or employee of TSEC.

#### *Miscellaneous Provisions:*

*Assignment:* Neither party shall assign TSEC GUVNL PPA nor any portion hereof without the prior written consent of the other party provided further that any assignee shall expressly assume the assignor's obligations thereafter arising under TSEC GUVNL PPA pursuant to documentation satisfactory to such other party. In furtherance of the foregoing, GUVNL acknowledges that the financing documents may provide that upon an event of default by TSEC under the financing documents, the financing parties may cause TSEC to assign to a third party the interest, rights and obligations of TSEC thereafter arising under TSEC GUVNL PPA. GUVNL further acknowledges that the financing parties may in addition to the exercise of their rights as set forth, cause TSEC to sell or lease the project and cause any new lessee or purchaser of the project to assume all of the interests, rights and obligations of TSEC thereafter arising under TSEC GUVNL PPA.

*CDM:* TSEC shall share CDM benefits with GUVNL on gross basis starting from 100% to TSEC in the first year

after commissioning and thereafter reducing by 10% every year till the sharing becomes equal between TSEC and GUVNL in the sixth year. Thereafter, sharing of CDM benefit shall remain equal till the time that benefit accrues.

**8.1 Supplemental Power Purchase Agreements between TSEC and GUVNL dated September 21, 2011, July 19, 2012 and December 28, 2012 and September 8, 2017.**

Supplemental power purchase agreements were executed between TSEC and GUVNL wherein, amongst others, the project site in TSEC GUVNL PPA was replaced by Gujarat Solar Park at Village: Charanka, Taluka – Santhalpur, District Patan. Further, the tariff was modified in the supplemental power purchase agreements and GUVNL shall pay the tariff specified therein for the period specified. Further, by way of supplemental power purchase agreement dated September 8, 2017, the change in name of AES Solar Energy Gujarat Private Limited to Sindicatum Solar Energy Gujarat Private Limited was recorded. Further, consequent to name change from Sindicatum Solar Energy Gujarat Private Limited to TSEC, TSEC is in the process of intimating GUVNL to record change in name.

**9. Power Purchase Agreement dated April 6, 2015 between USUPL and UPPCL read with amendment to the power purchase agreement dated December 30, 2017**

A power purchase agreement dated April 6, 2015 has been executed between USUPL (project company formed by Sukhbir Agro Energy Limited) and UPPCL (“USUPL PPA”) wherein UPPCL has agreed to procure solar power up to 30 MW (AC) from Village Kankua, District Mahoba, State: Uttar Pradesh at tariff of ₹9.33/kWh for the first 12 years and for further 13 years, at tariff of eleventh year average pooled purchase cost.

***Relevant Definitions:***

***Commercial Operation Date:*** The date on which the plant is available for commercial operation and such date as specified in a written notice at least ten days in advance to UPNEDA or UPPCL.

***Scheduled Commercial Operation Date:*** 18 months from the effective date of the agreement, when the solar power project is required to be commissioned as per the terms specified. Commissioning certificate dated September 15, 2016 issued by UPPCL, certified successful commission of 30 MW solar power project of USUPL on September 15, 2016.

***Term of agreement:*** The USUPL PPA shall be deemed to have come into force with effect from the date of signing of USUPL PPA and shall remain in full force from the date of commissioning of last unit of the solar plant from which solar power is committed to be supplied. USUPL PPA shall be valid for a term from the effective date until the date occurring 12 years from the date of commercial operation of the solar power project. It may be extended for a further period, at least 180 days prior to the expiry date on agreed terms and conditions. Additionally, 180 days prior to expiry of USUPL PPA, UPPCL will extend the USUPL PPA will extend USUPL PPA for a further period of 13 years at the price of 11<sup>th</sup> year average pooled purchase cost. However, the budgetary support from Uttar Pradesh government as incentive will be available only for initial 12 years of USUPL PPA and will not be available for the extended 13 years.

Further, USUPL PPA shall be terminated early before expiry date if either USUPL or UPPCL terminates pursuant to the terms specified.

***Conditions Subsequent:*** USUPL has agreed to duly perform and complete certain activities at their own risk and cost within 210 days from the signing of USUPL PPA, unless such completion is affected by Force Majeure event or if any of the activities is specifically waived, subject to certain conditions specified, and such activities include, amongst others:

- (a) acquired land and taken possession of the total land required for the project or will acquired total land required for within 150 days of signing of USUPL PPA;
- (b) obtained all consents, clearances and permits required for the supply of power to USUPL;
- (c) achieved financial closure and has provided a certificate to UPNEDA from the lead bank to this effect;
- (d) sent a written notice to UPNEDA and UPPCL indicating the installed capacity for the power project expressed in MW;
- (e) signed a transmission agreement with UPPTCL/Discom confirming the evacuation and connectivity of

transmission system with the power project switchyard within 180 days;

- (f) fulfilled the qualifying requirements according to relevant selection criteria;
- (g) submitted to UPNEDA the relevant documents complying with the conditions within 210 days.

Consequence of non-fulfillment of conditions subsequent, depend on the capacity of the power plants and include payment of liquidated damages, encash the performance bank guarantee and for delay for over and above six months, grounds for UPNEDA/ UPPCL for termination of the USUPL PPA.

***Construction and Development of the Project:***

*USUPL's Obligation:* USUPL undertakes to be responsible, at their own cost and risk, for certain activities including the following:

- (a) obtaining all consents, clearances and permits and maintaining all consents, clearances and permits in full force and effect during the Term of Agreement;
- (b) designing, constructing, erecting, commissioning, completing and testing the power project in accordance with applicable laws, the grid code specified by Central Electricity Regulatory Commission or State Commission under the Electricity Act, 2003, terms and conditions of USUPL PPA and prudent utility practices;
- (c) commencement of supply of power up to the Contracted Capacity to UPPCL no later than the Scheduled Commissioning Date and continuance of the supply of power;
- (d) owing the power project throughout the Term of Agreement free and clear of encumbrances, except those expressly permitted;
- (e) maintaining its controlling shareholding prevalent at the time of signing of USUPL PPA up to a period of one year after Commercial Operation Date.

Further, the projects developed on conventional technology should have a minimum CUF of 15% in any given contract year. In case the developers fail to supply energy pertaining to minimum CUF, then the developer shall pay a penalty equal to 10% of the project tariff for shortfall in unit.

The grid connectivity and associated evacuation facilities from the solar power plant will be provided in accordance with Uttar Pradesh Electricity Regulatory Commission (Grant of Connectivity to Intra-State Transmission System) Regulations, 2010, as amended from time to time. Further, the USUPL provides certain specifications regarding grid connectivity which needs to be complied with.

USUPL PPA contains provisions with respect to interconnection facilities.

*Purchase and sale of Contracted Capacity:* Subject to the terms and conditions of the USUPL PPA, USUPL undertakes to sell to UPPCL and UPPCL undertakes to pay Tariff for all the energy supplied corresponding to the Contracted Capacity.

*Right to Contracted Capacity and Energy:* UPPCL, at any time during a contract year, shall not be obliged to purchase any additional energy from USUPL beyond Contracted Capacity, with a maximum CUF of 21%. If during any year it is found that USUPL has not been able to generate minimum energy 39,420 million Kwh (MU) on account of solely attributable to USUPL, the non-compliance shall attract compensation to UPPCL.

***Applicable Tariff:*** USUPL shall be entitled to the Tariff for the energy supplied during contract year pertaining to Contracted Capacity. Out of the total per unit tariff, the tariff which has been arrived from the latest bidding for conventional power project as conducted by UPPCL will be paid from the UPPCL kitty and the balance amount will be routed through UPNEDA to UPPCL and will be paid to USUPL on monthly basis for entire duration of the USUPL PPA. UPPCL and USUPL shall agree for extension for further 13 years on willingness of USUPL and the tariff for the sale of power for UPPCL for the extended period shall be the price of 11<sup>th</sup> year average pooled purchase cost. However, the budgetary support from Uttar Pradesh state government as incentive will be available for initial 12 years.

***Billing and Payment:*** UPPCL shall provide in respect of its monthly bills, an unconditional, revolving and

irrevocable letter of credit which may be drawn upon by as the terms specified. Additionally, as further support for the obligations, a default escrow account shall be established in favor of USUPL, as per the terms specified.

Further, upon the occurrence of any of the events specified in the USUPL PPA, including default in payment and non-availability of letter of credit for operation, USUPL shall have the right to divert power and sell it to third party, in the manner specified in the USUPL PPA.

**Dispatch and Scheduling:** The project shall be required to maintain compliance to the applicable grid code requirements and directions, specified by State Load Dispatch Centre/UPLDC from time to time.

**Metering:** Installation of meters, meter testing, meter calibration and meter reading shall be as per the relevant regulations, and as revised from time to time.

**Insurances:** USUPL shall effect and maintain or cause to be effected and maintained, at its own cost and expense, throughout the term of agreement, insurances against such risks, with such deductibles and with such endorsements and co-insured(s), which the prudent utility practices would ordinarily merit maintenance of and as required under the financing agreements.

**Force Majeure:** Force Majeure means any event or circumstances or combination of events specified in USUPL PPA, that wholly or partly prevents or unavoidably delays the parties in the performance of its obligations under USUPL PPA, but only if and to the extent that such events or circumstances are not within the reasonable control, directly or indirectly, of the party and could not have been avoided if the party had taken reasonable care or complied with prudent utility practices. Further, the USUPL PPA specifies certain force majeure exclusions, manner of notification of force majeure event, duty to perform and duty to mitigate of the parties and the available relief for a force majeure event.

**Change in Law:** Change in law means the occurrence of any of the events specified in the USUPL PPA after the effective date resulting into any additional recurring/ non-recurring expenditure by USUPL or any income to USUPL. USUPL PPA specifies that the aggrieved party shall be required to approach the central commission for seeking approval of change in law.

**Events of Default and Termination:**

**USUPL Event of Default:** The occurrence and/ or continuation of any of the events specified, unless any event occurs as a result of a Force Majeure event shall constitute event of default for USUPL (“**USUPL Event of Default**”), which includes:

- (a) the failure to commence supply of power to UPPCL up to the contracted capacity, by the end of the period specified in USUPL PPA;
- (b) except to bank, USUPL mortgages or charges or purports to assign, mortgage or charge any of its assets or rights related to the power project in contravention of USUPL PPA or USUPL transfers or novates any of its rights and/ or obligations under USUPL PPA in a manner contrary to the provisions of USUPL PPA, except in certain specified situations;
- (c) USUPL becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding up proceedings and such proceedings remain uncontested for a period of 30 days or any winding up or bankruptcy or insolvency order is passed against USUPL or USUPL goes into liquidation or dissolution or has a receiver appointed to manage its affairs, provided that a dissolution or liquidation of USUPL will not be USUPL Event of Default if such dissolution or liquidation is for the purpose of a merger, consolidation or reorganisation and where the resulting company retains creditworthiness similar to USUPL and expressly assumes all obligations of USUPL under USUPL PPA and is in a position to perform them;
- (d) USUPL repudiates USUPL PPA and does not rectify such breach within a period of 30 days from a notice from UPPCL in this regard;
- (e) occurrence of any other event which is specified in USUPL PPA to be a material breach/ default of USUPL.

**UPPCL Event of Default:** The occurrence and continuation of any of the following events unless any such event occurs a result of a Force Majeure or a breach by USUPL of its obligations under USUPL PPA shall constitute

event of default for UPPCL (“**UPPCL Event of Default**”):

- (a) UPPCL fails to pay monthly bill or supplementary bill, subject to certain specified conditions, for a period of 90 days after the due date and USUPL is unable to recover the amount outstanding to USUPL through letter of credit/ default escrow account;
- (b) UPPCL repudiates USUPL PPA and does not rectify such breach even within a period of 30 days from a notice from USUPL in this regard;
- (c) except where due to any USUPL failure to comply with its obligations, UPPCL is in material breach of any of its obligations pursuant to USUPL PPA, and such material breach is not rectified within 30 days of receipt of notice in this regard from USUPL to UPPCL;
- (d) UPPCL becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding up proceedings and such proceedings remain uncontested for a period of 30 days or any winding up or bankruptcy or insolvency order is passed against UPPCL or UPPCL goes into liquidation or dissolution or a receiver or any similar officer is appointed over all or substantially all of its assets or official liquidator is appointed to manage its affairs pursuant to law provided that it shall not constitute a UPPCL Event of Default where such dissolution or liquidation of UPPCL is for the purpose of a merger, consolidation or reorganisation where the resulting entity has the financial standing to perform its obligations under USUPL PPA and has creditworthiness similar to UPPCL and expressly assumes all obligations of UPPCL and is in a position to perform them;
- (e) occurrence of any other events which is specified in USUPL PPA to be a material breach or default of UPPCL.

*Procedure in cases of USUPL Event of Default:* Upon the occurrence and continuation of any USUPL Event of Default, UPPCL shall have the right to deliver to Solar Edge, a notice stating its intention to terminate USUPL PPA which shall specify in reasonable details, the circumstances giving rise to the issue of such notice.

Within a period of seven days following the consultation period of 60 days unless the parties have otherwise agreed to the contrary or the USUPL Event of Default giving rise to the consultation period shall have ceased to exist or shall have been remedied, UPPCL may terminate USUPL PPA by giving a written termination notice of 30 days to USUPL.

*Procedure in cases of UPPCL Event of Default:* Upon the occurrence and continuation of any UPPCL Event of Default, USUPL shall have the right to preliminary deliver to SECI default notice which notice shall specify in reasonable detail the circumstances giving rise to its issue.

Following the issue of preliminary default notice, the consultation period of 60 days or such longer period as the parties may agree, shall apply and it shall be the responsibility of the parties to discuss as to what steps shall be taken with a view to mitigate the consequences of the relevant event of default having regard to all the circumstances. During the consultation period, the parties shall continue to perform their respective obligations under USUPL PPA. After a period of seven days following the expiry of the consultation period and unless the parties shall have otherwise agreed to the contrary or UPPCL Event of Default giving rise to the consultation period shall have ceased to exist or shall have been remedied, USUPL shall be free to sell the Contracted Capacity to any third party of choice.

Provided further that at the end of three months period from this period, USUPL PPA may be terminated by USUPL.

*Termination due to Force Majeure:* If force majeure event or its effects continue to be present beyond the period as specified, either party shall have the right to cause termination of USUPL PPA. In such an event, USUPL PPA shall terminate on the date of such termination notice.

**Indemnity:** USUPL shall indemnify, defend and hold UPPCL harmless against, amongst others:

- (a) any and all third party claims against UPPCL for any loss of or damage to property of such third party or death or injury to such third party arising out of a breach by USUPL of any of its obligations under USUPL PPA; and
- (b) any and all losses, damages, costs and expenses including legal costs, fines, penalties and interest actually



suffered or incurred by UPPCL from third party claims arising by reason of a breach by USUPL of any of its obligations under USUPL PPA, subject to certain conditions;

UPPCL shall indemnify, defend and hold USUPL harmless against:

- (a) any and all third party claims against USUPL for any loss of or damage to property of such third party or death or injury to such third party arising out of a breach by procurers of any of its obligations under USUPL PPA and;
- (b) any and all losses, damages, costs and expenses including legal costs, fines, penalties and interests actually suffered or incurred by USUPL from third party claims by reason of a breach of procurers of any its obligations, on the conditions specified.

Further, the non-payment of losses shall constitute an event of default under USUPL PPA.

Additionally, except as provided in USUPL PPA, neither USUPL nor UPPCL nor its respective officers, directors, agents, employees or affiliates shall be liable or responsible to the other party or its affiliates, officers, directors, agents, employees, successors or permitted assigns or their respective insurers for incidental, indirect, or consequential damages connected with or resulting from performance or non-performance of USUPL PPA, including claims in the nature of lost revenues, income or profits, any increased expense, reduction in or loss of power generation or equipment used, irrespective of whether such claims are based on breach of warranty, tort, strict liability, contract, breach of statutory duty, operation of law or otherwise.

Further, UPPCL shall have no recourse against any officer, director, or shareholder of USUPL or any affiliate for such claims. USUPL shall have no recourse against any officer, director or shareholder of UPPCL or any affiliates for such claims.

**Assignment and Charges:** USUPL PPA shall not be assigned by any party other than by mutual consent between the parties to be evidenced in writing.

Further, USUPL shall not create or permit to subsist any encumbrance over all or any of its rights and benefits under USUPL PPA.

#### **9.1 Amended Power Purchase Agreements between USUPL and UPPCL dated December 30, 2017**

Amended power purchase agreement was executed between USUPL and UPPCL dated December 30, 2017 wherein, it was agreed that in case of extension of the USUPL PPA, USUPL will have to supply power from the 13<sup>th</sup> year to 25<sup>th</sup> year at the tariff as will be decided by state commission at the appropriate time taking into consideration, amongst others, return on equity, O&M expenses and interest on working capital loan. UPPCL or USUPL can approach the state commission before the end of 11<sup>th</sup> year for determination of tariff for the remaining 13 years.

## CORPORATE GOVERNANCE

*The section below is a summary of the corporate governance framework in relation to Terra InvIT, implemented by or to be implemented by the Investment Manager, as applicable and as specified in this section.*

### The Investment Manager

The Investment Manager is the investment manager of Terra InvIT. For further details on the background of the Investment Manager, please see *'Parties to the Terra InvIT – The Investment Manager'* on page 201.

### Composition of the Board

As on date of this Final Placement Memorandum, not less than 50% of the board of directors of the Investment Manager comprises of independent directors and are not directors or members of the governing board of the Investment Manager of another infrastructure investment trust registered under the InvIT Regulations.

The Board comprises of:

Sr. No.	Name	DIN	Designation
1.	Mr. Hardik Shah	06648474	Non- Executive Director
2.	Mr. Sanjay Grewal	01971866	Whole-time executive director
3.	Mr. Vinay Pabba	02711931	Independent Director
4.	Mr. Pradeep Kumar	03614568	Independent Director

### InvIT Committee

The Board has constituted the InvIT Committee pursuant to a resolution dated March 3, 2021 and operation and functioning of the InvIT Committee would be under the strict supervision of the Board. The InvIT Committee consist of the following members:

1. Mr. Hardik Shah; and
2. Mr. Sanjay Grewal

Among others, the Board has delegated to the InvIT Committee the authority and responsibility of performing all activities in relation to the proposed Issue by Terra InvIT and any future issues that may be undertaken by the Terra InvIT. Further, the InvIT Committee shall have the authority to decide and finalise the Issue Opening Date, Issue Closing Date, and the Issue Price, allotment of Units to investors and approve any amendments to the documents in relation to the Issue including the offer documents.

### Policies Adopted in Relation to the Terra InvIT

The Board will adopt policies for corporate governance as may be required from time to time in accordance with applicable law and the SEBI InvIT Regulations. The Board has adopted the following policies under the corporate governance framework of the Terra InvIT, however all these policies will be effective from the Completion Date:

#### *Distribution Policy*

The Board has adopted the distribution policy pursuant to a resolution of dated February 17, 2021 and as amended by resolution dated July 21, 2021, in relation to the Terra InvIT. The distribution policy provides a structure for distribution of the net distributable cash flows of the SPVs to the Terra InvIT and the Terra InvIT to the Unitholders. For details of the Distribution Policy, see *'Distribution'* on page 190.

#### *Code of Conduct ("Code")*

The Board has adopted the Code pursuant to a resolution dated February 17, 2021, in relation to the Terra InvIT and conduct of the Terra InvIT and the Parties to the Terra InvIT. The policy provides for principles and procedures for the Sponsor, the Investment Manager, the Project Manager, the Trustee and their respective employees, as may be applicable, for ensuring interest of the Unitholders and proper conduct and carrying out of the business and affairs of the Terra InvIT in accordance with applicable law. The key principles of the Code are set out below:

- a) The Terra InvIT and the Parties to the Terra InvIT shall conduct all affairs of the Terra InvIT in the interest of all the Unitholders.
- b) The Terra InvIT and Parties to the Terra InvIT shall make adequate, accurate, explicit and timely disclosure of relevant material information to all Unitholders in accordance with the SEBI InvIT Regulations from time to time.
- c) The Terra InvIT and Parties to the Terra InvIT shall try to avoid conflicts of interest, as far as possible, in managing the affairs of the Terra InvIT and keep the interest of all Unitholders paramount in all matters. In case such events cannot be avoided, it shall be ensured that appropriate disclosures are made to the Unitholders and they are fairly treated.
- d) The Terra InvIT and Parties to the Terra InvIT shall ensure that fees charged by them with respect to activities of the Terra InvIT shall be fair and reasonable.
- e) The Investment Manager shall carry out the business of the Terra InvIT in accordance with the Trust Deed and the Investment Management Agreement and invest in accordance with the investment objectives stated in the Draft Placement Memorandum, and take investment decisions solely in the interest of Unitholders.
- f) The Terra InvIT, Parties to the Terra InvIT and any third party appointed by the Investment Manager shall not use any unethical means to sell, market or induce any person to buy Units of the Terra InvIT and where a third party appointed by the Investment Manager fails to comply with this condition, the Investment Manager shall be held liable for the same.
- g) The Terra InvIT and Parties to the Terra InvIT shall maintain high standards of integrity and fairness in all their dealings and in the conduct of their business.
- h) The Terra InvIT and Parties to the Terra InvIT shall render at all times high standards of service, exercise due diligence, ensure proper care and exercise independent professional judgment.
- i) The Terra InvIT and Parties to the Terra InvIT shall not make any exaggerated statement, whether oral or written, either about their qualifications or capabilities or experience.

### **Borrowing Policy**

The Investment Manager shall ensure that all funds borrowed in relation to the Terra InvIT are in compliance with the SEBI InvIT Regulations. Accordingly, the Investment Manager, has adopted the Borrowing Policy on February 17, 2021 and as amended by resolution dated July 21, 2021. The key terms of the Borrowing Policy include, *inter alia*:

- 1. The Terra InvIT may make borrowings and deferred payments from time to time, including availing loans from banks and financial institutions, by any instrument, in Indian or foreign currency in accordance with applicable law.
- 2. The Terra InvIT has the power to create, mortgage or secure any of its assets or provide guarantees in order to borrow funds in accordance with applicable law.
- 3. The borrowings made by the related parties shall be in line with the SEBI InvIT Regulations.
- 4. The Trustee shall, on receipt of advice from the Investment Manager, have the power to borrow monies (through any mode, including by way of issuance of debt securities, subordinated debt, equity or other Securities or instruments permitted under the SEBI InvIT Regulations or other applicable law) from any person or authority (whether government or otherwise, whether Indian or overseas) on such terms and conditions, and for such periods and purpose, as may be permitted under the SEBI InvIT Regulations and approved by the Unitholders, and offer such security as it may deem fit, for the purpose of making such borrowing. Further, the Trustee (acting in capacity of the trustee of the Terra InvIT) shall have the power to create charge, security interest and/or lien over any or all of the assets of the Terra InvIT (both, present or future), to secure and/or guarantee the performance of any of the obligations of the SPVs, as it may deem fit.

5. The Investment Manager shall submit an annual report to the Trustee and Unitholders of the Terra InvIT, either electronically or through physical copies, with the following:
- (i) Details of changes during the year pertaining to borrowings or repayment of borrowings (standalone at SPV level and consolidated at the Terra InvIT level); and
  - (ii) Details of outstanding borrowings and deferred payments of Terra InvIT including any credit rating(s), debt maturity profile, gearing ratios of the Terra InvIT on a consolidated and standalone basis as at the end of the year.

***Appointment of Auditor and Valuer Policy***

The Board has adopted the Appointment of Auditor and Valuer Policy pursuant to a resolution dated February 17, 2021, in relation to the Terra InvIT. The policy provides a framework for ensuring compliance by the Terra InvIT in the appointment of its auditor, and the auditing standards to be followed, and the appointment of its valuer, in accordance with applicable law as applicable to an investment infrastructure trust, including the SEBI InvIT Regulations. For key principles of the appointment of Auditor and Valuer, see, '***Other Parties***' on page 211.

For details of the Related Party Transactions Policy, see '***Related Party Transactions***' on page 188.

In addition to the above mentioned policies as required under the SEBI InvIT Regulations, the Board has also adopted among others, anti-bribery and anti-corruption policy, health safety and environment policy, prevention of sexual harassment policy, risk management policy and vigil mechanism policy.

**Representatives on the board of directors of each Asset SPV**

The Investment Manager, in consultation with the Trustee, shall appoint majority of the board of directors of the Asset SPVs.

## REGULATIONS AND POLICIES

*The following description is a summary of certain sector specific laws currently in force in India, which are applicable to the operations of the Terra InvIT and the Asset SPVs. The information detailed in this section has been obtained from publications available in the public domain. The description below may not be exhaustive, and is only intended to provide general information to investors, and is neither designed as, nor intended to substitute, professional legal advice. The information in this section is based on the current provisions of applicable law that are subject to change or modification by subsequent legislative, regulatory, administrative or judicial decisions in India. For information regarding regulatory approvals obtained by the Asset SPVs, please see 'Regulatory Approvals' on page 298.*

### **Laws Relating to the Business and Operations of the Terra InvIT and the Asset SPVs**

#### ***The Electricity Act, 2003 ("Electricity Act")***

The Electricity Act is the central legislation which covers, amongst others, generation, transmission, distribution, trading and use of electricity. Under the Electricity Act, the transmission, distribution and trade of electricity are regulated activities that require licenses from CERC, SERCs or a joint commission (constituted by an agreement entered into by two or more state governments or the central government in relation to one or more state governments, as the case may be).

Under the Electricity Act, the appropriate commission, guided by, *inter alia*, the principles and methodologies specified by the CERC, promotion of co-generation and generation of electricity from renewable sources of energy, principles rewarding efficiency in performance, objective of safeguarding consumers' interest and at the same time, recovery of the cost of electricity in reasonable manner, shall stipulate the terms and conditions for the determination of tariff. The Electricity Act currently requires the Central Government to, from time to time, prepare the national electricity policy and tariff policy, in consultation with the state governments and central electricity authority.

The Draft Electricity (Amendment) Bill, 2020 ("**Draft EAB**") is sought to be enacted to amend certain provisions of the Electricity Act. Amongst others, the Draft EAB provides for the constitution of Electricity Contract Enforcement Authority which will have sole authority and jurisdiction to adjudicate upon specified contract-related disputes in the electricity sector but shall not have any jurisdiction in any dispute involving tariff. Further, SERCs are required to progressively reduce cross-subsidy in the manner as may be provided in the National Electricity Tariff Policy. The appropriate commission shall fix tariff for retail sale of electricity without accounting for subsidy and shall be provided by the Government directly to the consumers. Draft EAB also provides for an entity termed Distribution Sub-licensee wherein a distribution licensee can authorise a sub-licensee to distribute electricity on its behalf with the prior permission of the SERC. Additionally, the Draft EAB empowers the Central Government to prepare and notify a National Renewable Energy Policy in consultation with state Governments and prescribe a minimum percentage of purchase of electricity from renewable and hydro sources of energy. In addition, the Electricity (Amendment) Bill, 2021 which is proposed to be introduced to the Lok Sabha seeks to de-license the distribution business, bring in competition, appoint member from law background in every commission, strengthen APTEL, and prescribe rights and duties of consumers.

#### ***National Electricity Policy***

The Central Government notified the National Electricity Policy on February 12, 2005, in accordance with the provisions of the Electricity Act. The National Electricity Policy provides guidelines for accelerated development of the power sector, providing supply of electricity to all areas and protecting interests of consumers and other stakeholders keeping in view availability of energy resources, technology available to exploit these resources, economics of generation using different resources, and energy security issues.

The National Electricity Policy provides that the SERCs should specify appropriate tariffs in order to promote renewable energy, up until renewable energy power producers relying on non-conventional technologies can compete with conventional sources of energy. The SERCs are required to ensure progressive increase in the share of generation of electricity from non-conventional sources and provide suitable measures for connectivity with grid and sale of electricity to any person. Further, the SERCs are required to specify, for the purchase of electricity from renewable energy sources, a percentage of the total consumption of electricity in the area of a distribution licensee. Furthermore, the National Electricity Policy provides that such purchase of electricity by distribution companies should be through a competitive bidding process. The National Electricity Policy permits the SERCs

to determine appropriate differential prices for the purchase of electricity from renewable energy power producers, in order to promote renewable sources of energy.

#### ***Draft Renewable Energy Act, 2015 (“Renewable Energy Act”)***

The Central Government has released the draft Renewable Energy Act to address various issues limiting the growth potential of renewable energy sector. The Renewable Energy Act is in the consultation stage and would be proposed in the parliament once other amendments and legislations (under National Tariff Policy and Electricity Act 2003) to facilitate the implementation of the said legislation are also identified and implemented.

The Renewable Energy Act aims to boost demand for renewable energy by creating a mandatory national level RPO targets with provision for penalties on Discoms/states in case of non/under compliance. In addition, it envisages timely provisioning of infrastructure, payment security mechanisms and other steps to improve operations for developers.

#### ***Jawaharlal Nehru National Solar Mission (“JNNSM”)***

The JNNSM was launched by the Government on January 11, 2010. The JNNSM has set a goal of 100 GW of solar power in India by 2022 and seeks to implement and achieve the target in three phases (Phase I from 2012 to 2013, Phase II from 2013 to 2017 and Phase III from 2017 to 2022). JNNSM attempts to reduce the cost of solar power generation in the country through long term policy, large scale deployment goals, aggressive R&D and domestic production of critical raw materials, components and products, and as a result, accomplish grid tariff parity by 2022. JNNSM also targets to create an enabling policy framework to achieve this objective and make India a global leader in solar energy. Further, the Government on March 22, 2017 sanctioned the implementation of a certain scheme to enhance the capacity of solar parks from 20,000 MW to 40,000 MW for setting up at least 50 solar parks each with a capacity of 500 MW and above. To facilitate the implementation of JNNSM, SECI has been established under the administrative control of the Ministry of New and Renewable Energy in, 2011 to facilitate the implementation of JNNSM.

#### ***National Tariff Policy***

The Government notified the revised National Tariff Policy effective from January 28, 2016. Amongst others, the National Tariff Policy seeks to ensure availability of electricity to consumers at reasonable and competitive rates, ensure financial viability of the sector and attract investments, promote competition, efficiency in operations and improvement in quality of supply, promote generation of electricity from renewable sources and evolve a dynamic and robust electricity infrastructure for better consumer services. The National Tariff Policy provides that SERCs shall reserve a minimum percentage for purchase of solar energy from the date of notification of the policy which shall be such that it reaches 8% of total consumption of energy by March 2022.

#### ***Central Electricity Regulatory Commission (Terms and Conditions for Tariff Determination from Renewable Energy Sources) Regulations, 2017***

CERC has announced the Central Electricity Regulatory Commission (Terms and Conditions for Tariff Determination from Renewable Energy Sources) Regulations, 2017 (the “**Tariff Regulations**”) which supersede the regulations issued in 2012. The Tariff Regulations govern the determination of tariff, for a generating station or a unit commissioned during the ‘Control Period’ (being a period of three years specified in the Tariff Regulations starting from the Financial Year ended March 31, 2018). The tariff period under the Tariff Regulations is required to be considered from the date of commercial operations of the renewable energy stations. The Tariff Regulations further stipulates the criteria which should be taken into consideration by CERC while determining the tariff for the sale of electricity generated from renewable sources. CERC shall determine the generic tariff on the basis of suo motu petition at least six months in advance at the beginning of each year of the Control Period. The Tariff Regulations also provide the mechanism for sharing of carbon credits from approved clean development mechanism projects between generating company and the concerned beneficiaries.

#### ***Renewable Purchase Obligations***

The Electricity Act and the National Tariff Policy require the SERCs to specify, for the purchase of electricity from renewable sources, a percentage of the total consumption of electricity within the area of a distribution licensee, which are known as RPOs. RPOs are required to be met by obligated entities (distribution licensees, captive power plants and open access consumers) by purchasing renewable energy, either by renewable energy power producers or by purchasing RECs. In the event of default by an obligated entity in any Financial Year, the

SERCs may direct the obligated entity to pay a penalty or to deposit an amount determined by the relevant SERC, into a fund to be utilised for, amongst others, the purchase of renewable energy certificates.

***Central Electricity Regulatory Commission (Indian Electricity Grid Code) Regulations, 2010 (“Grid Code”)***

The Indian power system encompassing of all aspects of generation, transmission, distribution and supply of electricity, is a conglomeration of a number of various agencies. The CERC in the Grid Code has specified a single set of technical and commercial rules encompassing all the utilities connected to or using the inter-State transmission system and provides, amongst others, documentation of the principles and procedures which define the relationship between the various users of the inter-State transmission system, National Load Despatch Centre, as well as the regional and state load despatch centres. Further, the Grid Code provides for facilitation of the optimal operation of the grid, facilitation of coordinated and optimal maintenance planning of generation and transmission facilities in the grid and facilitation of development and planning of economic and reliable national / regional grid. The Grid Code also seeks facilitation of the development of renewable energy sources by specifying the technical and commercial aspects for integration of these resources into the grid.

***Central Electricity Regulatory Commission (Open Access in Inter-State Transmission) Regulations, 2008 (the “CERC Open Access Regulations”)***

The CERC Open Access Regulations apply to the applications made for grant of open access for energy transfer schedules commencing on or after April 1, 2008 for use of the transmission lines or associated facilities with such lines on the inter-State transmission system. CERC Open Access Regulations clarifies that, subject to other regulations, the long-term customer shall have first priority for using the inter-State transmission system for the designated use. CERC Open Access Regulations apply for utilisation of surplus capacity available thereafter on the inter-State transmission system by virtue of (a) inherent design margins; (b) margins available due to variation in power flows; and (c) margins available due to in-built spare transmission capacity created to cater to future load growth or generation addition. It provides for a structure which facilitates both bilateral transaction (transaction for exchange of energy between a specified buyer and a specified seller, directly or through a trading licensee), and collective transactions (set of transactions discovered in power exchange through anonymous, simultaneous competitive bidding by buyers and sellers). Additionally, the CERC Open Access Regulations provides for congestion management wherein the grant of all applications at a particular stage of advance scheduling is likely to cause congestion in one or more of the transmission corridors to be used, nodal agency shall conduct electronic bidding for grant of open access for the available surplus transmission capacity amongst the applicants at that stage.

***Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations, 2010 (“CEA Safety Regulations”)***

CEA Safety Regulations framed by Central Electricity Authority of India under the Electricity Act to regulate measures relating to safety and electric supply in India. Amongst others, the CEA Safety Regulations has indicated general safety requirements pertaining to construction, installation, protection, operation and maintenance of electric supply lines and apparatus. The generating units of capacity specified by the appropriate Government under the Electricity Act will be required to be inspected by the electrical inspector prior to commissioning. Further, the project owner, whose electrical installation and apparatus exceeds 650 volts, is required to file an application in accordance with the CEA Safety Regulations before commencement of supply or recommencement after shutdown for six months and above and this approval may be granted by the electrical inspector upon inspection. All new electrical installations also require approval from the electrical inspector prior to energisation of the equipment.

**Net Metering Regulations**

These regulations have been formulated by various states to promote the generation of electricity from renewable energy sources in respect of the grid connected solar rooftop photovoltaic systems. These regulations regulate the supply of excess electricity from an eligible consumer allowing the consumer to export the excess quantum of electricity produced from his/her premises to the distribution licensee. Under these regulations, the eligible consumer can avail the benefit of the excess quantum supplied to be carried forward to the next billing cycle as credited units of electricity.

## State Level Solar Policies

The various states in India, from time to time, have announced specific policies relating to solar power projects and the matters relating thereto. These policies provide for, amongst others, fiscal incentives and procedural relaxations for setting up of solar power projects in the relevant states for promoting renewable energy and its adoption. The Asset SPVs operations are also subject to the solar policies formulated in the states in which it undertake/may undertake projects.

### *Indian Trusts Act, 1882 (“Indian Trusts Act”)*

The Indian Trusts Act governs all private trusts in India. The Indian Trusts Act sets out the purpose for which private trusts can be established, the manner in which they may be created, executed and extinguished. The person creating a trust is the author. The person to whom the author grants the authority to regulate the trust is the trustee. The persons for whose benefit such trust has been created are the beneficiaries. Further, the Indian Trusts Act sets out the rights, duties, liabilities and powers of the trustees and the beneficiaries vis-a-vis the trust. The Terra InvIT has been settled in accordance with the provisions of the Indian Trusts Act.

### *Environmental Laws*

The major legislations in India which protect the environment against pollution and also regulate the related activities include the Water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and Control of Pollution) Act, 1981 and the Environment (Protection) Act, 1986 (“**Environment Act**”). The primary purpose of these legislations is to control, abate and prevent pollution. In order to achieve these objectives, PCBs, which are vested with diverse powers to deal with water and air pollution, have been set up in each state. PCBs are responsible for setting the standards for maintenance of clean air and water, directing the installation of pollution control devices in industries and undertaking inspection to ensure that industries are functioning in compliance with the standards prescribed. These authorities issue consent to establish and consent to operate which are to be required to be renewed periodically. These authorities also have the power of search, seizure and investigation in case they of any alleged violation of the regulations.

Further, MoEF mandates that Environment Impact Assessment (“**EIA**”) must be conducted for specified projects. In the process, the MoEF receives proposals for the setting up of projects and assesses their impact on the environment before granting clearances to the projects. Such clearances must be obtained in accordance with the procedure specified in the EIA Notification S.O. 1533, issued on September 14, 2006 and amended from time to time, under the provisions of the Environment Act.

CPCB, under the MoEF has classified industrial sectors under the red, orange, green or white categories. The white category relates to those industrial sectors which are practically non-polluting, including solar power generation through photovoltaic cells, wind power projects of all capacities and mini hydroelectric power. In relation to the white category of industries, only intimation to the relevant PCB is required, and there is no requirement to obtain a consent to operate for this category.

### *Public Liability Insurance Act, 1991*

The Public Liability Insurance Act, 1991 (“**Public Liability Act**”), imposes liability on the owner or controller of hazardous substances for any damage arising out of an accident involving such hazardous substances. The owner or handler is required to maintain insurance policies insuring against liability under the legislation. Further, the rules made under the Public Liability Act mandate that the employer has to contribute towards the Environment Relief Fund, a sum equal to the premium paid on the insurance policies (which is payable to the insurer).

### *Other Laws and Regulations*

In addition to the aforementioned, the other laws and regulations that may be applicable to the Terra InvIT and the Asset SPVs include the following:

- *Factories Act, 1948\**
- *The Contract Labour (Regulation and Abolition) Act, 1970\**
- *The Child Labour (Prohibition and Regulation) Act, 1986*
- *The Employees’ Compensation Act, 1923\*\**



- *The Employees' State Insurance Act, 1948*\*\*
- *The Employee's Provident Fund and Miscellaneous Provisions Act, 1952*\*\*
- *The Equal Remuneration Act, 1976*\*\*\*
- *The Maternity Benefit Act, 1961*\*\*
- *The Minimum Wages Act, 1948*\*\*\*
- *The Payment of Gratuity Act, 1972*\*\*
- *The Payment of Bonus Act, 1965*\*\*\*
- *The Payment of Wages Act, 1936*\*\*\*
- *The Sexual Harassment of Women at Workplace (Prevention, Prohibition, and Redressal) Act, 2013*

*\*The Occupational Safety, Health and Working Conditions Code, 2020 (enacted by the Parliament of India and assented to by the President of India on September 28, 2020) will come into force on such date as may be notified in the official gazette by the Central Government and different dates may be appointed for different provisions of the Occupational Safety, Health and Working Conditions Code, 2020. Once effective, it will subsume, inter alia, the Factories Act, 1948 and the Contract Labour (Regulation and Abolition) Act, 1970.*

*\*\*The Code on Social Security, 2020 (enacted by the Parliament of India and assented to by the President of India on September 28, 2020) will come into force on such date as may be notified in the official gazette by the Central Government and different date may be appointed for different provisions of the Code on Social Security, 2020. Once effective, it will subsume, inter alia, the Employees' Compensation Act, 1923, the Employees' State Insurance Act, 1948, the Employee's Provident Fund and Miscellaneous Provisions Act, 1952, the Maternity Benefit Act, 1961 and the Payment of Gratuity Act, 1972.*

*\*\*\*The Code on Wages, 2019 (enacted by the parliament of India and assented to by the President of India on August 8, 2019) will come into force on such date as may be notified in the official gazette by the Central Government and different date may be appointed for different provisions of the Code on Wages, 2019. Once effective, it will subsume the Equal Remuneration Act, 1976, the Minimum Wages Act, 1948, the Payment of Bonus Act, 1965 and the Payment of Wages Act, 1936.*

In addition to the above, compliance with the provisions of various tax-related legislations, intellectual-property related legislations and other applicable law for our day-to-day operations is also required.

## RELATED PARTY TRANSACTIONS

In terms of Regulation 2(1)(zv) of the SEBI InvIT Regulations, related party shall be as defined as under the Companies Act, 2013 or under the applicable accounting standards and shall also include: (i) Parties to the Terra InvIT; and (ii) promoters, directors, and partners of the Parties to the Terra InvIT (“**Related Parties**”). For further details in relation to related party transactions for the past three years i.e., for the Financial Years ended March 31, 2021, 2020 and 2019, see ‘*Combined Financial Statements*’ on page 214. The Parties to the Terra InvIT, may, from time to time, enter into related party transactions, in accordance with applicable law.

### Procedure for dealing with Related Party Transactions

The Board has adopted the Related Party Transactions Policy (“**RPT Policy**”) pursuant to its resolution dated December 17, 2020 and as updated by resolution dated July 21, 2021.

Under the RPT Policy, the Investment Manager is required to establish an internal control system to ensure that all related party transactions of the Terra InvIT are on an arm’s length basis and compliant with applicable law and the Terra InvIT Documents and other circulars and guidelines issued by SEBI from time to time. The Investment Manager is required to obtain the approval of the Unitholders’ for such related party transactions, as may be required under applicable law. Further, the Investment Manager is required to convene meetings of the Unitholders in accordance with the Terra InvIT Documents, and maintain records pertaining to such meetings in the manner prescribed under applicable law. The Investment Manager is also required to ensure compliance with any additional guidelines issued in this regard by SEBI and other relevant regulatory or governmental authorities from time to time.

### Framework of Approval for Related Party Transactions

- (i) All related party transaction shall be reviewed and recommended by the audit and risk management committee of the Investment Manager for prior approval.
- (ii) All related party transaction shall be noted by the Board. Transactions not on arm’s length/not in ordinary course of business will require the approval of the Board.
- (iii) Every material related party transaction, in accordance with the RPT Policy, shall require approval of the Unitholders.

### Present and On-going Related Party Transactions

#### *Related Party Transactions of the Terra InvIT in relation to the setting up of the Terra InvIT and this Issue*

A number of present and on-going transactions of the Terra InvIT with certain Related Parties have been entered into in relation to the setting up of the Terra InvIT. The Trustee and the Investment Manager confirm that the following related party transactions have been, or shall be, entered into by the Terra InvIT, on an arm’s length basis in accordance with the relevant accounting standards, in the best interest of the Unitholders, consistent with the strategy and investment conditions of the Terra InvIT:

#### (i) *Trust Deed*

The Terra InvIT has been settled by the Investment Manager (acting as the settlor) on the instructions of the Sponsor, as an irrevocable trust under the provisions of the Trusts Act in Mumbai, India pursuant to the Trust Deed dated January 28, 2021. The Trustee will be paid fees in accordance with the terms of the Trust Deed. For details see, ‘*Parties to the Terra InvIT – The Trustee*’ and ‘*Background and Structure of the Terra InvIT – Fees and Expenses*’ on pages 198 and 95.

#### (ii) *Investment Management Agreement*

The Trustee (acting on behalf of the Terra InvIT) has entered into the Investment Management Agreement dated January 29, 2021, read with deed of adherence to be entered into amongst the Trustee, Project SPVs and Specified SPVs with the Investment Manager for managing and administering the Terra InvIT, in accordance with the InvIT Regulations. The Investment Manager will be paid fees in accordance with the terms of the Investment Management Agreement. For details see, ‘*Parties to the Terra InvIT – The Investment Manager*’ and ‘*Background and Structure of the Terra InvIT – Fees and Expenses*’ on pages 201 and 95.

(iii) **Project Management Agreement**

For details in relation to the Project Management Agreement, see '*Parties to the Terra InvIT – Key terms of the Project Management Agreement*' on page 207.

(iv) **Securities Acquisition Agreements**

Please see the section entitled '*Background and Structure of the Terra InvIT - Acquisition of the Project SPVs by the Terra InvIT*' and '*Background and Structure of the Terra InvIT - Acquisition of the Specified SPVs by the Terra InvIT*' on pages 101 and 102 for a description of the key terms of the Securities Acquisition Agreement.

For details in relation risks involved with respect to such related party transactions, see '*Risk factors - We have in the past entered into a number of Related Party transactions and may continue to enter into Related Party transactions in the future, and there can be no assurance that we could not have achieved more favourable terms if such transactions had not been entered into with Related Parties.*' on page 35.

**Future Related Party Transactions**

Certain transactions may be entered with Related Parties in the future and the Trustee and the Investment Manager confirm that such related party transactions shall be, entered into, in compliance with the SEBI InvIT Regulations and the Related Party Transactions Policy. An indication of potential related party transactions is set out below:

Pursuant to letter dated July 23, 2021 issued by the Sponsor to the Terra InvIT and the Investment Manager, the Sponsor has intimated that it has entered into Sponsor SPA for acquisition of 100% equity of four entities owning and operating solar assets located in Rajasthan, Punjab and Madhya Pradesh with long term power purchase agreements with a mix of state and central off-takers. The aggregated portfolio size is 49 MW(AC)/ 55.4 MW(DC). The consummation of the transaction is subject to various conditions precedents including approval from lenders. The Sponsor SPA contains standard representations and warranties and indemnities (including specific indemnities) from the counter party that are customary and appropriate for a transaction of this type and nature. The Sponsor may make available these solar assets for acquisition to Terra InvIT in the future.

Further, the Terra InvIT has availed financial advisory services from an affiliate of KKR which is a related party to the Terra InvIT.

Additionally, in terms of the SEBI InvIT Regulations, any transactions between two or more InvITs with a common investment manager or sponsor, shall be deemed to be related party transactions. In this regard, Galaxy Investments II Pte. Ltd., an affiliate of our Sponsor, is proposing to acquire assets in the roads infrastructure sector and set up a trust under the SEBI InvIT Regulations. The Investment Manager is proposed to be appointed to act as the investment manager of the proposed InvIT pursuant to an appropriate investment management agreement. Any transactions, between the Terra InvIT and the proposed InvIT shall be considered as related party transaction and shall be entered into in accordance with the RPT Policy.

**Declaration by the Sponsor in relation to related party transactions**

Other than as stated below, the Sponsor does not have any ownership interest in business which competes or is likely to compete, either directly or indirectly with the activities of the Terra InvIT. "Compete" shall mean engaging in the business of the owning, operation and maintenance of solar power generation projects in the Republic of India:

KKR Asia Pacific Infrastructure Investors SCSp (which indirectly holds investment in the Sponsor), through its affiliate(s), owns 23.69 % of the issued and outstanding unit capital of India Grid Trust, an infrastructure investment trust registered with the Securities and Exchange Board of India. India Grid Trust is managed by IndiGrid Investment Managers Limited, in which Electron IM Pte. Ltd., an entity affiliated with funds, vehicles and/or entities managed and/or advised by or otherwise controlled by KKR or its affiliates, holds 74% of the issued and outstanding share capital. India Grid Trust currently owns 100% of the issued and paid-up share capital in (i) FRV India Solar Park II – Private Limited; and (ii) FRV Andhra Pradesh Solar Farm-I Private Limited. India Grid Trust's strategy is inter alia to acquire solar projects with long term power purchase agreements, operational track record and financially strong counterparties / off-taker such as SECI and NTPC. The business of India Grid Trust (which is managed by IndiGrid Investment Managers Limited) may compete with that of the Terra InvIT.

The Sponsor has declared that it shall perform its duty in relation to the Terra InvIT independent of the related business as stated above.

## DISTRIBUTIONS

*Statements contained in this section entitled ‘Distributions’ that are not historical facts are forward-looking statements. Such statements are subject to certain risks and uncertainties that could cause actual results to differ materially from those that may be projected. Under no circumstances should the inclusion of such information herein be regarded as a representation, warranty or prediction with respect to the accuracy of the underlying assumptions by the Terra InvIT, Sponsor, the Investment Manager or any other person. Bidders are cautioned not to place undue reliance on these forward-looking statements that are stated only as at the date of this Final Placement Memorandum. For details in relation to such forward-looking statements, please see the section entitled ‘Forward-Looking Statements and Financial Projections’ on page 17.*

The net distributable cash flows of the Terra InvIT (the “**Distributable Income**”) are based on the cash flows generated from the underlying operations undertaken by the SPVs. For details of the business and operations presently undertaken by the SPVs, please see the section entitled ‘**Business**’ on page 132. Currently, cash flows receivable by the Terra InvIT may be in the form of dividend, capital reduction, interest income or principal repayment received from the SPVs in relation to any debt sanctioned by the Terra InvIT, or a combination of both.

In terms of the SEBI InvIT Regulations, not less than 90% of the net distributable cash flows of the SPVs, shall be distributed to the Terra InvIT, subject to applicable provisions in the Companies Act, 2013 and not less than 90% of the net distributable cash flows of the Terra InvIT shall be distributed to the Unitholders.

The Terra InvIT shall declare and distribute at least 90% of the Distributable Income to the Unitholders. Such distribution shall be declared and made such that the time period between any two declarations of distribution shall not exceed one year. However, if any infrastructure asset is sold by the Terra InvIT or the SPVs, or if the equity shares or interest in the SPVs are sold by the Terra InvIT and if the Terra InvIT proposes to re-invest the sale proceeds into another infrastructure asset within one year, it shall not be required to distribute any sales proceeds to the Terra InvIT or to the Unitholders. Further, if the Terra InvIT proposes not to invest the sale proceeds into any other infrastructure asset within one year, it shall be required to distribute the same in the manner specified above. In accordance with the SEBI InvIT Regulations, distributions by the Terra InvIT shall be made no later than 15 days from the date of such declarations. The distribution, when made, shall be made in Indian Rupees. For details on the risks relating to distribution, please see the section entitled ‘**Risk Factors**’ on page 19.

### Distribution Policy

#### *Method of calculation of Distributable Income*

The Distributable Income of the Terra InvIT shall be calculated in accordance with the SEBI InvIT Regulations, any circular, notification or guidance issued thereunder and the Terra InvIT Documents. Presently, the Terra InvIT proposes to calculate distributable income in the manner provided below:

#### (i) *Calculation of net distributable cash flows at the Asset SPV level:*

Description
<b>Profit after tax as per profit and loss account (standalone) (A)</b>
<b>Reversal of Distributions charged to P&amp;L</b>
Add: Interest (including interest on unpaid interest, if any) on loans availed from / debentures issued to Terra InvIT, as per profit and loss account
<b>Adjustment of Non-cash items</b>
Add: Depreciation, impairment (in case of impairment reversal, same will be deducted) and amortisation as per profit and loss account.
Add/Less: Any other item of non-cash expense / non-cash income (net of actual cash flows for these items), including but not limited to
<ul style="list-style-type: none"> <li>any decrease/increase in carrying amount of an asset or a liability recognised in profit and loss account on measurement of the asset or the liability at fair value;</li> <li>interest cost as per effective interest rate method (difference between accrued and actual paid);</li> <li>deferred tax, lease rents, provisions, etc.</li> </ul>
<b>Adjustments for Assets on Balance Sheet</b>
Add/Less: Decrease / increase in working capital
Add/Less: Loss / gain on sale of assets / investments
Add: Net proceeds (after applicable taxes) from sale of assets / investments adjusted for proceeds reinvested or planned to be reinvested.
Add: Net proceeds (after applicable taxes) from sale of assets / investments not distributed pursuant to an earlier plan to reinvest, if such proceeds are not intended to be invested subsequently.

<b>Description</b>
Less: Capital expenditure, if any
Less: Investments made in accordance with the investment objective, if any
<b>Adjustments for Liabilities on Balance Sheet</b>
Less: Repayment of third-party debt (principal) / redeemable preference shares / debentures, etc., net of any debt raised by refinancing of existing debt
Less: Net cash set aside to comply with borrowing requirements such as DSRA, minimum cash balance, etc.
Add: Proceeds from additional borrowings (including debentures / other securities), fresh issuance of equity shares / preference shares, etc.
Less: Payment of any other liabilities (not covered under working capital)
<b>Other Adjustments</b>
Less: Any provision or reserve deemed necessary by the Investment Manager for expenses / liabilities which may be due in future
Add / Less: Amounts added or retained in accordance with the transaction documents or the loan agreements in relation to the Asset SPV
Add / Less: Any other adjustment to be undertaken by the Board to ensure that there is no double counting of the same item for the above calculations
Add: Such portion of the existing cash balance available, if any, as deemed necessary by the Investment Manager in line with the SEBI InvIT Regulations
<b>Total Adjustments (B)</b>
<b>Net Distributable Cash Flows (C)=(A+B)</b>

*(ii) Calculation of net distributable cash flows at the consolidated Terra InvIT level:*

<b>Description</b>
<b>Inflow from Asset SPV Distributions</b>
Cash flows received from Asset SPVs in the form of interest / accrued interest / additional interest
Add: Cash flows received from Asset SPVs in the form of dividend
Add: Cash flows from the Asset SPVs towards the repayment of the debt provided to the Asset SPVs by the Trust and/ or redemption of debentures issued by Asset SPVs to the Trust
Add: Cash flows from the Asset SPVs through capital reduction by way of a buy back or any other means as permitted, subject to applicable law
<b>Inflow from Investments / Assets</b>
Add: Cash flows from sale of equity shares or any other investments in Asset SPVs adjusted for amounts reinvested or planned to be reinvested
Add: Cash flows from the sale of the Asset SPVs not distributed pursuant to an earlier plan to reinvest, or if such proceeds are not intended to be invested subsequently
<b>Inflow from Liabilities</b>
Add: Cash flows from additional borrowings (including debentures / other securities), fresh issuance of units, etc.
<b>Other Inflows</b>
Add: Any other income accruing at the Terra InvIT and not captured above, as deemed necessary by the Investment Manager, including but not limited to interest / return on surplus cash invested by the Terra InvIT
<b>Total cash inflow at the InvIT level (A)</b>
<b>Outflow for InvIT Expenses / Taxes</b>
Less: Any payment of fees, interest and expenses incurred at the Trust, including but not limited to the fees of the Investment Manager, Project Manager, Trustee, Auditor, Valuer, Credit Rating Agency, etc.
Less: Income tax (if applicable) for standalone Terra InvIT and / or payment of other statutory dues
<b>Outflow for Liabilities</b>
Less: Repayment of third-party debt (principal) / redeemable preference shares / debentures, etc., net of any debt raised by refinancing of existing debt
Less: Net cash set aside to comply with borrowing requirements such as DSRA, minimum cash balance, etc.
<b>Outflow for Assets</b>
Less: Amount invested in any of the Asset SPVs
Less: Amounts set aside to be invested or planned to be invested, as deemed necessary by the Investment Manager in compliance with the SEBI InvIT Regulations
Less: Investments including acquisition of other Asset SPVs
<b>Other Outflows</b>
Less: Any provision or reserve deemed necessary by the Investment Manager for expenses which may be due in future
Add / Less: Amounts added/ retained in accordance with the transaction documents or the loan agreements in relation to the Terra InvIT
Less: Any other expense of the InvIT not captured herein as deemed necessary by the Investment Manager
Add / Less: Any other adjustment to be undertaken by the Board to ensure that there is no double counting of the same item for the above calculations

Description
Total cash outflow/retention at the InvIT level (B)
Net Distributable Cash Flows (C) = (A+B)

In terms of the SEBI InvIT Regulations, if the distribution is not made within 15 days from the date of declaration, the Investment Manager shall be liable to pay interest to the Unitholders at the rate of 15% per annum until the distribution is made. Such interest shall not be recovered by the Investment Manager in the form of fee or any other form payable to the Investment Manager by the Terra InvIT.

## **RIGHTS OF UNITHOLDERS**

*The rights and interests of Unitholders are included in this Final Placement Memorandum and the SEBI InvIT Regulations. Under the Trust Deed and the Investment Management Agreement, these rights and interests are safeguarded by the Terra InvIT and the Investment Manager, respectively. Any rights and interests of Unitholders as specified in this Final Placement Memorandum would stand qualified by and deemed to be amended to the extent of any amendment to the SEBI InvIT Regulations.*

### ***Beneficial Interest***

Each Unit represents an undivided beneficial interest in the Terra InvIT. A Unitholder has no equitable or proprietary interest in the Terra InvIT Assets and is not entitled to transfer of the Terra InvIT Assets (or any part thereof) or any interest in the Terra InvIT Assets (or any part thereof). A Unitholder's right is limited to the right to require due administration of the Terra InvIT in accordance with the provisions of the Trust Deed and the Investment Management Agreement.

### ***Ranking***

No Unitholder of the Terra InvIT shall enjoy superior voting or any other rights over another Unitholder. Further, the Units shall not have multiple classes. However, subordinate Units may be issued only to the Sponsor and its Associates, where such subordinate units carry only inferior voting or any other rights compared to other Units in the future in accordance with Regulation 4(2)(h) of the SEBI InvIT Regulations.

### ***Redressal of grievances***

The Investment Manager shall ensure adequate and timely redressal of all Unitholders' grievances pertaining to the activities of the Terra InvIT, and the Trustee shall periodically review the status of Unitholders' complaints and their redressal undertaken by the Investment Manager. The Investment Manager shall maintain records of the Unitholders' grievances and the actions taken thereon, including copies of correspondences made with the Unitholders.

### ***Distribution***

The Unitholders shall have the right to receive distribution in accordance with the SEBI InvIT Regulations and in the manner provided in this Final Placement Memorandum. For details, see '***Distribution***' on page 190.

### ***Meeting of Unitholders***

Meetings of Unitholders will be conducted in accordance with the SEBI InvIT Regulations.

### ***Passing of resolutions***

1. With respect to any matter requiring approval of the Unitholders:
  - (i) a resolution shall be considered as passed when the votes cast by Unitholders, so entitled and voting, in favour of the resolution exceed a certain percentage as specified in the SEBI InvIT Regulations, of votes cast against;
  - (ii) the voting may be done by postal ballot or electronic mode;
  - (iii) a notice of not less than 21 days shall be provided to the Unitholders;
  - (iv) voting by any Unitholder (including, the Sponsor in its capacity as a Unitholder), who is a related party in such transaction, as well as associates of such Unitholder(s) shall not be considered on the specific issue; and
  - (v) the Investment Manager shall be responsible for all the activities pertaining to conducting of meeting of the Unitholder, subject to oversight by the Trustee. However, for issues pertaining to the Investment Manager, including a change in the Investment Manager, removal of Investment Manager or change in control of Investment Manager; the Trustee shall convene and handle all activities pertaining to conduct of the meetings. Additionally, for issues pertaining to the Trustee, including change in Trustee, the Trustee shall not be involved in any manner in the conduct of the meeting.

2. For the Terra InvIT:
  - (i) an annual meeting of all Unitholders shall be held not less than once a year within 120 days from the end of each financial year and the time between two meetings shall not exceed 15 months;
  - (ii) with respect to the annual meeting of Unitholders,
    - a) any information that is required to be disclosed to the Unitholders and any issue that, in the ordinary course of business, may require approval of the Unitholders may be taken up in the meeting including:
      - latest annual accounts and performance of the Terra InvIT;
      - approval of auditors and fee of such auditors, as may be required;
      - latest valuation reports;
      - appointment of valuer, as may be required; and
      - any other issue; and
    - b) for any issue taken up in such meetings which require approval from the Unitholders other than as specified in Regulation 22(6) of the SEBI InvIT Regulations and paragraph 4 below, votes cast in favour of the resolution shall be more than the votes cast against the resolution.
3. Notwithstanding generally of the foregoing, in case of the following, approval from the Unitholders shall be required where the votes cast in favour of the resolution shall be more than the votes cast against the resolution:
  - (i) any approval from the Unitholders required in terms of Regulation 18 (*Investment conditions and dividend policy*), Regulation 19 (*Related Party Transactions*) and Regulation 21 (*Valuation of assets*) of the SEBI InvIT Regulations to the extent applicable;
  - (ii) any transaction, other than any borrowing, the value of which is equal to or greater than 25% of the Terra InvIT Assets;
  - (iii) increasing period for compliance with investment conditions to one year in accordance with Regulation 18(5)(c) of the SEBI InvIT Regulations;
  - (iv) any issue, in the ordinary course of business, which in the opinion of the Sponsor or the Terra InvIT or the Investment Manager, is material and requires approval of the Unitholders, if any;
  - (v) de-classification of the status of the Sponsor; and
  - (vi) any issue for which SEBI requires approval.
4. In case of the following, approval from the Unitholders shall be required where the votes cast in favour of the resolution shall not be less than one and a half times the votes cast against the resolution:
  - (i) any issue, not in the ordinary course of business, which in the opinion of the Sponsor or Investment Manager or the trustees of the Terra InvIT requires approval of the Unitholders;
  - (ii) any issue for which SEBI requires approval; and
  - (iii) any issue taken up on request of the Unitholders including:
    - a) removal of the Investment Manager and appointment of another investment manager to the Terra InvIT;
    - b) removal of the Auditors and appointment of another auditor to the Terra InvIT;



- c) removal of the Valuer and appointment of another valuer to the Terra InvIT;
- d) delisting of the Terra InvIT, if the Unitholders have sufficient reason to believe that such delisting would act in the interest of the Unitholders;
- e) any issue which the Unitholders have sufficient reason to believe that is detrimental to the interest of the Unitholders; and
- f) change in the Trustee, if Unitholders have sufficient reason to believe that acts of the Trustee are detrimental to the interest of Unitholders.

With respect to the rights of the Unitholders under clause 4(iii) above:

- (i) save as set out in (iii) below, not less than 25% of the Unitholders by value, other than any party related to the transactions and its associates, shall apply, in writing, to the Terra InvIT for the purpose;
- (ii) on receipt of such application, the Terra InvIT shall require, with the Investment Manager to place the issue for voting in the manner as specified in the SEBI InvIT Regulations; and
- (iii) with respect to clause 4(iii)(e) above, not less than 60% of the Unitholders by value shall apply, in writing, to the Terra InvIT for the purpose.

#### ***Information rights***

The Investment Manager, on behalf of the Terra InvIT, shall also submit such information to the Unitholders, on a periodical basis as may be required under the SEBI InvIT Regulations. The Investment Manager (on behalf of the Terra InvIT) shall disclose to the Unitholders and SEBI, all such information and in such manner as specified under the SEBI InvIT Regulations and such other requirements as may be specified by SEBI.

#### ***Buyback of Units***

Any buyback of Units shall be in accordance with the Trust Deed and the SEBI InvIT Regulations.

#### ***Listing of Units***

Listing of Units shall be in accordance with the SEBI InvIT Regulations.

## DILUTION

Dilution is the amount by which the Issue Price exceeds the net asset value (“NAV”) per Unit, immediately after the completion of this Issue. NAV per Unit is determined by subtracting the total liabilities of the Terra InvIT from the total assets of the Terra InvIT and dividing by the number of Units issued and outstanding immediately before this Issue. There was no pro forma NAV before this Issue for the Units.

The Terra InvIT will issue 4,60,00,000 Units\* at an Issue Price of ₹100 for each Unit. The following provides the per Unit dilution as on date:

<b>Combined NAV per Unit before this Issue</b>	Not applicable
<b>Combined NAV per Unit after this Issue*</b>	108.47
<b>Dilution in NAV per Unit to Unitholders</b>	-
<b>Dilution to Unitholders as a percentage of the Issue Price</b>	-

*\*Subject to allotment of units by the board of directors of the Investment Manager*

## SECTION V – PARTIES TO THE TERRA INVIT

*The summaries of the key terms of certain material contracts and agreements included in this section are not complete and are subject to, and are qualified in their entirety by reference to, the provisions of the respective material contracts and agreements. Copies of the material contracts and agreement described in this section are available for inspection at the principal place of business of the Terra InvIT. For further details, please see ‘Material Contracts and Documents for Inspection’ on page 320.*

### A. The Sponsor

#### 1. Terra Asia Holdings II Pte. Ltd.

##### *History and Certain Corporate Matters*

Terra Asia Holdings II Pte. Ltd. is the Sponsor of the Terra InvIT. The Sponsor was incorporated on January 6, 2020 in Singapore with registration number 202000858R. The Sponsor is a private company limited by shares. The Sponsor is registered with the SEBI under the Securities and Exchange Board of India (Foreign Portfolio Investors) Regulations, 2019 as a category I foreign portfolio investor with the registration number INSGFP040720. The Sponsor’s registered office is situated at 10 Changi Business Park, Central 2, #05-01, Hansapoint, Singapore – 486 030. For further details, see ‘General Information’ on page 69.

##### *Background and Past Experience of Sponsor*

The Sponsor is an affiliate of the funds, vehicles and/or entities managed and/or advised by affiliates of KKR. Founded in 1976, KKR is a leading global investment firm that offers alternative asset management and capital markets and insurance solutions with approximately US\$428.9 billion of assets under management as of June 30, 2021. KKR sponsors investment funds that invest in private equity, credit and real assets and has strategic partners that manage hedge funds. KKR’s insurance subsidiaries offer retirement, life and reinsurance products under the management of Global Atlantic. KKR aims to generate attractive investment returns by following a patient and disciplined investment approach, employing world-class people, and supporting growth in its portfolio companies and communities. In 2008, KKR established a dedicated infrastructure team and strategy focused on global investment opportunities. KKR has been one of the more active infrastructure investors globally over the past several years, having committed more than \$30 billion across over 50 infrastructure investments. Currently, KKR’s infrastructure platform has expanded to include over 60 dedicated investment professionals across 10 offices covering a broad spectrum of investment opportunities in various infrastructure subsectors, including: midstream energy, renewables, power & utilities, water and wastewater, waste, telecommunications and transportation, among others. KKR continually monitors infrastructure sectors and infrastructure-related investments for emerging trends, and may identify and prioritize investments in other sectors as conditions change or cycles evolve. KKR has invested or committed \$6.2 billion of equity in private equity deals in India since 2010 with 20 investments made and 10 active portfolio companies currently. KKR’s Asia Pacific infrastructure portfolio includes India Grid Trust, TSK Corporation, Eco Solutions Group, First Gen, and Pinnacle Towers.

KKR Asia Pacific Infrastructure Investors SCSp (which indirectly holds investment in the Sponsor), through its affiliate(s), owns 23.69 % of the issued and outstanding unit capital of India Grid Trust, an infrastructure investment trust registered with the Securities and Exchange Board of India. India Grid Trust is managed by IndiGrid Investment Managers Limited, in which Electron IM Pte. Ltd., an entity affiliated with funds, vehicles and/or entities managed and/or advised by or otherwise controlled by KKR or its affiliates, holds 74% of the issued and outstanding share capital. India Grid Trust currently owns 100% of the issued and paid-up share capital in (i) FRV India Solar Park II – Private Limited; and (ii) FRV Andhra Pradesh Solar Farm-I Private Limited. India Grid Trust’s strategy is inter alia to acquire solar projects with long term power purchase agreements, operational track record and financially strong counterparties / off-taker ssuch as SECI and NTPC. The business of India Grid Trust (which is managed by IndiGrid Investment Managers Limited) may compete with that of the Terra InvIT. The Sponsor’s associates have a fund management experience of at least five years in the infrastructure sector, on which Sponsor has relied on for its eligibility under the SEBI InvIT Regulations.

The net worth of the Sponsor as on December 31, 2020, stood at ₹12,323.74 lakhs. The Sponsor shall comply with the minimum net worth requirement set out in Regulation 4(2)(d)(ii) of the SEBI InvIT Regulations.

### ***Other Confirmations***

As of the date of this Final Placement Memorandum, Sponsor is in compliance with the eligibility criteria provided under Regulation 4 of the SEBI InvIT Regulations and is a “fit and proper person” as prescribed under SEBI Intermediaries Regulations.

### ***Details of the Holding or the Proposed Holding by Sponsor in the Terra InvIT***

The Sponsor proposes to hold 77.11% of the Units of the Terra InvIT on a post-Issue basis immediately after the Issue. Further, the Units held by the Sponsor will be subject to lock-in requirements in accordance with the SEBI InvIT Regulations. For further details, see, ‘**Background and Structure of Terra InvIT - Acquisition of the Project SPVs by the Terra InvIT**’ and ‘**Background and Structure of Terra InvIT - Acquisition of the Specified SPVs by the Terra InvIT**’ on pages 101 and 102.

## **B. The Trustee – Axis Trustee Services Limited**

### ***History and Certain Corporate Matters***

Axis Trustee Services Limited is the Trustee of the Terra InvIT. The Trustee is a registered intermediary with SEBI under the Securities and Exchange Board of India (Debtenture Trustees) Regulations, 1993, as a debenture trustee since January 31, 2014, having registration number IND000000494 and is valid until suspended or cancelled by SEBI. The Trustee’s registered office is Axis House, Bombay Dyeing Mills Compound, Pandhurang Budhkar Marg, Worli Mumbai - 400 025, Maharashtra, India. The Trustee’s address for correspondence is The Ruby, 2<sup>nd</sup> Floor, SW, 29 Senapati Bapat Marg, Dadar West, Mumbai – 400 028, Maharashtra, India. For further details, see ‘**General Information**’ on page 69.

### ***Background of the Trustee***

The Trustee is a trusteeship company which has been registered with SEBI, and has been promoted by Axis Bank Limited for providing corporate and other trusteeship services. The Trustee is a wholly-owned subsidiary of Axis Bank Limited. The Trustee also acts as a security trustee and is involved in providing services in relation to security creation, compliance and holding security on behalf of lenders. The Trustee is also authorised to provide services inter alia as: (i) a facility agent for complex structured transactions; (ii) an escrow agent; (iii) a trustee to alternative investment funds and venture capital funds; (iv) custodian of documents as a safe-keeper; and (v) a trustee to real estate investment funds.

The Trustee confirms that it has maintained, and undertakes to ensure that it will at all times maintain, adequate infrastructure personnel and resources to perform its functions, duties and responsibilities with respect to the Terra InvIT, in accordance with the Trust Deed, the SEBI InvIT Regulations and other applicable law.

### ***Other Confirmations***

The Trustee is not an Associate of the Sponsor or the Investment Manager. Further, as of the date of this Final Placement Memorandum, the Trustee is in compliance with the eligibility criteria provided under Regulation 4 of the SEBI InvIT Regulations and is a “fit and proper person” as prescribed under SEBI Intermediaries Regulations.

### ***Details of the Holding or the Proposed Holding by Trustee in the Terra InvIT***

Trustee does not propose to hold the Units of the Terra InvIT.

### ***Board of Directors of the Trustee***

The board of directors of the Trustee is entrusted with the responsibility for the overall management of the Trustee. Please see below the details in relation of the board of directors of the Trustee:

<b>Sr. No.</b>	<b>Name</b>	<b>Age</b>	<b>DIN</b>	<b>Designation</b>
1.	Ms. Deepa Rath	44	09163254	Managing Director and Chief Executive Officer
2.	Mr. Rajesh Kumar Dahiya	53	07508488	Non-Executive Director
3.	Mr. Ganesh Sankaran	51	07580955	Non-Executive Director

### ***Functions, Duties and Responsibilities of the Trustee***

In accordance with the Trust Deed and the SEBI InvIT Regulations, following are the functions, duties and responsibilities of the Trustee:

**(a) Interests of the Unitholders**

The Trustee shall exercise due diligence in carrying out its duties and shall carry on and conduct its business in a proper and efficient manner to protect the interests of the Unitholders in accordance with the Terra InvIT Documents. The Trustee shall periodically review the status of Unitholders' complaints and their redressal undertaken by the Investment Manager in accordance with the SEBI InvIT Regulations.

**(b) Appointment of the Investment Manager and the Project Manager**

The Trustee shall, on behalf of the Terra InvIT, appoint the Investment Manager to manage and administer the Terra InvIT and for this purpose, execute the Investment Management Agreement with the Investment Manager. Further, the Trustee shall obtain the prior approval of SEBI in the event of a proposed change of the Investment Manager. The Trustee, in consultation with the Investment Manager shall, on behalf of the Terra InvIT, appoint the Project Manager and for this purpose, execute the Project Management Agreement with the Project Manager.

The Trustee shall oversee activities of the Investment Manager and the Project Manager in the interest of the Unitholders, and ensure that they comply with the SEBI InvIT Regulations and obtain a compliance certificate from the Investment Manager and Project Manager on a quarterly basis, in the form prescribed by SEBI.

**(c) Supervision of the activities of the Investment Manager and the Project Manager**

- (i) The Trustee shall delegate all such powers to the Investment Manager as may be required by the Investment Manager to carry out its obligations under the Investment Management Agreement and under applicable law
- (ii) The Trustee shall oversee the activities of the Investment Manager in the interest of the Unitholders, ensure that the Investment Manager complies with the SEBI InvIT Regulations, and obtain a compliance certificate from the Investment Manager on a quarterly basis in the form prescribed by SEBI.
- (iii) The Trustee shall ensure that the Investment Manager complies with reporting and disclosure requirements in accordance with the SEBI InvIT Regulations or other applicable laws and in case of any delay or discrepancy, require the Investment Manager to rectify such delay or discrepancy on an urgent basis.
- (iv) The Trustee shall require the Investment Manager to set up such systems and procedures and submit such reports to the Trustee, as may be necessary for effective monitoring of the functioning of the Terra InvIT.
- (v) The Trustee shall ensure that the activity of the Terra InvIT is being operated in accordance with the provisions of the Trust Deed, the SEBI InvIT Regulations and the Draft Placement Memorandum or offer document (as applicable), and in the event that any discrepancy is noted, the Trustee shall inform the same to the SEBI immediately in writing.
- (vi) The Trustee shall review all documents, reports, records and information submitted by the Investment Manager to the Trustee in accordance with Regulation 10 of the InvIT Regulations.
- (vii) The Trustee shall review and oversee the transactions carried on between the Investment Manager and its Associates and where the Investment Manager has advised that there may be a conflict of interest, the Trustee must obtain a certificate from a practising chartered accountant or a Valuer as applicable specifying that such transactions are on an arms' length basis.
- (viii) The Trustee shall ensure that the Investment Manager submits the valuation reports issued by the Valuer to the Trustee and Unitholders in accordance with the SEBI InvIT Regulations.

- (ix) The Trustee shall require the Investment Manager to set up such systems and procedures and submit such reports to the Trustee, as may be necessary for effective monitoring of the functioning of the Terra InvIT.
- (x) The Trustee shall ensure that the Investment Manager convenes meetings of the Unitholders in accordance with the SEBI InvIT Regulations and shall oversee voting by the Unitholders and declare the outcome of such meetings (except where the Trustee is required to carry out such functions under the SEBI InvIT Regulations). The Trustee shall ensure that the Investment Manager convenes meetings of Unitholders within the period prescribed under the SEBI InvIT Regulations and the period between such meetings shall not exceed the period prescribed under the SEBI InvIT Regulations.
- (xi) The Trustee shall delegate all such powers to the Project Manager as may be required by the Project Manager to carry out its obligations under the Project Management Agreement and under Applicable Law.
- (xii) The Trustee shall oversee activities of the Project Manager in the interest of the Unitholders, ensure that the Project Manager complies with the SEBI InvIT Regulations and the Project Management Agreement and obtain a compliance certificate from the Project Manager on a quarterly basis, in the form prescribed by SEBI, if any.

**(d) Documents and information to be provided to Unitholders**

The Trustee, either by itself or through the Investment Manager, shall from time to time file such reports and provide such information as may be required by the SEBI or stock exchanges (if applicable) or other governmental agencies, with respect to the activities carried on by the Terra InvIT.

**(e) Change In Control**

The Trustee shall obtain prior approval of the Unitholders if required under the Terra InvIT Documents, the SEBI InvIT Regulations, other applicable law and any power purchase agreement, for any proposed change in control of the Sponsor or Inducted Sponsor, the Investment Manager or the Project Manager, as applicable. Further, the Trustee shall obtain the prior approval of SEBI in the event of a proposed change in control of the Investment Manager.

**(f) Subscription amounts**

The Trustee shall and shall ensure that the Investment Manager ensures that subscription amounts in case of any offering by the Terra InvIT (including the Issue) are collected and kept in a separate bank account in the name of the Terra InvIT and only utilised against allotment of Units or refund of money to the applicants in accordance with the SEBI InvIT Regulations, and the same will be utilised for the objectives stated in the Draft Placement Memorandum or the offer document.

**(g) Distribution**

The Trustee shall ensure that Distributions are made by the Terra InvIT to the Unitholders, from time to time, and shall ensure that the Investment Manager makes timely declaration of Distributions to the Unitholders.

**(h) Maintenance of books of accounts and other records**

The Trustee shall maintain all the records that are required to be maintained pursuant to Regulation 26(2) of the SEBI InvIT Regulations and applicable law. The Trustee shall require the Investment Manager to maintain proper books of accounts, financial statements, documents and records with respect to the matters of the Terra InvIT in accordance with the SEBI InvIT Regulations or appoint a service provider and cause such service provider to maintain such proper books of accounts, documents and records.

**(i) Payment of statutory charges, or levies payable by the Terra InvIT and operation of bank accounts**

- (i) The Trustee shall, in accordance with the applicable law and on receipt of advice from the Investment Manager, pay all taxes, duties and any other statutory charges or levies that may be

payable by the Terra InvIT on behalf of the Unitholders from the Trust Fund, subject to the provisions of the Terra InvIT Documents.

- (ii) The Trustee shall also be responsible for opening and operating bank accounts on behalf of the Terra InvIT.

**(j) Attainment of objects of the Terra InvIT**

The Trustee shall ensure that all acts, deeds and things are done with a view to attain the objects of the Terra InvIT, Applicable Law and the Terra InvIT Documents, in order to secure the best interests of the Unitholders.

**(k) Reports to be filed by the Terra InvIT**

The Trustee shall file such reports as may be required by the SEBI or any other governmental authority or as required under applicable law in relation to the activities carried on by the Terra InvIT.

**(l) Unitholder Complaints**

The Trustee shall periodically review the status of Unitholders' complaints and their redressal by the Investment Manager. The Investment Manager shall provide quarterly reports on Unitholders' grievances to the Trustee, as applicable.

**(m) Segregation of assets and liabilities**

The assets and liabilities of the Terra InvIT shall at all times be segregated from the assets and liabilities of the Trustee and the assets and liabilities of other trusts managed by the Trustee. The Terra InvIT Assets shall be held for the exclusive benefit of the Unitholders and such assets shall not be subject to the claims of any creditor or any person claiming under any other fund or trust administered or managed by the Trustee or the Investment Manager.

**(n) Valuer**

- (i) The Trustee shall ensure that the Valuer is not an Associate of the Sponsor, the Investment Manager or the Trustee and shall ensure compliance with the provisions of the SEBI InvIT Regulations.
- (ii) The Trustee shall ensure that the remuneration of the Valuer is not linked to or based on the value of the asset being valued.
- (iii) The Trustee shall ensure that the Investment Manager ensures that a detailed valuation is undertaken of the Terra InvIT Assets by the Valuer at such intervals and in the manner specified under the SEBI InvIT Regulations and the Terra InvIT Documents.

**(o) Investment by Trustee**

The Trustee shall not invest in or subscribe to the Units.

**C. The Investment Manager – Virescent Infrastructure Investment Manager Private Limited**

***History and Certain Corporate Matters***

Virescent Infrastructure Investment Manager Private Limited (“**Virescent Infrastructure**”) is the Investment Manager of the Terra InvIT. Virescent Infrastructure was incorporated in India as a private limited company on August 22, 2020 under the Companies Act, 2013 with corporate identification number U74999MH2020PTC344288. The Investment Manager's registered office and address for correspondence is 10th Floor, Parinee Crescenzo, C-30, 'G' Block, Bandra Kurla Complex, Bandra (East), Mumbai 400051, Maharashtra, India. For further details, see '**General Information**' on page 69.

***Background and Past Experience of the Investment Manager***

Virescent Infrastructure has the infrastructure for acting as the manager, and to manage the assets and investments of the Terra InvIT. Virescent Infrastructure is a newly incorporated private limited company, however its key

managerial personnel have over five years of experience each, in providing advisory services in the infrastructure sector, therefore, it will be relying on the experience/ expertise of its employees in the financial management, advisory and/or infrastructure development sector, to comply with the eligibility requirements under the SEBI InvIT Regulations. Accordingly, the Investment Manager is in compliance with the eligibility requirements prescribed under the SEBI InvIT Regulations.

The net worth of Virescent Infrastructure as on March 31, 2021, stood at ₹1,164 lakhs on a standalone basis. Virescent Infrastructure shall (i) comply with the minimum net worth requirement set out in Regulation 4(2)(e)(i) of the SEBI InvIT Regulations.

The equity shareholding pattern of the Investment Manager is as follows:

S. No.	Name of the shareholder	No. of shares held	Percentage (%)
1.	Sponsor	11,009,999	99.99
2.	Terra I <sup>#</sup>	1	Negligible
<b>Total</b>		<b>11,010,000</b>	<b>100</b>

<sup>#</sup> Nominee of Sponsor.

### ***Functions, Duties and Responsibilities of the Investment Manager***

Below is the brief description of the functions, duties and responsibilities of Virescent Infrastructure provided in the Investment Management Agreement in accordance with the SEBI InvIT Regulations, which *inter-alia*, include:

- a) Coordinating with the Trustee, as may be necessary, with respect to the operations of the Terra InvIT.
- b) Ensuring that the Terra InvIT Assets is valued by an independent valuer and submitted to the Trustee and Unitholders either electronically or through physical copies, and to the Stock Exchange in such form and within the timeframes as prescribed in the SEBI InvIT Regulations (including particularly Regulation 21 therein).
- c) Arranging for adequate insurance coverage for the infrastructure assets of the Terra InvIT in accordance with the SEBI InvIT Regulations.
- d) Maintaining proper books of accounts, documents and records with respect to the Terra InvIT, in the manner set out in the Trust Deed and in accordance with Applicable Law.
- e) Ensuring that audit of the accounts of the Terra InvIT by the Auditors is undertaken in accordance with the SEBI InvIT Regulations and its report is submitted to the Trustee and Unitholders either electronically or through physical copies, and to the Stock Exchange in such form and within the time period specified in the InvIT Regulations.
- f) Making Distributions to Unitholders in accordance with 18 of the SEBI InvIT Regulations. Subject to applicable law, at least such percentage of the net distributable cash flows of the SPVs and HoldCos shall be distributed to the Terra InvIT, and within such time periods, as may be prescribed in the SEBI InvIT Regulations. The Investment Manager shall maintain a record (for such periods as may be prescribed by the SEBI InvIT Regulations) of the Distributions declared and made to the Unitholders.
- g) Consider and supervise implementation of the borrowing arrangements of the Terra InvIT, SPVs and/or HoldCo, cause any sum to be retained in cash on behalf of them and determine its utilisation.
- h) Convening meetings of the Unitholders in accordance with Regulation 22 of the SEBI InvIT Regulations, including at the written request of the Unitholders as specified therein, and maintaining records pertaining to the meetings in accordance with Regulation 26 of the SEBI InvIT Regulations.
- i) Intimating the Trustee prior to any change in control of the Investment Manager to enable the Trustee to seek prior approval from the Unitholders (and the SEBI, if applicable) and ensuring that that any change is given effect to in compliance with the provisions of the SEBI InvIT Regulations and applicable law.
- j) Placing before the board of directors, a report on the activity and performance of the Terra InvIT in accordance with the SEBI InvIT Regulations. To designate an appropriately qualified employee to act as the compliance officer for monitoring of compliance with the SEBI InvIT Regulations and any circulars or guidelines issued thereunder and intimating the SEBI in case of non-compliance.



- k) Monitoring the financing position of the Terra InvIT and the Terra InvIT Fund including the HoldCo/SPVs.
- l) Maintaining records pertaining to the activity of the Terra InvIT in terms of SEBI InvIT Regulations (including specifically Regulation 26).
- m) Managing the Terra InvIT in accordance with the SEBI InvIT Regulations and the Terra InvIT Objectives, and shall ensure that the investments made by the Terra InvIT are in accordance with the applicable investment conditions enumerated in the SEBI InvIT Regulations, in accordance with the objects of the Terra InvIT.
- n) Overseeing the activities of the Project Manager, ensuring that the Project Manager complies with the SEBI InvIT Regulations, and obtaining a compliance certificate from the Project Manager, in the form as may be specified under the SEBI InvIT Regulations, on a quarterly basis.
- o) Reviewing the transactions carried out between the Project Manager and its Associates and where the Project Manager has advised that there may be a conflict of interest, to obtain confirmation from a practicing chartered accountant or valuer, as applicable, that such transaction is on an arms' length basis.
- p) Ensuring adequate and timely redressal of Unitholders' grievances pertaining to the activities of the Terra InvIT
- q) Submitting to the Trustee the following:
  - (i) quarterly reports on the activities of the Terra InvIT including receipts for all funds received by it and for all payments made, status of compliance with the SEBI InvIT Regulations, specifically Regulations 18, 19 and 20 of the SEBI InvIT Regulations, performance report, status of development of under-construction projects, within time period specified under the SEBI InvIT Regulations;
  - (ii) Valuation reports as required under the SEBI InvIT Regulations within the time period specified under the SEBI InvIT Regulations;
  - (iii) decision to acquire or sell or develop or bid for any asset or project or expand existing completed infrastructure assets of the Terra InvIT or projects along with rationale for the same;
  - (iv) details of complaints received from the Unitholders and their redressal of the complaints;
  - (v) details of any action which requires approval from the Unitholders as may be required under the SEBI InvIT Regulations;
  - (vi) details of transactions it enters into with its Associates;
  - (vii) details of any other material fact including change in its directors, change in its shareholding, any legal proceedings that may have a significant bearing on the activity of the Terra InvIT, within the time period specified under the SEBI InvIT Regulations; and
  - (viii) such information, document, reports and records as pertaining to the activities of the Terra InvIT as may be reasonably necessary for the Trustee with respect to its responsibilities under the Trust Deed or for effective monitoring of the functioning of the Terra InvIT or the SEBI InvIT Regulations and as may be required by the SEBI, or stock exchanges or any other governmental agency, with respect to the activities carried on by the Terra InvIT.
- r) Ensuring all activities of the intermediaries, agents, or service providers appointed by the Investment Manager are in accordance with the SEBI InvIT Regulations and guidelines and circulars issued thereunder, as applicable.
- s) Appointing in consultation with the Trustee, the Valuer, Auditor (for a period of not more than five consecutive years or such other period as may be prescribed under the SEBI InvIT Regulations), registrar and transfer agent, merchant bankers, custodians, any other intermediary or service providers as may be required for managing the assets of the Terra InvIT and as per the provisions of the SEBI InvIT Regulations and other Applicable Law.

- t) Ensuring that disclosures and reporting to the Unitholders, SEBI, the Trustee, and the stock exchanges are in accordance with the applicable provisions of the SEBI InvIT Regulations (including disclosure to the Trustee and the Unitholders of any information having a bearing on the operation or performance of the Terra InvIT) in accordance with the timelines specified in the SEBI InvIT Regulations.
- u) Taking responsibility for all activities pertaining to the issue of Units including filing of the offer documents with the SEBI and dealing with all matters relating to the allotment of Units to Unitholders.
- v) Ensuring that disclosures in the placement memorandum or offer document are material, true, correct and adequate and in accordance with the SEBI InvIT Regulations. The InvIT may list its Units on one or more stock exchanges subject to compliance with the conditions specified under the SEBI InvIT Regulations and directions issued by the SEBI or the stock exchanges, as applicable.
- w) Fulfilling its obligations under the applicable provisions of the SEBI InvIT Regulations and the Terra InvIT Documents.
- x) Submitting within the time period prescribed under the SEBI InvIT Regulations, annual reports and half yearly reports to all the Unitholders electronically or provide physical copies and, if applicable, to the stock exchanges.
- y) Other duties include:
  - (i) ensuring that computation and declaration of the net asset value of the Terra InvIT is based on the valuation done by the Valuer in accordance with the SEBI InvIT Regulations;
  - (ii) maintaining regular interaction with the Trustee on performance of the Terra InvIT and providing the Trustee with any information in relation to the operations of the Terra InvIT as may be required;
  - (iii) keeping the Unitholders updated on investment activities of the Terra InvIT in compliance with the SEBI InvIT Regulations and in accordance with the terms of the Terra InvIT Documents;
  - (iv) collecting all dividends, fees, property and other payments due and receivable by the Terra InvIT and declaring Distribution to the Unitholders in the manner set out in the Trust Deed and in terms of the SEBI InvIT Regulations;
  - (v) ensuring that the infrastructure assets of the Terra InvIT or the HoldCo/ SPVs have proper legal titles, if applicable and that all the material contracts entered into or on behalf of the Terra InvIT or the SPVs, or the HoldCo are legal, valid, binding and enforceable by and on behalf of the Terra InvIT or SPVs or the HoldCos, as applicable;
  - (vi) ensuring that it has and continues to have adequate infrastructure and sufficient key personnel with adequate experience and qualification to undertake management of the Terra InvIT;
  - (vii) undertaking all the compliances including signing and verifying any tax returns that the Terra InvIT may be required to file under the applicable law;
  - (viii) ensuring that any possible conflict of interest involving its role as an Investment Manager is reported to the Trustee and the Unitholders;
  - (ix) ensuring that disclosures and reporting to the Unitholders, SEBI, Trustee and to the extent applicable, the stock exchanges are in accordance with applicable law and InvIT Regulations;
  - (x) provide SEBI, Trustee, and the stock exchanges where applicable, such information as may be sought by SEBI or by the Trustee or stock exchanges (as applicable), pertaining to the activities of the Terra InvIT;
  - (xi) in consultation with the Trustee, to appoint the majority of the board of directors or the governing board of the HoldCo and/or SPVs, as applicable;
  - (xii) ensuring that the Terra InvIT does not undertake lending to any person other than the HoldCo/ SPVs in which the Terra InvIT has invested in, subject to disclosures required to be made in

accordance with the SEBI InvIT Regulations. Provided that, Investment in debt securities as permitted under the SEBI InvIT Regulations shall not be considered as lending;

- (xiii) ensuring that no scheme is launched under the Terra InvIT;
- (xiv) providing to the Trustee such assistance as may be required by the Trustee in fulfilling its obligation towards the Terra InvIT under Applicable Law or as may be required by any regulatory authority with respect to the Terra InvIT.

### ***Board of Directors of the Investment Manager***

The board of directors of Virescent Infrastructure is entrusted with the responsibility for the overall management of the Investment Manager. Please see below the details in relation of the board of directors of the Virescent Infrastructure:

Sr. No.	Name	DIN
1.	Mr. Hardik Shah	06648474
2.	Mr. Sanjay Grewal	01971866
3.	Mr. Vinay Pabba	02711931
4.	Mr. Pradeep Kumar	03614568

### ***Brief profiles of the Directors of the Investment Manager***

Please see below a brief profiles of the directors of the Investment Manager:

**Mr. Hardik Shah**, aged 36 years, is a non-executive director on the board of the Investment Manager since August 22, 2020. He holds a bachelor's degree in management studies from University of Mumbai and a post graduate diploma in business management from S.P Jain Institute of Management & Research. He is also a Chartered Financial Analyst as recognised by the CFA Institute. He was previously associated with companies including Brookfield Advisors India Private Limited, Macquarie Infrastructure and Real Assets (India) Private Limited, Macquarie Capital (India) Private Limited, Macquarie Corporate Holdings Pty Limited, Macquarie Bank Limited.

**Mr. Sanjay Grewal**, aged 53 years, is an executive director on the board of the Investment Manager since August 22, 2020. He is also the chief executive officer of the Investment Manager. He holds a master's degree in business administration from University of Hartford and a bachelor's degree in commerce from Shri Ram College of Commerce. He has over 2 decades of experience and is previously associated with companies including Altico Capital India Limited, Citicorp International Limited, Lehman Brothers Asia Holdings Limited.

**Mr. Vinay Pabba**, aged 53 years, is an independent non-executive director on the board of the Investment Manager since November 26, 2020. He holds a degree in mechanical engineering from Indian Institute of Technology, Madras and a post graduate degree in business management from Xavier Labour Relations Institute, Jamshedpur. He holds an advanced diploma in finance from the Institute of Chartered Financial Analysts of India and a master of science in finance from the ICFAI University. He is also a member of the Council of Chartered Financial Analysts. He was previously associated with Brookfield Advisors India Private Limited, Greenko Wind Projects Private Limited, Indian Revenue Service, Aster Private Limited, Vijai Electricals Limited and Indu Projects Limited. He is also a director on the board of, inter alia, Varp Power Private Limited, Fototentia Diagnostics Private Limited, Tristup Solar Private Limited and Varp Solar Skylight Private Limited.

**Mr. Pradeep Kumar**, aged 65 years, is an independent non-executive director on the board of the Investment Manager since January 8, 2021. He holds a master's degree in science from University of Madras and is a certified associate of the Indian Institute of Banks. He was previously associated with State Bank of India. He is also a director on the board of, inter alia, Shriam Transport Finance Company Limited, Karnataka Bank Limited and Brigade Enterprises Limited.

### ***Other Confirmations***

The Investment Manager confirms that it has, and undertakes to ensure that it will at all times maintain, adequate infrastructure, personnel and resources to perform its functions, duties and responsibilities with respect to the management of the Terra InvIT, in accordance with SEBI InvIT Regulations, the Investment Management Agreement and applicable law. None of the directors of the Investment Manager hold or propose to hold any Units in this Issue.

Further, as of the date of this Final Placement Memorandum, the Investment Manager is in compliance with the eligibility criteria provided under Regulation 4 of the SEBI InvIT Regulations and is a “fit and proper person” as prescribed under SEBI Intermediaries Regulations.

Galaxy Investments II Pte. Ltd., an affiliate of our Sponsor, is proposing to acquire assets in the roads infrastructure sector and set up a trust under the SEBI InvIT Regulations. The Investment Manager is proposed to act as the investment manager of the proposed InvIT.

#### ***Details of the Holding or the Proposed Holding by Investment Manager in the Terra InvIT***

Virescent Infrastructure does not propose to hold any Units of the Terra InvIT.

#### ***Brief profiles of the key personnel of the Investment Manager***

In addition to Mr. Sanjay Grewal, whose details is provided in ‘*Brief profiles of the Directors of the Investment Manager*’ above, the details of the other key personnel of the Investment Manager are set forth below:

##### **1. Mr. Parin Mehta**

Mr. Parin Mehta, aged 40 years, is the chief financial officer of Virescent Infrastructure. He holds a bachelor’s degree in commerce from University of Mumbai and is an affiliate member of the Association of Chartered Certified Accountants. He has over 18 years of experience in investment banking, corporate finance and project finance functions having been previously associated with companies including Edelweiss Financial Services Limited, PricewaterhouseCoopers Private Limited, IDFC Group, Standard Chartered Bank, Morgan Stanley Advantages Services Private Limited, and Grant Thornton India Private Limited.

##### **2. Mr. Atul Raizada**

Mr. Atul Raizada, aged 51 years, is the chief operating officer of Virescent Infrastructure. He holds a bachelor’s degree in engineering from Nagpur University. He has further completed various programmes including, senior management programme at the Indian Institute of Management, Indore, finance for non-executives programme at London School of Business. He has over 28 years of experience in projects and operations management in the renewable energy sector having been previously associated with Flex Industries Limited, Jindal Poly Films, Orient Press Limited, Converting Services and Supplies, Suzlon Infrastructure Services Limited, Green Infra Limited, Hero Future Energies Private Limited.

#### **D. The Project Manager – Virescent Renewable Energy Project Manager Private Limited**

##### ***History and Certain Corporate Matters***

Virescent Renewable Energy Project Manager Private Limited (“**Virescent Renewable**”) is the Project Manager of the Terra InvIT appointed pursuant to the project management agreement entered into amongst the Project Manager, the Trustee, the Investment Manager dated March 3, 2021. Virescent Renewable was incorporated as a private limited company in India on November 27, 2020 under the provisions of the Companies Act, 2013 with the corporate identification number U74999MH2020PTC350874. Its registered office and address for correspondence is 10th Floor, Parinee Crescenzo, C-30, ‘G’ Block, Bandra Kurla Complex, Bandra (East), Mumbai 400051, Maharashtra India. For further details, see ‘*General Information*’ on page 69.

##### ***Background and past experience of the Project Manager***

Virescent Renewable is responsible for managing and operating the assets of the Terra InvIT and undertaking other operational activities of the Terra InvIT in accordance with the SEBI InvIT Regulations and the Project Management Agreement. Virescent Renewable has employees with relevant experience in managing portfolios in the renewable energy sector including wind and solar power projects. The Project Manager will provide either directly or through the appointment and supervision of appropriate agents, services associated with the management of renewable energy projects, including, (i) business management, including revenue management, operations and maintenance and corporate governance; (ii) financial management including budgeting, reporting, treasury and banking support; (iii) human resource management; (iv) health, safety, security and environmental management; (v) regulatory and government management; and (vi) engineering, procurement and construction management.

### ***Other Confirmations***

As of the date of this Final Placement Memorandum, the Project Manager is in compliance with the eligibility criteria provided under Regulation 4 of the SEBI InvIT Regulations and is a “fit and proper person” as prescribed under SEBI Intermediaries Regulations.

### ***Key terms of the Project Management Agreement***

The Project Manager has entered into a project management agreement dated March 3, 2021, with the Trustee (acting on behalf of the Terra InvIT), Investment Manager, and Project SPVs effective from the date on which the Terra InvIT acquires one or more of the Project SPVs, in accordance with the SAA, to provide project operations and maintenance services in relation to the Project SPVs. Further, the Project Manager will enter into a deed of adherence with the Trustee (acting on behalf of the Terra InvIT), Investment Manager, Project SPVs and the Specified SPVs wherein the Specified SPVs have undertaken that they shall be bound by and shall abide by, the provisions of the project management agreement, as if it was an original party with respect to the terms, conditions, stipulations, obligations, covenants, undertakings, representations and warranties of the “Project SPVs” set out in the project management agreement (project management agreement together with the deed of adherence referred to as “**Project Management Agreement**”). The key terms of Project Management Agreement are provided below:

1. **Services:** The Trustee, in consultation with the Investment Manager has appointed Virescent Renewable to act as the Project Manager to the Asset SPVs and to undertake, by itself or by appointment of contractor, project operations and maintenance services in relation to the Asset SPVs.
2. **Covenants:**
  - (i) The Project Manager has agreed to certain covenants, including:
    - a) at all times act in good faith;
    - b) provide access to the Trustee (acting on behalf of the Terra InvIT) and the Investment Manager to all data and information pertaining to the Asset SPVs, in a proper and timely manner;
    - c) exercise the level of skill, care, attention and diligence as may reasonably be expected of an experienced, professional, prudent and competent third party skilled in providing project management services, such as the Services;
    - d) not cause to be done or taken any act in violation of, or infringing, the Terra InvIT Documents or applicable law; and
    - e) discharge all obligations in respect of achieving timely completion of any infrastructure project of the Terra InvIT, and wherever applicable, implementation, operation, maintenance and management of such infrastructure project.
  - (ii) In the event of a change in control of the Project Manager, the Trustee (on behalf of the Terra InvIT), in consultation with the Investment Manager, shall ensure that it has obtained the written consent of the relevant regulatory, statutory, legal or government authorities prior to such change in control
3. **Duties:** The Project Manager has agreed to undertake certain duties, including:
  - (i) to either directly or through the appointment and supervision of appropriate contractors or agents, provide operations and management services in relation to the Asset SPVs;
  - (ii) to either directly or through the appointment of appropriate contractors, oversee the progress of development, approval status and other aspects of the Asset SPVs or any that may be under development or to be established until its completion in accordance with any agreement that may be entered into in this regard;
  - (iii) to either directly or through the appointment and supervision of appropriate contractors, discharge all its obligations hereunder for achieving timely completion of the infrastructure

projects, wherever applicable, implementation, development, maintenance, operation and management of the infrastructure projects, in accordance with the terms of the Project Management Agreement and the SEBI InvIT Regulations;

- (iv) to provide compliance certificate(s), as may be specified, to the Investment Manager and the Trustee on a quarterly basis, in the form prescribed by SEBI, if any;
  - (v) to provide the Investment Manager with details of transactions carried out between itself and its associates and disclose any conflict of interest in such cases to the Investment Manager and applicable law;
  - (vi) to intimate the Trustee prior to any change in control of the Project Manager to enable the Trustee to seek requisite approval from regulatory, statutory, legal or government authorities, lenders in accordance with applicable law or the Terra InvIT Documents to relevant contractual arrangements pertaining to the Asset SPVs, if applicable;
  - (vii) to provide to the Trustee and Investment Manager or to such other person as the Trustee and/or the Investment Manager may direct, all information that may be necessary for each of them to maintain the records of the Terra InvIT and as may be required for making submissions to SEBI or any other governmental authority;
  - (viii) to ensure that the transactions or arrangements entered into by the Project Manager with a related party are on an arm's-length basis;
  - (ix) keeping the Investment Manager informed on all matters which have a material bearing on the operations of the Asset SPVs;
  - (x) keeping proper records for actions taken in respect of the Asset SPVs; and
  - (xi) complying with the instructions of the Investment Manager and the Trustee in accordance with the SEBI InvIT Regulations.
4. ***Obligations of the Asset SPVs:*** The Asset SPVs shall ensure that all information reasonably required by the Project Manager for the performance of its obligations is provided to the Project Manager or a contractor in a timely manner and as and when required.
5. ***Compensation:*** The Asset SPVs have agreed to pay the fees, as specified in the Project Management Agreement, to the Project Manager, in consideration of the services provided by the Project Manager. The manner and process of payment of such fees shall be as mutually determined by the Project Manager and each of the Asset SPVs.
6. ***Representations and Warranties:***
- (i) Each party to the Project Management Agreement, other than the Asset SPVs has represented and warranted to the other party that they are fit and proper person based on the criteria specified in Schedule II of the SEBI Intermediaries Regulations.
  - (ii) The Trustee, Investment Manager, the Project Manager and the Asset SPVs have provided certain representations and warranties, such as:
    - a) due incorporation or establishment, as the case may be;
    - b) due authorisation for the consummation of the Project Management Agreement;
    - c) non-contravention of constitutional documents, applicable law, agreements to which such entity in a party;
    - d) legal validity and binding nature of the Project Management Agreement, except as may be limited by applicable bankruptcy, insolvency, reorganisation or other laws affecting enforcement of creditors' rights generally, and general principles of equity; and
    - e) no liquidation, dissolution, winding up, commencement of bankruptcy, insolvency, liquidation or similar proceedings, whether voluntary or involuntary, with respect to

it, whether pending or has been pending, or to the best knowledge of such party, threatened.

7. **Representations and Warranties by the Project Manager:** The Project Manager has provided certain representations and warranties, such as:
- (i) no disciplinary action has been taken against it by the SEBI or any other governmental agencies;
  - (ii) neither it nor any of its promoter(s) or directors is debarred from accessing the securities market by the SEBI;
  - (iii) neither it nor any of its promoter(s) or directors is a promoter, director or person in control of any other company or a sponsor, investment manager or trustee of any other InvIT or InvIT which is debarred from accessing the capital market under any order or directions made by the SEBI;
  - (iv) neither it nor any of its promoter(s) or directors is in the list of willful defaulters published by the RBI;
  - (v) to the best of its knowledge, there are no claims, investigations or proceedings before any governmental agency in progress or, pending against or relating to the Project Manager, which could reasonably be expected to prevent the Project Manager from fulfilling its obligations set out in the Project Management Agreement or arising from the Project Management Agreement; and
  - (vi) it has no knowledge of any existing ground on which any such claim, investigation or proceeding might be commenced with any reasonable likelihood of success.
8. **Term & Termination:** The Project Management Agreement shall remain effective from the date on which the Terra InvIT acquires one or more of the Asset SPVs, in accordance with the SAA unless terminated in accordance or with the provisions of the Project Management Agreement or extended by mutual consent expressed in writing by the parties. The Project Management Agreement shall terminate:
- (i) automatically, with respect to a particular Asset SPV, upon the InvIT ceasing to hold any equity shares of such Asset SPV;
  - (ii) by the Investment Manager, after consultation with the Trustee, by delivery of a written notice to the Project Manager at any time (with prior intimation to the Asset SPVs), upon breach of any of the terms, covenants, conditions or provisions of the Project Management Agreement by the Project Manager and failure of the Project Manager to remedy the said breach within a period of 30 days or such other period as may be mutually agreed by the Parties, subject to the appointment of a new project manager in accordance with the SEBI InvIT Regulations;
  - (iii) by any party, by delivery of a written notice to the other Party upon the bankruptcy of such other Party or if winding up or liquidation proceedings are commenced against such other Party (and such proceedings persist for a period of more than three months);
  - (iv) by the Project Manager, by delivery of a written notice of not less than three months to the Trustee, the Asset SPVs and the Investment Manager, subject to SEBI InvIT Regulations and applicable law; or
  - (v) on mutual agreement between the parties for such termination
9. **Indemnity:** The Trustee, the Investment Manager, the Asset SPVs and their respective directors, employees, officers and the InvIT (“**Indemnified Parties**”) shall be indemnified by the Project Manager against any actions, claims, suits, proceedings, direct losses (for the avoidance of doubt, does not include indirect, remote, special, punitive and inconsequential losses), costs, damages, liabilities and expenses, including legal fee from and incurred or suffered by the Indemnified Parties in connection with the breach of any of the terms of the Project Management Agreement by the Project Manager, or arising out of gross negligence, willful default or fraud on part of the Project Manager, in carrying out its obligations under the Project Management Agreement, the other Terra InvIT Documents and applicable law. Notwithstanding anything to the contrary contained herein and/or in any other agreement or writing, the

Trustee, the Asset SPVs and the Investment Manager acknowledge and agree that the aggregate maximum liability of the Project Manager in any financial year pursuant to any provision of the Project Management Agreement shall cumulatively not exceed the fee payable to the Project Manager in such financial year in accordance with the terms of the Project Management Agreement, provided further that such aggregate maximum liability shall not be applicable in the event such liability of the Project Manager arises out of any fraud of the Project Manager.

***Details of the Holding or the Proposed Holding by Project Manager in the Terra InvIT***

The Project Manager does not propose to hold the Units of the Terra InvIT.



## **SECTION VI – OTHER PARTIES**

### **AUDITOR**

The Investment Manager, in consultation with the Trustee, pursuant to a resolution passed by its board of directors dated July 19, 2021, has appointed MSKA & Associates as the Terra InvIT's Auditor for a period of not more than five years. The Auditor has audited the Combined Financial Statements, and their report in relation to such Combined Financial Statements dated July 23, 2021, has been included in this Final Placement Memorandum.

#### **Functions, Duties and Responsibilities of the Auditor**

The Investment Manager shall appoint an auditor of the Terra InvIT for a period of not more than five consecutive years, provided that an auditor, not being an individual, may be reappointed for a period of another five consecutive years, subject to the approval of the Unitholders in an annual meeting, in accordance with provisions of the SEBI InvIT Regulations. With respect to the appointment of the auditor of the Terra InvIT and the fees of such an auditor, an approval from the Unitholders shall be required at the annual meeting in accordance with Regulation 22 of the SEBI InvIT Regulations.

The Investment Manager shall ensure that the auditor carries out an audit of the accounts of the Terra InvIT, not less than once a year and such report is submitted to the Unitholders and the Trustee, either electronically or through physical copies.

In accordance with the SEBI InvIT Regulations, the auditor of the Terra InvIT shall:

- a. conduct an audit of the accounts of the Terra InvIT and draft the audit report based on the accounts examined by him, and after taking into account the relevant accounting and auditing standards, as may be specified by SEBI;
- b. to the best of its information and knowledge, ensure that the accounts and financial statements give a true and fair view of the state of the affairs of the Terra InvIT, including profit or loss and cash flow for the period and such other matters as may be specified;
- c. have a right of access at all times to the books of accounts and vouchers pertaining to activities of the Terra InvIT; and
- d. have a right to require such information and explanation pertaining to activities of the Terra InvIT, as it may consider necessary for the performance of its duties as an auditor from the employees of Terra InvIT or Parties to the Terra InvIT or the Asset SPVs or any other person in possession of such information.

#### **Auditing Standards**

The Auditor shall conduct an audit of the accounts of the Terra InvIT and issue the audit report based on the accounts examined, after taking into account the relevant accounting and auditing standards, as may be specified by SEBI and/or the ICAI, from time to time, in this regard.

## VALUER

The Investment Manager, in consultation with the Trustee, pursuant to a resolution passed by its board of directors dated July 19, 2021, has appointed Mr. S. Sundararaman as the Valuer of the Terra InvIT for a period of up to two years. In accordance with the SEBI InvIT Regulations, the Valuer has undertaken a full valuation of the Asset SPVs which are proposed to be acquired by the Terra InvIT pursuant to the Formation Transactions and his report in relation to such valuation dated July 23, 2021 has been included in this Final Placement Memorandum.

The Valuer is not an Associate of the Sponsor, the Investment Manager or the Trustee, and has not less than five years of experience in the valuation of infrastructure assets.

### *Functions of the Valuer*

The functions, duties and responsibilities of the Valuer will be in accordance with the SEBI InvIT Regulations. Presently, in terms of the SEBI InvIT Regulations, the Valuer is required to comply with the following conditions at all times:

- a. the Valuer shall ensure that the valuation of the Terra InvIT Assets is impartial, true and fair and is in accordance with Regulation 21 of the SEBI InvIT Regulations;
- b. the Valuer shall ensure adequate and robust internal controls to ensure the integrity of its valuation reports;
- c. the Valuer shall ensure that it has sufficient key personnel with adequate experience and qualification to perform valuations;
- d. the Valuer shall ensure that it has sufficient financial resources to enable it to conduct its business effectively and meet its liabilities;
- e. the Valuer and any of its employees involved in valuing of the assets of the Terra InvIT, shall not, (i) invest in Units of the Terra InvIT or in the assets being valued; and (ii) sell the assets or Units of Terra InvIT held prior to being appointed as the Valuer, till the time such person is designated as Valuer of the Terra InvIT and not less than six months after ceasing to be valuer of the Terra InvIT;
- f. the Valuer shall conduct valuation of the Terra InvIT Assets with transparency and fairness and shall render, at all times, high standards of service, exercise due diligence, ensure proper care and exercise independent professional judgment;
- g. the Valuer shall act with independence, objectivity and impartiality in performing the valuation;
- h. the Valuer shall discharge its duties towards the Terra InvIT in an efficient and competent manner, utilising its knowledge, skills and experience in best possible way to complete given assignment;
- i. the Valuer shall not accept remuneration, in any form, for performing a valuation of the Terra InvIT Assets from any person other than the Terra InvIT or its authorised representative;
- j. the Valuer shall before accepting any assignment, from any related party of the Terra InvIT, disclose to the Terra InvIT any direct or indirect consideration which the Valuer may have in respect of such assignment;
- k. the Valuer shall disclose to the Terra InvIT any pending business transactions, contracts under negotiation and other arrangements with the Investment Manager or any other party whom the Terra InvIT is contracting with and any other factors that may interfere with the Valuer's ability to give an independent and professional valuation of the assets;
- l. the Valuer shall not make false, misleading or exaggerated claims in order to secure assignments;
- m. the Valuer shall not provide misleading valuation, either by providing incorrect information or by withholding relevant information;
- n. the Valuer shall not accept an assignment which interferes with its ability to do fair valuation; and

- o. the Valuer shall, prior to performing a valuation, acquaint itself with all laws or regulations relevant to such valuation.

## **SECTION VII – FINANCIAL INFORMATION**

### **COMBINED FINANCIAL STATEMENTS**

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**Independent Auditor's Report on special purpose combined financial statements of the Project SPVs to be transferred to the Virescent Renewable Energy Trust in connection with the proposed private placement of the Units**

To,  
Virescent Renewable Energy Trust [Terra InvIT]

The Board of Directors  
Axis Trustee Services Limited [As the Trustee of the Terra InvIT]

The Board of Directors  
Virescent Infrastructure Investment Manager Private Limited [As the Investment Manager of the Terra InvIT]

**Opinion**

We have audited the accompanying special purpose combined financial statements consisting of the following nine companies:

1. TN Solar Power Energy Private Limited (TN Solar),
2. Universal Mine Developers and Service Providers Private Limited (UMD Project),
3. Terralight Kanji Solar Private Limited (formerly known as Shapoorji Pallonji Solar PV Private Limited (Terralight Kanji),
4. Solar Edge Power and Energy Private Limited (Solar Edge),
5. Terralight Rajapalayam Solar Private Limited (Rajaypalyam)
6. PLG Photovoltaic Private Limited (PLGPL)
7. Sindicatum Solar Energy Private Limited (SSEPL)
8. Sindicatum Solar Energy Gujarat Private Limited (SSEGPL)
9. Universal Saur Urja Private Limited (USUPL)

(together referred as 'Project SPVs' or 'Project SPV Group' and individually 'Project SPV') which are proposed to be transferred from Terra Asia Holdings II Pte Limited, Singapore (hereinafter referred as 'Sponsor') to Virescent Renewable Energy Trust (the 'Terra InvIT') (Terra InvIT and Project SPVs on a combined basis have been referred to as the "Terra InvIT Group") pursuant to the private placement of Units which will be listed of the Terra InvIT ('Private Placement'), and which comprises the:

- a. Combined balance sheet as at March 31, 2021, March 31, 2020 and March 31, 2019;
- b. Combined statement of profit and loss (including other comprehensive income) for the years ended March 31, 2021, March 31, 2020 and March 31, 2019;
- c. Combined statement of cash flows for the years ended March 31, 2021, March 31, 2020 and March 31, 2019;
- d. Combined statement of changes in equity for the years ended March 31, 2021, March 31, 2020 and March 31, 2019;
- e. A summary of significant accounting policies and other explanatory information (together referred to as 'Special Purpose Combined Financial Statements') for the year ended March 31, 2021.

In our opinion and to the best of our information and according to the explanations given to us, the aforesaid special purpose combined financial statements give a true and fair view in accordance with the basis of preparation as specified in note 2.1 to the special purpose combined financial statements in case of:

- a. the combined balance sheet, of the state of affairs of the Project SPV Group as at March 31, 2021, March 31, 2020 and March 31, 2019;
- b. the combined statement of profit and loss (including other comprehensive income) of the Project SPV Group's loss for the years ended March 31, 2021, March 31, 2020 and March 31, 2019;
- c. the combined cash flow statement, of the cash movements of the Project SPV Group for the years ended March 31, 2021, March 31, 2020 and March 31, 2019;
- d. the combined statement of changes in equity, of the movement of the unit holders for the years ended March 31, 2021, March 31, 2020 and March 31, 2019;

## **Basis of Opinion**

We conducted our audit in accordance with the Standards on Auditing (SAs) issued by the Institute of Chartered Accountants of India. Our responsibilities under those Standards are further described in the Auditor's Responsibilities for the Audit of the Special Purpose Combined Financial Statements section of our report. We are independent of the Terra InvIT in accordance with the Code of Ethics issued by the Institute of Chartered Accountants of India ("the ICAI") together with the ethical requirements that are relevant to our audit of the combined financial statements, and we have fulfilled our other ethical responsibilities in accordance with these requirements and the Code of Ethics. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

## **Basis of Accounting and Restriction on Distribution and Use**

Without modifying our opinion, we draw attention to note 2.1 to the Special Purpose Combined Financial Statements, which describes the basis of accounting including the approach to and purpose of preparation of these Special Purpose Combined Financial Statements. The Special Purpose Combined Financial Statements have been prepared by Terra InvIT and the Investment Manager to meet the requirements of Securities and Exchange Board of India (Infrastructure Investment Trust) Regulations, 2014, as amended from time to time including any guidelines and circulars issued thereunder (together referred to as 'InvIT Regulations') and for inclusion in the Draft Placement Memorandum prepared by the Investment Manager in connection with the Draft Private Placement. As a result, the Combined Financial Statements may not be suitable for another purpose. Consequently, these Special Purpose Combined Financial Statements may not necessarily be indicative of financial performance, financial position and cash flows of the Project SPV Group that would have occurred if it had operated as a single group of entities during the periods presented.

This report is addressed to and is provided to the Terra InvIT, Trustee and the Investment Manager solely for the inclusion in the Draft Placement Memorandum, Placement Memorandum and Final Placement Memorandum in connection with the proposed Private Placement and may not be suitable for another purpose. Our report should not be used, referred to or distributed for any other purpose or to any other party without our prior written consent. Accordingly, we do not accept or assume any liability or any duty of care for any other purpose or to any other person to whom this report is shown or into whose hands it may come without our prior consent in writing.

## **Management's Responsibility for the Special Purpose Combined Financial Statements**

The Investment Manager of the Terra InvIT is responsible for the preparation of these Special Purpose Combined Financial Statements that give a true and fair view of the combined financial position, combined financial performance (including other comprehensive income), combined cash flows, combined statement of change in equity in accordance with the basis of preparation specified in note 2.1 to the Special Purpose Combined Financial Statements.

The respective Board of Directors of the Project SPVs are responsible for the maintenance of adequate accounting records in accordance with the provisions of the Companies Act, 2013; for safeguarding the assets of the Project SPVs and for preventing and detecting frauds and other irregularities; the selection and application of appropriate accounting policies; making judgements and estimates that are reasonable and prudent; and the design, implementation and maintenance of adequate internal financial controls, that were operating effectively for ensuring the accuracy and completeness of the accounting records, relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error, which have been used for the purpose of preparation of these special purpose combined financial statements by the Investment Manager, as aforesaid.

In preparing the special purpose combined financial statements, Directors of the Investment Manager are responsible for assessing the Project SPV's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the Project SPV or to cease operations or has no realistic alternative but to do so.

The Board of Directors of the Investment Manager and respective Project SPV are also responsible for overseeing the Project SPV's financial reporting process.

### **Auditor's Responsibility**

Our objectives are to obtain reasonable assurance about whether the Special Purpose Combined Financial Statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with SAs and other pronouncements issued by ICAI will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these Special Purpose Combined Financial Statements.

As part of an audit in accordance with SAs and other pronouncements issued by ICAI, we exercise professional judgment and maintain professional skepticism throughout the audit. We also:

- Identify and assess the risks of material misstatement of the Special Purpose Combined Financial Statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.
- Obtain an understanding of internal financial control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for expressing an opinion on the effectiveness of the internal control.
- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by management.
- Conclude on the appropriateness of management's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Terra InvIT Group's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the Special Purpose Combined Financial Statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the Terra InvIT Group to cease to continue as a going concern.
- Evaluate the overall presentation, structure and content of the Special Purpose Combined Financial Statements, including the disclosures, and whether the Special Purpose Combined Financial Statements represent the underlying transactions and events in a manner that achieves fair presentation.

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings that we identify during our audit.

We also provide those charged with governance with a statement that we have complied with relevant ethical requirements regarding independence, and to communicate with them all relationships and other matters that may reasonably be thought to bear on our independence, and where applicable, related safeguards.

### **Other Matter**

The financial statements of each of the Project SPV for the years ended March 31, 2020 and March 31, 2019 have been prepared as per Ind AS and have been audited by the respective auditors of Project SPV who has issued an unmodified opinion on these financial statements and have been used for the purpose of preparation of the special purpose combined financial statements by the Investment Manager (on behalf of the Terra InvIT) and have been relied upon by us for our audit of these special purpose combined financial statements.

The Projects SPV and the periods which were audited by other auditors are as follows:

S. No.	Project SPV	Periods	Revenue (in ₹ Lakhs)	Total Assets (in ₹ Lakhs)	Cashflow (in ₹ Lakhs)
1	TN Solar	Year ended 31 March 2020	2,858.92	20,183.84	(653.03)
		Year ended 31 March 2019	2,880.95	19,562.05	491.74
2	UMD Project	Year ended 31 March 2020	3,113.00	21,558.52	(466.76)
		Year ended 31 March 2019	3,052.87	20,883.23	300.26
3	Terralight Kanji	Year ended 31 March 2020	3,840.89	27,131.27	(217.41)
		Year ended 31 March 2019	3,839.34	26,289.91	212.86
4	Solar Edge	Year ended 31 March 2020	11,263.16	88,769.53	4,535.15
		Year ended 31 March 2019	10,347.41	87,884.35	(10,937.90)
5	PLGPL	Year ended 31 March 2020	3,116.73	23,963.51	(139.56)
		Year ended 31 March 2019	3,142.88	24,076.85	1,652.79
6	SSEPL	Year ended 31 March 2020	1,562.15	6,946.23	(766.96)
		Year ended 31 March 2019	1,542.06	7,499.29	303.17
7	SSEGPL	Year ended 31 March 2020	1,841.72	15,100.79	206.85
		Year ended 31 March 2019	1,849.71	15,911.15	298.27
8	USUPL	Year ended 31 March 2020	4,667.48	19,845.38	(1,166.54)
		Year ended 31 March 2019	4,853.01	24,020.10	1,388.76

#### Report on Other Legal and Regulatory Requirements

As required by the InvIT Regulations, we report that:

- we have obtained all information and explanations which, to the best of our knowledge and belief, were necessary for the purpose of our audit;
- the combined balance sheet and the combined statement of profit and loss, are in agreement with the books of account of the respective Project SPV;
- the Special Purpose Combined Financial Statements comply with the Indian Accounting Standards as notified under the Companies (Indian Accounting Standards) Rules, 2015 prescribed under section 133 of the Act and the basis of preparation as specified in note 2.1 to these Special Purpose Combined Financial Statements; and
- In our opinion and to the best of our information and according to the explanations given to us, the Special Purpose Combined Financial Statements give the disclosures, in accordance with the InvIT Regulations, in respect of the net assets at fair value as at March 31, 2021 and the total returns at fair value for the year ended March 31, 2021 and for the year ended March 31, 2020.

For **MSKA & Associates**  
Chartered Accountants  
ICAI Firm Registration Number: 105047W

Ananthakrishnan Govindan  
Partner  
Membership Number: 205226  
UDIN: 21205226AAAAFT1172

Hyderabad  
July 23, 2021



**Virescent Renewable Energy Trust**  
**Combined Balance Sheet**  
**All amounts are in INR lakhs unless otherwise stated**

Particulars	Notes	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>ASSETS</b>				
<b>Non-current assets</b>				
Property, plant and equipment	3	1,53,602.97	1,99,155.82	2,13,532.35
Capital work-in-progress	4	-	-	51.50
Goodwill		236.47	236.47	236.47
Intangible assets	5	0.13	0.37	0.64
Financial assets				
Investments	6	0.50	4,120.49	655.75
Others	7	136.62	2,090.57	1,079.73
Income tax assets (net)	8	445.38	554.63	690.98
Deferred tax assets (net)	9	4,968.66	4,976.60	2,501.68
Other non-current assets	10	31.36	131.22	423.45
<b>Total non-current assets</b>		<b>1,59,422.09</b>	<b>2,11,266.17</b>	<b>2,19,172.55</b>
<b>Current assets</b>				
Inventories	11	67.84	58.81	19.57
Financial assets				
Trade receivables	12	10,784.07	19,529.48	10,192.81
Cash and cash equivalents	13	12,560.78	7,865.17	9,338.73
Other bank balances	14	17,890.71	5,328.37	4,421.57
Loans	15	-	-	3,182.00
Others	7	3,893.43	2,271.72	2,666.01
Other current assets	10	176.28	232.65	167.22
<b>Total current assets</b>		<b>45,373.11</b>	<b>35,286.20</b>	<b>29,987.91</b>
<b>Assets held for sale</b>	16	3,437.87	-	-
<b>Total assets</b>		<b>2,08,233.07</b>	<b>2,46,552.37</b>	<b>2,49,160.46</b>
<b>EQUITY AND LIABILITIES</b>				
<b>Equity</b>				
Equity share capital	17	43,619.57	43,619.57	41,719.57
Instrument entirely equity in nature	18	3,929.00	3,929.00	3,929.00
Other equity	19	(56,031.36)	(6,670.86)	3,616.51
<b>Total equity</b>		<b>(8,482.79)</b>	<b>40,877.71</b>	<b>49,265.08</b>
<b>Non-controlling interest</b>		<b>322.70</b>	<b>332.18</b>	<b>350.86</b>
<b>LIABILITIES</b>				
<b>Non-current liabilities</b>				
Financial liabilities				
Borrowings	20	1,13,438.00	1,59,820.17	1,59,874.00
Lease liabilities	21	120.83	120.47	148.24
Provisions	22	31.32	25.20	13.13
Other non-current liabilities	23	2,074.94	1,672.00	-
<b>Total non-current liabilities</b>		<b>1,15,665.09</b>	<b>1,61,637.84</b>	<b>1,60,035.37</b>
<b>Current liabilities</b>				
Financial liabilities				
Borrowings	20	63,572.79	3,610.41	1,061.28
Lease liabilities	21	23.73	54.96	66.17
Trade payables	24	2,138.35	2,373.83	7,913.43
Others	25	12,899.14	17,713.87	14,369.73
Provisions	22	3.35	0.22	2.73
Income tax liabilities (net)	8	37.79	3.82	43.10
Other current liabilities	23	22,052.92	19,947.53	16,052.71
<b>Total current liabilities</b>		<b>1,00,728.07</b>	<b>43,704.64</b>	<b>39,509.15</b>
<b>Total liabilities</b>		<b>2,16,393.16</b>	<b>2,05,342.48</b>	<b>1,99,544.52</b>
<b>Total equity and liabilities</b>		<b>2,08,233.07</b>	<b>2,46,552.37</b>	<b>2,49,160.46</b>

Significant accounting policies

2

The accompanying notes form an integral part of the combined financial statements.

In terms of our report attached

**For MSKA & Associates**  
Chartered Accountants  
ICAI Firm's Registration No: 105047W

For and on behalf of the Board of Directors  
**Virescent Infrastructure Investment Manager Private Limited**  
(acting as Investment Manager to Virescent Renewable Energy Trust)

**Ananthakrishnan G**  
Partner  
Membership No: 205226

**Sanjay Grewal**  
Director  
DIN: 01971866

**Hardik Shah**  
Director  
DIN: 06648474

**Charmy Bhoot**  
Company Secretary

Place: Hyderabad  
Date: 23 July 2021

Place: New York  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

**Virescent Renewable Energy Trust**  
**Combined Statement of Profit and Loss**  
**All amounts are in INR lakhs unless otherwise stated**

Particulars	Notes	Year ended 31 March 2021	Year ended 31 March 2020	Year ended 31 March 2019
I Revenue from operations	26	34,423.98	35,134.95	32,766.51
II Other income	27	2,448.22	1,312.11	618.46
III <b>Total income (I + II)</b>		<b>36,872.20</b>	<b>36,447.06</b>	<b>33,384.97</b>
IV <b>Expenses</b>				
Operating and maintenance expenses	28	1,491.20	1,564.73	1,366.70
Employee benefits expense	29	165.32	139.69	193.20
Finance costs	30	22,243.56	20,093.22	18,669.65
Depreciation and amortization expense	31	13,660.65	14,908.46	14,296.37
Other expenses	32	6,453.00	2,311.89	4,142.11
<b>Total expenses (IV)</b>		<b>44,013.73</b>	<b>39,017.99</b>	<b>38,668.03</b>
V <b>Profit/(Loss) before exceptional items (III-IV)</b>		<b>(7,141.53)</b>	<b>(2,570.93)</b>	<b>(5,283.06)</b>
VI Exceptional items	33	33,177.48	3,445.95	2,322.64
VII <b>Profit/(Loss) before tax (V-VI)</b>		<b>(40,319.01)</b>	<b>(6,016.88)</b>	<b>(7,605.70)</b>
VIII <b>Tax Expense:</b>	34			
Current tax		465.20	503.89	49.01
Deferred tax charge/(credit)		7.94	(2,474.92)	(4,673.27)
<b>Total tax expense (VIII)</b>		<b>473.14</b>	<b>(1,971.03)</b>	<b>(4,624.26)</b>
IX <b>Profit / (loss) for the year</b>		<b>(40,792.15)</b>	<b>(4,045.85)</b>	<b>(2,981.44)</b>
X <b>Other comprehensive income</b>				
(i) Item that will not be reclassified to profit or loss		(0.10)	(0.81)	0.07
(ii) Income tax relating to item that will not be reclassified to profit or loss		-	-	-
XI <b>Total other comprehensive income</b>		<b>(0.10)</b>	<b>(0.81)</b>	<b>0.07</b>
XII <b>Total comprehensive income for the year (X+XI)</b>		<b>(40,792.25)</b>	<b>(4,046.66)</b>	<b>(2,981.37)</b>
<b>Profit / (loss) for the year</b>		<b>(40,792.15)</b>	<b>(4,045.85)</b>	<b>(2,981.44)</b>
Attributable to:				
Equity holders		(40,792.15)	(4,045.85)	(2,981.44)
<b>Total comprehensive loss for the year</b>		<b>(40,792.25)</b>	<b>(4,046.66)</b>	<b>(2,981.37)</b>
Attributable to:				
Equity holders		(40,792.25)	(4,046.66)	(2,981.37)
<b>Profit/(Loss) for the year attributable to</b>				
Owners of the company		-40,782.77	-4,027.98	-2,969.93
<b>Non Controlling interest</b>		-9.48	-18.68	-11.44
Earnings per unit - Refer note 37				

**Significant accounting policies**

2

The accompanying notes form an integral part of the combined financial statements.

In terms of our report attached

**For MSA & Associates**  
Chartered Accountants  
ICAI Firm's Registration No: 105047W

For and on behalf of the Board of Directors  
**Virescent Infrastructure Investment Manager Private Limited**  
(acting as Investment Manager to Virescent Renewable Energy Trust)

**Ananthkrishnan G**  
Partner  
Membership No: 205226

**Sanjay Grewal**  
Director  
DIN: 01971866

**Hardik Shah**  
Director  
DIN: 06648474

**Charmy Bhoot**  
Company Secretary

Place: Hyderabad  
Date: 23 July 2021

Place: New York  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

**Virescent Renewable Energy Trust**  
**Combined Cash Flow Statement**  
**All amounts are in INR lakhs unless otherwise stated**

	Year ended 31 March 2021	Year ended 31 March 2020	Year ended 31 March 2019
<b>Operating activities</b>			
Loss before tax from continuing operations	(40,319.01)	(6,016.88)	(7,605.70)
Profit/(loss) before tax from discontinued operations			
<b>Loss before tax</b>	<b>(40,319.01)</b>	<b>(6,016.88)</b>	<b>(7,605.70)</b>
<i>Adjustments to reconcile profit before tax to net cash flows:</i>			
Depreciation and amortisation expense	13,660.65	14,908.46	14,296.37
Impairment loss	32,495.61		2,322.64
Finance cost	22,243.56	20,093.22	18,669.65
Loss on sale of property, plant and equipment (net)	108.80	120.35	5.01
Loss on receivable written off	5.36	-	-
Bad debt Expenses	-	3,182.00	-
Impairment loss on investment	649.13	-	2,377.13
Provision for doubtful advances	-	263.95	-
Allowance for doubtful advances	-	302.97	-
Excess provisions written back	(1,276.54)	(266.50)	-
Foreign exchange loss	-	20.48	13.43
Interest income	(801.03)	(881.07)	(409.98)
Amortization of VGF receipt	(144.26)	(152.00)	-
Dividend income	-	(0.04)	(30.27)
<b>Operating profit before working capital changes and other adjustments</b>	<b>26,622.27</b>	<b>31,574.94</b>	<b>29,638.28</b>
<i>Working capital adjustments:</i>			
(Increase)/ Decrease in inventories	(9.03)	(39.24)	3.64
(Increase)/ Decrease in trade receivables	8,745.55	(9,336.67)	(2,931.76)
(Increase)/ Decrease in financial and other asset	(1,448.05)	23.48	1,338.50
Increase/ (Decrease) in trade payable	1,041.06	(5,273.10)	(12,815.21)
Increase/ (Decrease) in other financial and other liability	4,772.78	4,637.65	2,664.55
<b>Cash flow from operating activities post working capital changes</b>	<b>39,724.58</b>	<b>21,587.06</b>	<b>17,897.99</b>
Income tax paid(net)	(315.02)	(390.94)	(326.06)
<b>Net cash flows from operating activities</b>	<b>39,409.56</b>	<b>21,196.11</b>	<b>17,571.93</b>
<b>Investing activities</b>			
Purchase of property, plant and equipment (including capital work in progress)	(716.14)	(294.61)	(27,878.04)
Sale of property, plant and equipment (including capital work in progress)	4.17	2.30	78.43
Investment income recognised in profit or loss	748.65	855.60	383.31
Purchase of investments	(13,331.26)	(5,691.86)	(14,255.00)
Sale of investments	2,785.31	40.85	12,148.37
Loan given to associates	-	-	(3,182.00)
<b>Net cash flows used in investing activities</b>	<b>(10,509.27)</b>	<b>(5,087.73)</b>	<b>(32,704.93)</b>
<b>Financing activities</b>			
Proceeds from issue of equity instruments	-	1,900.00	3,922.00
Proceeds from borrowings	1,44,097.22	17,251.56	55,180.25
Transaction with owners of acquired business undertaking for the year	(3,384.94)	(6,230.43)	16,558.60
Repayment of borrowings	(1,40,856.47)	(14,012.40)	(46,591.96)
Repayment of lease liabilities	(37.10)	(44.74)	(16.07)
VGF funds received	570.00	1,900.00	-
Share issue expenses	-	(35.75)	(4.47)
Finance cost paid	(24,593.39)	(18,310.19)	(18,465.08)
<b>Net cash flows from/(used in) financing activities</b>	<b>(24,204.68)</b>	<b>(17,581.95)</b>	<b>10,583.26</b>
Net increase in cash and cash equivalents	4,695.61	(1,473.56)	(4,549.73)
Cash and cash equivalents at the beginning of the year	7,865.17	9,338.73	13,888.46
<b>Cash and cash equivalents at period/year end (Refer Note: 13)</b>	<b>12,560.78</b>	<b>7,865.17</b>	<b>9,338.73</b>

The accompanying notes form an integral part of the combined financial statements.

In terms of our report attached  
**For MSA & Associates**  
Chartered Accountants  
ICAI Firm's Registration No: 105047W

For and on behalf of the Board of Directors  
**Virescent Infrastructure Investment Manager Private Limited**  
(acting as Investment Manager to Virescent Renewable Energy Trust)

**Ananthkrishnan G**  
Partner  
Membership No: 205226

**Sanjay Grewal**                      **Hardik Shah**                      **Charmy Bhoot**  
Director                                  Director                                  Company Secretary  
DIN: 01971866                      DIN: 06648474

Place: Hyderabad  
Date: 23 July 2021

Place: New York  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

a. Equity share capital

Particulars	Amount
Equity shares of INR 10 each issued, subscribed and fully paid	
As at 1 April 2018	43,575.03
Changes in equity share capital during the year	-
As at 31 March 2019	43,575.03
Changes in equity share capital during the year	1,900.00
As at 31 March 2020	45,475.03
Changes in equity share capital during the year	-
As at 31 March 2021	45,475.03

b. Instrument entirely equity in nature

Particulars	Amount
Compulsorily convertible preference shares (CCPS) of INR 10 each issued, subscribed and fully paid	
As at 1 April 2018	7.00
Changes in CCPS capital during the year	3,922.00
As at 31 March 2019	3,929.00
Changes in CCPS capital during the year	-
As at 31 March 2020	3,929.00
Changes in CCPS capital during the year	-
As at 31 March 2021	3,929.00

b. Other equity

Particulars	Reserves and Surplus				Non Controlling interest	Equity of acquired business undertaking	Total
	Capital reserve	General reserve	Security premium reserve	Retained earnings			
Balance as at 1 April 2018	116.74	7.00	12,159.44	(22,845.36)	414.35	542.44	(9,605.39)
Loss for the year	-	-	-	(2,970.00)	(11.44)	-	(2,981.44)
Other comprehensive income for the year, net of income tax	-	-	-	0.07	-	-	0.07
Share issue expenses	-	-	-	(4.47)	-	-	(4.47)
Consequent to change in Groups interest	-	-	-	52.05	(52.05)	-	-
Transaction with owners of acquired business undertaking for the year	-	-	-	-	-	16,558.60	16,558.60
Balance as at 31 March 2019	116.74	7.00	12,159.44	(25,767.71)	350.86	17,101.04	3,967.37
Impact on account of change in transition date of Ind AS 116	-	-	-	6.79	-	-	6.79
Loss for the year	-	-	-	(4,027.17)	(18.68)	-	(4,045.85)
Other comprehensive income for the year, net of income tax	-	-	-	(0.81)	-	-	(0.81)
Share issue expenses	-	-	-	(35.75)	-	-	(35.75)
Transaction with owners of acquired business undertaking for the year	-	-	-	-	-	(6,230.43)	(6,230.43)
Balance as at 31 March 2020	116.74	7.00	12,159.44	(29,824.65)	332.18	10,870.61	(6,338.68)
Loss for the year	-	-	-	(40,782.67)	(9.48)	-	(40,792.15)
Other comprehensive income for the year, net of income tax	-	-	-	(0.10)	-	-	(0.10)
Share issue expenses	-	-	-	-	-	-	-
Impact of Fair valuation of Non-Convertible Debentures	-	-	-	(5,192.79)	-	-	(5,192.79)
Transaction with owners of acquired business undertaking for the year	-	-	-	-	-	(3,384.94)	(3,384.94)
Transfer to capital reserve	7,485.67	-	-	-	-	(7,485.67)	-
Balance as at 31 March 2021	7,602.41	7.00	12,159.44	(75,800.21)	322.70	-	(55,708.66)

Securities premium

Securities premium includes premium on issued of shares and issue of shares through conversion of compulsory convertible debentures. It will be utilised in accordance with the provisions of the Companies Act, 2013.

General reserve

Under the erstwhile Companies Act 1956, general reserve was created through an annual transfer of net income at a specified percentage in accordance with applicable regulations. The purpose of these transfers was to ensure that if a dividend distribution in a given year is more than 10% of the paid-up capital of the Company for that year, then the total dividend distribution is less than the total distributable results for that year. Consequent to introduction of Companies Act 2013, the requirement to mandatory transfer a specified percentage of the net profit to general reserve has been withdrawn. However, the amount previously transferred to the general reserve can be utilised only in accordance with the specific requirement of Companies Act, 2013.

The accompanying notes form an integral part of the combined financial statements.

In terms of our report attached

For MSKA & Associates

Chartered Accountants

ICAI Firm's Registration No: 105047W

For and on behalf of the Board of Directors

Virescent Infrastructure Investment Manager Private Limited

(acting as Investment Manager to Virescent Renewable Energy Trust)

Ananthakrishnan G

Partner

Membership No: 205226

Sanjay Grewal

Director

DIN: 01971866

Hardik Shah

Director

DIN: 06648474

Charmy Bhoot

Company Secretary

Place: Hyderabad

Date: 23 July 2021

Place: New York

Date: 23 July 2021

Place: Mumbai

Date: 23 July 2021

Place: Mumbai

Date: 23 July 2021

## **Virescent Renewable Energy Trust**

### **Summary of significant accounting policies and other explanatory information**

#### **1. Corporate Information**

The combined financial statements comprise financial statements of Universal Mine Developers and Service Providers Private Limited ("UMD"), TN Solar Power Energy Private Limited ("TN Solar"), Terralight Kanji Solar Private Limited [Formerly known as Shapoorji Pallonji Solar PV Private Limited] ("Terralight Kanji" or "SP Solar PV"), Solar Edge Power and Energy Private Limited ("SEPEPL"), Terralight Solar Energy Tinwari Private Limited [Formerly known as Sindicatum Solar Energy Private Limited] ("TSETPL" or "SSEPL"), Terralight Solar Energy Charanka Private Limited [Formerly known as Sindicatum Solar Energy Gujarat Private Limited] ("TSECPL" or "SSEGPL"), PLG Photovoltaic Private Limited ("PLG"), Universal Saur Urja Private Limited ("USUPL") –and an operating asset ("Rajapalayam assets") housed under Shapoorji Pallonji Infrastructure Capital Company Private Limited (individually referred to as "SPV" and together referred to as "SPV Group"). These Rajapalayam assets, acquired by Terra Asia Holdings II Pte. Limited (Terra II) as part of slump sale have been housed under Terralight Rajapalayam Solar Private Limited [Formerly known as "Shapoorji Pallonji Suryaprakash Private Limited"] ("Terralight Rajapalayam" or "SP Suryaprakash") by way of Amended securities subscription and purchase agreement dated September 26, 2020. The SPVs are companies domiciled in India. UMD, Terralight Kanji, SEPEPL and Terralight Rajapalayam have their registered office at 10th Floor, Parinee Crescenzo, C- 30, G Block, Bandra Kurla Complex, Bandra (East) Mumbai 400051. TN Solar has its registered office at 14, 1<sup>st</sup> Floor, Sreyas Virat, 3<sup>rd</sup> Cross Road, Raja Annamalaipuram, Chennai 600 028, TSETPL and TSECPL have their registered office at B 93, Basement, Defence Colony, New Delhi 110 024, PLG has registered office at Kalika Dham, P- 4/B, C.I.T. ROAD, Sch No. 55, Kolkata - 700014 and USUPL has registered office at 274-A, New Adarsh Nagar, Guru harsahai, Teh. Jalalabad, Distt. Firozpur, Punjab -152022.

UMD, TN Solar, Terralight Kanji and Terralight Rajapalayam are special purpose vehicles which have entered into Power purchase agreement with Tamil Nadu Electricity Generation and Distribution Corporation of India (TANGEDCO), TSETPL has entered into Power purchase agreement with NTPC Vidyut Vyapar Nigam Limited (NVVNL), TSECPL and PLG have entered into power purchase agreement with Gujarat Urja Vikas Nigam Limited (GUVNL), USUPL has entered into Power purchase agreement with UP Power Corporation Limited (UPPCL) and Solar edge has entered in power purchase agreement with Solar Energy Corporation of India Limited (SECI) to sell solar power generated from its solar power project set up in various locations.

5 entities namely UMD, TN Solar, Terralight Kanji, SEPEPL and Terralight Rajapalayam comprising an overall 258 MWp of solar assets located in Maharashtra and Tamil Nadu were acquired by Terra Asia Holdings II Pte Limited ("Terra II") in October 2020 from the Shapoorji Pallonji Group and other 4 entities namely TSETPL, TSECPL, PLG and USUPL comprising an overall 70 MWp of solar assets located in Gujarat, Uttar Pradesh and Rajasthan were acquired by Terra Asia Holdings II Pte Limited ("Terra II") in May 2021 from the Sindicatum Group.

Terra Asia Holding II Pte Ltd. (hereinafter together referred as "Sponsor") settled the Virescent Renewable Energy Trust on January 28, 2021 as an irrevocable trust, pursuant to the Trust Deed, under the provisions of the Indian Trusts Act, 1882 and registered with Securities and Exchange Board of India ("SEBI") vide Certificate of Registration dated February 25, 2021 as an Infrastructure Investment Trust under Regulation 3(1) of the Securities Exchange Board of India (Infrastructure Investment Trust) Regulations, 2014. The Investment Manager has transferred to the Trustee a sum of Rs. 10,000 each towards the initial settlement of Virescent Renewable Energy Trust. The Trustee to Virescent Renewable Energy Trust is Axis Trustee Services Limited (the "Trustee") and the Investment Manager is Virescent Infrastructure Investment Manager Pvt Ltd (the "Investment Manager"). Sponsor proposed to transfer their shareholding in UMD, TN Solar, Terralight Kanji, Solar Edge, Terralight Rajapalayam, TSETPL, TSECPL, PLG and USUPL to Virescent Renewable Energy Trust. As required by the Guidance Note on Combined and Carve-Out Financial Statements issued by the Institute of Chartered Accountants of India, the details of various entities comprised in the combined financial statements is as given below:

<b>Name of SPV</b>	<b>Proposed Shareholding by Virescent Renewable Energy Trust</b>	<b>Nature of Proposed Investment</b>	<b>Status</b>	<b>Principal Activities</b>	<b>Country of incorporation</b>
UMD	100%	Subsidiary	Operating	Generation and Distribution of Solar energy	India
TN Solar	100%	Subsidiary	Operating		India
Terralight Kanji	100%	Subsidiary	Operating		India
SEPEPL	100%	Subsidiary	Operating		India
TSETPL	100%	Subsidiary	Operating		India
TSECPL	100%	Subsidiary	Operating		India
PLG	100%	Subsidiary	Operating		India
USUPL	100%	Subsidiary	Operating		India
Rajapalayam assets	100%	Subsidiary	Operating		India

## **Virescent Renewable Energy Trust**

### **Summary of significant accounting policies and other explanatory information**

## **2. Significant Accounting Policies**

### **2.1 Basis of preparation and presentation**

The Combined Financial Statements of the SPV Group comprise the Combined Balance Sheet as at 31 March 2021, 31 March 2020 and 31 March 2019 and the Combined Statement of Profit and Loss, Combined Cash Flow Statement, Combined Statement of Changes in Equity and a Summary of Significant Accounting Policies and Other Explanatory Information for the years ended 31 March 2021, 31 March 2020 and 31 March 2019.

The Combined Financial Statements were authorized for issue in accordance with resolutions passed by the Board of Directors of the Investment manager on XX XXXX 2021.

The Combined Financial Statements have been prepared in accordance with Indian Accounting Standards as defined in Rule 2(1)(a) of the Companies (Indian Accounting Standards) Rules, 2015 prescribed under Section 133 of the Companies Act, 2013 ("Ind AS") read with SEBI (Infrastructure Investment Trusts) Regulations, 2014 and the circulars issued thereunder ("InvIT Regulations") and the Guidance Note on Combined and Carve-Out Financial Statements issued by the Institute of Chartered Accountants of India ("Guidance Note").

The combined financial statements are special purpose financials statements and have been prepared by the Investment manager to meet the requirement of SEBI (Infrastructure Investment Trusts) Regulations, 2014 ("InvIT Regulations") and for inclusion in the placement memorandum prepared by Investment Manager in connection with the proposed private placement of units of Virescent Renewable Energy Trust. As required under the InvIT Regulations, the combined financial statements are prepared, based on an assumption that all the assets and liabilities of this business unit for earlier periods were part of Virescent Renewable Energy Trust. Accordingly, equity portion of Rajapalayam assets for last 2 financial years (for the year ended 31 March 2019 and 31 March 2020) have been classified as 'Equity of acquired business undertaking' for the preparation of these combined financial statements. For year ended 31 March 2021, the residual value of 'Equity of acquired business undertaking' has been transferred to 'Capital reserve' owing to BTA between Terra II and Shapoorji Pallonji Infrastructure Capital Company Private Limited (SPICC) for transferring Rajapalayam assets to Terralight Rajapalayam and consequently 100% of Terralight Rajapalayam equity being held by Terra II. As a result, the combined financial statements may not be suitable for another purpose.

The Combined financial statements are presented in India Rupees which is also the functional currency of the SPV Group. All values are rounded to the nearest lakhs, unless otherwise indicated.

These Combined Financial Statements correspond to the classification provisions contained in Ind AS 1 'Presentation of Financial Statements'. For clarity purposes, various items are aggregated in the Combined Statement of Profit and Loss and Combined Balance Sheet. These items are disaggregated separately in the notes to the Combined Financial Statements, where applicable or required.

These Combined Financial Statements have been prepared on a historical cost convention and on an accrual basis except for certain financial assets and liabilities measured at fair value (refer accounting policy regarding financial instruments)

#### **a) Basis of Combination and carveout**

The Combined Financial Statements have been prepared using uniform accounting policies for like transactions and other events in similar circumstances. The financial statements of all the SPVs used for the purpose of combination are drawn up to the same reporting date i.e. year ended on 31 March each year. The financial statements of the SPVs have been prepared in accordance with the accounting standards notified under the Section 133 of the Companies Act 2013 (the Act) [Companies (Indian Accounting Standards) Rules, 2015] and other relevant provisions of the Act.

The procedure for preparing Combined Financial Statements of the SPV Group are stated below –

- Combine like items of assets, liabilities, equity, income, expenses, and cash flows of the SPVs
- Since Terralight Rajapalayam was an existing entity with negligible operations – it acquired 50MW solar assets of Rajapalayam asset through a business transfer agreement (BTA) which was entered as part of the acquisition transaction, share subscription agreement of Terralight Rajapalayam and BTA was entered on the same day. So, the Audited Special Purpose Combined Ind-AS Financial Statements as of and for the year ended 31 March 2021 are prepared by combining

## **Virescent Renewable Energy Trust**

### **Summary of significant accounting policies and other explanatory information**

the carve-out financials of the Rajapalayam Assets. The combined financials for the years ended 31 March 2019, 31 March 2020 and 31 March 2021, consist of the carve out financials of Rajapalayam asset

- Net assets taken over by Terralight Rajapalayam from Rajapalayam assets have been adjusted for purchase consideration paid by Terralight Rajapalayam. The same has been reflected under "Equity of acquired undertaking" as part of Other Equity and transferred to capital reserve as on 31 March 2021.

#### **b) Date of commencement of commercial operations**

The details of incorporation, commencement of operations and residual concession life are as given below:

<b>Name of the entity</b>	<b>Date of incorporation</b>	<b>Commencement of operation</b>	<b>Residual Concession Life*</b>
UMD	11 Jul 2008	12MW Project: 16 November 2015 13MW Project: 21 March 2016	19 years, 11 months, 21 days
TN Solar	14 Oct 2013	8MW Project: 28 September 2015 10MW Project: 02 November 2015 5MW Project: 28 December 2015	19 years, 8 months, 28 days
Terralight Kanji	06 May 2010	30MW: 26 March 2016	19 years, 11 months, 26 days
SEPEPL	29 June 2015	30MW: 22 April 2018 50MW: 26 April 2018 50MW: 8 April 2018	22 years, 26 days
TSETPL	17 June 2008	5MW: 15 October 2011	15 years, 6 months and 8 days
TSECPL	12 May 2010	15 MW – March 2012- October 2012	16 years, 7 months and 1 day
PLG	11 June 2007	20 MW January 2012	15 Years 9 Months and 25 Days
USUPL	30 Jan 2015	30 MW: September 2016	20 years, 5 months and 14 day
Rajapalayam assets	NA	50MW: 26 September 2018	22 years, 5 months, 26 days

\*Residual useful life as on 31 March 2021

#### **c) Use of estimates and judgements**

The preparation of financial statements requires management to make certain estimates and assumptions that affect the amounts reported in the financial statements and notes thereto. The management believes that these estimates and assumptions are reasonable and prudent. However, actual results could differ from these estimates. Any revision to accounting estimates is recognized prospectively in the current and future period. An overview of the areas that involve a higher degree of judgement or complexity, and of items which are more likely to be materially adjusted due to estimates and assumptions turning out to be different than those originally assessed have been disclosed below. Detailed information about each of these estimates and judgments is included in the relevant notes together with information about the basis of calculation for each affected line item in the financial statements.

Estimate and judgements are continually evaluated and are based on historical experience and other factors, including expectations of future events that may have a financial impact on the entity and that are believed to be reasonable under circumstances.

##### **i. Impairment of plant and equipment**

The carrying amounts of the Company's plant and equipment are reviewed at each reporting date to determine whether there is any indication of impairment. The evaluation of applicability of indicators of impairment of non-financial assets requires assessment of several external and internal factors which could result in deterioration of recoverable amount of the assets. Management uses various estimation techniques for forecasting the future cashflows and has applied judgement in estimating the units generated from solar power plant, timing of cashflows, period of power purchase agreement and the weighted average cost of capital.

##### **ii. Useful lives of depreciable/amortisable assets**

Management of each SPV reviews its estimate of the useful lives of depreciable/amortisable assets at each reporting date, based on the expected utility of the assets. Uncertainties in these estimates relate to technical and economic obsolescence that may change the utility of certain software, site equipment and other plant and equipment.

##### **iii. Recognition of deferred tax assets**

## **Virescent Renewable Energy Trust**

### **Summary of significant accounting policies and other explanatory information**

The extent to which deferred tax assets can be recognized is based on an assessment of the probability of the future taxable income against which the deferred tax assets can be utilized.

#### **iv. Fair value measurement of Non-convertible debentures**

The SPV Group has determined the fair value of Non-Convertible Debentures based on the expected cash flows on redemption of NCD. The expected cashflows is determined by the management based on its judgement towards the occurrence of certain events within the redemption period upon which the SPV Group is liable to redeem the NCDs at premium. These events are not within the control of the management hence the ultimate outcome may be different from management estimate.

#### **v. Recoverability of trade receivables**

The SPV Group's trade receivables and unbilled revenue are only from, Government owned counterparty and are recoverable under the power purchase agreement. There are certain receivables from these Government customers which are under dispute or negotiation. The Company determines the recoverability of these receivables based on its assessment of the terms of the power purchase agreement and in consultation with legal counsel.

#### **vi. Contingent liabilities**

The SPV Group is the subject of legal proceedings and tax issues covering a range of matters, which are pending in various jurisdictions. Due to the uncertainty inherent in such matters, it is difficult to predict the outcome of such matters. The cases and claims against the SPV Group often raise difficult and complex factual and legal issues, which are subject to many uncertainties, including but not limited to the facts and circumstances of each case and claim, the jurisdiction and the differences in applicable law. In the normal course of business management of each SPV consults with legal counsel and certain other experts on matters related to litigation and taxes. The SPV Group accrues a liability when it is determined that an adverse outcome is probable, and the amount of the loss can be reasonably estimated.

## **2.2 Summary of significant accounting policies**

The following is the summary of significant accounting policies applied by the SPV Group in preparing its combined financial statements:

### **a) Basis of classification as current and non-current**

The SPV Group presents assets and liabilities in the combined balance sheet based on current/non-current classification.

An asset is current when it is:

- Expected to be realized or intended to be sold or consumed in the normal operating cycle
- Held primarily for the purpose of trading
- Expected to be realized within twelve months after the reporting period or
- Cash or cash equivalent unless restricted from being exchanged or used to settle a liability for at least twelve months after the reporting period.

All other assets have been classified as non-current.

A liability is current when:

- It is expected to be settled in the normal operating cycle
- It is held primarily for the purpose of trading
- It is due to be settled within twelve months after the reporting period or
- There is no unconditional right to defer the settlement of the liability for at least twelve months after the reporting period.

The SPV Group classifies all other liabilities as non-current.

Deferred tax assets and liabilities are classified as non-current assets and liabilities.

Operating cycle of the SPV Group is the time between the acquisition of assets for processing and their realization in cash or cash equivalents. As the SPV Group's normal operating cycle is not clearly identifiable, it is assumed to be twelve months.

### **b) Fair value measurement**

The SPV Group measures financial instruments at fair value at each balance sheet date.

Fair value is the price that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants at the measurement date. The fair value measurement is based on the presumption that the transaction to sell the asset or transfer the liability takes place either:



## **Virescent Renewable Energy Trust**

### **Summary of significant accounting policies and other explanatory information**

- In the principal market for the asset or liability, or
- In the absence of a principal market, in the most advantageous market for the asset or liability.

The principal or the most advantageous market must be accessible by the SPV Group.

The fair value of an asset or a liability is measured using the assumptions that market participants would use when pricing the asset or liability, assuming that market participants act in their economic best interest. Refer Note 36(ii) for fair value hierarchy.

External valuers are involved for valuation of significant assets such as property plant and equipment, where required. Involvement of external valuers is decided by each SPV management on a need basis and relevant approvals. The valuers involved are selected based on criteria like market knowledge, reputation, independence and professional standards. The management of each SPV decides after discussion with the external valuers, which valuation techniques and inputs to use for each case.

At each reporting date, the management of each SPV analyses the movement of assets and liabilities which are required to be remeasured or reassessed as per the SPV's accounting policies. For this analysis, the management of each SPV verifies the major inputs applied in the latest valuation by agreeing the information in the valuation computation to contracts and other relevant documents.

The management in conjunction with each SPV's external valuers also compares the change in fair value of each asset and liability with relevant external sources to determine whether the change is reasonable.

For the purpose of fair value disclosures, the SPV Group has determined classes of assets and liabilities on the basis of the nature, characteristics and risks of the asset or liability and the level of the fair value hierarchy, as explained above.

This note summarizes accounting policy for fair value. Other fair value related disclosures are given in the relevant notes.

- Disclosures of Statement of Net Assets at fair value and Statement of Total Returns at fair value
- Quantitative disclosures of fair value measurement hierarchy (note 36)
- Financial instruments (including those carried at amortized cost) (note 36).

#### **c) Revenue Recognition**

To determine whether to recognize revenue, the SPV Group follows a 5-step process:

1. Identifying the contract with a customer
2. Identifying the performance obligations
3. Determining the transaction price
4. Allocating the transaction price to the performance obligations
5. Recognising revenue when/as performance obligation(s) are satisfied.

In all cases, the total transaction price is allocated amongst the various performance obligations based on their relative standalone selling price. The transaction price excludes amounts collected on behalf of third parties. The consideration promised include fixed amounts, variable amounts, or both.

Revenue is recognised to the extent that it is probable that the economic benefits will flow to the SPV Group and the revenue can be reliably measured, regardless of when the payment is being made.

Revenue is recognised either at a point in time or over time, when (or as) the SPV Group satisfies performance obligations by transferring the promised goods or services to its customers.

While this represents significant new guidance, the implementation of this new guidance had no impact on the timing or amount of revenue recognised by the SPV Group in any year.

#### **Sale of Energy**

Revenue from sale of energy is recognised at point in time for each unit of energy delivered to the customer in accordance with tariff provided in power purchase agreement (PPA). Further unit of electricity generated till the end of reporting date over actual bill raised is recognized as unbilled revenue. The SPVs accounts for discount or rebate incentive given to customer as reduction from revenue.

## **Virescent Renewable Energy Trust**

### **Summary of significant accounting policies and other explanatory information**

In TSECPL and PLG, revenue from sale of energy is recognised by applying the average rate to the energy output estimated over the term of the PPA. The Company uses the total estimated revenue and the total estimated kilo-watt hours to compute the average rate used to record revenue on the actual energy output supplied. The difference between actual billing and revenue recognized is recorded as deferred revenue. An estimated average rate per unit is used for the purpose of recognition of revenue. Further unit of electricity generated till the end of reporting date over actual bill raised is recognized as unbilled revenue. The Company accounts for discount or rebate incentive given to customer as reduction from revenue.

#### **Other income**

All other income is recognized on accrual basis when no significant uncertainty exists on their receipt.

#### **Interest income**

Interest income from a financial asset is recognized when it is probable that the economic benefits will flow to the SPV Group and the amount of income can be measured reliably. Interest is accrued on time proportion basis, by reference to the principle outstanding at the effective interest rate.

#### **Dividends**

Income from dividend on investments is accrued in the year in which it is declared, whereby the SPV Group's right to receive is established.

### **d) Taxation**

#### **Current income tax**

Current income tax assets and liabilities are measured at the amount expected to be recovered from or paid to the tax authorities. The tax rates and tax laws used to compute the amount are those that are enacted or substantively enacted at the reporting date.

Current income tax relating to items recognized outside statement of profit or loss is recognized outside statement of profit or loss (either in other comprehensive income or in equity). Current tax items are recognized in correlation to the underlying transaction either in OCI or directly in equity. Management periodically evaluates positions taken in the tax returns with respect to situations in which applicable tax regulations are subject to interpretation and establishes provisions where appropriate.

#### **Deferred tax**

Deferred tax is provided using the liability method on temporary differences between the tax bases of assets and liabilities and their carrying amounts for financial reporting purposes at the reporting date.

Deferred tax assets are recognized for all deductible temporary differences, the carry forward of unused tax credits and any unused tax losses. Deferred tax assets are recognized to the extent that it is probable that taxable profit will be available against which the deductible temporary differences, and the carry forward of unused tax credits and unused tax losses can be utilized.

The carrying amount of deferred tax assets is reviewed at each reporting date and reduced to the extent that it is no longer probable that sufficient taxable profit will be available to allow all or part of the deferred tax asset to be utilized. Unrecognized deferred tax assets are re-assessed at each reporting date and are recognized to the extent that it has become probable that future taxable profits will allow the deferred tax asset to be recovered.

Deferred tax assets and liabilities are measured at the tax rates that are expected to apply in the year when the asset is realized or the liability is settled, based on tax rates (and tax laws) that have been enacted or substantively enacted at the reporting date.

Deferred tax relating to items recognized outside statement of profit or loss is recognized outside statement of profit or loss. Deferred tax items are recognized in correlation to the underlying transaction either in OCI or directly in equity.

Deferred tax assets and deferred tax liabilities are offset if a legally enforceable right exists to set off current tax assets against current tax liabilities and the deferred taxes relate to the same taxable SPV Group and the same taxation authority.

#### **Minimum alternative tax (MAT)**

Minimum alternative tax (MAT) credit is recognised as an asset only when and to the extent there is convincing evidence that the Project SPV will pay income tax higher than that computed under MAT, during the year that MAT is permitted to be set off under the Income Tax Act, 1961 (specified period). In the year, in which the MAT credit becomes eligible to be recognised as

## **Virescent Renewable Energy Trust**

### **Summary of significant accounting policies and other explanatory information**

an asset in accordance with the recommendations contained in the guidance note issued by the Institute of Chartered Accountants of India (ICAI), the said asset is created by way of a credit to the Statement of Profit and Loss and shown as Deferred tax. The Project SPV Group reviews the same at each balance sheet date and writes down the carrying amount of unused tax credit to the extent there is no longer convincing evidence to the effect that the Project SPV Group will pay income tax higher than MAT during the specific year.

#### **e) Property, plant and equipment (PPE)**

Freehold land is carried as historical cost. All other items of property, plant and equipment and capital work in progress are stated at cost, net of recoverable taxes, trade discount and rebates less accumulated depreciation and impairment loss, if any. Such cost includes purchase price, borrowing cost and any cost directly attributable to bringing the assets to its working condition for its intended use.

Subsequent costs are included in the asset's carrying amount or recognized as a separate asset, as appropriate, only when it is probable that future economic benefits associated with the item will flow to the SPV Group and the cost of the item can be measured reliably. The carrying amount of any component accounted for as a separate asset is derecognized when replaced.

Depreciation on PPE held by SPVs (except USUPL)\*\* is calculated on a straight-line basis over the estimated useful lives of the assets as follows:

<b>Asset Category</b>	<b>Useful Life#</b>
Plant and equipment	32 years
Data processing equipment (computers)	3 years
Furniture and fixtures	10 years
Site Equipments	15 years
Office Equipment	5 years
Vehicles	10 years

\*\* Depreciation on PPE held by USUPL is calculated on written down value method and estimated useful life is as under:

<b>Asset Category</b>	<b>Useful Life#</b>
Plant and equipment	25 years
Data processing equipment (computers)	3 years
Furniture and fixtures	5-10 years
Buildings	30 years
Office Equipment	5 years
Vehicles	10 years

*# As per Schedule II to the Companies Act 2013 except for plant and machinery where useful life is based on technical assessment.*

Depreciation on additions (disposals) during the year is provided on a pro-rata basis i.e., from the date on which asset is ready for use and up to the date on which the asset is disposed of/fully depreciated.

An item of property, plant and equipment and any significant part initially recognized is derecognized upon disposal or when no future economic benefits are expected from its use or disposal. Any gain or loss arising on derecognition of the asset (calculated as the difference between the net disposal proceeds and the carrying amount of the asset) is included in the statement of profit or loss when the asset is derecognized. The residual values, useful lives and methods of depreciation of property, plant and equipment are reviewed at each financial year end and adjusted prospectively, if appropriate.

#### **f) Intangible Assets**

##### *Recognition and initial measurement*

Purchased intangible assets are stated at cost less accumulated amortization and impairment, if any.

## **Virescent Renewable Energy Trust**

### **Summary of significant accounting policies and other explanatory information**

#### *Internally developed intangible assets*

Expenditure on the research phase of projects is recognised as an expense as incurred.

Costs that are directly attributable to a project's development phase are recognised as intangible assets, provided the SPVs can demonstrate the following:

- the technical feasibility of completing the intangible asset so that it will be available for use.
- its intention to complete the intangible asset and use or sell it
- its ability to use or sell the intangible asset
- how the intangible asset will generate probable future economic benefits
- the availability of adequate technical, financial and other resources to complete the development and to use or sell the intangible asset.
- its ability to measure reliably the expenditure attributable to the intangible asset during its development

Development costs not meeting these criteria for capitalisation are expensed as incurred.

#### *Subsequent measurement (amortisation)*

All finite-lived intangible assets, including internally developed intangible assets, are accounted for using the cost model whereby capitalised costs are amortised on a straight-line basis over their estimated useful lives. The estimated useful life of an identifiable intangible asset is based on a number of factors including the effects of obsolescence, demand, competition, and other economic factors (such as the stability of the industry, and known technological advances), and the level of maintenance expenditures required to obtain the expected future cash flows from the asset.

Residual values and useful lives are reviewed at each reporting date. The Management estimates that the useful life for computer software is 3 years.

#### **g) Inventories**

Inventories are stated at the lower of cost and net realisable value. The cost of inventories comprises of all costs of purchase, costs of conversion and other costs incurred in bringing the inventories to their present location and condition. Costs of inventories are computed using the weighted average cost formula.

Net realisable value is the estimated selling price in the ordinary course of business less the estimated cost of completion and applicable selling expenses. Provision for obsolescence and slow moving inventory is made based on management's best estimates of net realisable value of such inventories.

#### **h) Lease**

Ind AS 116 was notified in March 2019 and it replaces Ind AS 17 Leases. The Group has applied Ind AS 116 with effective date of 1 April 2019 using modified retrospective approach, under which the cumulative effect of initial application is recognized as on 1 April 2018. Lessor accounting under Ind AS 116 is substantially unchanged from Ind AS 17. Under Ind AS 116, the Group recognizes the right-of use assets and lease liabilities as stated in the lease accounting policy.

The Group does not have any material lease under Ind AS 17. Hence, the application of Ind AS 116 does not have any material impact on the financial statements of the Group.

#### **Where the SPV Group is the lessee**

A lease is defined as 'a contract, or part of a contract, that conveys the right to control the use of an identified asset for a period in exchange for consideration'.

##### **Recognition and initial measurement**

At lease commencement date, the Group recognises a right-of-use asset and a lease liability. The right-of-use asset is measured at cost, which is made up of the initial measurement of the lease liability, any initial direct costs incurred by the Group, an estimate of any costs to dismantle and remove the asset at the end of the lease (if any), and any lease payments made in advance of the lease commencement date (net of any incentives received).

The Group measures the lease liability at the present value of the lease payments unpaid at that date, discounted using the interest rate implicit in the lease if that rate is readily available or the Group's incremental borrowing rate. Lease payments

## **Virescent Renewable Energy Trust**

### **Summary of significant accounting policies and other explanatory information**

included in the measurement of the lease liability are made up of fixed payments (including in substance fixed payments) and variable payments based on an index or rate

#### **Subsequent measurement**

The Group depreciates the right-of-use assets on a straight-line basis from the lease commencement date to the earlier of the end of the useful life of the right-of-use asset or the end of the lease term. The Group also assesses the right-of-use asset for impairment when such indicators exist.

The liability will be reduced for payments made and increased for interest. It is re-measured to reflect any reassessment or modification, or if there are changes in in-substance fixed payments. When the lease liability is re-measured, the corresponding adjustment is reflected in the right-of-use asset.

#### **Others**

The Group has elected to account for short-term leases and leases of low-value assets using the practical expedients. Instead of recognizing a right-of-use asset and lease liability, the payments in relation to these are recognised as an expense in statement of profit and loss on a straight-line basis over the lease term.

#### **Where the Group is the lessor**

Leases which effectively transfer to the lessee substantially all the risks and benefits incidental to ownership of the leased item are classified and accounted for as finance lease. Lease rental receipts are apportioned between the finance income and capital repayment based on the implicit rate of return. Contingent rents are recognised as revenue in the period in which they are earned

Leases in which the Group does not transfer substantially all the risks and rewards of ownership of an asset are classified as operating leases. The respective leased assets are included in the balance sheet based on their nature. Rental income is recognized on straight-line basis over the lease term

#### **i) Impairment of non-financial assets**

Assessment is done at each balance sheet date as to whether there is any indication that an asset (tangible and intangible) may be impaired. If any such indication exists, an estimate of the recoverable amount of the asset / cash generating unit is made. Recoverable amount is higher of an asset's or cash generating unit's net selling price and its value in use. Value in use is the present value of estimated future cash flows expected to arise from the continuing use of an asset and from its disposal at the end of its useful life. For the purpose of assessing impairment, the recoverable amount is determined for an individual asset, unless the asset does not generate cash inflows that are largely independent of those from other assets or groups of assets. The smallest identifiable group of assets that generates cash inflows from continuing use that are largely independent of the cash inflows from other assets or groups of assets, is considered as a cash generating unit (CGU). An asset or CGU whose carrying value exceeds its recoverable amount is considered impaired and is written down to its recoverable amount.

Impairment losses of continuing operations are recognized in the statement of profit and loss.

Assessment is also done at each Balance Sheet date as to whether there is any indication that an impairment loss recognized for an asset in prior accounting periods may no longer exist or may have decreased.

#### **j) Provisions, contingent liabilities and contingent assets**

Provisions are recognized when the SPV Group has a present obligation (legal or constructive) as a result of a past event, it is probable that an outflow of resources embodying economic benefits will be required to settle the obligation and a reliable estimate can be made of the amount of the obligation. When the SPV Group expects some or all of a provision to be reimbursed, the reimbursement is recognized as a separate asset, but only when the reimbursement is virtually certain. The expense relating to a provision is presented in the statement of profit and loss net of any reimbursement.

If the effect of the time value of money is material, provisions are discounted using a current pre-tax rate that reflects, when appropriate, the risks specific to the liability. When discounting is used, the increase in the provision due to the passage of time is recognized as a finance cost.

A contingent liability is disclosed when there is a possible obligation that arises from events and whose existence is only confirmed by one or more doubtful future events or when there is an obligation that is not recognized as a liability or provision because it is not likely that an outflow of resources will be required.

A contingent asset is not recognized but disclosed in the financial statements, where economic inflow is probable.

## **Virescent Renewable Energy Trust**

### **Summary of significant accounting policies and other explanatory information**

#### **k) Government grant**

Government grants are assistance by government in the form of transfers of resources to an entity in return for past or future compliance with certain conditions relating to the operating activities of the entity.

Grants from the government are recognised when there is a reasonable assurance that the grant will be received, and the Company will comply with all attached conditions.

Solar edge records proceed from Viability Gap Funding (VGF) for setting up 130MW Solar Power Project on fulfilment of underlying conditions as deferred government grant.

Solar edge amortizes the VGF as deferred income that is recognised in profit or loss on a systematic basis over the term of Power Purchase Agreement i.e., 25 years under the head 'Note 23- Revenue from operations'.

#### **l) Financial Instruments**

Financial instruments are recognised when the SPV Group becomes a party to the contractual provisions of the instrument and are measured initially at fair value adjusted for transaction costs, except for those carried at fair value through profit or loss which are measured initially at fair value.

If the SPV Group determines that the fair value at initial recognition differs from the transaction price, the SPV Group accounts for that instrument at that date as follows:

- at the measurement basis mentioned above if that fair value is evidenced by a quoted price in an active market for an identical asset or liability (i.e. a Level 1 input) or based on a valuation technique that uses only data from observable markets. The SPV Group recognises the difference between the fair value at initial recognition and the transaction price as a gain or loss.
- in all other cases, at the measurement basis mentioned above, adjusted to defer the difference between the fair value at initial recognition and the transaction price. After initial recognition, the SPV Group recognises that deferred difference as a gain or loss only to the extent that it arises from a change in a factor (including time) that market participants would take into account when pricing the asset or liability.

Subsequent measurement of financial assets and financial liabilities is described below.

#### **Financial assets**

##### **Classification and subsequent measurement**

For the purpose of subsequent measurement, financial assets are classified into the following categories upon initial recognition:

##### **Financial assets at amortised cost**

A financial instrument is measured at amortised cost if both the following conditions are met:

- The asset is held within a business model whose objective is to hold assets for collecting contractual cash flows, and
- Contractual terms of the asset give rise on specified dates to cash flows that are solely payments of principal and interest (SPPI) on the principal amount outstanding.

After initial measurement, such financial assets are subsequently measured at amortised cost using the effective interest method.

##### **Financial assets at fair value**

Mutual funds – All mutual funds in scope of Ind-AS 109 are measured at fair value through profit and loss (FVTPL).

##### **De-recognition of financial assets**

A financial asset is primarily de-recognised when the rights to receive cash flows from the asset have expired or the SPV Group has transferred its rights to receive cash flows from the asset.

## **Virescent Renewable Energy Trust**

### **Summary of significant accounting policies and other explanatory information**

#### **Financial liabilities**

##### **Subsequent measurement**

After initial recognition, the financial liabilities are subsequently measured at amortised cost using effective interest method. Amortised cost is calculated after considering any discount or premium on acquisition and fees or costs that are an integral part of the EIR. The effect of EIR amortisation is included as finance costs in the statement of profit and loss.

##### **De-recognition of financial liabilities**

A financial liability is de-recognised when the obligation under the liability is discharged or cancelled or expires. When an existing financial liability is replaced by another from the same lender on substantially different terms, or the terms of an existing liability are substantially modified, such an exchange or modification is treated as the de-recognition of the original liability and the recognition of a new liability. The difference in the respective carrying amounts is recognised in the statement of profit and loss.

##### **Offsetting of financial instruments**

Financial assets and financial liabilities are offset and the net amount is reported in the balance sheet if there is a currently enforceable legal right to offset the recognised amounts and there is an intention to settle on a net basis, to realise the assets and settle the liabilities simultaneously.

#### **m) Impairment of financial assets**

All financial assets except for those at FVTPL are subject to review for impairment at least at each reporting date to identify whether there is any objective evidence that a financial asset or a group of financial assets is impaired. Different criteria to determine impairment are applied for each category of financial assets.

In accordance with Ind-AS 109, the SPV Group applies expected credit loss (ECL) model for measurement and recognition of impairment loss for financial assets carried at amortised cost.

ECL is the weighted average of difference between all contractual cash flows that are due to the SPV Group in accordance with the contract and all the cash flows that the SPV Group expects to receive, discounted at the original effective interest rate, with the respective risks of default occurring as the weights. When estimating the cash flows, the SPV Group is required to consider –

- All contractual terms of the financial assets (including prepayment and extension) over the expected life of the assets.
- Cash flows from the sale of collateral held or other credit enhancements that are integral to the contractual terms.

#### **n) Investment in subsidiaries, joint venture and associates**

Investments in subsidiaries, joint ventures and associates are carried at cost less accumulated impairment losses, if any. Where an indication of impairment exists, the carrying amount of the investment is assessed and written down immediately to its recoverable amount. On disposal of these investments, the difference between net disposal proceeds and the carrying amounts are recognised in the Statement of Profit and Loss.

#### **o) Earning per share**

Basic earnings per share is calculated by dividing the net profit or loss for the period attributable to equity shareholders (after deducting attributable taxes) by the weighted average number of equity shares outstanding during the period. The weighted average number of equity shares outstanding during the period is adjusted for events including a bonus issue.

For the purpose of calculating diluted earnings per share, the net profit or loss for the period attributable to equity shareholders and the weighted average number of shares outstanding during the period are adjusted for the effects of all dilutive potential equity shares.

#### **p) Post employment, long term and short term employment benefits**

The SPVs provides post-employment benefits through various defined contribution and defined benefit plans.

## **Virescent Renewable Energy Trust**

### **Summary of significant accounting policies and other explanatory information**

#### *Defined contribution plans*

A defined contribution plan is a plan under which the SPV pays fixed contributions into an independent fund administered by the government. The SPV has no legal or constructive obligations to pay further contributions after its payment of the fixed contribution, which are recognised as an expense in the year that related employee services are received.

#### *Defined benefit plans*

The defined benefit plans sponsored by the SPV define the amount of the benefit that an employee will receive on completion of services by reference to length of service and last drawn salary. The legal obligation for any benefits remains with the SPV. Gratuity is post-employment benefit and is in the nature of a defined benefit plan. The liability recognised in the financial statements in respect of gratuity is the present value of the defined benefit obligation at the reporting date, together with adjustments for unrecognised actuarial gains or losses and past service costs. The defined benefit obligation is calculated at or near the reporting date by an independent actuary using the projected unit credit method.

Actuarial gains and losses arising from past experience and changes in actuarial assumptions are credited or charged to the statement of OCI in the year in which such gains or losses are determined.

#### *Other long-term employee benefits*

Liability in respect of compensated absences becoming due or expected to be availed more than one year after the balance sheet date is estimated on the basis of an actuarial valuation performed by an independent actuary using the projected unit credit method. Actuarial gains and losses arising from past experience and changes in actuarial assumptions are charged to statement of profit and loss in the year in which such gains or losses are determined.

#### *Short-term employee benefits*

Expense in respect of other short term benefits is recognised on the basis of the amount paid or payable for the period during which services are rendered by the employee.

### **q) Segment reporting**

The SPV Group is engaged in "Solar power Projects" which in the context of Ind AS 108 "Operating Segment" is considered as the only segment. The SPV Group's activities are restricted within India and hence, no separate geographical segment disclosure is considered necessary.

### **r) Borrowing costs**

Borrowing cost include interest calculated using the effective interest method, amortization of ancillary costs and other costs the SPV Group incurs in connection with the borrowing of funds. Borrowing costs directly attributable to the acquisition, construction or production of a qualifying asset are capitalized during the period of time that is necessary to complete and prepare the asset for its intended use or sale. A qualifying asset is one that necessarily takes substantial period of time to get ready for its intended use. Capitalisation of borrowing costs is suspended in the period during which the active development is delayed due to, other than temporary, interruption. All other borrowing costs are charged to the statement of profit and loss as incurred.

### **s) Cash and cash equivalents**

Cash and cash equivalent in the balance sheet comprise cash at banks and on hand and short-term deposits with an original maturity of three months or less, which are subject to an insignificant risk of changes in value.

### **t) Foreign Exchange Transactions:**

In preparing the financial statements of the SPVs, transactions in currencies other than the SPV's functional currency viz. Indian Rupee are recognised at the rates of exchange prevailing at the dates of the transactions. At the end of each reporting period, monetary items denominated in foreign currencies are retranslated at the rates prevailing at that date. Exchange differences on monetary items are recognised in profit or loss in the period in which they arise.

Non - monetary items are carried at historical cost or fair value

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3 Property, plant and equipment

	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>Net carrying amounts of :</b>			
Freehold land	6,652.22	6,656.59	6,182.90
Leasehold improvements	4.93	8.50	12.08
Building	3,053.33	3,232.33	3,419.28
Plant and machinery	1,43,695.22	1,88,989.14	2,03,621.00
Furniture and fixtures	2.63	6.04	7.90
Vehicles	22.88	27.16	30.80
Office equipment	21.00	31.36	28.90
Site Equipments	1.87	2.05	2.23
Computers	14.72	12.00	6.19
Right of use (Land)	134.17	190.65	221.07
	<b>1,53,602.97</b>	<b>1,99,155.82</b>	<b>2,13,532.35</b>

4 Capital work in progress

- - 51.50

	Freehold land	Plant and equipment	Leasehold improvements	Building	Furniture and fixtures	Vehicles	Office equipment	Site Equipments	Computers	Right of Use of Asset (Land)	Total
<b>Gross carrying value:</b>											
<b>Balance as at 1 April 2018</b>	<b>5,965.02</b>	<b>1,47,845.38</b>	<b>7.24</b>	<b>4,718.87</b>	<b>18.24</b>	<b>207.02</b>	<b>64.08</b>	<b>2.36</b>	<b>14.09</b>	<b>49.10</b>	<b>1,58,891.40</b>
Additions	223.14	1,07,232.52	9.59	7	0.40	-	0.46	0.32	4.83	189.33	1,07,667.67
Disposals/ adjustments	(5.26)	-	-	-	(0.08)	(171.72)	(4.58)	-	(1.67)	-	(183.31)
<b>Balance as at 31 March 2019</b>	<b>6,182.90</b>	<b>2,55,077.90</b>	<b>16.83</b>	<b>4,726</b>	<b>18.56</b>	<b>35.30</b>	<b>59.96</b>	<b>2.68</b>	<b>17.25</b>	<b>238.43</b>	<b>2,66,375.76</b>
Additions	473.69	112.36	-	-	-	0.58	13.27	-	9.53	35.98	645.41
Disposals/ adjustments	-	(226.71)	-	-	(0.19)	-	(0.04)	-	-	(10.13)	(237.07)
<b>Balance as at 31 March 2020</b>	<b>6,656.59</b>	<b>2,54,963.55</b>	<b>16.83</b>	<b>4,726</b>	<b>18.37</b>	<b>35.88</b>	<b>73.19</b>	<b>2.68</b>	<b>26.78</b>	<b>264.28</b>	<b>2,66,784.10</b>
Additions	-	705.84	-	-	-	-	0.18	-	10.12	-	716.14
Disposals/ adjustments	(4.37)	(240.58)	-	-	(3.53)	-	(6.44)	-	(2.51)	-	(257.43)
<b>Balance as at 31 March 2021</b>	<b>6,652.22</b>	<b>2,55,428.81</b>	<b>16.83</b>	<b>4,726</b>	<b>14.84</b>	<b>35.88</b>	<b>66.93</b>	<b>2.68</b>	<b>34.39</b>	<b>264.28</b>	<b>2,67,242.81</b>
<b>Accumulated depreciation and Impairment loss:</b>											
<b>Balance as at 1 April 2018</b>	-	<b>35,084.48</b>	<b>1.38</b>	<b>1,111</b>	<b>8.50</b>	<b>49.77</b>	<b>24.06</b>	<b>0.28</b>	<b>8.36</b>	<b>0.28</b>	<b>35,836.82</b>
Depreciation expense	-	14,049.78	3.37	196	2.17	14.67	9.78	0.17	3.58	17.08	14,296.12
Impairment	-	2,322.64	-	-	-	-	-	-	-	-	2,322.64
Disposals / adjustments	-	-	-	-	(0.01)	(59.94)	(2.78)	-	(0.88)	-	(63.61)
<b>Balance as at 31 March 2019</b>	-	<b>51,456.90</b>	<b>4.75</b>	<b>1,307</b>	<b>10.66</b>	<b>4.50</b>	<b>31.06</b>	<b>0.45</b>	<b>11.06</b>	<b>17.36</b>	<b>52,391.97</b>
Depreciation expense	-	14,623.88	3.58	187	1.70	4.22	10.78	0.18	3.72	73.19	14,908.20
Disposals / adjustments	-	(106.37)	-	-	(0.03)	-	(0.01)	-	-	(16.92)	(123.33)
<b>Balance as at 31 March 2020</b>	-	<b>65,974.41</b>	<b>8.33</b>	<b>1,493.62</b>	<b>12.33</b>	<b>8.72</b>	<b>41.83</b>	<b>0.63</b>	<b>14.78</b>	<b>73.63</b>	<b>67,176.84</b>
Depreciation expense	-	13,398.73	3.57	179	1.28	4.28	9.59	0.18	7.30	56.48	13,660.41
Impairment loss	-	32,495.61	-	-	-	-	-	-	-	-	32,495.61
Disposals / adjustments	-	(135.16)	-	-	(1.40)	-	(5.49)	-	(2.41)	-	(144.46)
<b>Balance as at 31 March 2021</b>	-	<b>1,11,733.59</b>	<b>11.90</b>	<b>1,672.62</b>	<b>12.21</b>	<b>13.00</b>	<b>45.93</b>	<b>0.81</b>	<b>19.67</b>	<b>130.11</b>	<b>1,13,188.40</b>
<b>Net carrying value:</b>											
<b>Balance as at 31 March 2019</b>	<b>6,182.90</b>	<b>2,03,621.00</b>	<b>12.08</b>	<b>3,419.28</b>	<b>7.90</b>	<b>30.80</b>	<b>28.90</b>	<b>2.23</b>	<b>6.19</b>	<b>221.07</b>	<b>2,13,532.35</b>
<b>Balance as at 31 March 2020</b>	<b>6,656.59</b>	<b>1,88,989.14</b>	<b>8.50</b>	<b>3,232.33</b>	<b>6.04</b>	<b>27.16</b>	<b>31.36</b>	<b>2.05</b>	<b>12.00</b>	<b>190.65</b>	<b>1,99,155.82</b>
<b>Balance as at 31 March 2021</b>	<b>6,652.22</b>	<b>1,43,695.22</b>	<b>4.93</b>	<b>3,053.33</b>	<b>2.63</b>	<b>22.88</b>	<b>21.00</b>	<b>1.87</b>	<b>14.72</b>	<b>134.17</b>	<b>1,53,602.97</b>

(i) Refer note 39 for information on property, plant and equipment pledged as security by the SPV group.

(ii) As required by Ind AS 36 - Impairment of Assets, the SPV Group has determined the recoverable amounts of the solar power plant during the year ended 31 March 2021 on the basis of the value in use by estimating the future cash flows over the year of Power Purchase Agreements (PPA) of the respective project assets. For such estimation, management has followed discounted cash flow approach using discount factor of 13.85%-17.80% across different entities. Based on management evaluation, these assumptions were considered reasonable as at 31 March 2021. The recoverable amounts of the solar plant were lower than the carrying values of the as at 31 March 2021 by INR 32,495.61 lakhs. The SPV Group has also obtained valuation reports from an external consultant during year ended 31 March 2021, in order to arrive at the above conclusion. These assumptions are reassessed on a yearly basis for the purpose of determination of the recoverable amounts of the transmission assets. Any change in key assumptions can have a material effect on the recoverable amounts of the cash generating unit.

(iii) Post acquisition of SSEGPL, SSEPL and PLGPL by Terra Asia Holdings II Pte Limited, during the year, the new management team has re-assessed the useful life of such plant. This assessment was done based on detailed technical evaluation of its Solar Assets along with a comparison with industry practice. Pursuant to which, the useful life of solar assets considered by the erstwhile management is deemed to be an error in estimate. Accordingly, based on criteria laid out in Ind AS 101 – First Time Adoption of INDAS, this has been considered as a prior period error and accounted on the date of IndAS transition as appropriate adjustment to book value of solar assets. The error has been corrected by re-estimating useful life of solar assets to 32 years which corresponds to depreciation rates provided in Central Electricity Regulatory Commission (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2017. Depreciation rate for first 13 years of the project stand at 5.28% with balance to be depreciated over the remaining useful life of the project.

(iv) Capital work-in-progress comprises of solar plants under construction.

**5 Intangible assets**

**Net carrying amounts of :**

Computer software

	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
	0.13	0.37	0.64
	<b>0.13</b>	<b>0.37</b>	<b>0.64</b>

**Gross carrying value:**

**Balance as at 1 April 2018**

Additions

Disposals

Adjustments

**Balance as at 31 March 2019**

Additions

Disposals

Adjustments

**Balance as at 31 March 2020**

Additions

Disposals

Adjustments

**Balance as at 31 March 2021**

Computer software	Total
<b>0.16</b>	<b>0.16</b>
0.73	0.73
-	-
-	-
<b>0.89</b>	<b>0.89</b>
-	-
-	-
<b>0.89</b>	<b>0.89</b>
-	-
-	-
<b>0.89</b>	<b>0.89</b>

**Accumulated amortisation:**

**Balance as at 1 April 2018**

Elimination on disposals of assets

Amortisation expense

Adjustments

**Balance as at 31 March 2019**

Elimination on disposals of assets

Amortisation expense

Adjustments

**Balance as at 31 March 2020**

Amortisation expense

**Balance as at 31 March 2021**

<b>0.02</b>	<b>0.02</b>
-	-
0.23	0.23
-	-
<b>0.25</b>	<b>0.25</b>
0.27	0.27
<b>0.52</b>	<b>0.52</b>
0.24	0.24
<b>0.76</b>	<b>0.76</b>

**Net carrying value:**

**Balance as at 31 March 2019**

**Balance as at 31 March 2020**

**Balance as at 31 March 2021**

<b>0.64</b>	<b>0.64</b>
<b>0.37</b>	<b>0.37</b>
<b>0.13</b>	<b>0.13</b>

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All amounts are in INR lakhs unless otherwise stated

6 Investments	Face Value per share	As at 31 March 2021		As at 31 March 2020		As at 31 March 2019	
		Units/ shares	Amount	Units/ shares	Amount	Units/ shares	Amount
<b>Non-current</b>							
<b>(a) Investment in unquoted equity instruments - at cost, fully paid up</b>							
Sindicatum Carbon Capital India Private Limited *	10	-	-	65,50,000	655	65,50,000	655
<b>(a) Investment in unquoted equity instruments</b>							
<b>Investment carried at fair value through profit or loss (FVTPL)</b>							
<b>Other entities</b>							
M/S Saraswat Cooperative Bank Limited	10	4,950	0.50	7,450	0.75	7,450	0.75
<b>(c) Investment in unquoted compulsorily convertible preference shares- at cost, fully paid up</b>							
M/s Sindicatum Renewable Energy India Private Limited *							
<b>Total</b>			<b>0.50</b>		<b>4,120.49</b>		<b>655.75</b>
<b>Total non-current investments</b>							
Aggregate amount of unquoted investments			0.50		4,120.49		655.75

\* Investment in equity instruments in Sindicatum Carbon Capital India Private Limited and compulsory convertible preference shares in Sindicatum Renewable Energy India Private Limited which were classified as associates in respective SPVs

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	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>7 Other financial assets</b>			
<b>Non-Current</b>			
(Unsecured and considered good)			
Financial assets carried at amortised cost			
Security deposits	67.36	82.05	73.32
Bank deposits with maturity of more than 12 months	5.10	1,944.36	942.25
Other receivable	64.16	64.16	64.16
	<b>136.62</b>	<b>2,090.57</b>	<b>1,079.73</b>
<b>Current</b>			
(Unsecured and considered good)			
Financial assets carried at amortised cost			
Security deposits	24.96	7.66	8.44
Unbilled revenue	3,727.08	2,192.41	2,585.92
Advance to related parties	78.00	-	-
Other receivable	63.39	71.65	71.65
	<b>3,893.43</b>	<b>2,271.72</b>	<b>2,666.01</b>

**Notes:**

- Bank deposits are lien marked with term lenders.
- Bank deposits includes interest accrued and not due amounting to INR 3.97 lakhs, INR 77.73 lakhs, INR 61.99 lakhs as at 31 March 2021, 31 March 2020 and as at 31 March 2019 respectively.

**8 Income tax assets and liabilities**

**Current tax assets**

Income tax receivable (net of provisions)	445.38	554.63	690.98
	<b>445.38</b>	<b>554.63</b>	<b>690.98</b>

**Current tax liabilities**

Income tax payable (net of advance tax)	37.79	3.82	43.10
	<b>37.79</b>	<b>3.82</b>	<b>43.10</b>

	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>9 Deferred tax assets</b>			
<b>Deferred tax assets in relation to:</b>			
Provision for expenses	-	78.77	2.52
Expenses allowable in future years	3.77	4.39	2.25
Brought forward losses	1,356.25	5,565.28	2,792.03
Deferred revenue (viability gap funding)	5,129.07	5,046.80	4,046.55
MAT credit	1,571.45	1,138.87	874.95
<b>Deferred tax liabilities in relation to:</b>			
Property, plant and equipment	3,053.63	6,815.27	5,182.49
Borrowing	34.13	34.13	34.13
Deferred payment liabilities	4.12	8.11	-
<b>Deferred tax assets (net)</b>	<b>4,968.66</b>	<b>4,976.60</b>	<b>2,501.68</b>

(a) Movement in deferred tax liabilities for the year ended 31 March 2021 is as follows:

Description	Opening Balance	Recognised in Profit or loss	Recognised in other comprehensive Income	Closing balance
<b>Deferred tax assets in relation to:</b>				
Provision for expenses	78.77	(78.77)	-	
Expenses allowable in future years	4.39	(0.62)	-	3.77
Brought forward losses	5,565.28	(4,209.03)	-	1,356.25
Deferred revenue (viability gap funding)	5,046.80	82.27	-	5,129.07
MAT credit	1,138.87	432.58	-	1,571.45
	<b>11,834.11</b>	<b>(3,773.57)</b>	<b>-</b>	<b>8,060.54</b>
<b>Deferred tax liabilities in relation to:</b>				
Property, plant and equipment	6,815.27	(3,761.64)	-	3,053.63
Borrowing	34.13	-	-	34.13
Deferred payment liabilities	8.11	(3.99)	-	4.12
	<b>6,857.51</b>	<b>(3,765.63)</b>	<b>-</b>	<b>3,091.88</b>
<b>Deferred tax assets (net)</b>	<b>4,976.60</b>	<b>(7.94)</b>	<b>-</b>	<b>4,968.66</b>

(b) Movement in deferred tax liabilities for the year ended 31 March 2020 is as follows:

Description	Opening Balance	Recognised in Profit or loss	Recognised in other comprehensive Income	Closing balance
<b>Deferred tax assets in relation to:</b>				
Provision for expenses	2.52	76.25	-	78.77
Expenses allowable in future years	2.25	2.14	-	4.39
Brought forward losses	2,792.03	2,773.25	-	5,565.28
Deferred revenue (viability gap funding)	4,046.55	1,000.25	-	5,046.80
MAT credit	874.95	263.92	-	1,138.87
	<b>7,718.30</b>	<b>4,115.81</b>	<b>-</b>	<b>11,834.11</b>
<b>Deferred tax liabilities in relation to:</b>				
Property, plant and equipment	5,182.49	1,632.78	-	6,815.27
Deferred payment liabilities	-	8.11	-	8.11
Borrowing	34.13	-	-	34.13
	<b>5,216.62</b>	<b>1,640.89</b>	<b>-</b>	<b>6,857.51</b>
<b>Deferred tax assets (net)</b>	<b>2,501.68</b>	<b>2,474.92</b>	<b>-</b>	<b>4,976.60</b>

(c) Movement in deferred tax liabilities for the year ended 31 March 2019 is as follows:

Description	Opening Balance	Recognised in Profit or loss	Recognised in other comprehensive Income	Closing balance
<b>Deferred tax assets in relation to</b>				
Provision for expenses	249.75	(247.23)	-	2.52
Expenses allowable in future years	1.49	0.76	-	2.25
Brought forward losses	4,975.97	(2,183.94)	-	2,792.03
Deferred revenue (viability gap funding)	3,496.77	549.78	-	4,046.55
MAT credit	1,373.30	(498.35)	-	874.95
	<b>10,097.28</b>	<b>(2,378.98)</b>	<b>-</b>	<b>7,718.30</b>
<b>Deferred tax liabilities in relation to</b>				
Property, plant and equipment	12,391.26	(7,208.77)	-	5,182.49
Borrowing	(122.39)	156.52	-	34.13
	<b>12,268.87</b>	<b>(7,052.25)</b>	<b>-</b>	<b>5,216.62</b>
<b>Deferred tax assets (net)</b>	<b>(2,171.59)</b>	<b>4,673.27</b>	<b>-</b>	<b>2,501.68</b>

(e) Some SPVs in the SPV Group are eligible for tax-holiday benefits under section 80-IA of the Income-tax Act, 1961. Management of the SPVs is of the opinion that the benefit of the tax holiday would be available to its operations for the period of tax holiday. Accordingly, no deferred tax asset or liability has been recognised in financial statements for the future tax consequences attributable to differences between the financial statement carrying amounts of existing assets and liabilities, and their respective tax bases, as these are expected to realise / settle within the tax holiday period.

**(f) Tax losses and unabsorbed depreciation on which deferred tax asset is not recognised:**

Assessment year	Tax losses	Unabsorbed depreciation
AY 2020-21	10,665.58	10,511.69
AY 2019-20	13,454.41	13,865.57
AY 2018-19	5,565.76	6,128.24
AY 2017-18	6,409.11	17,218.05
AY 2016-17	5,039.81	5,023.21
AY 2015-16	2.76	-
AY 2014-15	0.70	3,294.62
AY 2013-14	0.27	16,123.00
AY 2012-13	-	73.99

Tax losses can be carried forward for a period of eight years from the date of incurrence of such losses and unabsorbed depreciation can be carried forward indefinitely.

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	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>10 Other assets</b>			
<b>Non-Current</b>			
Balances with Government authorities	-	98.49	98.49
Capital advances	-	0.13	324.96
Other receivables	31.36	32.60	-
	<b>31.36</b>	<b>131.22</b>	<b>423.45</b>
<b>Current</b>			
Prepaid expenses	168.99	230.79	164.88
Advances to vendors	3.60	0.43	0.43
Advances to employees	0.49	-	-
Balances with government authorities	-	-	0.25
Other receivables	3.20	1.43	1.66
	<b>176.28</b>	<b>232.65</b>	<b>167.22</b>
<b>11 Inventories</b>			
Spares and consumables	67.84	58.81	19.57
	<b>67.84</b>	<b>58.81</b>	<b>19.57</b>
<b>12 Trade receivables</b>			
Secured, considered good	129.83	-	-
Unsecured, considered good	10,654.24	19,529.48	10,192.81
Significant increase in credit risk	-	-	-
Credit impaired	-	-	-
	10,784.07	19,529.48	10,192.81
Less: Allowance for doubtful debts	-	-	-
	<b>10,784.07</b>	<b>19,529.48</b>	<b>10,192.81</b>
<b>13 Cash and cash equivalents</b>			
Balances with banks			
- In current account	9,909.31	2,729.44	6,120.75
- in deposit account	2,651.45	5,135.54	3,217.98
Cash in hand	0.02	0.19	-
	<b>12,560.78</b>	<b>7,865.17</b>	<b>9,338.73</b>
<b>14 Other bank balances</b>			
Bank deposits with original maturity of more than three months but less than twelve months	17,890.71	5,328.37	4,421.57
	<b>17,890.71</b>	<b>5,328.37</b>	<b>4,421.57</b>
<b>Note:</b>			
a. Bank deposits includes interest accrued and not due amounting to INR 209.98 lakhs, INR 83.8 lakhs, INR 76.8 lakhs as at 31 March 2021, 31 March 2020 and as at 31 March 2019 respectively.			
<b>15 Loans</b>	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>Current (unsecured and considered doubtful)</b>			
Loan to given to associates	-	3,182.00	3,182.00
Less: Allowance for doubtful loans	-	-3,182.00	-
	<b>-</b>	<b>-</b>	<b>3,182.00</b>
<b>Notes:</b>			
a. The loans classified as current are repayable on demand.			
<b>16 Assets held for sale</b>			
Investment in equity instruments of Sindicatum Carbon Capital India Pvt Ltd	5.87	-	-
Investment in unquoted compulsorily convertible preference shares of Sindicatum Renewable Energy India Private Limited	3,432.00	-	-
	<b>3,437.87</b>	<b>-</b>	<b>-</b>
<b>Detail of asset held for sale:</b>			
On 23 April 2021 the SPV group has sold the investment in equity instruments in Sindicatum Carbon Capital India Private Limited and compulsory convertible preference shares in Sindicatum Renewable Energy India Private Limited which were classified as associates up to 31 March 2021. The sale of these investment is part of the overall business acquisition of the SPVs by Terra Asia Holding II Pte. Ltd. As per the business acquisition agreement, these investments were planned to be sold to erstwhile promoter group companies. Accordingly, these investments have been classified as 'Assets held for sale' as of 31 March 2021			

17 Equity share capital

	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>Authorised</b>			
467,100,000 (31 March 2020: 467,100,000; 31 March 2019: 447,100,000) equity shares of INR 10 each	46,710.00	46,710.00	44,710.00
<b>Issued, subscribed and fully paid up</b>			
436,195,683 (31 March 2020: 436,195,683; 31 March 2019: 417,195,683) equity shares of INR 10 each fully paid up	43,619.57	43,619.57	41,719.57
	<b>43,619.57</b>	<b>43,619.57</b>	<b>41,719.57</b>

Notes:

(i) Terms and rights attached to equity shares

The SPV Group has only one class of equity shares having a par value of INR 10 per share. Each holder of equity shares is entitled to one vote per share. In the event of liquidation of the SPV Group, holder of equity shares will be entitled to receive remaining assets of the SPV Group after distribution of all preferential amount. The distribution will be in proportion to the number of equity shares held by the shareholders.

(ii) Reconciliation of the number of shares and amount outstanding at the beginning and at the end of the year:

Particulars	As at 31 March 2021		As at 31 March 2020		As at 31 March 2019	
	Number	Amount	Number	Amount	Number	Amount
Equity shares outstanding at the beginning of the year	43,61,95,683	43,619.57	41,71,95,683	41,719.57	41,71,95,683	41,719.57
Add : Issued during the year	-	-	1,90,00,000	1,900.00	-	-
<b>Equity shares outstanding at the end of the year</b>	<b>43,61,95,683</b>	<b>43,619.57</b>	<b>43,61,95,683</b>	<b>43,619.57</b>	<b>41,71,95,683</b>	<b>41,719.57</b>

(iii) Shares held by each shareholder holding more than 5 percent shares:

Particulars	As at 31 March 2021		As at 31 March 2020		As at 31 March 2019	
	Numbers	% holding	Numbers	% holding	Numbers	% holding
Shapoorji Pallonji Solar Holdings Private Limited (formerly known as 'Praddin Energy Private Limited')	-	-	20,39,11,799	46.75%	19,46,01,799	46.65%
Shapoorji Pallonji Infrastructure Capital Company Private Limited.	-	-	7,59,89,999	17.42%	6,62,99,999	15.89%
Terra Asia Holdings II Pte Ltd	27,99,01,794	64.17%	-	-	-	-
Sindicatum Captive Energy Singapore Pte. Limited	11,91,80,440	27.32%	12,97,24,783	29.74%	12,97,24,783	31.09%
Sindicatum Renewable Energy India Private Limited	3,71,13,445	8.51%	2,65,69,097	6.09%	2,65,69,097	6.37%
	<b>43,61,95,679</b>	<b>100.00%</b>	<b>43,61,95,678</b>	<b>100.00%</b>	<b>41,71,95,678</b>	<b>100.00%</b>

(iv) No shares have been issued by the SPV Group for consideration other than cash, during the year of five years immediately preceding the reporting years.

18 Instruments entirely equity in nature

	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>Authorised</b>			
100,000,000 (31 March 2020: 100,000,000; 31 March 2019: 100,000,000) Compulsorily convertible preference shares of INR 10 each	10,000.00	10,000.00	10,000.00
<b>Issued, subscribed and fully paid up</b>			
39,290,000 (31 March 2020: 39,290,000; 31 March 2019: 39,290,000) Compulsorily convertible preference shares of INR 10 each	3,929.00	3,929.00	3,929.00
	<b>3,929.00</b>	<b>3,929.00</b>	<b>3,929.00</b>

(i) Terms of compulsorily convertible preference shares (CCPS)

The SPV group has issued 2% Preference shares which are Non-Cumulative and Compulsorily Convertible on or before 15 years from the date of allotment, into Equity Shares of the SPV group at a predetermined price of INR 10/- per share at the sole option of the SPV group. These Preference Shares would carry voting rights only on resolutions placed before the SPV which directly affect the rights attached to these Preference Shares, in accordance with Section 47 (2) of Companies Act, 2013. The Equity Shares to be issued and allotted pursuant to conversion will rank pari passu with the existing Equity Shares of the SPV in all respects.

(ii) Reconciliation of the number of shares and amount outstanding at the beginning and at the end of the year:

Particulars	As at 31 March 2021		As at 31 March 2020		As at 31 March 2019	
	Number	Amount	Number	Amount	Number	Amount
Preference shares outstanding at the beginning of the year	3,92,90,000	3,929.00	3,92,90,000	3,929.00	70,000	7.00
Add : Issued during the year	-	-	-	-	3,92,20,000	3,922.00
<b>Preference shares outstanding at the end of the year</b>	<b>3,92,90,000</b>	<b>3,929.00</b>	<b>3,92,90,000</b>	<b>3,929.00</b>	<b>3,92,90,000</b>	<b>3,929.00</b>

(iii) Shares held by each shareholder holding more than 5 percent shares:

Particulars	As at 31 March 2021		As at 31 March 2020		As at 31 March 2019	
	Numbers	% holding	Numbers	% holding	Numbers	% holding
Shapoorji Pallonji Solar Holding Private Limited.	-	-	48,00,000	12.22%	48,00,000	12.22%
Shapoorji Pallonji Infrastructure Capital Company Private Limited.	-	-	3,44,90,000	87.78%	3,44,90,000	87.78%
Terra Asia Holdings II Pte Ltd	3,92,90,000	100.00%	-	-	-	-
	<b>3,92,90,000</b>	<b>100.00%</b>	<b>3,92,90,000</b>	<b>100.00%</b>	<b>3,92,90,000</b>	<b>100.00%</b>

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	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>19 Other equity</b>			
General reserve	7.00	7.00	7.00
Securities premium reserve	12,159.44	12,159.44	12,159.44
Retained earnings	(75,800.21)	(29,824.65)	(25,767.71)
Capital reserve	7,602.41	116.74	116.74
Equity of acquired business undertaking	-	10,870.61	17,101.04
	<b>(56,031.36)</b>	<b>(6,670.86)</b>	<b>3,616.51</b>
	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>19.1 Capital reserve</b>			
Balance at the beginning of the year	116.74	116.74	116.74
Increase/(decrease) during the year*	7,485.67	-	-
<b>Balance at the end of the year</b>	<b>7,602.41</b>	<b>116.74</b>	<b>116.74</b>
<b>19.2 Retained earnings</b>			
Balance at the beginning of the year	(29,824.65)	(25,767.71)	(22,845.36)
Impact on account of change in transition date of Ind AS 116	-	6.79	-
Loss for the year	(40,792.15)	(4,045.85)	(2,970.00)
Other comprehensive income arising from remeasurement of defined benefit obligation, net of income tax	(0.10)	(0.81)	0.07
Impact of Fair valuation of Non-Convertible Debentures	(5,192.79)	-	-
Share issue expense	-	(35.75)	(4.47)
Transferred to general reserve	-	-	-
Transfer to non controlling interest	9.48	18.68	-
Consequent to change in Groups interest	-	-	52.05
<b>Balance at the end of the year</b>	<b>(75,800.21)</b>	<b>(29,824.65)</b>	<b>(25,767.71)</b>

The portion of profits not distributed among the shareholders are termed as retained earnings (free reserves). The SPV Group may utilize the retained earnings for making investments for future growth and expansion plans, for the purpose of generating higher returns for the shareholders, for distributing dividend and bonus or for any other purpose, as approved by the Board of Directors of the SPV Group.

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	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>20 Borrowings</b>			
<b>Non-current</b>			
<b>(Secured, at amortised cost)</b>			
Term loans from banks and financial institutions	30,057.47	1,44,299.02	1,45,210.50
<b>(Unsecured, at amortised cost)</b>			
Compulsory convertible debentures	83,380.53	-	-
Unsecured loans	-	15,521.15	14,663.50
	<b>1,13,438.00</b>	<b>1,59,820.17</b>	<b>1,59,874.00</b>
<b>Current</b>			
<b>(Secured, at amortised cost)</b>			
Cash credit facility from banks	-	3,086.25	769.12
Term loans from banks and financial institutions	59,301.85	-	-
<b>(Unsecured)</b>			
Unsecured loans(at amortised cost)	-	524.16	292.16
Non convertible debentures (at amortised cost)	4,270.94	-	-
	<b>63,572.79</b>	<b>3,610.41</b>	<b>1,061.28</b>

**Notes**

**(a) Reconciliation of financial liabilities arising from financing activities:**

Particulars	Non-current borrowings and Current maturities of long-term borrowings	Lease liabilities	Current borrowings
<b>Balance as at 1 April 2018</b>	<b>1,60,962.25</b>	<b>-</b>	<b>1,207.88</b>
Cash flows:			
Proceeds from borrowings	54,552.34	-	627.91
Repayment of borrowings	(45,817.45)	(16.07)	(774.51)
Other non-cash changes:			
Amortisation of incremental borrowing cost	(557.62)	-	-
Recognised on adoption of Ind AS 116	-	224.50	-
Interest expense on lease liability	-	5.98	-
<b>Balance as at 31 March 2019</b>	<b>1,69,139.51</b>	<b>214.41</b>	<b>1,061.28</b>
Cash flows:			
Proceeds from borrowings	14,681.42	-	2,570.13
Repayment of borrowings	(13,991.40)	(44.72)	(21.00)
Other non-cash changes:			
Amortisation of incremental borrowing cost	134.37	-	-
Other adjustments	15.33	5.74	-
<b>Balance as at 31 March 2020</b>	<b>1,69,979.23</b>	<b>175.43</b>	<b>3,610.41</b>
Cash flows:			
Proceeds from borrowings	84,786.58	-	59,310.65
Repayment of borrowings	(1,36,315.42)	(37.10)	(4,541.05)
Other non-cash changes:			
Amortisation of incremental borrowing cost	128.02	-	-
Other adjustments	-	6.23	5,192.78
<b>Balance as at 31 March 2021</b>	<b>1,18,578.41</b>	<b>144.56</b>	<b>63,572.79</b>

Notes

(b) For repayment terms and security details of the outstanding non-current borrowings (including current maturities) refer the table below:

S.No.	Nature of borrowing	Name of SPV	As at	Repayment terms and security disclosure	
			31 March 2021	31 March 2020	31 March 2019
1	Term loans from banks	Universal Mine Developers and Service Providers Private Limited	-	12,945.67	13,508.92
					Term loan from State Bank of India is secured by a) the first charge on all immovable properties and Assets and first charge by way of hypothecation on all b) movable properties and assets including, but not limited, to plant & machinery, machinery spares, tools & accessories, furniture, fixtures, vehicles and other movable assets of the project, c) all current assets related to the project, Project Bank Accounts and Insurance Contracts/ Proceeds and Pledge of 51% of the Share Capital of the Company held by the Promoter. Tenure of the loan is 15 years from the date of drawdown.  - The Term Loan carries a floating rate of interest at 1.40% above the SBI' Base Rate with monthly rests - Number of instalments of the Term Loan 56 structured quarterly instalments.
2	Term loans from banks	Terralight Kanji Solar Private Limited (formerly Shapoorji Pallonji Solar PV Private Limited)	-	16,175.04	17,122.12
					Term loan from The Saraswat Co-operative Bank Ltd carrying rate of interest 9.75% p.a is secured by the mortgage of project land and hypothecation of all movable properties and assets including, but not limited, to plant & machinery, machinery spares, tools & accessories, furniture, fixtures, vehicles and other movable assets of the project. Tenure of the loan is 12 years from the date of drawdown. -For the Loan Account # 28470010000649 for the term loan amount of INR 17880 lakhs last Installment of INR 4272 lakhs payable on 26th February 2028 -For the Loan Account # 24700100000678 for the term loan amount of INR 1120 lakhs, last installment of Rs 268 lakhs is payable on 21st January 2029.
3	Term loans from banks	TN Solar Power Energy Private Limited	-	11,713.00	12,265.96
					Term loan from State Bank of India is secured by a) the first charge on all immovable properties and Assets and first charge by way of hypothecation on all b) movable properties and assets including, but not limited, to plant & machinery, machinery spares, tools & accessories, furniture, fixtures, vehicles and other movable assets of the project, c) all current assets related to the project, Project Bank Accounts and Insurance Contracts/ Proceeds and Pledge of 51% of the Share Capital of the Company held by the Promoter. Tenure of the loan is 15 years from the date of drawdown.  - The Term Loan carries a floating rate of interest at 1.25% above the SBI' Base Rate with monthly rests - Number of instalments of the Term Loan 56 structured quarterly instalments.
4	Term loans from banks	Rajapalayam assets	-	13,651.13	4,455.00
					Term Loan is at the rate of 10.15%-10.25% p.a payable monthly linked to consortium of Saraswat Cooperative Bank Limited (SCBL). It is secured by first pari passu charge on receivables from the Solar Project along with the other lenders of the Consortium; First pari passu charge on the land of the project and construction thereon situated at Thenkarai village, Rajapalayam Block, Virudhunagar District, Tamil Nadu along with other lenders of the consortium by way of legal/ equitable mortgage. First pari passu charge on all the current and fixed assets of the proposed project. The repayment of the loan is to be done in 60 quarterly instalments.
5	Term loans from banks	Solar Edge Power And Energy Private Limited	-	60,663.46	63,212.09
					Term Loan is at the rate of 10.15%-10.75% p.a payable monthly linked to consortium of Indusind Bank Limited (IBL). It is secured by first pari passu charge on present and future immovable properties, tangible/ intangible movable assets, current assets, bank accounts, all the rights, title, interest, benefits, claims whatsoever of the project agreement, insurance policies related to the project, pledge of shares held by shareholders representing 51% of total share capital of the company. The tenure of the loan is 20 years from the date of first disbursement. The repayment of the loan is to be done in 75 quarterly instalments.
6	Unsecured loan from other entities	Terralight Kanji Solar Private Limited (formerly Shapoorji Pallonji Solar PV Private Limited)	-	4,265.00	4,158.00
					Unsecured loan is from Shapoorji Pallonji Solar Holdings Private Limited; Interest of 12.50%-13.51% per annum is charged by the Company on the loan balance.
7	Unsecured loan from other entities	TN Solar Power Energy Private Limited	-	271.25	20.00
					Unsecured loans from related parties i.e., Shapoorji Pallonji Solar Holdings Private Limited (INR 473.00 lakhs) and to Shapoorji Pallonji Infrastructure Capital Company Private Limited (INR 1439.00 lakhs) were converted into 191.20 lakhs 2% compulsorily convertible preference shares of INR 10/- each in October 2018. - Interest at the rate of 12.5%-13.53% per annum was charged by the Company on the loan balance during FY 2019-20.
8	Unsecured loan from other entities	Solar Edge Power And Energy Private Limited	-	10,984.90	10,485.50
					Interest rate on unsecured loan from Shapoorji Pallonji Infrastructure Capital Company Private Limited ranges from 12.25% to 13.51% p.a during FY 2019-20 and are repayable in 3 years.
9	Compulsorily convertible debentures	Solar Edge Power And Energy Private Limited	12,153.27	-	-
					Unlisted, Unsecured, Compulsorily Convertible Debentures (CCDs) each having a face value of INR 10, issued for a term not exceeding 30 years, in a single tranche, on private placement basis to Terra Asia Holdings II Pte. Ltd. CCDs carries coupon rate to 14% per annum, payable annually (but, may be mutually agreed to be otherwise), these shall be converted based on conversion ratio as per the below formula (subject to the terms and conditions of the SSPA). [Face value of the CCDs] / [Fair Market Value of the equity shares as on date of conversion of the CCDs, on a Fully Diluted Basis].
10	Compulsorily convertible debentures	Universal Mine Developers and Service Providers Private Limited	15,065.87	-	-
					Unlisted, Unsecured, Compulsorily Convertible Debentures (CCDs) each having a face value of INR 10, issued for a term not exceeding 30 years, in two tranches, on private placement basis to Terra Asia Holdings II Pte. Ltd. CCDs carries coupon rate to 14% per annum, payable annually (but, may be mutually agreed to be otherwise), these shall be converted based on conversion ratio as per the below formula (subject to the terms and conditions of the SSPA). [Face value of the CCDs] / [Fair Market Value of the equity shares as on date of conversion of the CCDs, on a Fully Diluted Basis].
11	Compulsorily convertible debentures	Terralight Kanji Solar Private Limited (formerly Shapoorji Pallonji Solar PV Private Limited)	24,182.21	-	-
					Unlisted, Unsecured, Compulsorily Convertible Debentures (CCDs) each having a face value of INR 10, issued for a term not exceeding 30 years, in two tranches, on private placement basis to Terra Asia Holdings II Pte. Ltd. CCDs carries coupon rate to 14% per annum, payable annually (but, may be mutually agreed to be otherwise), these shall be converted based on conversion ratio as per the below formula (subject to the terms and conditions of the SSPA). [Face value of the CCDs] / [Fair Market Value of the equity shares as on date of conversion of the CCDs, on a Fully Diluted Basis].
12	Compulsorily convertible debentures	TN Solar Power Energy Private Limited	13,445.86	-	-
					Unlisted, Unsecured, Compulsorily Convertible Debentures (CCDs) each having a face value of INR 10, issued for a term not exceeding 30 years, in two tranches, on private placement basis to Terra Asia Holdings II Pte. Ltd. CCDs carries coupon rate to 14% per annum, payable annually (but, may be mutually agreed to be otherwise), these shall be converted based on conversion ratio as per the below formula (subject to the terms and conditions of the SSPA). [Face value of the CCDs] / [Fair Market Value of the equity shares as on date of conversion of the CCDs, on a Fully Diluted Basis].
13	Compulsorily convertible debentures	Rajapalayam assets	18,533.32	-	-
					Unlisted, Unsecured, Compulsorily Convertible Debentures (CCDs) each having a face value of INR 10, issued for a term not exceeding 30 years, in two tranches, on private placement basis to Terra Asia Holdings II Pte. Ltd. CCDs carries coupon rate to 14% per annum, payable annually (but, may be mutually agreed to be otherwise), these shall be converted based on conversion ratio as per the below formula (subject to the terms and conditions of the SSPA). [Face value of the CCDs] / [Fair Market Value of the equity shares as on date of conversion of the CCDs, on a Fully Diluted Basis].
14	Secured loan from bank and financial institutions	Universal Saur Urja Private Limited	13,732.43	14,652.21	16,049.74
					During the financial Year 2018-19, term loan was taken from financial institutions L&T Infrastructure Financial Company Limited and the same was re-financed with India Renewable Energy Development Agency. ("IREDA") of INR 18,000 lakhs which carries interest 10.50% p.a. payable monthly. The loan is repayable in 40 structured quarterly instalments. The loan is secured by hypothecation of present and future plant and machinery and other spares, tools and accessories, furniture, fixtures, vehicles and all other movable assets and current assets of the Company, Immoveable properties (owned and/leased) and pledge of equity shares of the company by the holders of the equity shares of the Company.
15	Term loans from banks	Terralight Solar Energy Charanka Private Limited (Formerly known as "Sindicatum Solar Energy Gujarat Private Limited")	5,908.35	6,778.59	7,593.04
					During the financial year 2017-18, term loan from financial institutions (L&T Infra Debt Fund Ltd. ("L&T Infra") and L&T Infrastructure Finance Co. Ltd. ("L&T Infrastructure")) of INR 7160.26 lakhs and INR 2000.00 lakhs respectively was taken which carries interest @ 10.5% and 12.05% respectively, payable monthly. The loans are repayable in 52 structured quarterly instalments.  Both the loans are secured by hypothecation of present and future plant and machinery and other spares, tools and accessories, furnitures, fixtures, vehicles and all other movable assets and current assets of the company and assignment of lease hold right over land and pledge of equity shares of the company by the holders of the equity shares of the company.

16	Term loans from banks	PLG Photovoltaic Private Limited (Formerly known as 'PLG Photovoltaic Limited')	12,193.94	14,149.84	15,974.71	Term loan from L&T Infra Debt Fund Ltd. ("L&T Infra") is secured by a) the first charge on all immovable properties and Assets and first charge by way of hypothecation on all b) movable properties and assets including, but not limited, to plant & machinery, machinery spares, tools & accessories, furniture, fixtures, vehicles and other movable assets of the project, c) all current assets related to the project d) assignment of lease hold right over land and pledge of equity shares of the company by the holders of the equity shares of the Company Tenure of the loan is 13.5 years from the date of drawdown.  - The Term Loan carries a rate of interest at 9.80% p.a and 10.65% p.a respectively payable monthly - Number of instalments of the Term Loan 54 structured quarterly instalments.
17	Term loans from financial institutions and bank	Terralight Solar Energy Private Limited (Formerly known as "Sindicatum Solar Energy Private Limited")	3,363.15	3,729.14	4,294.43	During the financial 2017-18, term loan from financial institutions (L&T Infra Debt Fund Ltd. ("L&T Infra") and L&T Infrastructure Finance Co. Ltd ("L&T Infrastructure")) of INR 3887.51 lakhs and INR 1000.00 lakhs respectively was taken which carries interest @ 10.5% and 10.85%p.a. respectively, payable monthly. The loan is repayable in 12 years and 9 months in quarterly instalments, of INR 58.31 lakhs and INR 15.00 lakhs respectively. Both the loans are secured by hypothecation of present and future plant and machinery and other spares, tools and accessories, furniture, fixtures, vehicles and all other movable assets and current assets of the Company and assignment of lease hold right over land and pledge of equity shares of the company by the holders of the equity shares of the Company. Loan from Saraswat Bank Ltd. of INR 29.00 lakhs was taken as on March 2018 for a period of 5 years, which is secured to the extent of the value of the asset taken on lease, carries interest @ 8.35%p.a. and instalment of INR 0.59 lakhs payable monthly.

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**(c) Terms of repayment and interest rate of current borrowings:**

S.No.	Nature of borrowing	Name of SPV	As at	As at	As at	Repayment terms and security disclosure
			31 March 2021	31 March 2020	31 March 2019	
1	Unsecured loan from other entities	Universal Mine Developers and Service Providers Private Limited	-	524.16	292.16	The loan from Shapoorji Pallonji Infrastructure Capital Company Private Limited INR 291.5 lakhs carries interest rate of 12%-14.96% p.a during the FY 2019-20 and payable on demand. The Loan from Shapoorji Pallonji Solar Holdings Private Limited INR 232.66 lakhs carries interest rate of 12.25%-14.96% p.a during the financial year 2019-20 and payable on demand.
2	Cash credit facility from banks	Universal Mine Developers and Service Providers Private Limited	-	385.67	-	Working Capital facility from State Bank of India is secured by a) the first charge on all immovable properties and Assets and first charge by way of hypothecation on all b) movable properties and assets including, but not limited, to plant & machinery, machinery spares, tools & accessories, furniture, fixtures, vehicles and other movable assets of the project, c) all current assets related to the project, Project Bank Accounts and Insurance Contracts/ Proceeds and Pledge of 51% of the Share Capital of the Company held by the Promoter.  These facilities carry an interest rate of 9.75%-11.15% per annum and is repayable on demand.
3	Cash credit facility from banks	TN Solar Power Energy Private Limited	-	288.67	-	Working Capital facility from State Bank of India is secured by a) the first charge on all immovable properties and Assets and first charge by way of hypothecation on all b) movable properties and assets including, but not limited, to plant & machinery, machinery spares, tools & accessories, furniture, fixtures, vehicles and other movable assets of the project, c) all current assets related to the project, Project Bank Accounts and Insurance Contracts/ Proceeds and Pledge of 51% of the Share Capital of the Company held by the Promoter.  These facilities carry an interest rate of 5.50%-11.15% per annum and is repayable on demand.
4	Cash credit facility from banks	Terralight Kanji Solar Private Limited (formerly Shapoorji Pallonji Solar PV Private Limited)	-	1,490.69	769.12	Cash credit (Working Capital facility) from the Saraswat Co-Operative Bank Limited is secured by First charge on the Company's book debts, operating cash flows, receivables, commissions, revenues pertaining to the Project, both present and future  These facilities carry an interest rate of 5.50%-9.75% per annum and is repayable on demand.
5	Cash credit facility from banks	Rajapalayam assets	-	921.22	-	Working Capital Loan from Saraswat Cooperative Bank Limited (SCBL). It is secured by first pari passu charge on receivables from the Solar Project along with the other lenders of the Consortium. Rate of Interest is 9.85% - 10.25% p.a.
6	Term loans from banks	Solar Edge Power And Energy Private Limited	59,301.85	-	-	Term Loan from consortium of Standard Chartered Bank repayable within 12 months from first utilization date. Rate of Interest 7.75% -10.75%p.a. Loan is secured by First ranking pari passu pledge over 100% equity shares and all other quasi-equity instruments (including CCDs, OCDs, NCDs, shareholder loans etc., to the extent permitted by applicable law) of the Borrower held by the Parent and the New Shareholders, if any; First ranking pari passu charge over Project real estate of the Borrower; First ranking pari passu charge over all present- and future-owned plant and machinery and electrical and transmission equipment of the Borrower; First ranking pari passu charge over present- and future-owned movable assets of the Borrower, including, but not limited to, assets with respect to its Project; First ranking pari passu charge over all present- and future-owned current assets and receivables of the Borrower including, but not limited to, with respect to the Project, Project Agreements and all bank accounts;
6	Non convertible Debentures	Solar Edge Power And Energy Private Limited	1.00	-	-	During the year ended 31 March 2021, Universal Mine Developers and Service Providers Private Limited, TN Solar Power Energy Private Limited, Shapoorji Pallonji Solar PV Private Limited, Solar Edge Power and Energy Private Limited and Rajapalayam assets (collectively known as NCD Issuer entities) has issued Series A, B, C and D non-convertible debentures for an aggregate value of INR 8.80 lakhs carrying interest rate of 7% p.a. to Shapoorji Pallonji Solar Holdings Private Limited vide debenture subscription agreements dated 09 September 2020. As per the terms of the debenture subscription agreement, these non-convertible debentures are redeemable at a premium upon occurrence of certain events within a period of 5 years which may be extended by additionally period of 2.5 years. Further, as the premium on these non-convertible debentures are payable to Shapoorji Pallonji Solar Holdings Private Limited for the acquisition of NCD Issuer entities by Terra Asia Holdings II Pte. Limited, Singapore, the premium on fair valuation of these non-convertible debentures have been accounted under "Other Equity" for the year ended 31 March 2021. Of this INR 5,192.79 lakhs provision for NCD redemption premium, NCDs worth INR 3 lakhs have been redeemed at a value of INR 352.76 lakhs on 28 December 2020 and INR 577.89 lakhs as on 25 February 2021 as the conditions have duly satisfied to that extent.
7	Non convertible Debentures	TN Solar Power Energy Private Limited	1,394.97	-	-	During the year ended 31 March 2021, Solar Edge Power and Energy Private Limited has issued Non-convertible debentures for an aggregate value of INR 1.00 lakhs to Shapoorji Pallonji Solar Holdings Private Limited vide debenture subscription agreements dated 09 September 2020. As per the terms of the debenture subscription agreement, these non-convertible debentures are redeemable at a premium upon occurrence of certain events within a period of 3.5 years. These non-convertible debentures are payable to Shapoorji Pallonji Solar Holdings Private Limited for the acquisition of NCD Issuer entities by Terra Asia Holdings II Pte. Limited, Singapore. Based on internal assessment of the management, the event for redemption of non-convertible debentures at premium is less likely to happen, hence these non-convertible debentures are carried at face value.
8	Non convertible Debentures	Universal Mine Developers and Service Providers Private Limited	1,244.95	-	-	
9	Non convertible Debentures	Terralight Kanji Solar Private Limited (formerly Shapoorji Pallonji Solar PV Private Limited)	1,630.02	-	-	

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	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>21 Lease liabilities</b>			
<b>Non-current</b>			
Lease obligations	120.83	120.47	148.24
	<b>120.83</b>	<b>120.47</b>	<b>148.24</b>
<b>Current</b>			
Lease obligations	23.73	54.96	66.17
	<b>23.73</b>	<b>54.96</b>	<b>66.17</b>
<b>22 Provisions</b>			
<b>Non-current</b>			
Provision for compensated absences	10.93	5.05	-
Provision for gratuity (net)( refer note 41)	20.39	20.15	13.13
	<b>31.32</b>	<b>25.20</b>	<b>13.13</b>
<b>Current</b>			
Provision for compensated absences	1.57	0.05	2.14
Provision for gratuity (net)( refer note 41)	1.78	0.17	0.59
	<b>3.35</b>	<b>0.22</b>	<b>2.73</b>
<i>(This space has been intentionally left blank)</i>			
<b>23 Other liabilities</b>			
<b>Non-current</b>			
Deferred revenue (viability gap funding)	2,074.94	1,672.00	-
	<b>2,074.94</b>	<b>1,672.00</b>	<b>-</b>
<b>Current</b>			
Advances from customers	2,000.00	2,000.00	0.14
Statutory liabilities	139.96	121.79	413.97
Deferred revenue	19,727.19	17,662.77	15,563.63
Deferred revenue (viability gap funding)	98.80	76.00	-
Others	86.97	86.97	74.97
	<b>22,052.92</b>	<b>19,947.53</b>	<b>16,052.71</b>
<b>24 Trade payables</b>			
i. total outstanding dues of micro enterprises and small enterprises (see note 35)	-	0.81	0.21
ii. total outstanding dues of creditors other than micro enterprises and small enterprises	2,138.35	2,373.02	7,913.22
	<b>2,138.35</b>	<b>2,373.83</b>	<b>7,913.43</b>
<b>25 Other financial liabilities</b>			
<b>Current</b>			
Current maturities of long term borrowing	5,140.41	10,159.06	9,265.51
Payable for purchase of property, plant and equipment	-	251.22	230.74
Interest accrued on borrowings	7,537.30	6,811.14	4,408.03
Capital creditors	221.43	492.45	465.45
	<b>12,899.14</b>	<b>17,713.87</b>	<b>14,369.73</b>

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	Year ended 31 March 2021	Year ended 31 March 2020	Year ended 31 March 2019
<b>26 Revenue from operations</b>			
Sale of power	34,413.94	35,133.35	32,764.04
Other operating revenues			
Scrap sales	10.04	1.60	2.47
	<b>34,423.98</b>	<b>35,134.95</b>	<b>32,766.51</b>

**Note:**

**(a) Disaggregated revenue information**

Set out below is the disaggregation of the the SPV Group's revenue from contracts with customers:

Particulars	Year ended 31 March 2021	Year ended 31 March 2020	Year ended 31 March 2019
<b>Type of goods/services</b>			
Income from generation of electricity	34,413.94	35,133.35	32,764.04
<b>Total revenue from contracts with customers</b>	<b>34,413.94</b>	<b>35,133.35</b>	<b>32,764.04</b>
<b>Geographical region</b>			
India	34,413.94	35,133.35	32,764.04
Outside India	-	-	-
<b>Total revenue from contracts with customers</b>	<b>34,413.94</b>	<b>35,133.35</b>	<b>32,764.04</b>
<b>Type of customer</b>			
Government customer	34,413.94	35,133.35	32,764.04
Non-government customer	-	-	-
<b>Total revenue from contracts with customers</b>	<b>34,413.94</b>	<b>35,133.35</b>	<b>32,764.04</b>
<b>Revenue of timing of recognition</b>			
Revenue recognised at point in time	34,413.94	35,133.35	32,764.04
Revenue recognised over time	-	-	-
<b>Total revenue from contracts with customers</b>	<b>34,413.94</b>	<b>35,133.35</b>	<b>32,764.04</b>

**(b) Assets and liabilities related to contracts with customers**

Trade receivables	10,784.07	19,529.48	10,192.81
Unbilled revenue	3,727.08	2,192.41	2,585.92

**(c) Revenue recognised in relation contract liabilities**

<b>Contract liabilities related to sale of power</b>			
Advances from customers	2,000.00	2,000.00	0.14
Deferred revenue	19,727.19	17,662.77	15,563.63
Deferred revenue (viability gap funding)	2,173.74	1,748.00	-

Remaining performance obligations as at the reporting date are expected to be substantially recognised over the remaining period of power purchase agreement by the SPV Group.

**(d) Reconciling the amount of revenue recognised in the statement of profit and loss with the contracted price**

Revenue as per contracted price	34,248.04	34,908.68	32,320.28
<b>Adjustments:</b>			
Rebate	165.90	224.67	443.76
<b>Revenue from contracts with customers</b>	<b>34,413.94</b>	<b>35,133.35</b>	<b>32,764.04</b>

**27 Other income**

**Interest income**

Interest income earned on:			
- bank deposits (at amortised cost)	768.52	818.13	405.74
- financial assets (at amortised cost)	-	9.86	3.26
Interest received on income tax refund	4.13	0.01	-
Other interest income	28.38	53.07	0.98
	<b>801.03</b>	<b>881.07</b>	<b>409.98</b>

**Other income**

Sundry balances written back	1,527.76	266.50	-
Insurance claim received	67.21	6.93	129.15
Dividend income from financial assets measured at FVTPL	-	0.04	30.27
Net gain on current investments measured at FVTPL	-	32.74	-
Miscellaneous income	52.22	124.83	49.06
	<b>1,647.19</b>	<b>431.04</b>	<b>208.48</b>
	<b>2,448.22</b>	<b>1,312.11</b>	<b>618.46</b>

**Virescent Renewable Energy Trust**  
**Notes forming part of the combined financial statements**  
**All amounts are in INR lakhs unless otherwise stated**

	Year ended 31 March 2021	Year ended 31 March 2020	Year ended 31 March 2019
<b>28 Operating and maintenance expenses</b>			
Spares and consumables	45.01	48.43	17.25
Operating and maintenance fees	1,446.19	1,516.30	1,349.45
	<b>1,491.20</b>	<b>1,564.73</b>	<b>1,366.70</b>
<b>29 Employee benefits expense</b>			
Salaries and wages	157.83	128.08	184.64
Contribution to provident and other fund	0.56	-	0.85
Gratuity expense	5.72	10.40	5.56
Staff welfare expenses	1.21	1.21	2.15
	<b>165.32</b>	<b>139.69</b>	<b>193.20</b>
<b>30 Finance Costs</b>			
Interest expense on borrowings	19,460.26	19,646.96	17,456.02
Interest expense on financial liabilities at amortised cost	13.91	18.67	192.64
Other finance costs	2,757.10	422.77	1,009.83
Interest on statutory dues	12.29	4.82	11.16
	<b>22,243.56</b>	<b>20,093.22</b>	<b>18,669.65</b>
<b>31 Depreciation and amortisation expense</b>			
Depreciation on property, plant and equipment	13,660.41	14,908.20	14,296.12
Amortisation of intangible assets	0.24	0.26	0.25
	<b>13,660.65</b>	<b>14,908.46</b>	<b>14,296.37</b>
<b>32 Other expenses</b>			
Power and fuel	163.44	127.41	122.42
Rent	28.86	10.67	96.22
Repair and maintenance			
- Machinery	596.65	528.05	661.36
- Others	15.88	24.10	8.80
Insurance	386.92	217.12	257.80
Rates and taxes	70.84	46.24	102.79
Communication expenses	19.02	11.91	7.19
Travelling and conveyance	12.66	35.80	55.85
Printing and stationery	0.14	0.13	1.03
Freight cartage and other distribution cost	0.46	0.17	-
Rebate	-	3.16	-
CSR expenditure (refer note below)***	19.22	23.42	27.98
Donation and contributions	-	-	0.21
Legal and professional charges	4,585.33	657.53	221.51
Payments to auditors	57.35	29.40	29.67
Security expenses	115.35	112.42	108.70
Testing and inspection charges	0.57	1.41	1.98
Fees and subscription	-	-	0.50
Bank charges	14.93	24.76	18.38
Loss on sale and write off of property, plant and equipment (net)	102.84	120.35	5.01
Trade and other receivables written off	5.36	-	-
Business Development Expenses	0.65	4.56	3.79
Allowance for doubtful advances*	-	302.97	-
Loss on receivable written off	168.41	-	-
Loss on foreign exchange fluctuation	-	20.48	13.43
Provision for diminution in value of investment	-	-	2,377.13
Miscellaneous expenses	88.12	9.83	20.36
<b>Please don't delete this row</b>			
<b>Total</b>	<b>6,453.00</b>	<b>2,311.89</b>	<b>4,142.11</b>
<b>33 Exceptional items</b>			
Provision for impairment (refer note 3)	32,495.61	-	2,322.64
Impairment of investments	649.13	-	-
Provision for doubtful advances	-	263.95	-
Net loss on Fair valuation of Securities	32.74	-	-
Provision for doubtful loans**	-	3,182.00	-
<b>Total</b>	<b>33,177.48</b>	<b>3,445.95</b>	<b>2,322.64</b>

**Note:**

Payments to the auditors (excluding input tax)

I To statutory auditors			
a) Audit fees	54.92	28.15	28.42
b) Tax audit fees	0.98	0.50	1.25
c) Cost audit fees	1.46	0.75	-
	<b>57.35</b>	<b>29.40</b>	<b>29.67</b>

\* Syndicatam Carbon Capital India Pvt Ltd ("SCC") had earlier provided corporate guarantee with respect to loan of INR 300 lakhs being advanced to Nawanshahr Power Private Limited ("NPPL") by a third party (Lender). On account of default in repayment of loan by NPPL, Lender invoked the corporate guarantee. Due to paucity of funds with SCC to meet said liability, Terralight Solar Energy Private Limited ("TSETPL", formerly Syndicatam Solar Energy Private Limited) met the liability arising out of invocation of corporate guarantee (along with interest) amounting to INR 329.97 lakhs. Lender had agreed to repay the corporate guarantee amount to TSETPL as and when any money is being recovered by the Lender. Though certain amount has been recovered during the year, however, TSETPL is not fully certain of recovery of remaining amount of INR 302.97 lakhs due to NPPL's inability to repay the lender, hence provisions has been recorded in the financial statements against the aforesaid amount of INR 302.97 lakhs.

\*\* In the financial year 2017-18, USUPL gave loans to Gobind Infra Private Limited, and Sukhbir Logistics Private Limited totalling to INR 3182.00 lakhs. These company's operations are expected to remain stagnant and they are unlikely to earn adequate income or generate adequate cash in the foreseeable future for repayment of the dues owed to TSETPL in a time bound manner.

During financial year 2018-19 provision for the entire amount has been made in the financial statement which was written off during the year.

**\*\*\* CSR expenditure as per Section 135 of the Companies Act 2013**

Section 135 of the Companies Act, 2013, which came into effect on 1 April 2014, requires the Company to constitute a Corporate Social Responsibility (CSR) Committee of Directors, adopt a CSR Policy and spend at least 2% of its average net profits made during the immediately preceding three financial years towards CSR activities as set out in Schedule VII to the Companies Act, 2013. In accordance with the provisions of Section 135 of the Companies Act, 2013, the Company was required to spend INR 19.22 lakhs on prescribed CSR activities. The detail of CSR expense is as follows:-

	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
a) Gross amount required to be spent by the SPVs during the year	19.22	23.42	27.98
b) Amount spent during the year			
i) Construction/acquisition of any asset	7.94	5.45	27.95
ii) On purposes other than (i) above	11.28	17.97	0.03

	Year ended 31 March 2021	Year ended 31 March 2020	Year ended 31 March 2019
<b>34 Income taxes</b>			
<b>Income tax recognised in the Statement of profit and loss</b>			
<b>Current tax</b>			
In respect of the current year	465.20	383.51	49.01
In respect of the previous year	-	120.38	-
	<b>465.20</b>	<b>503.89</b>	<b>49.01</b>
<b>Deferred tax</b>			
In respect of the current year	7.94	(2,474.92)	(4,673.27)
	<b>7.94</b>	<b>(2,474.92)</b>	<b>(4,673.27)</b>
<b>Total income tax expense recognised in the current year</b>	<b>473.14</b>	<b>(1,971.03)</b>	<b>(4,624.26)</b>
<b>The Income tax expense for the year can be reconciled to the accounting profit as follows:</b>			
Profit before tax from continuing and discontinuing operations	(7,141.53)	(2,570.93)	(5,283.06)
Statutory income tax rate	26%	26%	26%
Income tax expense at statutory income tax rate	(10,432.79)	(1,563.95)	(1,963.37)
Effect of Income that is exempt from taxation	-	-	(7.87)
Effect of expenses that are not deductible in determining taxable profit	219.77	1,224.87	1,116.28
Effect of accelerated capital allowances	-	(2,772.63)	(3,261.60)
Effect of expenses that are allowed under income tax	-	(73.00)	(3.23)
Effect of past losses for which deferred tax asset is recognised	-	1,620.88	2,167.69
Effect of concessions (tax holiday and similar exemptions)	1,097.97	451.49	-
Losses on which deferred tax is not created	(1,003.69)	67.69	-
Deferred tax assets recognised for previous periods brought forward			
depreciation	(35.92)	(991.83)	
Brought forward depreciation utilised during the year	-	(721.61)	
Other adjustments	9,414.90	578.41	(2,671.07)
Impact of change in tax rate	-	-	-
MAT adjustment	-	2.59	(1.09)
Adjustments recognised in the current year in relation to the previous years	1,212.91	206.06	-
	<b>473.14</b>	<b>(1,971.03)</b>	<b>(4,624.26)</b>

SPVs offsets tax assets and liabilities if and only if it has a legally enforceable right to set off current tax assets and current tax liabilities and the deferred tax assets and deferred tax liabilities relate to income taxes levied by the same tax authority.

As at 31 March 2019 the SPVs had INR 13,353.16 lakhs of unabsorbed depreciation under income tax laws, of which entire amount is expected to get reversed within the tax holiday period. Accordingly deferred tax asset is not recognised.

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	For the Year ended 31 March 2021	For the Year ended 31 March 2020	For the Year ended 31 March 2019
<b>35 Disclosure under the Micro, Small and Medium Enterprises Development Act, 2006 ("MSMED Act, 2006") is as under:</b>			
i) Principal amount due to suppliers under MSMED Act	-	0.81	0.21
ii) Interest accrued and due to suppliers under MSMED Act on the above amount	5.05	-	-
iii) Payment made to suppliers (other than interest) beyond appointed day during the year	-	-	-
iv) Interest paid to suppliers under MSMED Act	-	-	-
v) the amount of further interest remaining due and payable even in the succeeding years, until such date when the interest dues as above are actually paid to the small enterprise, for the purpose of disallowance as a deductible expenditure under section 23.	-	-	-
vi) Interest due and payable to suppliers under MSMED Act towards payments already made	0.08	-	-
vii) Interest accrued and remaining unpaid at the end of the accounting year	-	-	-

\*The details of amounts outstanding to micro enterprises and small enterprises under the Micro, Small and Medium Enterprises Development Act (MSMED), 2006 are as per available information with the group.

**36 Information on segment reporting pursuant to Ind AS 108 - Operating Segments**

The SPV Group's primary business segment is reflected based on principal business activities carried on by the SPV Group i.e. generation of power and all other related activities which as per Ind AS 108 on "Operating Segments" is considered to be the only reportable business segment. The SPV Group derives its major revenues from sale of power. The SPV Group is operating in India which is considered as a single geographical segment.

**37 Earnings Per Unit (EPU)**

The number of units that Virescent Renewable Energy Trust will issue to investors in the proposed private placement and to Terra Asia Holding II PTE Ltd. (together referred to as 'the Sponsor') in exchange of the shareholdings in the SPV Group is not presently ascertainable. Hence the disclosures in respect of Earnings per Unit have not been given.

**38 Capital commitments and contingent liabilities**

- Solar Edge Power and Energy Private Limited has contingent Liability as on 31 March 2021 is Nil, 31 March 2020 is Nil and 31 March 2019 is INR 432.00 lakhs arising on account of liquidated damages for delay in commissioning project)
- There are no capital commitments as on 31 March 2021, 31 March 2020 and 31 March 2019.
- During 2015-16, Terralight Solar Energy Tinwari Private Limited ('TSETPL', formerly Sindicatum Solar Energy Private Limited) received demand notice from the Income Tax Authorities requiring to pay additional tax of INR 21.81 lakhs for assessment year 2012-13. The demand pertains to disallowance of certain expenses claimed by TSETPL. The demand was subsequently revised to INR 9.74 lakhs by assessing officer based on rectification filed by TSETPL u/s 154 of the Income Tax Act, 1961. TSETPL had paid INR 3.50 lakhs and is confident of reversal of demand raised by assessing officer.

	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
Income tax matters in dispute	9.74	9.74	9.74

**39 Assets pledged as security**

	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>Non-current assets</b>			
Property, plant and equipment	99,094.34	1,24,416.19	1,33,513.61
Capital work-in-progress	-	-	51.50
Other financial assets	70.93	85.41	73.32
Other non-current assets	31.32	131.12	423.45
<b>Current assets</b>			
Inventories	49.13	43.08	9.06
Trade receivables	2,875.72	3,032.20	1,979.70
Cash and cash equivalents	4,803.00	7,732.60	5,844.00
Other bank balances	7,057.16	4,380.36	3,836.29
Loans	-	-	3,182.00
Other financial assets	2,629.77	1,397.30	2,665.91
Other current assets	86.68	121.85	73.13

40 Leases

(a) Information for leases where the SPVs are lessee

(i) Right of use assets

	31 March 2021	31 March 2020	31 March 2019
Land	129.64	149.64	136.60
Office building	4.53	41.01	84.47
	<b>134.17</b>	<b>190.65</b>	<b>221.07</b>

The SPVs had entered into agreements with the Government for acquiring right over a land for a period of 30 years for the purpose of setting up power plant based on renewable energy sources.

(ii) Lease liabilities are presented in the statement of financial position as follows:

	31 March 2021	31 March 2020	31 March 2019
Current	23.73	54.96	66.17
Non-current	120.83	120.47	148.24
	<b>8.88</b>	<b>29.06</b>	<b>53.32</b>

The SPV group has leases for the land and corporate offices. With the exception of short-term leases and leases of low-value underlying assets, each lease is reflected on the balance sheet as a right-of-use asset and a lease liability. The SPV group classifies its right-of-use assets in a consistent manner to its property, plant and equipment.

The SPV group had a leasehold land at various places which was taken on a lease for a period of 30 year in the year for the purpose of setting up power plant based on renewable energy sources. SPV group paid an annual rent between INR 0.75- INR 6.00 lakhs every year. Annual rent shall be subject to revision after every 5-10 years and such revision shall not exceed 5%-25% of rent paid in immediately previous period.

The following are amounts recognised in profit or loss:

	31 March 2021	31 March 2020	31 March 2019
Depreciation expense of right-of-use assets	56.48	73.19	17.08
Interest expense on lease liabilities	13.91	18.67	15.00
Rent expense*	28.86	10.67	96.22
<b>Total</b>	<b>99.25</b>	<b>102.53</b>	<b>128.30</b>

\*Rent expense in term of short term leases

The table below describes the nature of the SPVs leasing activities by type of right-of-use asset recognised on balance sheet:

Right-of-use asset	No of right-of-use assets leased	Remaining term (in years)	No of leases with extension options	No of leases with termination options
Land	4	19-21	Nil	Nil
Office building	1	-	Nil	Nil

The maturity analysis of lease liabilities are disclosed in note 43(B).

Lease payments not recognised as a liability

SPVs has elected not to recognise a lease liability for short term leases (leases with an expected term of 12 months or less) or for leases of low value assets. Payments made under such leases are expensed on a straight-line basis. SPVs does not have any liability to make variable lease payments for the right to use the underlying asset recognised in the financials.

The expense relating to payments not included in the measurement of the lease liability for short term leases is INR 28.86, INR 10.67 , INR 96.22 as at 31 March 2021, 31 March 2020 and 31 March 2019 respectively.

Total cash outflows for the leases amounts to INR 65.96 lakhs, INR 55.39 lakhs , INR 112.29 lakhs as at 31 March 2021, 31 March 2020 and 31 March 2019 respectively.

41 Employee benefit plans

(a) Defined contribution plans

The SPV's contribution to Provident Fund aggregating INR 0.56 lakhs, Nil and INR 0.85 lakhs has been recognised in the Statement of Profit or Loss under the head Employee Benefits Expense for the year ended 31 March 2021, 31 March 2020 and 31 March 2019.

(b) Defined benefit plans

Gratuity

The SPV's operates a gratuity plan covering qualifying employees. The benefit payable is the greater of the amount calculated as per the Payment of Gratuity Act, 1972 or the Company scheme applicable to the employee. The benefit vests upon completion of five years of continuous service and once vested it is payable to employees on retirement or on termination of employment. In case of death while in service, the gratuity is payable irrespective of vesting. The gratuity plan is unfunded.

Through its defined benefit plans the SPV is exposed to a number of risks, the most significant of which are detailed below:

Life expectancy

The majority of the plan's obligations are to provide benefits for the life of the member, so increases in life expectancy will result in an increase in the plan's liabilities. This is particularly significant in the Company's defined benefit plans, where inflationary increases result in higher sensitivity to changes in life expectancy.

Salary risk

The present value of the defined benefit plan liability is calculated by reference to the future salaries of plan participants. As such, an increase in the salary of the plan participants will increase the plan's liability.

The significant actuarial assumptions used for the purposes of the actuarial valuations were as follows:

	31-Mar-21
Discount rate(s)	6.57%
Expected rate(s) of salary increase	10.00%
Rate of Employee Turnover	10.00%

Defined benefit plans – as per actuarial valuation on March 31, 2021

Particulars	Unfunded Plan Gratuity		
	As at 31 March 2021	As at 31 March 2020	As at 31 March 2020
Amounts recognised in the Statement of Profit and Loss are as follows:			
1. Current service cost	6.91	2.95	3.21
2. Past Service Credit			
3. Interest on net defined benefit liability / (asset)	1.28	1.02	2.33
<b>Components of defined benefit costs recognised in profit or loss</b>	<b>8.19</b>	<b>3.97</b>	<b>5.55</b>
Remeasurement on the net defined benefit liability			
Actuarial (gains) and losses arising from changes in financial assumptions	0.10	1.21	(0.07)
Actuarial (gains) and losses arising from experience adjustments	-	(0.40)	-
Actuarial (gains) and losses recognised for the period Asset Limit effect			
<b>Components of defined benefit costs recognised in other</b>	<b>0.10</b>	<b>0.81</b>	<b>(0.07)</b>

<b>I. Net Asset/(Liability) recognised in the Balance Sheet</b>			
1. Present value of defined benefit obligation	22.17	20.32	13.72
2. Fair value of plan assets	-	-	-
3. Surplus/(Deficit)	8.29	5.02	5.48
4.Amount not recognised due to asset limit			
5. Current portion of the above	1.78	0.17	0.59
6. Non current portion of the above	20.39	20.15	13.13

<b>II. Change in the obligation during the year ended March 31,</b>	<b>2,021</b>	<b>2,020</b>	<b>2,019</b>
1. Present value of defined benefit obligation at the beginning of the year	20.32	13.72	10.77
Acquisition adjustment	(6.44)	1.63	-
<b>2. Expenses Recognised in Profit and Loss Account</b>			
- Current Service Cost	6.91	2.95	3.21
- Past Service Cost	-	-	-
- Interest Expense (Income)	1.28	1.02	2.33
-Exchange (gain)/loss	-	0.24	-
<b>3. Recognised in Other Comprehensive Income</b>			
<b>Remeasurement (gains) / losses</b>			
- Actuarial (Gain)/ Loss arising from:			
i. Financial Assumptions	0.10	1.21	(0.07)
ii. Experience Adjustments	-	(0.40)	-
iii. Asset Limit Effect	-	-	-
4. Benefit payments	-	(0.05)	(2.53)
<b>5. Present value of defined benefit obligation at the end of year</b>	<b>22.17</b>	<b>20.32</b>	<b>13.72</b>

Notes:

The current service cost and net interest expenses for the year is included in the "Employee benefits expenses" line item in the statement of profit. The remeasurement of the net defined benefit liability is included in other comprehensive income.

The sensitivity of the defined benefit obligation to changes in the weighted principal assumptions is: (in Rupees)

Principal assumption	Changes in assumption	Impact on defined benefit obligation	
		Increase in assumption (1%)	Decrease in assumption (1%)
Discount rate	31-Mar-21	(1.45)	1.65
Salary growth rate	31-Mar-21	1.12	(1.15)
Rate of Employee Turnover	31-Mar-21	(0.01)	0.01
Discount rate	31-Mar-20	(1.50)	1.66
Salary growth rate	31-Mar-20	0.52	0.51
Rate of Employee Turnover	31-Mar-20	-	-
Discount rate	31-Mar-19	(0.36)	0.36
Salary growth rate	31-Mar-19	(0.33)	0.33
Rate of Employee Turnover	31-Mar-19	-	-

The above sensitivity analyses are based on a change in an assumption while holding all other assumptions constant. In practice this is unlikely to occur, and changes in some of the assumptions may be correlated. When calculating the sensitivity of the defined benefit obligation to significant actuarial assumptions the same method (present value of the defined benefit obligation calculated with the projected unit credit method at the end of the reporting period) has been applied as when calculating the defined benefit liability recognised in the Balance sheet.

Particulars	2021	2020	2019
Experience Adjustments	-	(0.40)	-

The methods and types of assumptions used in preparing the sensitivity analyses did not change compared to previous period.

The estimate of future salary increases, considered in actuarial valuation, takes account of inflation, seniority, promotion and other relevant factors, such as supply and demand in the employment market.

#### 42 Fair value measurements

##### i) Financial instruments by category

Particulars	As at 31 March 2021		As at 31 March 2020		As at 31 March 2019	
	FVTPL	Amortised cost	FVTPL	Amortised cost	FVTPL	Amortised cost
<b>Financial assets</b>						
Investments	0.50	-	0.75	-	0.75	-
Trade receivables	-	10,784.07	-	19,529.48	-	10,192.81
Cash and cash equivalents	-	12,560.78	-	7,865.17	-	9,338.73
Other bank balances	-	17,890.71	-	5,328.37	-	4,421.57
Other financial assets	-	4,030.05	-	4,362.29	-	3,745.74
<b>Total</b>	<b>0.50</b>	<b>45,265.61</b>	<b>0.75</b>	<b>37,085.31</b>	<b>0.75</b>	<b>30,880.85</b>
<b>Financial liabilities</b>						
Borrowings	-	1,82,151.20	-	1,73,589.64	-	1,70,200.79
Lease liabilities	-	144.56	-	175.43	-	214.41
Trade payables	-	2,138.35	-	2,373.83	-	7,913.43
Other financial liabilities	-	7,758.73	-	7,554.81	-	5,104.22
<b>Total</b>	<b>-</b>	<b>1,92,192.84</b>	<b>-</b>	<b>1,83,693.71</b>	<b>-</b>	<b>1,83,432.85</b>

Investment in associates and subsidiaries in respective SPVs, are measured at cost as per IndAS 27, 'Separate financial statements' and hence, not presented here.

The carrying amounts of current financial assets and liabilities are considered a reasonable approximation of their fair values. Other non-current financial assets and non-current borrowings bear a market interest rate and hence their carrying amounts are also considered a reasonable approximation of their fair values.

##### ii) Fair value hierarchy

Financial assets and financial liabilities measured at fair value in the combined balance sheet are divided into three levels of a fair value hierarchy. The three levels are defined based on the observability of significant inputs to the measurement, as follows:

Level 1: Quoted prices (unadjusted) in active markets for financial instruments.

Level 2: The fair value of financial instruments that are not traded in an active market is determined using valuation techniques which maximise the use of observable market data rely as little as possible on entity specific estimates.

Level 3: If one or more of the significant inputs is not based on observable market data, the instrument is included in level 3.

Financial assets measured at fair value - recurring fair value measurements:

As at 31 March 2021	Level 1	Level 2	Level 3	Total
<b>Financial assets</b>				
<b>Investments measured at fair value through profit and loss</b>				
Investment in unquoted equity instruments	-	0.50	-	<b>0.50</b>
<b>As at 31 March 2020</b>				
<b>Financial assets</b>				
<b>Investments measured at fair value through profit and loss</b>				
Investment in unquoted equity instruments	-	0.75	-	<b>0.75</b>
<b>As at 31 March 2019</b>				
<b>Financial assets</b>				
<b>Investments measured at fair value through profit and loss</b>				
Investment in unquoted equity instruments	-	0.75	-	<b>0.75</b>

##### Valuation process and technique used to determine fair value

The fair value of investments in mutual fund units is based on the net asset value ("NAV") as stated by the issuers of these mutual fund units in the published statements as at each reported balance sheet date. NAV represents the price at which the issuer will issue further units of mutual fund and the price at which issuers will redeem such units from the investors.

#### 43 Financial risk management

##### i) Risk management

The SPV group's is exposed to various risks in relation to financial instruments. The SPV group's financial assets and liabilities by category are summarized in Note 42. The SPV Group's Board of Directors has overall responsibility for the establishment and oversight of the SPV Group's risk management framework. The main types of risks are credit risk, liquidity risk and market risk.

##### A) Credit risk

Particulars	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
Trade receivables	10,784.07	19,529.48	10,192.81
Cash and cash equivalents	12,560.78	7,865.17	9,338.73
Other bank balances	17,890.71	5,328.37	4,421.57
Other financial assets	4,030.05	4,362.29	3,745.74
	<b>45,265.61</b>	<b>37,085.31</b>	<b>30,880.85</b>

Credit risk arises from the possibility that counter party will cause financial loss to the SPV group's by failing to discharge its obligation as agreed. To manage this, the SPV group's periodically assesses the financial reliability of customers, taking into account the financial condition, current economic trends, and analysis of historical bad debts and ageing of accounts receivable. Individual risk limits are set accordingly.

##### Trade receivables and unbilled revenue

The SPV Group's trade receivables and unbilled revenue (grouped under other financial assets) are only from, Government owned counterparty and are recoverable under the power purchase agreement. Therefore, these trade receivables and unbilled revenue are considered of high quality and accordingly no life time expected credit losses are recognised on such receivables.. Further, during the periods presented, the SPV Group has made no write-offs of receivables.

##### Financial assets (other than trade receivables)

The SPV Group provides for expected credit losses on loans and advances other than trade receivables by assessing individual financial instruments for expectation of any credit losses.

- For cash and cash equivalents and bank balances other than cash and cash equivalents - Since the SPV Group deals with only high-rated banks and financial institutions, credit risk in respect of cash and cash equivalents, other bank balances and bank deposits is evaluated as very low.

- For loans and other financial assets - Credit risk is evaluated based on the SPV Group's knowledge of the credit worthiness of those parties and loss allowance is measured. Since, this category includes loans and receivables of varied natures and purpose, there is no trend that the the SPV Group can draw to apply consistently to entire population.

**B) Liquidity risk**

Liquidity risk is the risk that the SPV Group may encounter difficulty in meeting its present and future obligations associated with financial liabilities that are required to be settled by delivering cash or another financial asset. The SPV Group's objective is to, at all times maintain optimum levels of liquidity to meet its cash and collateral obligations. Ultimate responsibility for liquidity risk management rests with the Board of Directors. The SPV group's manages liquidity risk by maintaining adequate reserves, banking facilities and reserve borrowing facilities, by continuously monitoring forecast and actual cash flows, and by matching the maturity profiles of financial assets and liabilities Management monitors rolling forecasts of the SPV group's liquidity position and cash and cash equivalents on the basis of expected cash flows.

**Maturities of financial liabilities**

The tables below analyse the SPV Group's financial liabilities into relevant maturity groupings based on their contractual maturities for all non-derivative financial liabilities. The amounts disclosed in the table are the contractual undiscounted cash flows.

31 March 2021	Less than 1 year	1-5 year	More than 5 years	Total
<b>Non-derivatives</b>				
Borrowings	68,742.86	36,350.30	82,648.88	1,87,742.04
Lease liabilities	14.10	46.92	206.54	267.56
Trade payables	2,138.35	-	-	2,138.35
Other financial liabilities	7,758.73	-	-	7,758.73
<b>Total</b>	<b>78,654.04</b>	<b>36,397.22</b>	<b>82,855.42</b>	<b>1,97,906.68</b>
31 March 2020	Less than 1 year	1-5 year	More than 5 years	Total
<b>Non-derivatives</b>				
Borrowings	18,823.57	84,877.87	1,41,153.37	2,44,854.81
Lease liabilities	51.63	46.92	220.05	318.60
Trade payables	2,373.83	-	-	2,373.83
Other financial liabilities	7,554.81	-	-	7,554.81
<b>Total</b>	<b>28,803.84</b>	<b>84,924.79</b>	<b>1,41,373.42</b>	<b>2,55,102.05</b>
31 March 2019	Less than 1 year	1-5 year	More than 5 years	Total
<b>Non-derivatives</b>				
Borrowings	16,934.24	85,416.27	1,56,816.58	2,59,167.09
Lease liability	63.97	84.46	234.13	382.56
Trade payables	7,913.43	-	-	7,913.43
Other financial liabilities	5,104.22	-	-	5,104.22
<b>Total</b>	<b>30,015.86</b>	<b>85,500.73</b>	<b>1,57,050.71</b>	<b>2,72,567.30</b>

**C) Market risk - Interest rate risk**

The SPV Group's policy is to minimise interest rate cash flow risk exposures on long-term financing. At the reporting periods end, the SPV Group is exposed to changes in market interest rates through bank borrowings at variable interest rates. The SPV Group's investments in fixed deposits pay fixed interest rates.

**Interest rate risk exposure**

Below is the overall exposure of the SPV group's to interest rate risk on long term borrowings:

Particulars	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>Variable rate:</b>			
Borrowings	1,06,425.13	83,229.74	87,578.04
<b>Total variable rate exposure</b>	<b>1,06,425.13</b>	<b>83,229.74</b>	<b>87,578.04</b>

**Sensitivity**

A reasonably possible change of 50 basis points in interest rate would have resulted in variation in the interest expense for the SPV group's by the amounts indicated in the table below. This calculation also assumes that the change occurs at the balance sheet date and has been calculated based on risk exposures outstanding as at that date. The year end balances are not necessarily representative of the average debt outstanding during the period. Below is the sensitivity of profit or loss and equity due to changes in interest rates, assuming no change in other variables:

Particulars	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>Interest sensitivity</b>			
Interest rates – increase by 50 basis points (Previous year: 50 basis points)	(532.13)	(416.15)	(437.89)
Interest rates – decrease by 50 basis points (Previous year: 50 basis points)	532.13	416.15	437.89

**D) Market risk - Price risk**

The SPV Group's exposure to price risk arises from investments held and classified in the balance sheet at fair value through profit or loss. To manage the price risk arising from investments, the SPV Group diversifies its portfolio of assets.

**E) Financing arrangements**

The the SPV Group had access to the following undrawn borrowing facilities at the end of the reporting period:

Particulars	As at 31 March 2021	As at 31 March 2020	As at 31 March 2019
<b>Floating rate</b>			
Expiring within one year (bank overdraft and other facilities)	-	1,925.65	1,830.88
Expiring after one year (bank loans)	-	-	-

**44 Capital management policies and procedures**

For the purpose of the SPV group's capital management, capital includes issued equity share capital, instruments entirely equity in nature and all other equity reserves attributable to the equity holders of the SPV group's.

The SPV group's capital management objectives are

- to ensure the SPV group's ability to continue as a going concern
- to provide an adequate return to shareholders

- A) Management assesses the SPV group's capital requirements in order to maintain an efficient overall financing structure. This takes into account the subordination levels of the SPV group's various classes of debt. The SPV group manages the capital structure and makes adjustments to it in the light of changes in economic conditions and the risk characteristics of the underlying assets.

The amounts managed as capital by the SPV group's for the reporting periods under review are summarised as follows:

Particulars	As at	As at	As at
	31 March 2021	31 March 2020	31 March 2019
Long-term borrowings	1,13,438.00	1,59,820.17	1,59,874.00
Current maturities of long-term borrowings including finance lease obligations	5,140.41	10,159.06	9,265.51
Short-term borrowings	63,572.79	3,610.41	1,061.28
Interest accrued on borrowings	7,537.30	6,811.14	4,408.03
<b>Total borrowings</b>	<b>1,89,688.50</b>	<b>1,80,400.78</b>	<b>1,74,608.82</b>
Less:			
Cash and cash equivalents	12,560.78	7,865.17	9,338.73
Other bank balances	17,890.71	5,328.37	4,421.57
<b>Net debts</b>	<b>1,59,237.01</b>	<b>1,67,207.24</b>	<b>1,60,848.52</b>
<b>Total equity*</b>	<b>(8,482.79)</b>	<b>40,877.71</b>	<b>49,265.08</b>
<b>Net debt to equity ratio</b>	<b>-</b>	<b>4.09</b>	<b>3.26</b>

\*Equity includes equity share capital and other equity of the SPVs that are managed as capital.

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**45 Information on related party transactions pursuant to Ind AS 24 - Related Party Disclosures**

Following are the related parties and transactions entered with related parties for the years ended 31 March 2021, 31 March 2020 and 31 March 2019 :

**Sponsor**

Terra Asia Holdings II Pte Ltd

**Investment Manager**

Virescent Infrastructure Investment Manager Private Limited (VIIM)

**Project Manager**

Virescent Renewable Energy Project Manager Private Limited (VREPM)

**Key managerial personnel of the SPV Group**

Solar Edge Power And Energy Private Limited

Mr. Narayan Das Rath

Mr. Sunil V Kulkarni

The following transactions were carried out with the related parties in the ordinary course of business:

**i. Transactions during the year ended 31 March 2021**

Management Fee (VIIM)	1,911.59
Management Fee (VREPM)	26.20

**i. Balances outstanding as at 31 March 2021**

Management Fee (VIIM)	1,429.85
Management Fee (VREPM)	24.75

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- 46** In Terralight Kanji Solar Private Limited (formerly Shapoorji Pallonji Solar PV Private Limited), the TamilNadu Generation and Distribution Corporation Limited(TANGEDCO) had disallowed generation during FY 2016-17 in excess of 19% Capacity Utilization factor and accordingly a portion of the Invoice value raised during the year totalling to INR 113 lakhs (approx) has remained unpaid and outstanding. This amount is included in the Trade Receivables(Note 12) as on 31 March 2021. This disallowance was made with respect to invoices raised by all Solar power suppliers of TANGEDCO. The suppliers, including the SPV, had originally filed a writ petition with the Hon'ble High Court of Madras in November 2017 challenging the said disallowance. The petition was withdrawn in the month of January 2019 and subsequently, the National Solar Energy Federation of India(NSEFI) of which the SPV is also a member has filed an appeal on behalf of its aggrieved members, with the Tamil Nadu Electricity Regulatory Commission(TNERC).The TNERC, vide its order dated 22 December 2020 dismissed the petition and directed that the payments to the Solar power suppliers shall be limited to the annual generation that corresponds to the CUF of 19%. The NSEFI is in the process of filing an appeal against the said Order with the Appellate Tribunal of Electricity. The management had sought and obtained a legal opinion in this matter according to which, the NSEFI has a fair chance of success in the Appeal that it is advised to file before the APTEL.

Since the Energy Purchase Agreements between the SPV and TANGEDCO do not provide for any such disallowance, no provision is considered necessary in this regard.

In TN Solar Power Energy Private Limited, The TamilNadu Generation and Distribution Corporation Limited(TANGEDCO) had disallowed generation during FY 2016-17 & FY 2017-18 in excess of 19% Capacity Utilization factor and accordingly a portion of the Invoice value raised during the respective years totalling to INR 387.00 lakhs (approx) has remained unpaid and outstanding. This amount is included in the Trade Receivables(Note 12) as on 31 March 2021. This disallowance was made with respect to invoices raised by all Solar power suppliers of TANGEDCO. The suppliers, including the SPV, had originally filed a writ petition with the Hon'ble High Court of Madras in November 2017 challenging the said disallowance. The petition was withdrawn in the month of January 2019 and subsequently, the National Solar Energy Federation of India(NSEFI) of which the SPV is also a member has filed an appeal on behalf of its aggrieved members, with the Tamil Nadu Electricity Regulatory Commission(TNERC). The TNERC, vide its order dated 22 December 2020 dismissed the petition and directed that the payments to the Solar power suppliers shall be limited to the annual generation that corresponds to the CUF of 19%. The NSEFI is in the process of filing an appeal against the said Order with the Appellate Tribunal of Electricity. The management had sought and obtained a legal opinion in this matter according to which, the NSEFI has a fair chance of success in the Appeal that it is advised to file before the APTEL.

Since the Energy Purchase Agreements between the SPV and TANGEDCO do not provide for any such disallowance, no provision is considered necessary in this regard.

In Universal Mine Developers and Service Providers Private Limited, the TamilNadu Generation and Distribution Corporation Limited(TANGEDCO) had disallowed generation during FY 2016-17 & FY 2017-18 in excess of 19% Capacity Utilization factor and accordingly a portion of the Invoice value raised during the respective years totalling to INR 180 lakhs (approx) has remained unpaid and outstanding. This amount is included in the Trade Receivables(Note 12) as on 31st March 2021 (and 31st March 2020). This disallowance was made with respect to invoices raised by all Solar power suppliers of TANGEDCO. The suppliers, including the SPV, had originally filed a writ petition with the Hon'ble High Court of Madras in November 2017 challenging the said disallowance. The petition was withdrawn in the month of January 2019 and subsequently, the National Solar Energy Federation of India(NSEFI) of which the SPV is also a member has filed an appeal on behalf of its aggrieved members, with the Tamil Nadu Electricity Regulatory Commission(TNERC). The TNERC, vide its order dated 22 December 2020 dismissed the petition and directed that the payments to the Solar power suppliers shall be limited to the annual generation that corresponds to the CUF of 19%. The NSEFI is in the process of filing an appeal against the said Order with the Appellate Tribunal of Electricity. The management had sought and obtained a legal opinion in this matter according to which, the NSEFI has a fair chance of success in the Appeal that it is advised to file before the APTEL.

Since the Energy Purchase Agreements between the SPV and TANGEDCO do not provide for any such disallowance, no provision is considered necessary in this regard.

In PLG Photovoltaic Private Limited and Terralight Solar Energy Charanka Private Limited (Formerly Sindicatum Solar Energy Gujarat Private Limited), The Gujarat Electricity Regulatory Commission (State Commission) vide an order dated January 29, 2010 finalised the tariff rates for procurement of power by Gujarat Urja Vikas Nigam Limited (GUVNL) from Solar Energy Developers in the state of Gujarat. GUVNL filed a petition before GERC, seeking the redetermination of tariff rates, basis the actual capital cost, cost of funds deployed etc. GERC vide its order dated August 08, 2013, turned down the petition filed by GUVNL. The above order of GERC was challenged by GUVNL before "Appellate Tribunal for Electricity, (APTEL)" and it was turned down by the appellate authority vide its order dated 22 August 2014. GUVNL subsequently moved to the Supreme Court and the matter is yet to be heard. Considering the status, it is not possible for the management to estimate the extent of the change, if any, in the tariff applicable under the 2010 Tariff Order. Based on external legal opinion, the management is confident of dismissal of appeal filed by GUVNL and hence no adjustments have been made in the financial statements.

#### **47 Government Grants**

Government of India (GOI) through Ministry of New and Renewable Energy (MNRE) has notified on 14 March 2016 Guidelines to select Solar Power Developers for setting up 5000 MW of grid connected Solar PV Power Projects under Phase II Batch IV of the National Solar Mission (NSM). The guidelines inter alia provides for implementing the Projects through 'Viability Gap Funding' (VGF) support under State Specific VGF Scheme to the Solar Power Developer (SPD) in order to minimise the impact of tariff on buying utilities.

As per VGF securitization agreement entered into with Solar Energy Corporation of India Limited (SECI), on fulfillment of certain conditions laid down in the agreement, Solar Edge Power and Energy Private Limited is eligible for VGF facility of INR 2470 lakhs for below mentioned projects.

Project	VGF Amount (INR Lakhs)
30 MW at Mhatragaon, Beed	570.00
50 MW at Mhatragaon, Beed	950.00
50 MW at Wadhave, Muktainagar	950.00
	<b>2,470.00</b>

During the previous year, the SPV has complied with the conditions to be fulfilled for disbursement of VGF facility for 50 MW Project in Beed and 50MW Project in Muktainagar and has received INR 1900 lakhs under the VGF Agreement. The balance amount of INR 570 lakhs was received in May 2020.

The SPV amortises the grant (VGF Facility from SECI) as deferred income that is recognised in profit or loss on a systematic basis over the term of Power Purchase Agreement i.e 25 years under the head 'Note 27- Other income'. The unamortised portion of the grant is disclosed under 'Note 23 "Other liabilities"'.

Events and other contingencies on accordance of which the VGF that has been recognised may be recovered is as under:

- If the Project fails to generate any power continuously for 1 year any time during the term of PPA or
- If the Project is dismantled and/or its major assets (the Project components such as Solar PV modules, invertors, power conditioning units, module mounting structures, Grid interconnecting transformers, control, protection and metering equipment etc) are sold by SPV during the term of PPA except for replacement of any equipment including major assets of the Project during the term of PPA without diluting the charge of SECI over such asset or
- If it is found at any stage that the SPV has misrepresented the facts/information to meet the eligibility conditions stipulated in Request for Selection (RFS) document issued by SECI or
- If the SPV defaults any terms and conditions of loan documents and the lender takes any step for recovery, including for winding up of the SPV or
- If (i) the SPV becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding up proceedings and such proceedings remain uncontested for a period of 30 days, or (ii) any winding up or bankruptcy or insolvency order is passed against the SPV, or (iii) the SPV goes into liquidation or dissolution or has a receiver or any similar officer appointed to manage its affairs pursuant to Law or
- Save and except permitted by SECI for transferring of controlling shareholding pattern within the same Group Companies subject to the conditions that the management control remains within the same Group Companies, if the SPV fails to maintain its controlling shareholding represented to SECI at the time of signing PPA upto period of 1 year after COD of the Project as per terms and conditions of PPA or
- If any attachment or distraint is levied on the mortgaged/ charged property or any thereof and/or proceedings are taken or commenced for recovery of any dues from the SPV or
- If during the subsistence of the VGF Agreement, the SPV fails to comply with the applicable law in relation the Project provided that such non-compliance results in revocation or reversal of any consent or approval obtained by the SPV in relation to the Project.



48 Disclosures as required by SEBI Circular no. CIR/IMD/DF/14/2016 dated 20 October 2016

(a) Project wise operating cash flows for the year ended 31 March 2021:

Particulars	Solar Edge Power and Energy Private Limited	Terralight Kanji Solar Private Limited (formerly Shapoorji Pallonji Solar PV Private Limited)	TN Solar Power Energy Private Limited	Universal Mine Developers and Service Providers Private Limited	Rajapalayam Assets	PLG Photovoltaic Private Limited	Terralight Solar Energy Tinwari Private Limited (formerly Sindicatum Solar Energy Private Limited)	Terralight Solar Energy Charanka Private Limited (formerly Sindicatum Solar Energy Gujarat Private Limited)	Universal Saur Urja Private Limited	Total
<b>Profit/(Loss) before tax</b>	<b>(17,977.69)</b>	<b>(3,683.34)</b>	<b>(3,672.22)</b>	<b>(3,987.10)</b>	<b>(8,717.14)</b>	<b>(3,230.29)</b>	<b>29.92</b>	<b>(511.86)</b>	<b>1,430.71</b>	<b>(40,319.01)</b>
Adjustments for:										
Depreciation and amortisation expense	3,917.13	1,494.35	1,056.71	1,181.79	1,009.06	1,744.96	597.51	1,128.90	1,530.24	13,660.65
Impairment loss on PPE	14,275.00	1,685.00	3,245.00	3,059.00	7,563.98	2,667.63	-	-	-	32,495.61
Loss on sale of property, plant and equipment (net)	-	3.37	-	-	-	98.47	-	5.96	-	108.80
Loss on receivable written off	-	-	-	-	-	-	5.36	-	-	5.36
Impairment loss on investment	-	-	-	-	-	317.13	332.00	-	-	649.13
Excess provisions written back	(641.28)	-	(426.52)	(208.74)	-	-	-	-	-	(1,276.54)
Interest income	(123.59)	(52.18)	(41.21)	(36.45)	(63.71)	(169.58)	(58.08)	(93.11)	(163.12)	(801.03)
Amortization of VGF receipt	(144.26)	-	-	-	-	-	-	-	-	(144.26)
Finance cost	8,439.77	3,257.00	1,924.61	2,108.64	2,331.87	1,503.01	382.87	716.14	1,579.65	22,243.56
<b>Operating profit before working capital changes and other adjustments</b>	<b>7,745.08</b>	<b>2,704.20</b>	<b>2,086.37</b>	<b>2,117.14</b>	<b>2,124.06</b>	<b>2,932.33</b>	<b>1,289.58</b>	<b>1,246.03</b>	<b>4,377.48</b>	<b>26,622.27</b>
Working capital changes and other adjustments										
Inventories	(6.98)	0.41	(1.36)	0.40	(2.43)	1,266.70	(166.87)	563.11	85.21	13,102.31
Trade receivables	286.44	2,495.30	1,683.80	1,840.96	2,568.98	-	-	2.29	(1.36)	(9.03)
Financial and other assets	(1,051.58)	(2,102.08)	(11.00)	500.59	1,241.84	(87.07)	(129.83)	-	-	8,745.55
Trade payables	(150.71)	(35.47)	(150.79)	(164.20)	1,438.91	79.24	(46.71)	96.71	(42.17)	(1,448.05)
Financial and other liabilities	88.18	769.73	958.29	1,256.78	(100.69)	1,274.53	2.97	543.19	(20.20)	1,041.06
<b>Cash flow from/(used in) operating activities post working capital changes</b>	<b>6,910.43</b>	<b>3,832.09</b>	<b>4,565.31</b>	<b>5,551.67</b>	<b>7,270.57</b>	<b>4,199.03</b>	<b>1,122.71</b>	<b>1,809.14</b>	<b>4,462.69</b>	<b>39,724.58</b>
Income tax paid (net)	(7.21)	-	(2.50)	-	-	(126.24)	28.36	35.21	(242.64)	(315.02)
<b>Net cash generated from/(used in) operating activities</b>	<b>6,903.22</b>	<b>3,832.09</b>	<b>4,562.81</b>	<b>5,551.67</b>	<b>7,270.57</b>	<b>4,072.79</b>	<b>1,151.07</b>	<b>1,844.35</b>	<b>4,220.05</b>	<b>39,409.56</b>

Project wise operating cash flows for the year ended 31 March 2020:

Particulars	Solar Edge Power and Energy Private Limited	Terralight Kanji Solar Private Limited (formerly Shapoorji Pallonji Solar PV Private Limited)	TN Solar Power Energy Private Limited	Universal Mine Developers and Service Providers Private Limited	Rajapalayam Assets	PLG Photovoltaic Private Limited	Terralight Solar Energy Tinwari Private Limited (formerly Sindicatum Solar Energy Private Limited)	Terralight Solar Energy Charanka Private Limited (formerly Sindicatum Solar Energy Gujarat Private Limited)	Universal Saur Urja Private Limited	Total
<b>Profit/(Loss) before tax</b>	<b>(2,086.66)</b>	<b>(153.88)</b>	<b>(86.53)</b>	<b>(62.51)</b>	<b>44.80</b>	<b>(952.27)</b>	<b>(18.33)</b>	<b>(421.85)</b>	<b>(2,279.67)</b>	<b>(6,016.88)</b>
Adjustments for:										
Depreciation and amortisation expense	4,430.20	1,559.93	1,187.47	1,300.79	1,235.91	1,757.76	603.93	1,129.68	1,702.79	14,908.46
Finance cost	8,355.00	2,264.61	1,518.23	1,647.61	1,516.38	1,719.70	449.80	814.93	1,806.96	20,093.22
(Gain) / loss on sale of property, plant and equipment (net)	-	-	-	-	-	-	-	-	-	-
Gain on sale of investments (net)	-	-	-	-	-	120.35	-	-	-	120.35
Gain on investments carried at fair value through profit or loss (net)	-	-	-	-	-	-	-	-	-	-
Foreign exchange loss	-	-	-	-	-	20.48	-	-	-	20.48
Excess provisions written back	(266.50)	-	-	-	-	-	-	-	-	(266.50)
Interest income	(283.52)	(57.39)	(4.26)	(3.89)	(53.08)	(168.75)	(78.43)	(94.99)	(136.76)	(881.07)
Remeasurement of defined benefit obligations (net of tax)	-	-	-	-	-	-	-	-	-	-
Bad debt Expenses	-	-	-	-	-	-	-	-	3,182.00	3,182.00
Allowance for doubtful advances	-	-	-	-	-	-	302.97	-	-	302.97
Advances and other sundry balance written off	-	-	-	-	-	263.95	-	-	-	263.95
Amortization of VGF receipt	(152.06)	-	-	-	-	-	-	-	-	(152.06)
<b>Operating profit before working capital changes and other adjustments</b>	<b>9,996.52</b>	<b>3,613.29</b>	<b>2,614.91</b>	<b>2,882.00</b>	<b>2,744.01</b>	<b>2,761.22</b>	<b>1,259.94</b>	<b>1,427.77</b>	<b>4,275.32</b>	<b>31,574.98</b>
Working capital changes and other adjustments										
Inventories	-	(0.39)	(2.61)	(2.22)	-	-	0.18	(25.75)	(8.45)	(39.24)
Trade receivables	(1,052.51)	(2,619.73)	(1,645.63)	(1,634.26)	(2,384.54)	-	-	-	-	(9,336.67)
Financial and other assets	1,101.78	(16.18)	(284.32)	(301.89)	(288.69)	(248.62)	6.09	17.08	38.26	23.48
Trade payables *	(536.96)	24.09	161.09	129.88	(4,691.50)	(193.06)	23.95	30.18	(220.77)	(5,273.10)
Financial and other liabilities	(49.71)	1,089.64	560.27	553.50	546.68	1,472.34	4.19	550.26	(89.52)	4,637.65
<b>Cash flow from/(used in) operating activities post working capital changes</b>	<b>9,459.10</b>	<b>2,090.71</b>	<b>1,403.71</b>	<b>1,627.01</b>	<b>(4,074.04)</b>	<b>3,791.88</b>	<b>1,294.35</b>	<b>1,999.54</b>	<b>3,994.84</b>	<b>21,587.09</b>
Income tax paid (net)	(28.35)	-	(2.50)	-	-	(140.50)	15.24	(30.26)	(204.57)	(390.94)
<b>Net cash generated from/(used in) operating activities</b>	<b>9,430.75</b>	<b>2,090.71</b>	<b>1,401.21</b>	<b>1,627.01</b>	<b>(4,074.04)</b>	<b>3,651.38</b>	<b>1,309.59</b>	<b>1,969.28</b>	<b>3,790.27</b>	<b>21,196.15</b>

Project wise operating cash flows for the year ended 31 March 2019:

Particulars	Solar Edge Power and Energy Private Limited	Terralight Kanji Solar Private Limited (formerly Shapoorji Pallonji Solar PV Private Limited)	TN Solar Power Energy Private Limited	Universal Mine Developers and Service Providers Private Limited	Rajapalayam Assets	PLG Photovoltaic Private Limited	Terralight Solar Energy Tinwari Private Limited (formerly Sindicatum Solar Energy Private Limited)	Terralight Solar Energy Charanka Private Limited (formerly Sindicatum Solar Energy Gujarat Private Limited)	Universal Saur Urja Private Limited	Total
<b>Loss before tax</b>	<b>(1,968.39)</b>	<b>(192.28)</b>	<b>16.77</b>	<b>(111.74)</b>	<b>369.05</b>	<b>(1,575.28)</b>	<b>130.38</b>	<b>(4,481.77)</b>	<b>207.56</b>	<b>(7,605.70)</b>
Adjustments for:										
Depreciation and amortisation expense	4,208.11	1,560.07	1,187.37	1,300.61	631.70	1,768.87	582.92	1,152.60	1,904.12	14,296.37
Impairment loss	-	-	-	-	-	-	-	-	-	-
Finance cost	7,133.17	2,281.75	1,443.28	1,630.34	14.85	2,164.09	514.39	967.14	2,520.64	18,669.65
Loss on sale of property, plant and equipment (net)	0.89	-	-	-	-	-	-	-	4.12	5.01
Impairment loss on investment	-	-	-	-	-	-	167.76	2,209.37	-	2,377.13
Foreign exchange loss	-	-	-	-	-	-	(0.11)	-	-	13.43
Interest income	(8.46)	(34.44)	(0.67)	-	(0.31)	(87.28)	(63.35)	(74.02)	(121.45)	(409.98)
Dividend income	(30.27)	-	-	-	-	-	-	-	-	(30.27)
<b>Operating profit before working capital changes and other adjustments</b>	<b>9,335.05</b>	<b>3,615.10</b>	<b>2,646.75</b>	<b>2,819.21</b>	<b>1,015.29</b>	<b>2,283.94</b>	<b>1,311.99</b>	<b>(226.68)</b>	<b>2,217.31</b>	<b>27,315.64</b>
Working capital changes and other adjustments										
Inventories	-	1.36	1.69	1.09	-	1,944.27	(161.00)	525.65	2,217.31	-
Trade receivables	(1,979.70)	113.09	158.25	32.40	(1,255.80)	-	(0.94)	2.66	(2.22)	3.64
Financial and other assets	(1,055.35)	419.20	(14.98)	(18.09)	76.26	156.62	(8.70)	(31.94)	1,815.48	(2,931.76)
Trade payables *	(17,244.19)	(613.42)	(11.62)	(6.40)	4,684.29	239.05	(147.13)	1.75	282.46	(12,815.21)
Financial and other liabilities	(32.36)	253.95	99.29	128.97	(3.94)	1,548.60	(5.17)	555.84	119.37	2,664.55
<b>Cash flow from operating activities post working capital changes</b>	<b>(10,976.55)</b>	<b>3,789.28</b>	<b>2,879.38</b>	<b>2,957.18</b>	<b>4,516.10</b>	<b>6,172.48</b>	<b>989.05</b>	<b>827.28</b>	<b>4,432.40</b>	<b>15,575.36</b>
Income tax paid (net)	-	-	-	-	-	(70.46)	(65.23)	(43.04)	(147.33)	(326.06)
<b>Net cash generated from/(used in) operating activities</b>	<b>(10,976.55)</b>	<b>3,789.28</b>	<b>2,879.38</b>	<b>2,957.18</b>	<b>4,516.10</b>	<b>6,102.02</b>	<b>923.82</b>	<b>784.24</b>	<b>4,285.07</b>	<b>15,249.30</b>

\* Trade payables includes creditor for capital goods

(b) Capitalisation statement

Particulars	Pre-issue as at 31 March 2021	As adjusted for issue*
Non-current borrowings	1,13,438.00	-
Current borrowings	63,572.79	-
Current maturities of non-current borrowings	5,140.41	-
<b>Total debt (A)</b>	<b>1,82,151.20</b>	<b>-</b>
Equity share capital	43,619.57	-
Instrument entirely equity in nature	3,929.00	-
Other equity	(56,031.36)	-
<b>Total equity (B)</b>	<b>(8,482.79)</b>	<b>-</b>
<b>Debt equity ratio [A/(A+B)]</b>	<b>-</b>	<b>-</b>

\* corresponding details post private placement are not available, hence the required disclosures in respect of the same have not been provided in the above table.

(c) Debt payment history

i) Solar Edge Power and Energy Private Limited

Particulars	As at 31 March 2021					As at 31 March 2020			As at 31 March 2019		
	Term loans	Non convertible debentures	Compulsorily convertible debentures	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan
Carrying amount of debt at the beginning of the year	60,663.45	-	-	-	10,984.90	63,212.08	-	10,485.50	57,900.00	-	6,300.00
Additional borrowings during the year	60,603.10	1.00	12,153.27	-	-	-	-	4,667.17	9,900.00	-	5,202.50
Repayments during the year	(61,964.70)	-	-	-	(10,984.90)	(2,548.63)	-	(4,167.77)	(4,587.92)	-	(1,017.00)
Other adjustments/settlements during the year	-	-	-	-	-	-	-	-	-	-	-
Carrying amount of debt at the end of the year	59,301.85	1.00	12,153.27	-	-	60,663.45	-	10,984.90	63,212.08	-	10,485.50

ii) Terralight Kanil Solar Private Limited (formerly Shaooorli Palloni Solar PV Private Limited)

Particulars	As at 31 March 2021					As at 31 March 2020			As at 31 March 2019		
	Term loans	Non convertible debentures	Compulsorily convertible debentures	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan
Carrying amount of debt at the beginning of the year	16,175.04	-	-	1,490.69	4,265.00	17,122.12	769.12	4,158.00	17,983.57	291.87	4,158.00
Additional borrowings during the year	-	2.40	24,182.21	-	-	-	721.57	217.00	-	477.25	-
Repayments during the year	(16,231.73)	(319.94)	-	(1,490.69)	(4,265.00)	(947.08)	-	(110.00)	(861.45)	-	-
Other adjustments/settlements during the year	-	1,947.56	-	-	-	-	-	-	-	-	-
Carrying amount of debt at the end of the year	-	1,630.02	24,182.21	-	-	16,175.04	1,490.69	4,265.00	17,122.12	769.12	4,158.00

iii) Universal Mine Developers and Service Providers Private Limited

Particulars	As at 31 March 2021					As at 31 March 2020			As at 31 March 2019		
	Term loans	Non convertible debentures	Compulsorily convertible debentures	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan
Carrying amount of debt at the beginning of the year	12,945.67	-	-	385.67	524.16	13,506.92	-	292.16	14,218.67	464.98	2,151.50
Additional borrowings during the year	-	2.40	15,065.87	-	-	-	385.67	253.00	-	-	150.66
Repayments during the year	(12,945.67)	(287.59)	-	(385.67)	(524.16)	(563.25)	-	(21.00)	(709.75)	(464.98)	(2,010.00)
Other adjustments/settlements during the year	-	1,530.14	-	-	-	-	-	-	-	-	-
Carrying amount of debt at the end of the year	-	1,244.95	15,065.87	-	-	12,945.67	385.67	524.16	13,506.92	-	292.16

iv) TN Solar Power Enerov Private Limited

Particulars	As at 31 March 2021					As at 31 March 2020			As at 31 March 2019		
	Term loans	Non convertible debentures	Compulsorily convertible debentures	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan
Carrying amount of debt at the beginning of the year	11,713.00	-	-	288.67	271.25	12,265.96	0.00	20.00	12,951.40	309.53	1,912.00
Additional borrowings during the year	-	2.40	13,445.86	-	-	-	288.67	297.25	-	-	20.00
Repayments during the year	(11,713.00)	(259.89)	-	(288.67)	(271.25)	(552.96)	-	(46.00)	(685.44)	(309.53)	(1,912.00)
Other adjustments/settlements during the year	-	1,652.45	-	-	-	-	-	-	-	-	-
Carrying amount of debt at the end of the year	-	1,394.96	13,445.86	0.00	-	11,713.00	288.67	271.25	12,265.96	0.00	20.00

v) Rajapalayam Asset

Particulars	As at 31 March 2021					As at 31 March 2020			As at 31 March 2019		
	Term loans	Non convertible debentures	Compulsorily convertible debentures	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan
Carrying amount of debt at the beginning of the year	13,651.13	-	-	921.22	-	4,455.00	-	-	-	-	-
Additional borrowings during the year	48.10	0.60	18,533.33	-	-	9,500.00	921.22	-	4,455.00	-	-
Repayments during the year	(13,699.23)	(83.23)	-	(921.22)	-	(319.20)	-	-	-	-	-
Other adjustments/settlements during the year	-	62.63	-	-	-	15.33	-	-	-	-	-
Carrying amount of debt at the end of the year	-	-	18,533.33	-	-	13,651.13	921.22	-	4,455.00	-	-

vi) Terralight Solar Energy Tinwari Private Limited (formerly Sindicatum Solar Energy Private Limited)

Particulars	As at 31 March 2021					As at 31 March 2020			As at 31 March 2019		
	Term loans	Non convertible debentures	Compulsorily convertible debentures	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan
Carrying amount of debt at the beginning of the year	3,765.05	-	-	-	-	4,330.34	-	-	4,623.26	-	-
Repayments during the year	(370.61)	-	-	-	-	(570.44)	-	-	(298.23)	-	-
Other adjustments/settlements during the year	4.63	-	-	-	-	5.15	-	-	5.31	-	-
Carrying amount of debt at the end of the year	3,399.07	-	-	-	-	3,765.05	-	-	4,330.34	-	-

vii) Universal Saur Uri Private Limited

Particulars	As at 31 March 2021					As at 31 March 2020			As at 31 March 2019		
	Term loans	Non convertible debentures	Compulsorily convertible debentures	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan
Carrying amount of debt at the beginning of the year	14,652.21	-	-	-	-	16,049.73	-	-	15,244.32	-	-
Additional borrowings during the year	-	-	-	-	-	-	-	-	17,000.00	-	-
Repayments during the year	(919.78)	-	-	-	-	(1,397.52)	-	-	(16,194.59)	-	-
Carrying amount of debt at the end of the year	13,732.43	-	-	-	-	14,652.21	-	-	16,049.73	-	-

viii) Terralight Solar Energy Charanka Private Limited (formerly Sindicatum Solar Enerov Gujarat Private Limited)

Particulars	As at 31 March 2021					As at 31 March 2020			As at 31 March 2019		
	Term loans	Non convertible debentures	Compulsorily convertible debentures	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan
Carrying amount of debt at the beginning of the year	6,855.44	-	-	-	-	7,669.90	-	-	8,437.98	-	-
Repayments during the year	(879.39)	-	-	-	-	(824.42)	-	-	(778.62)	-	-
Other adjustments/settlements during the year	9.15	-	-	-	-	9.96	-	-	10.54	-	-
Carrying amount of debt at the end of the year	5,985.20	-	-	-	-	6,855.44	-	-	7,669.90	-	-

ix) PLG Private Limited

Particulars	As at 31 March 2021					As at 31 March 2020			As at 31 March 2019		
	Term loans	Non convertible debentures	Compulsorily convertible debentures	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan	Term loans	Cash credit facility	Unsecured loan
Carrying amount of debt at the beginning of the year	14,149.84	-	-	-	-	15,974.71	-	-	15,335.82	-	-
Additional borrowings during the year	-	-	-	-	-	-	-	-	17,974.84	-	-
Repayments during the year	(2,070.14)	-	-	-	-	(1,944.13)	-	-	(16,762.47)	-	-
Other adjustments/settlements during the period	114.24	-	-	-	-	119.26	-	-	(573.47)	-	-
Carrying amount of debt at the end of the year	12,193.94	-	-	-	-	14,149.84	-	-	15,974.71	-	-

(d) Statement of net assets at fair value as at 31 March 2021: #

Particulars	Book value	Fair value
A. Assets	2,08,233.07	2,73,346.06
B. Liabilities (at book value)	2,16,393.16	2,16,393.16
C. Net assets (A-B)	(8,160.09)	56,952.90

\* The number of units that Virescent Renewable Energy Trust will issue to investors in connection with the proposed private placement of units of the Trust in exchange of the shareholdings in the SPV Group is not presently ascertainable. Accordingly, disclosures in respect of Net Asset Value (NAV) per unit have not been given.

# Fair values of total assets relating to the SPV Group as at 31 March 2021 as disclosed above are solely based on the fair valuation report of the independent valuer appointed under SEBI (Infrastructure Investment Trusts) Regulations, 2014.

**Notes**

Project wise break up of fair value of assets as at 31 March 2021:

Particulars	Fair value*	Fair value (based on discount factor used for impairment assessment)**
Solar Edge Power and Energy Private Limited	88,965.87	57,089.65
Terralight Kanji Solar Private Limited (formerly	32,998.51	23,484.08
TN Solar Power Energy Private Limited	24,412.33	14,457.15
Universal Mine Developers and Service Providers Private Limited	26,430.60	17,160.17
Rajapalayam assets	24,478.37	16,588.79
Universal Saur Urja Private Limited	29,855.70	N/A^
Terralight Solar Energy Charanka Private Limited (formerlySindicatum	13,664.69	N/A^
Solar Energy Gujarat Private Limited)		
PLG Photovoltaic Private Limited ( Formerly known as 'PLG Photovoltaic	20,561.55	12,717.92
Terralight Solar Energy Tinwari Private Limited (formerly Sindicatum	11,978.44	
Solar Energy Private Limited)		N/A^

\*Owing to change in shareholding of SPV group during year ended March 31, 2021 and assigning of AAA / stable rating to Virescent Renewable Energy Trust, fair value has been computed using potential weighted average cost of capital of current shareholders. These are computed values and no transaction has been executed between buyer and seller at this valuation.

\*\* Additionally, fair value has been disclosed based on discount factor used at the time of impairment assessment by the erstwhile shareholder before acquisition of SPV Group by Terra Asia Pacific Pte. Limited, Singapore.

^ No external / internal factors existed for impairment assessment

(e) Statement of total return at fair value:

Particulars	For the year ended 31 March 2021	For the year ended 31 March 2020
Total comprehensive income for the year (As per the Combined Statement of Profit and Loss)	(40,792.25)	(4,046.66)
Add: Other changes in fair value for the year	65,112.99	-
<b>Total return</b>	<b>24,320.74</b>	<b>(4,046.66)</b>

**49 Going Concern**

As at 31 March 2021, the SPV Group has accumulated losses of INR 75,800.21 lakhs and the net worth of the Group is fully eroded and the current liabilities of the SPV Group exceeded its current assets by INR 51,917.09 lakhs. During the year ended 31 March 2021, the losses amount to Rs. 40,792.25 lakhs. However, the SPV Group has generated cashflow from operating activities of INR 39,409.56 lakhs during the year. During the year, the SPV Group has been acquired by Terra Asia Holdings II Pte. Limited, Singapore an affiliate of KKR & Co. As per the business model of the SPV Group, major expenditure of SPV Group is towards interest on term loans from banks, financial institutions and compulsorily convertible debentures held by Terra Asia Holdings II Pte. Limited which is expected to be served from the operations of the SPV Group. Current liabilities of the SPV Group mainly include short-term loan from banks and financial institution amounting to Rs. 59,301.85 lakhs obtained during the year ended 31 March 2021 towards repayment of long-term loans. Subsequent to the year, the SPV Group has refinanced its short-term loan by obtaining a fresh long-term loan.

Considering the business model of the SPV, refinancing of the short-term loan subsequent to the year end with a long-term loan and change in shareholding of the SPV Group, the going concern assumptions of the Combined financial statements is considered appropriate.

**50** The outbreak of Coronavirus disease (COVID-19) has significantly affected the economic activities across the globe, including India. The various Governments across the world including India has taken drastic measures, including locking down of entire country to reduce the impact of catastrophe. Further, banks across India allowed moratorium as measure to provide support to all companies. Though the SPV Group is engaged in power generation which is an essential service, there is no significant Impact of COVID -19 on the business of the SPV Group. Some SPVs in group availed the moratorium offered by bank as the company to manage its liquidity. The SPV Group has taken appropriate measures to safeguard its employees and assets during COVID-19. This has resulted in continuous operation of the plant and generation of revenue every month. So the group does not carry any risk in the recoverability of carrying value of its assets including Property, plant and equipments, trade receivables and inventories. The Company does not anticipate any additional liability as at the balance sheet date.

In terms of our report attached  
**For MSKA & Associates**  
Chartered Accountants  
ICAI Firm's Registration No: 105047W

For and on behalf of the Board of Directors  
**Virescent Infrastructure Investment Manager Private Limited**  
(acting as Investment Manager to Virescent Renewable Energy Trust)

**Ananthakrishnan G**  
Partner  
Membership No: 205226

**Sanjay Grewal**  
Director  
DIN: 01971866

**Hardik Shah**  
Director  
DIN: 06648474

**Charmy Bhoot**  
Company Secretary

Place: Hyderabad  
Date: 23 July 2021

Place: New York  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

Place: Mumbai  
Date: 23 July 2021

## CAPITALISATION STATEMENT

The following tables present (a) the capital structure of the Terra InvIT (including any borrowing or deferred payments) on a combined basis as at March 31, 2021; and (b) the capital structure of each of the Asset SPVs (including any borrowing or deferred payment) on a standalone basis as at March 31, 2021.

The information presented below should be read in conjunction with the sections 'Combined Financial Statements' on page 214.

### I. For the Terra InvIT on a consolidated basis:

Particulars	As at March 31, 2021	As at March 31, 2021
	Pre-Issue (in ₹ lakhs)	Post-Issue (in ₹ lakhs)*
Borrowings (non-current, current borrowings including maturity of long term borrowings, redeemable preference shares, NCDs including interest accrued)	1,89,688.50	152,386.50
Creditors for capital expenditure	221.43	221.43
<b>Total borrowings including creditors for capital expenditure</b>	<b>189,909.93</b>	<b>152,607.93</b>
Additional contribution of the Terra InvIT		46,000.00
Unit capital^	47,548.57	47,548.57
Other equity	(56,031.36)	(56,031.36)
Non-controlling interest	322.70	322.70
<b>Total equity</b>	<b>(8,160.09)</b>	<b>37,839.91</b>
<b>Debt-equity ratio</b>	<b>-23.27:1</b>	<b>4.03:1</b>

^Represents sum of equity capital and instrument entirely equity in nature

\*Based on fresh infusion of unit capital and consequent utilisation of proceeds thereof

### II. For the Project SPVs on a standalone basis:

Particulars	As at March 31, 2021					As at March 31, 2021				
	Pre-Issue (in ₹ lakh)					Post-Issue (in ₹ lakhs)				
	Solar Edge	Terralight Kanji	TNS	UMD	Terralight Rajapalaya m	Solar Edge	Terralight Kanji	TNS	UMD	Terralight Rajapalaya m
Borrowings (non-current, current borrowings including maturity of long term borrowings, redeemable preference shares, NCDs including interest accrued)	72,219.82	28,220.42	16,291.56	17,990.30	19,772.18	72,219.82	28,220.42	16,291.56	17,990.30	19,772.18
Creditors for capital expenditure	0.00	0.00	64.65	140.13	0.00	0.00	0.00	64.65	140.13	0.00
<b>Total borrowings including creditors for capital expenditure</b>	<b>72,219.82</b>	<b>28,220.42</b>	<b>16,356.21</b>	<b>18,130.43</b>	<b>19,772.18</b>	<b>72,219.82</b>	<b>28,220.42</b>	<b>16,356.21</b>	<b>18,130.43</b>	<b>19,772.18</b>
Additional contribution of the Terra InvIT										
Unit capital^	14,900.00	4,057.08	6,262.00	6,700.10	0	14,900.00	4,057.08	6,262.00	6,700.10	0
Other equity	(22,481.93)	(7,160.04)	(5,733.69)	(6,779.66)	(950.35)	(22,481.93)	(7,160.04)	(5,733.69)	(6,779.66)	(950.35)
Non-controlling interest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Total equity</b>	<b>(7,581.93)</b>	<b>(3,102.96)</b>	<b>528.31</b>	<b>(79.56)</b>	<b>(950.35)</b>	<b>(7,581.93)</b>	<b>(3,102.96)</b>	<b>528.31</b>	<b>(79.56)</b>	<b>(950.35)</b>
<b>Debt-equity ratio</b>	<b>-9.53 : 1</b>	<b>-9.09 : 1</b>	<b>30.96 : 1</b>	<b>-227.88 : 1</b>	<b>-20.81 : 1</b>	<b>-9.53 : 1</b>	<b>-9.09 : 1</b>	<b>30.96 : 1</b>	<b>-227.88 : 1</b>	<b>-20.81 : 1</b>

^Represents sum of equity capital and instrument entirely equity in nature

### III. For the Specified SPVs on a standalone basis:

Particulars	As at March 31, 2021				As at March 31, 2021			
	Pre-Issue (in ₹ lakh)				Post-Issue (in ₹ lakh)			
	PLG	TSET	TSEC	USUPL	PLG	TSET	TSEC	USUPL
Borrowings (non-current, current borrowings including maturity of long term borrowings, redeemable preference shares, NCDs including interest accrued)	12,193.94	3,363.15	5,908.35	13,732.43	12,193.94	3,363.15	5,908.35	13,732.43

Particulars	As at March 31, 2021					As at March 31, 2021			
	Pre-Issue (in ₹ lakh)					Post-Issue(in ₹ lakh)			
Creditors for capital expenditure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Total borrowings including creditors for capital expenditure</b>	<b>12,193.94</b>	<b>3,363.15</b>	<b>5,908.35</b>	<b>13,732.43</b>	<b>12,193.94</b>	<b>3,363.15</b>	<b>5,908.35</b>	<b>13,732.43</b>	
Additional contribution of the Terra InvIT									
Unit capital^	4,123.72	1,855.46	9,832.27	1,673.40	4,123.72	1,855.46	9,832.27	1,673.40	
Other equity	(10,527.92)	1,163.19	(6,563.29)	3,888.70	(10,527.92)	1,163.19	(6,563.29)	3,888.70	
Non-controlling interest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<b>Total equity</b>	<b>(6,404.20)</b>	<b>3,018.65</b>	<b>3,268.98</b>	<b>5,562.10</b>	<b>(6,404.20)</b>	<b>3,018.65</b>	<b>3,268.98</b>	<b>5,562.10</b>	
<b>Debt-equity ratio</b>	<b>-1.90 : 1</b>	<b>1.11 : 1</b>	<b>1.81 : 1</b>	<b>2.47 : 1</b>	<b>-1.90 : 1</b>	<b>1.11 : 1</b>	<b>1.81 : 1</b>	<b>2.47 : 1</b>	

<sup>^</sup>Represents sum of equity capital and instrument entirely equity in nature

## MANAGEMENT'S DISCUSSION AND ANALYSIS OF FINANCIAL CONDITION AND RESULTS OF OPERATIONS

*Investors should read the following discussion and analysis of the Asset SPVs' financial condition and results of operations together with the sections 'Summary Financial Information of the Terra InvIT' and 'Combined Financial Statements' on pages 53 and 214, respectively. This discussion contains forward-looking statements and involves numerous risks and uncertainties, including, but not limited to, those described in the section 'Risk Factors' on page 19. Actual results could differ materially from those contained in any forward-looking statements and for further details regarding forward-looking statements, refer to 'Forward-Looking Statements and Financial Projections' on page 17.*

*Since the settlement and registration of the Terra InvIT, the Terra InvIT has not undertaken any meaningful business activities and therefore the Investment Manager does not believe that a discussion of the Terra InvIT's results of operations would be meaningful. Accordingly, the following discussion includes a discussion and analysis of the financial condition and results of operations of the Asset SPVs on a combined basis as at and for the Financial Years 2021, 2020 and 2019. Ind AS differs in certain material respects from Indian GAAP, IFRS and U.S. GAAP. Accordingly, the degree to which our financial statements will provide meaningful information to a prospective investor in countries other than India is entirely dependent on the reader's level of familiarity with Ind AS.*

*The Asset SPVs' financial year ends on March 31 of each year. Accordingly, all references to a particular financial year are to the 12-month period ended March 31 of such year.*

### Overview

We are an infrastructure investment trust established under the SEBI InvIT Regulations to invest, acquire, manage and operate renewable energy projects in India.

We were established by our Sponsor, Terra Asia Holdings II Pte. Ltd, an affiliate of the funds, vehicles and/or entities managed and/or advised by affiliates of KKR. The Sponsor is a 100% subsidiary of Terra Asia Holdings I Pte. Ltd., which is in turn controlled by KKR Asia Pacific Infrastructure Holdings Pte. Ltd. Founded in 1976, KKR is a leading global investment firm that offers alternative asset management and capital markets and insurance solutions with approximately US\$428.9 billion of assets under management as of June 30, 2021. KKR sponsors investment funds that invest in private equity, credit and real assets and has strategic partners that manage hedge funds. KKR's insurance subsidiaries offer retirement, life and reinsurance products under the management of Global Atlantic. KKR aims to generate attractive investment returns by following a patient and disciplined investment approach, employing world-class people, and supporting growth in its portfolio companies and communities. In 2008, KKR established a dedicated infrastructure team and strategy focused on global investment opportunities. KKR has been one of the more active infrastructure investors globally over the past several years, having committed more than \$30 billion across over 50 infrastructure investments. Currently, KKR's infrastructure platform has expanded to include over 60 dedicated investment professionals across 10 offices covering a broad spectrum of investment opportunities in various infrastructure subsectors, including: midstream energy, renewables, power & utilities, water and wastewater, waste, telecommunications and transportation, among others. KKR continually monitors infrastructure sectors and infrastructure-related investments for emerging trends, and may identify and prioritize investments in other sectors as conditions change or cycles evolve. KKR has invested or committed \$6.2 billion of equity in private equity deals in India since 2010 with 20 investments made and 10 active portfolio companies currently. For details in relation to the Sponsor, see '**Parties to the Terra InvIT**' on page 197.

Our portfolio, which are currently wholly-owned subsidiaries of the Sponsor, consisting of nine Asset SPVs spread across states of Tamil Nadu, Maharashtra, Uttar Pradesh, Rajasthan and Gujarat will be acquired by the Terra InvIT, pursuant to consummation of the Formation Transactions. Our portfolio comprises off-takers, being SECI, TANGEDCO, NVVN, GUVNL and UPPCL. As of March 31, 2021, the following solar power projects, comprise the Terra InvIT Assets generating approximately 316.6 MW of DC power / 258 MW of AC power and subsequently in May 2021, we further acquired 77.73 MW of DC power / 68 MW of AC power:

Project Name	State	Commercial Operation Date*	Contracted Capacity (MW AC)	Capacity (MW DC)	Tariff (₹ per unit)	Off taker	Duration of PPA (years)
Solar Edge Project	Maharashtra	April, 2018	130.0	169.0	4.43	SECI	25
Terralight Kanji Project	Tamil Nadu	March, 2016	30.0	36.0	7.01	TANGEDCO	25
TN Solar Project	Tamil Nadu	November, 2015	23.0	27.6	7.01	TANGEDCO	25
UMD Project	Tamil Nadu	January, 2016	25.0	30.0	7.01	TANGEDCO	25
Terralight Rajapalayam Project	Tamil Nadu	September, 2018	50.0	54.0	3.47	TANGEDCO	25
PLG Project	Gujarat	January, 2012	20.0	20.0	₹ 15/kWh for the first 12 years and ₹ 5/kWh thereafter	GUVNL	25
TSET Project	Rajasthan	October, 2011	5.0	5.75	₹ 17.91/kWh	NVVN	25
TSEC Project	Gujarat	March, 2012	13.0	15.0	In accordance with the tariff structure specified in the TSEC PPA <sup>1</sup>	GUVNL	25
USUPL Project	Uttar Pradesh	September, 2016	30.0	36.98	₹ 9.33/kWh for the first 12 years and from the 13th year, tariff will be as determined in accordance with the USUPL PPA.	UPPCL	25

\*Weighted average commercial operation date based on commissioned capacity

<sup>1</sup> Tariff structure for TSEC Project is as stated below:

Capacity	Tariff 1 (₹ / kWh)	Tariff 1 End Date	Tariff 2 (₹ / kWh)	Tariff 2 End Date
4.0	15.00	March 3, 2024	5.00	March 3, 2037
6.0	9.98	March 30, 2024	7.00	March 30, 2037
4.9	9.98	October 30, 2024	7.00	April 11, 2037
0.1	9.98	October 30, 2024	7.00	October 30, 2037

For details of the Terra InvIT Assets and the PPAs entered into by the Asset SPVs, see **‘Business- Details of the Asset SPVs and the Terra InvIT Assets’** and **‘Summary of Power Purchase Agreements’** on pages 139 and 154.

The revenue from operations of the Asset SPVs on a combined basis for the Financial Years ending March 31, 2021, March 31, 2020, and March 31, 2019 was ₹34,423.98 lakhs, ₹35,134.95 lakhs, and ₹32,766.51 lakhs respectively. The EBITDA and EBITDA Margin of the Asset SPVs on a combined basis for the Financial Years ending March 31, 2021, March 31, 2020, and March 31, 2019 was ₹26,314.46lakhs and 76.44%, ₹31,118.64lakhs and 88.57%, and ₹27,064.50 lakhs and 82.60% respectively. For more information about the Combined Financial Statements of the SPVs, see **‘Combined Financial Statements’** on page 214.

### Basis of Presentation

The Terra InvIT has not previously been in existence. On the Closing Date, our Terra InvIT Assets will comprise of nine Asset SPVs, namely Solar Edge, Terralight Kanji, TN Solar, UMD, Terralight Rajapalayam, PLG, TSET, TSEC and USUPL in the states of Maharashtra, Tamil Nadu, Gujarat, Uttar Pradesh and Rajasthan.

We have prepared the Audited Special Purpose Combined Financial Statements in order to present the historical financial position, results of operations, cash flow statement, along with related financial schedules and explanatory notes, on a combined basis, for the Financial Years ended March 31, 2021, March 31, 2020 and March 31, 2019.



The Audited Special Purpose Combined Financial Statements do not reflect what will be the consolidated financial position, results of operations and cash flows of the Terra InvIT, nor do they necessarily give an indication of the financial position, results of operations and cash flows of the Terra InvIT and the Asset SPVs for the future.

## **Factors affecting Results of Operations**

Our business and results of operations have been affected and will continue to be affected in future by a number of important factors, including:

- ***Operational performance of the underlying solar assets***

Our revenue is primarily dependent on the volume of power generated and sold by our Terra InvIT Assets. Our results of operations are materially influenced by the degree to which we operate our Terra InvIT Assets in order to achieve maximum generation of power in an efficient and cost-effective manner. The power generation capability of our Terra InvIT Assets is dependent on a number of factors, including suitable weather conditions, the length of scheduled and any unexpected downtime required for maintenance and upkeep of our power plants and the generation efficiency of our Terra InvIT Assets. Generation of solar energy do not typically vary much year on year with limited variation in annual radiation levels. Therefore, maintaining a consistent PLF over the years will ensure us to maintain stable cash flows from our Terra InvIT Assets.

- ***Tariff structures under the long-term PPA agreements;***

Our combined revenues primarily consist of sale of power generated from our solar power projects under the terms of our long term PPAs. As a result, a key factor affecting our results of operations is the terms of our PPAs and the creditworthiness of our off-takers. We have entered into long term PPAs with central and state off-takers such as SECI, TANGEDCO, GUVNL, NVVN and UPPCL. Except for one, all our PPAs are structured with pre-agreed fixed tariffs; all of which have a term of 25 years, thereby providing downside protection. For further details on the terms of our PPA, see '*Summary of Power Purchase Agreements*', '*Business*', '*Material Litigation and Regulatory Actions*'.

- ***Creditworthiness of the Off-takers***

The off-takers with whom we have entered into long term PPAs are central and state off-takers. Our projects provide stable long-term recurring revenue and we have generally received payments due to us under the PPAs. Considering these are central and state off-takers, any delays in payment are generally subsequently honoured. Further, delay or default beyond existing receivable cycle could have an adverse impact on the Asset SPVs and consequently affect our results of operations and cash flows.

- ***Factors affecting our O&M expenses***

One of the key activities of Terra InvIT will be the operation and maintenance of the Terra InvIT Assets. In particular, each of the PPAs require the Asset SPVs to maintain the Terra InvIT Assets in accordance with certain standards during its operation period. Within the scope of such operation and maintenance obligations, the Asset SPVs may be required to undertake routine and periodic maintenance for, amongst others, evacuation of solar power generated, minimising drawal of reactive power, automatic safety devices, etc. After the completion of the Formation Transactions, the activities of the Asset SPVs will be managed and supervised by the Project Manager pursuant to the Project Management Agreement. The Project Manager shall manage the critical day-to-day operation and maintenance of the Terra InvIT Assets. The Project Manager, through the Project Management Agreement, undertakes to (i) provide operations and management support, either directly or through the appointment and supervision of agents and/or contractors; and (ii) oversee the progress of development, approval status and other aspects of any expansion of the projects, or, of any new project proposed to be executed by the Asset SPVs.

While we aim to maintain a competitive cost of operations, increases in our cost structure could have a material adverse impact on our financial performance.

- ***Financing costs***

We have financed our existing projects with a combination of equity, debt financing, and cash flow from operations. Debt financing comprises of borrowings from commercial banks, financial institutions and related parties. As the tariffs under our PPAs do not increase (or decrease) correspondingly as a result of

any increase (or decrease) in interest costs, any increase in financing costs of borrowings from commercial banks, financial institutions, related parties could have an adverse impact on our costs of operations and therefore, our profitability and cash flows.

- **Tax benefits**

Under Section 80-IA of the Income Tax Act, a deduction equal to 100% of the profits and gains derived from, among others, power generating undertakings, provided prescribed conditions under the said section are satisfied, for any 10 consecutive years out of 15 years from the year in which the undertaking begins generating power or commences transmission or distribution of power, provided such year is prior to April 1, 2017 is available. Accordingly, the following Asset SPVs will be subject to the aforementioned deductions:

Name of the entity	COD– Financial Year	Has the entity claimed any deduction under section 80-IA	Expiration of 15 years
Solar Edge (130 MW (AC))	FY 2018-2019	Ineligible	N.A.
Terralight Kanji (previously known as Solar PV) (30 MW (AC))	FY 2015-2016	No	FY 2030-2031
TN Solar (23 MW (AC))	FY 2015-2016	No	FY 2030-2031
UMD (25 MW (AC))	FY 2015-2016	No	FY 2030-2031
Terralight Rajapalayam (previously known as SP Suryaprakash) (50 MW (AC))	FY 2018-2019	Ineligible	N.A.
PLG (20 MW (AC))	FY 2011-12	No	FY 2026-27
TSET(5 MW (AC))	FY 2011-12	Yes	-
TSEC (13 MW (AC))	FY 2011-12 and FY 2012-13	Yes	-
USUPL (30 MW (AC))	FY 2016-17	No	FY 2031-32

## Significant Accounting Policies

### 1.1 Basis of preparation and presentation

The Combined Financial Statements of the Terra InvIT comprise the Combined Balance Sheet as at March 31, 2021, March 31, 2020 and March 31, 2019 and the Combined Statement of Profit and Loss, Combined Cash Flow Statement, Combined Statement of Changes in Equity and a Summary of Significant Accounting Policies and Other Explanatory Information for the for the years ended March 31, 2021, March 31, 2020 and March 31, 2019.

The Combined Financial Statements were authorized for issue in accordance with resolutions passed by the Board of Directors of the Investment Manager on July 23, 2021.

The Combined Financial Statements have been prepared in accordance with Indian Accounting Standards as defined in Rule 2(1)(a) of the Companies (Indian Accounting Standards) Rules, 2015 prescribed under Section 133 of the Companies Act, 2013 (“**Ind AS**”) read with SEBI (Infrastructure Investment Trusts) Regulations, 2014 and the circulars issued thereunder (“**SEBI InvIT Regulations**”) and the Guidance Note on Combined and Carve-Out Financial Statements issued by the Institute of Chartered Accountants of India (“**Guidance Note**”).

The combined financials statements are special purpose financials statements and have been prepared by the Investment manager to meet the requirement of SEBI InvIT Regulations and for inclusion in the final placement memorandum prepared by Investment Manager in connection with the proposed private placement of units of Terra InvIT. As required under the SEBI InvIT Regulations, the combined financial statements are prepared, based on an assumption that all the assets and liabilities of this business unit for earlier periods were part of Terra InvIT. Accordingly, equity portion of Terralight Rajapalayam (previously known as SP Suryaprakash) (50 MW (AC)) for the last two financial years (for the year ended March 31, 2020 and March 31, 2019) have been classified as ‘*Equity of acquired business undertaking*’ for the preparation of these Combined Financial Statements. For year ended March 31, 2021, the residual value of ‘*Equity of acquired business undertaking*’ has been transferred to ‘*Capital*

*reserve*’ owing to business transfer agreement between the Sponsor and Shapoorji Pallonji Infrastructure Capital Company Private Limited (SPICC) for transferring Terralight Rajapalayam Project to Terralight Rajapalayam (previously known as SP Suryaprakash) and consequently 100% of Terralight Rajapalayam (previously known as SP Suryaprakash) equity being held by the Sponsor. As a result, the Combined Financial Statements may not be suitable for another purpose.

The Combined Financial Statements are presented in India Rupees which is also the functional currency of the Terra InvIT. All values are rounded to the nearest lakhs, unless otherwise indicated.

These Combined Financial Statements correspond to the classification provisions contained in Ind AS 1 ‘Presentation of Financial Statements’. For clarity purposes, various items are aggregated in the Combined Statement of Profit and Loss and Combined Balance Sheet. These items are disaggregated separately in the notes to the Combined Financial Statements, where applicable or required.

These Combined Financial Statements have been prepared on a historical cost convention and on an accrual basis except for certain financial assets and liabilities measured at fair value (refer accounting policy regarding financial instruments).

## 1.2 Basis of Combination and carve-out

The Combined Financial Statements have been prepared using uniform accounting policies for like transactions and other events in similar circumstances. The financial statements of all the Asset SPVs used for the purpose of combination are drawn up to the same reporting date i.e. year ended on March 31 each year. The financial statements of the Asset SPVs have been prepared in accordance with the accounting standards notified under the Section 133 of the Companies Act 2013 (the “Companies Act”) (“Companies (Indian Accounting Standards) Rules, 2015”) and other relevant provisions of the Act.

The procedure for preparing Combined Financial Statements of the Terra InvIT are stated below –

- Combine like items of assets, liabilities, equity, income, expenses, and cash flows of the Asset SPVs
- Since Terralight Rajapalayam (previously known as SP Suryaprakash) was an existing entity with negligible operations – it acquired 50MW solar assets of Terralight Rajapalayam Project through a business transfer agreement which was entered as part of the acquisition transaction by Terra II Asia Holdings Pte Ltd. The Combined Financial Statements for the years ended March 31, 2019, March 31, 2020 and March 31, 2021, also consists of the carve out financials of Terralight Rajapalayam Project.
- Net assets taken over by Terralight Rajapalayam (previously known as SP Suryaprakash) from Terralight Rajapalayam Project have been adjusted for purchase consideration paid by Terralight Rajapalayam (previously known as SP Suryaprakash). The same has been reflected under “*Equity of acquired undertaking*” as part of other equity and transferred to capital reserve as on March 31, 2021.

### a) Date of commencement of commercial operations

The details of incorporation, commencement of operations and residual concession life are as given below:

Name of the entity	Date of incorporation	Commencement of operation	Residual Concession Life*
Solar Edge	June 29, 2015	30 MW (AC) solar power plant: April 22, 2018 50 MW (AC) solar power plant: April 8, 2018 50 MW (AC) solar power plant: April 26, 2018	22 years, 26 days
Terralight Kanji (formerly	May 6, 2010	March 26, 2016	19 years, 11 months, 26 days

Name of the entity	Date of incorporation	Commencement of operation	Residual Concession Life*
known as Solar PV)			
TN Solar	October 14, 2013	8MW (AC) solar power plant: September 28, 2015 10MW (AC) solar power plant: November 2, 2015 5MW (AC) solar power plant: December 28, 2015	19 years, 8 months, 28 days
UMD	July 11, 2008	12MW (AC) solar power plant: November 16, 2015 13MW (AC) solar power plant: March 21, 2016	19 years, 11 months, 21 days
Terralight Rajapalayam (formerly known as SP Suryaprakash)	October 9, 2018	September 26, 2018	22 years, 5 months, 26 days
PLG	June 11, 2007	20 MW (AC) solar power plant: January 2012	15 Years 9 Months and 25 Days
TSET	June 17, 2008	5 MW (AC) solar power plant: October 2011	15 years, 6 months and 8 days
TSEC	May 12, 2010	13 MW (AC) solar power plant: March 2012, April 2012 & October 2012	16 years, 7 months and 1 day
USUPL	January 30, 2015	30 MW (AC) solar power plant: September 2016	20 years, 5 months and 14 day

\*Residual concession life as on March 31, 2021

## Principal Components of Income and Expenses

### Income

The Asset SPVs' total income comprises (i) revenue from operations and (ii) other income.

*Revenue from operations - comprise of (a) sale of power and amortisation of government grants and (b) other operating income*

*Break-up of revenue from operations is as under:*

Particulars	Financial Year ended March 31, 2021	Financial Year ended March 31, 2020	Financial Year ended March 31, 2019
Sale of Power and amortisation of government grants	34,413.94	35,133.35	32,764.04
Other Operating Income	10.04	1.60	2.47
Total (Revenue from Operations)	34,423.98	35,134.95	32,766.51

### *Sale of power and amortisation of government grants*

Our revenue from sale of power and amortisation of government grants accounted for ₹34,413.94 lakhs, ₹35,133.35 lakhs, and ₹32,764.04 lakhs for the Financial Years ended March 31, 2021, March 31, 2020 and March 31, 2019 respectively. Our revenue from sale of power primarily consists of revenue generated as per agreed terms with off-takers under respective power purchase agreements entered by the Asset SPVs, accounted as per the requirements under IndAS.

### *Other operating revenue*

Our revenue from other operating income accounted for ₹10.04 lakhs, ₹1.60 lakhs, and ₹2.47 lakhs for the Financial Years ended March 31, 2021, March 31, 2020 and March 31, 2019 respectively. Our revenue from other operating income primarily consists of sale of scraps

### *Other Income*

Our other income accounted for ₹2,448.22 lakhs, ₹1,312.11 lakhs, and ₹618.46 lakhs for the Financial Years ended March 31, 2021, March 31, 2020 and March 31, 2019 respectively. Our other income consists of interest income earned on bank deposits / financial assets, interest received on income tax refunds, sundry balances written back, insurance claim received, dividend income from financial assets and gain on foreign currency transactions and translations

### *Expenses*

Our expenses primarily consist of the following:

- Operating and maintenance expenses which comprise of expenses related to O&M contractor costs along with spares and consumables;
- Finance costs which primarily comprise of interest expense on borrowings and other ancillary finance costs;
- Employee benefit expenses;
- Depreciation and amortisation expenses, which comprise depreciation on property, plant and equipment and amortisation of intangible assets;
- Other expenses, which comprise various administration costs such as power and fuel, rent, repair and maintenance, insurance, rates, taxes, communication expenses, travelling and conveyance, printing and stationary, freight, cartage and other distribution cost, commission on sales, rebate, donation and contributions, legal and professional charges, payments to auditors, testing and inspection charges, fees and subscriptions, bank charges, loss on sale and write off of property, plant and equipment, trade and other receivables written off, business development expenses, miscellaneous expenses; and
- Additionally, we test impairment at regular intervals.

### **Results of Operations**

The following table sets forth selected financial data from the Audited Special Purpose Combined Financial Statements, the components of which are also expressed as a percentage of total income for the financial years indicated:

Particulars	Financial Year ended March 31, 2021		Financial Year ended March 31, 2020		Financial Year ended March 31, 2019	
	Amount (in ₹ lakhs)	% of Total Income	Amount (in ₹ lakhs)	% of Total Income	Amount (in ₹ lakhs)	% of Total Income
<b>Income</b>						
Revenue from operations	34,423.98	93.36	35,134.95	96.40	32,766.51	98.15
Other Income	2,448.22	6.64	1,312.11	3.60	618.46	1.85
<b>Total Income</b>	<b>36,872.20</b>	<b>100.00</b>	<b>36,447.06</b>	<b>100.00</b>	<b>33,384.97</b>	<b>100.00</b>
<b>Expenses</b>						
Operating and maintenance fees	1,491.20	4.04	1,564.73	4.29	1,366.70	4.09
Employee benefits expense	165.32	0.45	139.69	0.38	193.20	0.58
Finance Costs	22,243.56	60.33	20,093.22	55.13	18,669.65	55.92
Depreciation and amortisation expenses	13,660.65	37.05	14,908.46	40.90	14,296.37	42.82

Particulars	Financial Year ended March 31, 2021		Financial Year ended March 31, 2020		Financial Year ended March 31, 2019	
	Amount (in ₹ lakhs)	% of Total Income	Amount (in ₹ lakhs)	% of Total Income	Amount (in ₹ lakhs)	% of Total Income
Other expenses	6,453.00	17.50	2311.89	6.34	4,142.11	12.41
<b>Total Expenses</b>	<b>44,013.73</b>	<b>119.37</b>	<b>39,017.99</b>	<b>107.05</b>	<b>38,668.03</b>	<b>115.82</b>
Profit /(loss) before exceptional items	(7,141.53)	(19.37)	(2,570.93)	(7.05)	(5,283.06)	(15.82)
Exceptional Items	33,177.48	89.98	3,445.95	9.45	2,322.64	6.96
<b>Profit /(loss) before tax</b>	<b>(40,319.01)</b>	<b>(109.35)</b>	<b>(6,016.88)</b>	<b>(16.51)</b>	<b>(7,605.70)</b>	<b>(22.78)</b>
<b>Tax Expense</b>						
Current tax	465.20	1.26	503.89	1.38	49.01	0.15
Deferred tax charge/credit	7.94	0.02	(2,474.92)	(6.79)	(4,673.27)	(14.00)
<b>Total tax expense</b>	<b>473.14</b>	<b>1.28</b>	<b>(1,971.03)</b>	<b>(5.41)</b>	<b>(4,624.26)</b>	<b>(13.85)</b>
<b>Profit /(loss) after tax</b>	<b>(40,792.15)</b>	<b>(110.63)</b>	<b>(4,045.85)</b>	<b>(11.10)</b>	<b>(2,981.44)</b>	<b>(8.93)</b>
Total other comprehensive income	(0.10)	(0.00)	(0.81)	(0.00)	0.07	(0.00)
<b>Total comprehensive income/(loss) for the year, net of tax</b>	<b>(40,792.25)</b>	<b>(110.63)</b>	<b>(4,046.66)</b>	<b>(11.10)</b>	<b>(2,981.37)</b>	<b>(8.93)</b>

#### Financial Year ended March 31, 2021 compared to Financial Year ended March 31, 2020

##### Income

Total income increased by ₹425.14 lakhs, or 1.17%, from ₹36,447.06 lakhs in the Financial Year ended March 31, 2020 to ₹36,872.20 lakhs in the Financial Year ended March 31, 2021, primarily due to an increase in other income.

##### Revenue from operations

Revenue from operations decreased by ₹710.97 lakhs, or 2.02%, from ₹35,134.95 lakhs in the Financial Year ended March 31, 2020 to ₹34,423.98 lakhs in the Financial Year ended March 31, 2021, primarily due to reduction in CUF for Terralight Kanji Project, Terralight Rajapalayam Project, TN Solar Project and UMD Project (i.e. Tamil Nadu based projects).

The table below sets forth the changes in revenue from operations for each of the Terra InvIT Assets for the Financial Year ended March 31, 2021 and the Financial Year ended March 31, 2020:

Project	Financial Year 2021 (₹ in lakhs)	Financial Year 2020 (₹ in lakhs)	Percentage Change (%)
Solar Edge Project	11,233.16	11,261.56	(0.25)
Terralight Kanji Project	3,534.21	3,840.89	(7.98)
TN Solar Project	2,767.35	2,858.92	(3.20)
UMD Project	2,889.66	3,113.01	(7.17)
Terralight Rajapalayam Project	2,702.82	2,872.49	(5.91)
PLG Project	3,064.36	3,116.73	(1.68)
TSET Project	1,562.81	1,562.15	0.04
TSEC Project	1,812.62	1,841.72	(1.58)
USUPL Project	4,857.00	4,667.48	4.06

##### Other income

Other income increased by ₹1,136.11 lakhs or 86.59%, from ₹1,312.11 lakhs in the Financial Year ended March 31, 2020 to ₹2,448.22 lakhs in the Financial Year ended March 31, 2021 primarily due to ₹1,527.76 lakhs of sundry balances written back for capex creditors during Financial Year ended March 31, 2021. Other income represented 3.60% and 6.64% of our total income for the Financial Years ended March 31, 2020 and March 31, 2021, respectively.

## ***Expenses***

Total expenses increased by ₹4,995.74 lakhs or 12.80% from ₹39,017.99 lakhs in the Financial Year ended March 31, 2020 to ₹44,013.73 lakhs in the Financial Year ended March 31, 2021, primarily due to an increase in other expenses and finance costs. The increase was partially offset by a decrease in operating and maintenance expenses along with depreciation and amortisation.

### ***Operating and maintenance expenses***

Operating and maintenance expenses decreased by ₹73.53 lakhs or 4.70%, from ₹1,564.73 lakhs in the Financial Year ended March 31, 2020 to ₹1,491.20 lakhs in the Financial Year ended March 31, 2021, primarily on the account of decrease in operating and maintenance charges for Terralight Kanji Project, Terralight Rajapalayam Project, Solar Edge Project, TN Solar Project and UMD Project. This decrease is attributed to termination of the previous O&M Contracts and entering into new O&M Agreements pursuant to the change in equity ownership of the projects.

Operating and maintenance expenses represented 4.01 % and 3.39% of our total expenses for the Financial Years ended March 31, 2020 and March 31, 2021, respectively

### ***Finance costs***

Finance costs increased by ₹2,150.34 lakhs or 10.70 %, from ₹20,093.22 lakhs in the Financial Year ended March 31, 2020 to ₹22,243.56 lakhs in the Financial Year ended March 31, 2021. This increase is primarily attributable to:

- Prepayment charges for repayment of Term Loans to incumbent lenders during Financial Year ended March 31, 2021
- Increase in Interest expense due to replacement of Term Loans with CCDs from Terra Asia Holdings II Pte Ltd at higher rate of interest.

Finance costs represented 51.50% and 50.54% of our total expenses for the Financial Years ended March 31, 2020 and March 31, 2021, respectively

### ***Depreciation and amortisation expenses***

Our fixed assets as of March 31, 2021 amounted to ₹153,603.00 lakhs. Our depreciation and amortisation expense decreased by ₹1,247.81 lakhs, or 8.37%, from ₹14,908.46 lakhs in the Financial Year ended March 31, 2020 to ₹13,660.65 lakhs in the Financial Year ended March 31, 2021. This decreased is primarily attributable to the impairment in the value of Property, Plant and Equipment of ₹32,495.61 lakhs in the Financial Year ended March 31, 2021 which in turn resulted in lower carrying value of fixed assets, thereby resulting in decrease in depreciation and amortisation during the Financial Year ended March 31, 2021.

Depreciation and amortisation expense represented 38.21% and 31.04% of our total expenses in the Financial Year ended March 31, 2020 and Financial Year ended March 31, 2021, respectively

### ***Other expenses***

Other expenses increased by ₹4,141.11 lakhs, or 179.12%, from ₹2,311.89 lakhs in the Financial Year ended March 31, 2020 to ₹6,453.00 lakhs in the Financial Year ended March 31, 2021. This increase is primarily attributable to increase in legal and professional charges from ₹657.53 lakhs in Financial Year ended March 31, 2020 to ₹4,585.33 lakhs in Financial Year ended March 31, 2021

Other expenses represented 5.93% and 14.66% of our total expenses in the Financial Year ended March 31, 2020 and Financial Year ended March 31, 2021, respectively.

### ***Exceptional Items***

Expenses towards exceptional items increased by ₹29,731.53 lakhs or 863% from ₹3,445.95 lakhs in the Financial Year ended March 31, 2020 to ₹33,177.48 lakhs in the Financial Year ended March 31, 2021. This increase is primarily attributable to Impairment provided in value of Property, Plant and Equipment of ₹32,495.61 lakhs,

Impairment of ₹649.13 lakhs in value of Investments and ₹ 32.74 lakhs net loss on fair valuation of investments (sold post March 31, 2021) during Financial Year ended March 31, 2021

#### ***Profit/ loss before tax***

As a result of the factors outlined above, our loss before tax was ₹40,319.01 lakhs for the Financial Year ended March 31, 2021 as compared to a loss of ₹6,016.88 lakhs for the Financial Year ended March 31, 2020.

#### ***Tax expenses/credit***

We had a tax expense amounting to ₹473.14 lakhs for the Financial Year ended March 31, 2021 as compared to a tax credit of ₹1,971.03 lakhs for the Financial Year ended March 31, 2020. This was primarily due to reduction in deferred tax credit by ₹2,482.86 lakhs during the Financial Year ended March 31, 2021, based on assessment of future taxable profits.

#### ***Profit/ loss after tax***

As a result, our loss after tax was ₹40,792.15 lakhs for the Financial Year ended March 31, 2021 as compared to a loss of ₹4,045.85 lakhs for the Financial Year ended March 31, 2020.

#### ***Total comprehensive income/ loss for the year***

As a result of the factors outlined above, our total comprehensive loss amounted to ₹40,792.25 lakhs for the Financial Year ended March 31, 2021 as compared to a total comprehensive loss of ₹4,046.66 lakhs for the Financial Year ended March 31, 2020.

#### **Financial Year ended March 31, 2020 compared to Financial Year ended March 31, 2019**

##### ***Income***

Total income increased by ₹3,062.09 lakhs, or 9.17%, from ₹33,384.97 lakhs in the Financial Year ended March 31, 2019 to ₹36,447.06 lakhs in the Financial Year ended March 31, 2020, primarily due to an increase in revenue from operations and other income.

##### ***Revenue from operations***

Revenue from operations increased by ₹2,368.44 lakhs, or 7.23%, from ₹32,766.51 lakhs in the Financial Year ended March 31, 2019 to ₹35,134.95 lakhs in the Financial Year ended March 31, 2020, primarily due to higher generation of power. This higher generation is primarily attributed to impact of full year revenue in Financial Year Ended March 31, 2020 for Terralight Rajapalayam (50 MW (AC) project, which was commissioned on September 26, 2018

The table below sets forth the changes in revenue from operations for each of the Terra InvIT Assets for the Financial Year ended March 31, 2020 and the Financial Year ended March 31, 2019:

<b>Project</b>	<b>Financial Year ended March 31, 2020 (₹ in lakhs)</b>	<b>Financial Year ended March 31, 2019 (₹ in lakhs)</b>	<b>Percentage Change (%)</b>
Solar Edge Project	11,261.56	10,347.41	8.83
Terralight Kanji Project	3,840.89	3,839.35	0.04
TN Solar Project	2,858.92	2,881.13	(0.77)
UMD Project	3,113.01	3,052.88	1.97
Terralight Rajapalayam Project	2,872.49	1,255.79	128.74
PLG Project	3,116.73	3,142.88	(0.83)
TSET Project	1,562.15	1,542.06	1.30
TSEC Project	1,841.72	1,852.00	(0.56)
USUPL Project	4,667.48	4,853.01	(3.82)

##### ***Other income***

Other income increased by ₹693.65 lakhs or 112.16%, from ₹618.46 lakhs in the Financial Year ended March 31, 2019 to ₹1,312.11 lakhs in the Financial Year ended March 31, 2020 primarily due to interest income on bank



deposits. Other income represented 1.85% and 3.60% of our total income for the Financial Years ended March 31, 2019 and March 31, 2020, respectively.

### ***Expenses***

Total expenses increased by ₹349.96 lakhs or 0.91% from ₹38,668.03 lakhs in the Financial Year ended March 31, 2019 to ₹39,017.99 lakhs in the Financial Year ended March 31, 2020, primarily due to an increase in finance costs, depreciation and amortisation expenses and operating and maintenance expenses. This increase was partially off-set by decrease in other expenses

#### ***Operating and maintenance expenses***

Operating and maintenance expenses increased by ₹198.03 lakhs or 14.49%, from ₹1,366.70 lakhs in the Financial Year ended March 31, 2019 to ₹1,564.73 lakhs in the Financial Year ended March 31, 2020, primarily on the account of a full year impact of Terralight Rajapalayam Project installed during the financial year ended March 31, 2019, thereby leading to higher operating and maintenance charges of the Terra InvIT Assets. This is partially offset by the decrease in spares and consumables. Operating and maintenance expenses represented 3.53% and 4.01% of our total expenses for the Financial Years ended March 31, 2019 and March 31, 2020, respectively.

#### ***Finance costs***

Finance costs increased by ₹1,423.57 lakhs or 7.63%, from ₹18,669.65 lakhs in the Financial Year ended March 31, 2019 to ₹20,093.22 lakhs in the Financial Year ended March 31, 2020. This increase is primarily attributable to an increase in the interest expenses on borrowings from ₹17,456.02 lakhs in the Financial Year ended March 31, 2019 to ₹19,646.96 lakhs in the Financial Year ended March 31, 2020 owing to a full year impact of the additional borrowings for installation of Terralight Rajapalayam Project during the Financial year ended March 31, 2019. This was partially off-set by the decrease in other finance costs from ₹1,009.83 lakhs in the Financial Year ended March 31, 2019 to ₹422.77 lakhs in the Financial Year ended March 31, 2020;

Finance costs represented 48.28% and 51.50% of our total expenses for the Financial Years ended March 31, 2019 and March 31, 2020, respectively

#### ***Depreciation and amortisation expenses***

Our fixed assets as of March 31, 2020 amounted to ₹1,99,155.84 lakhs. Depreciation and amortisation expense increased by ₹612.09 lakhs, or 4.28%, from ₹14,296.37 lakhs in the Financial Year ended March 31, 2019 to ₹14,908.46 lakhs in the Financial Year ended March 31, 2020. This increase is primarily attributable to the increase in the depreciation on property plant and equipment from ₹14,296.37 lakhs in the Financial Year ended March 31, 2019 to ₹14,908.46 lakhs in the Financial Year ended March 31, 2020 owing to full year impact of the capitalisation of Terralight Rajapalayam Project installed during the Financial year ended March 31, 2019. Depreciation and amortisation expense represented 36.97% and 38.21% of our total expenses in the Financial Year ended March 31, 2019 and Financial Year ended March 31, 2020, respectively.

#### ***Other expenses***

Other expenses decreased by ₹1,830.22 lakhs, or 44.19 %, from ₹4,142.11 lakhs in the Financial Year ended March 31, 2019 to ₹2311.89 lakhs in the Financial Year ended March 31, 2020. This decrease is primarily attributable to decrease in provision for diminution in value of investment from ₹2,377.13 lakhs in the Financial Year ended March 31, 2019 to Nil in the Financial Year ended March 31, 2020

Other expenses represented 10.71% and 5.93% of our total expenses in the Financial Year ended March 31, 2019 and Financial Year ended March 31, 2020, respectively.

### ***Exceptional Items***

Expenses towards exceptional items increased by ₹1,123.31 lakhs or 48.36 % from ₹2,322.64 lakhs in the Financial Year ended March 31, 2019 to ₹3445.95 lakhs in the Financial Year ended March 31, 2020. This increase is primarily attributable to bad debt expenses of ₹3,182 lakhs in USUPL Project and provision for doubtful debt of ₹263.95 lakhs in PLG Project during Financial Year ended March 31, 2020 as compared to Impairment of ₹1,862.04 lakhs in value of Property, Plant & Equipment in the TSEC and PLG projects during Financial Year ended March 31, 2019.

***Profit/ loss before tax***

As a result of the factors outlined above, our loss before tax was ₹6,016.88 lakhs for the Financial Year ended March 31, 2020 compared to a loss of ₹7,605.70 lakhs for the Financial Year ended March 31, 2019.

***Tax expenses/credit***

We had a tax credit of ₹1,971.03 lakhs for the Financial Year ended March 31, 2020 as compared to a tax credit of ₹4,624.26 lakhs for the Financial Year ended March 31, 2019 owing to movement in deferred tax.

***Profit/ loss after tax***

As a result, our loss after tax was ₹4,045.85 lakhs for the Financial Year ended March 31, 2020 as compared to a loss of ₹2,981.44 lakhs for the Financial Year ended March 31, 2019.

***Other comprehensive income/ loss for the year***

Other comprehensive loss was ₹0.81 lakhs for the Financial Year ended March 31, 2020 compared to other comprehensive profit of ₹0.07 lakhs for the Financial Year ended March 31, 2019.

***Total comprehensive income/ loss for the year***

As a result of the factors outlined above, our total comprehensive loss amounted to ₹4,046.66 lakhs for the Financial Year ended March 31, 2020 as compared to a total comprehensive loss of ₹2,981.37 lakhs for the Financial Year ended March 31, 2019.

**Liquidity and Capital Resources**

The Terra InvIT has not previously been in existence and consequently has not been previously capitalised or financed. Each of the Asset SPVs operates in a capital-intensive sector and has historically financed the development of its solar power project and other capital expenditures through a combination of equity and debt financing from the Sponsor, borrowings from commercial banks, financial institutions and from related parties and cash generated from operations. The Asset SPVs' liquidity requirements relate to servicing debt, funding working capital requirements and maintaining cash reserves against fluctuations in operating cash flows.

**Cash Flows**

The following table sets forth certain information relating to the cash flows of the Asset SPVs on a combined basis for the periods indicated:

<i>(in ₹ lakhs)</i>			
<b>Particulars</b>	<b>Financial Year ended March 31, 2021</b>	<b>Financial Year ended March 31, 2020</b>	<b>Financial Year ended March 31, 2019</b>
Net cash flows generated from operating activities	39,409.56	21,196.11	17,571.93
Net cash used in investing activities	(10,509.27)	(5,087.72)	(32,704.93)
Net cash used in financing activities	(24,204.68)	(17,581.95)	10,583.26
Net increase/ (decrease) in cash and cash equivalents	4,695.61	(1,473.56)	(4,549.73)

***Cash flows from operating activities******Financial Year ended March 31, 2021***

Net cash from operating activities for the Financial Year ended March 31, 2021 was ₹39,409.56 lakhs and our operating profit before working capital changes for that period was ₹26,622.27 lakhs, as adjusted primarily for change in trade receivables of ₹8,745.55 lakhs and financial and other liabilities of ₹4,772.78 lakhs. This was offset by adjustment in financial and other assets of ₹1,448.05 lakhs and changes in trade payables of ₹1,041.06 lakhs.

#### *Financial Year ended March 31, 2020*

Net cash from operating activities for the Financial Year ended March 31, 2020 was ₹21,196.11 lakhs, as adjusted primarily for changes in trade receivables of ₹9,336.67 lakhs and trade payables of ₹5,273.10 lakhs respectively. This was offset by adjustment in financial and other liability of ₹4,637.65 lakhs.

#### *Financial Year ended March 31, 2019*

Net cash from operating activities for the Financial Year ended March 31, 2019 was ₹17,571.93 lakhs, as adjusted primarily for changes in financial and other liabilities of ₹2,664.55 lakhs and increase in trade receivables of ₹2,931.76 lakhs and decrease in trade payables of ₹12,815.21 lakhs. This was offset by changes in financial and other assets of ₹1,338.50 lakhs.

#### ***Cash flows from investing activities***

##### *Financial Year ended March 31, 2021*

Net cash used in investing activities for the Financial Year ended March 31, 2021 was ₹10,509.27 lakhs, primarily consisting of purchase of Property, Plant and Equipment of ₹716.14 Lakhs and investments of ₹13,331.26 lakhs. These payments were partially offset by investment income recognised in profit or loss of ₹748.65 lakhs.

##### *Financial Year ended March 31, 2020*

Net cash used in investing activities for the Financial Year ended March 31, 2020 was ₹5087.72 lakhs, primarily consisting of purchase of investments of ₹5,691.86 lakhs. These payments were partially offset by investment income recognised in profit and loss of ₹855.60 lakhs.

##### *Financial Year ended March 31, 2019*

Net cash used in investing activities for Financial Year ended March 31, 2019 was ₹32,704.93 lakhs, primarily consisting of purchase of property, plant and equipment of ₹27,878.04 lakhs and purchase of investments of ₹14,255.00 lakhs. These payments were partially offset by sale of investments of ₹12,148.37 lakhs.

#### ***Cash flows from financing activities***

##### *Financial Year ended March 31, 2021*

Net cash used in financing activities for the Financial Year ended March 31, 2021 was ₹24,204.68 lakhs, primarily reflecting repayment of borrowings of ₹1,40,856.47 lakhs, proceeds from fresh borrowing of ₹1,44,097.22 lakhs and finance cost paid of ₹24,593.39 lakhs

##### *Financial Year ended March 31, 2020*

Net cash used in financing activities for the Financial Year ended March 31, 2020 was ₹17,581.95 lakhs, primarily reflecting repayment of borrowings of ₹14,012.40 lakhs, proceeds from fresh borrowing of ₹17,251.56 lakhs and finance cost paid of ₹18,310.19 lakhs.

##### *Financial Year ended March 31, 2019*

Net cash generated from financing activities for the Financial Year ended March 31, 2019 was ₹10,583.26 lakhs, primarily from fresh borrowings of ₹55,180.25 lakhs, transactions with owners of acquired business undertaking of ₹16,558.60 lakhs, repayment of borrowings of ₹46,591.96 lakhs and finance costs paid of ₹18,465.08 lakhs.

#### **Off-balance Sheet Arrangements**

Neither Terra InvIT nor Asset SPVs have any off-balance sheet arrangements, derivative instruments or other relationships with unconsolidated entities that were established for the purpose of facilitating off-balance sheet arrangements.

#### **Contractual Obligations and Commercial Commitments**

The following table sets forth certain information relating to future payments due under contractual commitments as of March 31, 2021:

Particulars	Upto 1 year (₹ in lakhs)	1 to 5 years (₹ in lakhs)	Beyond 5 years (₹ in lakhs)	Total
Long term borrowings including current maturities	63,476.15		95,053.80	1,58,529.95
Lease liabilities including current portion	2.95	2.36	24.79	30.10
Trade payables	2,138.44			2,138.44
Other financial liabilities	7,758.73			7,758.73
<b>Non-Derivative financial liability</b>	<b>73,376.27</b>	<b>2.36</b>	<b>95,078.59</b>	<b>1,68,457.22</b>

### Contingent Liabilities

Based on our Combined Financial Statements, one of the Asset SPVs' i.e., Solar Edge had contingent liability of Nil as on March 31, 2021, Nil as of March 31, 2020 and ₹432 lakhs as on March 31, 2019 on account of liquidated damages for delay in commissioning the project. For further information, see '*Combined Financial Statements*' on page 214.

### Related Party Transactions

The Asset SPVs have in the course of their business entered into various transactions with related parties. These transactions include amongst others, transaction entered into with Sponsor and payments to the key managerial personnel of the Asset SPVs.

For further information, see '*Related Party Transactions*' on page 188 and '*Combined Financial Statements*' on page 214.

### Seasonality

Operating results for renewable energy projects vary significantly depending on natural variations from season to season and from year to year and may also change permanently because of climate change or other factors. The power generation in the renewable energy projects are dependent upon various seasonal factors and natural calamities. Renewable power generation is highly dependent on weather conditions and the profitability of our operations depends not only on observed weather conditions at the project site but also on the consistency of those weather conditions. The shorter daylight hours during the winter months will reduce the irradiation and consequently will have an adverse impact on the power generation through solar projects. Additionally, our Terra InvIT Assets may be affected by the monsoon season. While the northern and western parts of India experience monsoon rains during the period from June or July until September every year, the southern parts of India, experience monsoon rains even during the months of October to December.

The monsoon and winter seasons and threat of natural calamities such as cyclone may affect power generation and infrastructure of power plants. This may result in delays in periodic maintenance and reduce productivity, thereby adversely affect our business, financial condition and results of operations. For further details on the risk associated with seasonality, see '*Risk Factors – Our business will be subject to seasonal fluctuations and natural calamities that could have a material adverse effect on our business, financial condition and results of operations.*' on page 22.

### Significant Developments since March 31, 2021

Except as disclosed in this Final Placement Memorandum, including in relation to the Solar Edge Refinancing, wherein external debt has been re-financed as on June 30, 2021, and except for the ordinary course of business of the Asset SPVs, we are not aware of any circumstances that have arisen since March 31, 2021, that materially and adversely affect, or are likely to affect, our or the Asset SPVs' operations or profitability, the value of our or their respective assets, or our or the Asset SPVs' ability to pay our or their respective liabilities within the next twelve months. For details in relation to the Solar Edge Refinancing, see '*Financial Indebtedness*' on page 280.

Further, the following table sets forth the monthly un-audited revenue of Terra InvIT post March 31, 2021:

Months ended	(₹ in lakhs)
April 2021	3,430.96
May 2021	3,264.54
June 2021	3,048.39
July 2021	2,739.83

Months ended	(₹ in lakhs)
August 2021	2,826.56
<b>Total</b>	<b>15,310.28</b>

## Quantitative and Qualitative Disclosures about Market Risk

Market risk is the risk of loss related to adverse changes in market prices, including interest rate risk.

### *Interest rate risk*

As the solar power generation business is capital intensive, the Asset SPVs are exposed to interest rate risk. Interest rates for borrowings have been volatile in India in recent periods. The Asset SPVs solar power projects were funded to a large extent by debt and increases in interest expense could have an adverse effect on their results of operations and financial condition. As of March 31, 2021, certain of the Asset SPVs indebtedness were subject to variable rates. Although from time to time we may engage in interest rate hedging transactions or exercise any rights available to us under these financing arrangements to terminate the existing debt financing arrangement on the respective reset dates and enter into new financing arrangements, there can be no assurance that we will be able to do so on commercially reasonable terms, that our counterparties will perform their obligations, or that these agreements, if entered into, will protect us adequately against interest rate risks.

### *Liquidity risk*

Liquidity risk relates to the risk that the Terra InvIT or the Asset SPVs will not be able to meet its obligations associated with its financial liabilities. The Terra InvIT and the Asset SPVs are exposed to liquidity risk in respect of financing arrangements and short-term and long-term investment programs mainly in their growth projects.

It is expected that the Terra InvIT, through the Investment Manager, will regularly monitor liquidity requirements to ensure that it maintains adequate means of obtaining funds necessary in order to meet liquidity requirements in the short and longer term. Further, the Terra InvIT and the Asset SPVs aim to minimise the risk by generating sufficient cash flows from their current operations, cash and cash equivalents, liquid investments and by deploying a robust cash management system. However, as a result of the Terra InvIT's distribution policy and the requirements therefor in the InvIT Regulations, the Terra InvIT will be severely limited in its ability to maintain reserves of cash and cash equivalents, which could enhance liquidity risk. For further details, see '*Distribution*' on page 190.

The Terra InvIT and the Investment Manager confirm sufficiency of working capital to fulfill the present requirements of the Terra InvIT, for a period of up to twelve months from date of listing.

### *Inflation Risk*

In recent years, India has experienced relatively high rates of inflation. While we believe inflation has not had any material impact on our business and results of our operations, inflation generally impacts the overall economy and business environment and hence could affect us.

## FINANCIAL INDEBTEDNESS

The following is a summary of the indebtedness of the Asset SPVs, together with a brief description of certain material covenants of the relevant financing agreements. For additional details, Investors should also refer to the section entitled 'Use of Proceeds' and 'Combined Financial Statements', on pages 73 and 214.

The Asset SPVs have primarily availed loans, amongst others, for refinancing, takeout, or repayment of the outstanding amounts owed to the existing project lenders, funding of the debt service reserve sub-account, purchase of project site, improvement of project site condition, acquisition financing, capital expenditure and general corporate purposes. Additionally, certain Asset SPVs have availed a portion of the loan towards meeting the expenses in relation to availing such loan facility. Set forth below is a brief summary of the outstanding borrowings of the Asset SPVs, on a standalone basis, as of March 31, 2021:

Category of Borrowing	Aggregate Amount (₹ in lakhs)	Outstanding Amount as on as on March 31, 2021 (₹ in lakhs)
<b>Solar Edge</b>		
Secured <sup>#</sup>	61,410.00	59,301.85
CCD <sup>*</sup>	12,153.27	12,153.27
NCD	1.00	1.00
<b>Total (A)</b>	<b>73,564.27</b>	<b>71,456.12</b>
<b>Terralight Kanji</b>		
Secured	Nil.	Nil.
CCDs <sup>**</sup>	24,182.21	24,182.21
NCDs	1,949.96	1,631.20
<b>Total (B)</b>	<b>26,132.17</b>	<b>25,813.41</b>
<b>TN Solar</b>		
Secured	Nil.	Nil.
CCDs <sup>***</sup>	13,445.86	13,445.86
NCDs	1,654.85	1,396.20
<b>Total (C)</b>	<b>15,100.71</b>	<b>14,842.06</b>
<b>UMD</b>		
Secured	Nil.	Nil.
CCDs <sup>****</sup>	15,065.87	15,065.87
NCDs	1,532.54	1,246.20
<b>Total (D)</b>	<b>16,598.41</b>	<b>16,312.07</b>
<b>Terralight Rajapalayam</b>		
Secured	Nil.	Nil.
CCDs <sup>*****</sup>	18,533.33	18,533.33
NCDs	63.23	Nil
<b>Total (E)</b>	<b>18,596.56</b>	<b>18,533.33</b>
<b>PLG</b>		
Secured	18,000.00	12,193.94
CCDs	Nil.	Nil.
NCDs	Nil.	Nil.
<b>Total (F)</b>	<b>18,000.00</b>	<b>12,193.94</b>
<b>TSET</b>		
Secured	5,200.00	3,363.15
CCDs	Nil	Nil
NCDs	Nil	Nil
<b>Total (G)</b>	<b>5,200.00</b>	<b>3,363.15</b>
<b>TSEC</b>		
Secured	9,800.00	5,908.35
CCDs	Nil	Nil
NCDs	Nil	Nil
<b>Total (H)</b>	<b>9,800.00</b>	<b>5,908.35</b>
<b>USUPL</b>		
Secured	18,000.00	13,732.43
CCDs	Nil.	Nil.
NCDs	Nil.	Nil.
<b>Total (I)</b>	<b>18,000.00</b>	<b>13,732.43</b>
<b>Total loan of Asset SPVs</b>		
Secured	1,12,410.00	94,499.73
Debentures	88,582.13	87,655.14

Category of Borrowing	Aggregate Amount (₹ in lakhs)	Outstanding Amount as on as on March 31, 2021 (₹ in lakhs)
<b>Total (A+B+C+D+E+F+G+H+I)</b>	<b>2,00,992.13</b>	<b>1,82,154.87</b>

*#Pursuant to Solar Edge Refinancing, the external debt has been re-financed as on June 28, 2021 and the aggregate amount and outstanding amount, as on June 30, 2021 was 593,00,00,000 and 593,00,00,000, respectively. For additional details, see 'Financial Indebtedness – Principal Terms of the Borrowings' and 'Risk Factors – The Asset SPVs are subject to restrictive covenants and undertakings under its financing agreements. Any non-compliance or default by the Asset SPVs could limit its flexibility in managing its business or to use cash or other assets' on pages 281 and 30.*

*\*12,15,32,667 number of unrated, unlisted, unsecured, Compulsorily Convertible Debentures were issued by Solar Edge to the Sponsor at ₹10 each, for repayment of unsecured loans of Solar Edge.*

*\*\*24,18,22,113 number of unrated, unlisted, unsecured Compulsorily Convertible Debentures were issued by Terralight Kanji to the Sponsor at ₹10 each, for repayment of secured and unsecured loans of Terralight Kanji.*

*\*\*\*13,44,58,559 number of unrated, unlisted, unsecured Compulsorily Convertible Debentures were issued by TN Solar to the Sponsor at ₹10 each, for repayment of secured and unsecured loans of TN Solar.*

*\*\*\*\*15,06,58,705 number of unrated, unlisted, unsecured Compulsorily Convertible Debentures were issued by UMD to the Sponsor at ₹10 each, for repayment of secured and unsecured loans of UMD.*

*\*\*\*\*\*18,53,33,277 number of unrated, unlisted, unsecured Compulsorily Convertible Debentures were issued by Terralight Rajapalayam to the Sponsor at ₹10 each, of Terralight Rajapalayam as consideration for acquisition of the Rajapalayam undertaking as a going concern on a slump sale basis.*

### Principal Terms of the Borrowings availed by the Asset SPVs

- Interest and commissions:** The facilities availed by the Asset SPVs typically either have a fixed rate of interest, fixed up to each interest reset date, payable monthly or a benchmark floating rate of interest specified by the lender minus an applicable spread, payable monthly. The applicable spread varies amongst different loans.
- Maturity and Repayment:** The final maturity period of the re-financing loan availed by Solar Edge is 16 years and 9 months from the initial drawdown date i.e. June 30, 2021. The final maturity period of the other loans availed by the Asset SPVs is in approximately 10 years. These loans are repayable in installments in accordance with the repayment schedule specified in the relevant financing agreements.
- Voluntary Pre-Payment/ Repayment Terms:** After the expiry of the applicable lock-in period, the Asset SPVs have the right to prepay all or part of the outstanding amounts, subject to payment of a prepayment premium, which is typically 1% of the amount proposed to be repaid. Further, the Asset SPVs have the right to prepay all or part of the outstanding amounts without payment of a prepayment premium on the occurrence of certain events specified in the relevant facility agreement. Further, certain facility agreements have provisions for mandatory prepayment of the amount outstanding on the receipt of monies pursuant to occurrence of certain mandatory prepayment events such as receipt of insurance proceeds, proceeds from sale/ transfer/ disposal of movable/ immovable assets of the Asset SPVs, and proceeds in connection with breach of warranty or guarantee under any project documents.
- Security:** In terms of borrowings where security needs to be created, the Asset SPVs are, *inter alia*, required to create:
  - first charge by way of mortgage on all of Asset SPVs immovable properties (leasehold and/or freehold) pertaining to the project (including the project site) both present and future, together with all the structures and appurtenances thereon and thereunder, both present and future;
  - first charge on all of Asset SPVs tangible movable assets pertaining to the project, including movable plant and machinery, and other spares, tools and accessories, furniture, fixtures, vehicles and all other movable assets, both present and future;
  - first charge on the receivables, present and future;
  - first charge on all intangibles of Asset SPVs, if any, pertaining to the project, including but not limited to goodwill, intellectual property rights, and undertakings of the Asset SPVs, present and future; and a first charge on uncalled capital of the Asset SPVs, present and future;
  - first charge over all bank accounts of the Asset SPVs, including without limitation, the trust and retention account and the retention accounts and sub-accounts thereunder (including without limitation the debt service reserve sub-account, the IRR sub-account, the O&M reserve sub account) or any account in substitution thereof, opened pursuant to the provisions of the trust and retention account agreement or any of the project documents, wherein all receivables shall,

from time to time, be deposited and all permitted investment or other securities representing all amounts credited thereto;

- (f) pledge by the pledgors to the extent of 100% of the equity share capital of Asset SPVs, in dematerialised form (free from all restrictive covenants, lien or other encumbrance under any contract, arrangement or agreement including but not limited to the shareholders' agreement (if any), together with all accretions thereon; and
- (g) assignment by way of security of the subordinate loans (and all monies receivable in relation thereto).

The security creation above is indicative, and there may be additional requirements under the various borrowing arrangements entered into by the Asset SPVs.

In relation to security creation, for Solar Edge Refinancing, while the deed of hypothecation has been entered into and perfected by creation of charge, deed of mortgage and pledge agreement are in the process of being entered into and shall be created and perfected within 90 and 120 days from the initial drawdown, respectively. In relation to TSEC, the facilities availed are secured by mortgage on the land TSEC operates for which indenture of mortgage has not been executed on account of administrative and procedural delays, and failure to create and perfect security amounts to an event of default. For additional details, see '*Risk Factors – The Asset SPVs are subject to restrictive covenants and undertakings under its financing agreements. Any non-compliance or default by the Asset SPVs could limit its flexibility in managing its business or to use cash or other assets.*' on page 30.

5. **Undertakings:** The Sponsor (and in the case of PLG, the Sponsor and USUPL and in the case of TSET, the Sponsor and TSEC) have provided certain undertakings under the facility agreements in favor of the lenders, which includes:

- (a) until final settlement date, retain at least 51% of ownership of the relevant Asset SPV;
- (b) retain management control of the relevant Asset SPVs at all times;
- (c) ensure that the relevant Asset SPV is provided with requisite technical, financials and other managerial expertise to perform its obligations;
- (d) it shall infuse / extend amounts to discharge all payments made by such Asset SPV towards penalties resulting from a breach of any applicable law by it;
- (e) it shall infuse / extend additional funds to the Asset SPV to meet the shortfall (if any) in Debt Service Reserve Account and/or Internal Rate of Return in the normal course of business; and
- (f) it shall infuse / extend additional funds to the Asset SPV, to meet the O&M expenses, in case the O&M expenses exceeds the levels envisaged under the base case model agreed with the respective lenders

In the case of PLG, TSET, TSEC and USUPL, post completion of the Formation Transaction, the Terra InvIT will be required to provide such undertakings to the lenders in the same form given by the Sponsor. In the case of Solar Edge Refinancing, the Sponsor is required to provide an unconditional undertaking until the final settlement date or until Formation Transaction, post completion of which, the Terra InvIT shall be required to execute the undertaking. For additional details, see '*Risk Factors – The Asset SPVs are subject to restrictive covenants and undertakings under its financing agreements. Any non-compliance or default by the Asset SPVs could limit its flexibility in managing its business or to use cash or other assets.*' on page 30.

6. **Covenants:** Borrowing arrangements entered into by the Asset SPVs contain certain restrictive conditions and covenants restricting certain corporate actions and the respective Asset SPV is required to take the prior approval of the lender or their agent, as the case may be, before carrying out such activities. The negative covenants in loan documents the Asset SPVs have to comply with, typically include:



- (a) not effect any change in its capital structure including shareholding pattern without the prior written approval of the lenders' agent, other than as contemplated for the project or as contemplated under the financing documents;
- (b) not, without the prior written approval of the lenders' agent, recognise or register any transfer of shares made or to be made by the promoter save and except the transfer of shares with the other companies as specified;
- (c) confirm that the promoter retains management control of Asset SPV at all times;
- (d) not make any change in its management structure without the prior written approval of the lenders' agent (such approval not to be unreasonably withheld);
- (e) upon any change in the composition of its board of directors, provide a written intimation to the lender's agent within 15 days of such change and the lenders shall provide their objection or consent within 3 months from the receipt of such intimation from the Asset SPV;
- (f) not alter its memorandum of association or articles of association in any manner which would be detrimental to the interests of the project lenders and inconsistent with undertaking the project, or any of the project documents and/or financing documents (including security documents), without the prior approval of the lenders' agent;
- (g) not make any change to its business activity without the prior approval of the lenders' agent;
- (h) not effect any scheme of amalgamation or restructuring or reconstruction, without the prior approval of the lenders' agent, other than a 100% subsidiary or parent;
- (i) not, without the prior approval of the lenders' agent, create or effect security interest over the project assets/secured properties and contracts or any part thereof in favour of any other financial institution, bank, borrower, firms or persons other than permitted security interest;
- (j) not, without the prior approval of the lenders' agent, undertake any new project, either directly or through group companies, make any investment in any group company with recourse to project assets, or make any other investment except to the extent permitted or take any assets on lease;
- (k) other than permitted disposal, not, without the prior approval of the lenders' agent, sell or otherwise dispose any project assets, security properties or equity interest charged to/ for the benefit of the project lenders;
- (l) not, without the prior approval of the lenders' agent, augment, modernise, expand or otherwise make any changes to the project;
- (m) not, without the prior approval of the lenders' agent, initiate termination proceedings or grant any waiver under the material project documents or other project documents (if termination or waiver of such other project documents may result in a material adverse effect);
- (n) not, without the prior approval of the lenders' agent, enter into borrowing arrangements, either secured or unsecured, with any other bank or financial institution, except for those arranged as part of means of finance for the projects as approved by the project lenders save and except for permitted indebtedness;
- (o) not, without the prior approval of the lenders' agent, undertake any obligation, monetary or legal on behalf any of its group companies / subsidiaries other than its obligations under the O&M, EPC and other contracts in relation to O&M for the project;
- (p) not, without the prior approval of the lenders' agent, enter into contractual arrangements long term in nature that are prejudicial to the interests of the project lenders;
- (q) not, without the prior approval of the lenders' agent, issue any debentures, raise any loan, accept any deposits, issue any equity or preference shares or provide any loans to the promoter with any recourse to the project assets/ secured properties;

- (r) not, without the prior approval of the lenders' agent, prepay all or any part of any financial assistance or debt availed by it except as permitted under the financing documents;
- (s) not declare or pay any restricted payment unless the stipulated conditions have been complied with and a confirmation to this effect has been received from the lenders' agent; and
- (t) not, without the prior approval of the lenders' agent, open a bank account.

The covenants above are indicative, and there may be additional restrictive conditions and covenants under the various borrowing arrangements entered into by the Asset SPVs.

7. **Events of Default:** The borrowing arrangements entered into by the Asset SPVs contain standard events of default, including:

- (a) Non-payment on due date any amount payable pursuant to financing documents;
- (b) Breach of financial covenants or information covenants specified in the relevant financing documents;
- (c) Misrepresentation in any representation or statement made or document delivered under or in connection with the financing documents;
- (d) Cross-default with breach of obligations under finance documents;
- (e) Insolvency or insolvency proceedings initiated against the Asset SPV;
- (f) Failure to comply or pay sum due from any judgement or any expropriation, attachment, sequestration, distress or execution affects all or substantial part of the assets;
- (g) Unlawfulness or ineffectiveness of any financing document;
- (h) Cessation of business or abandonment of any project;
- (i) Repudiation or rescission of any finance document or project agreement;
- (j) Abandonment of any project;
- (k) Event of default, termination event or similar event occurs on the part of the Asset SPV under any project documents which would entitle the counterparty to terminate such project document;
- (l) Termination or suspension of any project document;
- (m) Any of the required insurance policies are not, or cease to be maintained in full force and effect or there is material deviation from the requirements specified;
- (n) An event has occurred or circumstance exists which would enable the insurer under any of the required insurance policies to avoid or materially reduce their liability thereunder;
- (o) Expropriation of business or assets by any governmental agency;
- (p) Any litigation, arbitration, investigative or administrative proceeding against the Asset SPV restraining them from performing obligations under the finance documents or has a material adverse effect;
- (q) Non-compliance with sanctions, anti-corruption laws, and money laundering laws;
- (r) Moratorium on payment to creditors excluding any moratorium granted by Reserve Bank of India on account of COVID-19 pandemic;
- (s) Any event or series of event occurs which has or could have material adverse effect.

Under the relevant facility agreements entered into by Solar Edge, PLG, TSET, TSEC and USUPL, the lenders have the right to appoint a nominee director to the board of directors of the relevant Asset SPV

upon the occurrence of an event of default.

8. **NCD Terms:** As part of acquisition of the Project SPVs from Shapoorji Pallonji Solar Holdings Private Limited and Shapoorji Pallonji Infrastructure Capital Company Private Limited, the Project SPVs have issued NCDs to Shapoorji Pallonji Solar Holdings Private Limited. The duration of the NCDs are not more than 10 years, subject to redemption events specified in the relevant debenture subscription agreements, with no voting rights and a rate of interest of 7% per annum payable annually. They are ranked at least pari passu in their right of payment with unsecured payment obligations of Project SPVs and subservient and subordinated to secured payment obligations of the Project SPVs. The NCDs are non-transferable and non-marketable, subject to the terms of the relevant securities subscription and purchase agreements. Additionally, if the Project SPVs fail to redeem the NCDs in accordance with the terms of the NCD documents, the debenture holders shall have the right to require the Sponsor to purchase all of the NCDs which the Project SPVs have failed to redeem, subject to applicable laws, by issuing a notice to the Sponsor within 15 business days of such aforesaid failure to redeem.

A brief description of certain additional terms of the NCDs issued by Project SPVs are as follows:

Sr. No.	Name of Project SPV	Type of Security Issued	Debenture Holder	Redemption Event
1.	Solar Edge	Solar Edge Series A NCDs: 10,000 number of Series A 7% Unrated, Unlisted, Unsecured, Redeemable, Non-Convertible Debentures	Shapoorji Pallonji Solar Holdings Private Limited	<p>Solar Edge NCDs are redeemable upon the occurrence of an external event – procurement of the GST Order<sup>(1)</sup> by the debenture holder (on behalf of Solar Edge) within a period of three and a half years. The debenture holder has the right to control the negotiation and defence of the claim, at their own cost and expense. Subject to and pursuant to the receipt of the GST Order<sup>(1)</sup>, all the Solar Edge Series A Debentures shall become redeemable upon</p> <p>(i) the later of (A) the expiry of six months from the date of the GST Order; or (B) the actual receipt by Solar Edge of the entirety of the first instalment (in the manner and as provided for in the GST Order) of the GST Receivables<sup>(2)</sup>, within the GST Claim Period<sup>(1)</sup>, provided that the payment of the first GST instalment has been made by SECI without any protest and in compliance with the GST Order; and</p> <p>(ii) SECI and/ or Maharashtra State Electricity Distribution Company Limited having not exercised their right to appeal the GST Order within a period of six months from the date of the GST Order. It is clarified that until the New Lender Discharge<sup>(3)</sup>, any such redemption shall be solely out of the proceeds of investment received by Solar Edge from the Sponsor in terms of the relevant loan document. Further, it is clarified that in case the New Lender Discharge has not occurred but the GST Receivables are in excess of INR 1,050 lakhs, such number of Solar Edge Series A Debentures as are proportionate to the GST</p>

Sr. No.	Name of Project SPV	Type of Security Issued	Debenture Holder	Redemption Event
				<p>Receivables in excess of INR 1,050 lakhs shall become redeemable only upon the occurrence of the New Lender Discharge.</p> <p>In the event the debenture holder is unable to procure the GST Order prior to the expiry of the GST Claim Period or in case the first GST instalment is not received within the GST Claim Period, then upon the expiry of such period, all Solar Edge Series A Debentures shall be redeemed at an amount calculated in the manner specified in the debenture documents, provided that in no case shall the Solar Edge Series A redemption amount exceed INR 99 lakhs under this circumstance and until the New Lender Discharge, any such redemption shall be solely out of the proceeds of investment received by Solar Edge from the Sponsor.</p> <p>Further, the debenture holder shall not have the right to admit any liability on behalf of Solar Edge or settle or compromise the GST Claim without prior written consent of Solar Edge.</p>
2.	Terralight Kanji	(a) Terralight Kanji Series A NCDs: 6,000 number of 7% Unrated, Unlisted, Unsecured, Redeemable, Non-Convertible Debentures; (b) Terralight Kanji Series B NCDs: 6,000 number of 7% Unrated, Unlisted, Redeemable, Unsecured Non-Convertible Debentures; (c) Terralight Kanji Series C NCDs: 6,000 number of 7% Unrated, Unlisted, Redeemable, Unsecured Non-Convertible Debentures; and (d) Terralight Kanji Series D NCDs: 6,000 number of 7% Unrated, Unlisted, Redeemable, Unsecured Non-Convertible Debentures (collectively, “ <b>Terralight Kanji NCDs</b> ”)	Shapoorji Pallonji Solar Holdings Private Limited	<p>Terralight Kanji NCDs, UMD NCDs and TN Solar NCDs redemptions are dependents on the CUF Claim<sup>(4)</sup> and Delayed Interest Claim<sup>(5)</sup>. The debenture holder shall have the right to assume control of the defence and negotiation of the CUF Claim and Delayed Interest Claim, at the debenture holder’s sole cost and expense, on behalf of Terralight Kanji, TN Solar and UMD and procure CUF Order<sup>(6)</sup> and Delayed Interest Claim Order<sup>(7)</sup>. Further, the debenture holder shall not have the right to admit any liability on behalf of Terralight Kanji, TN Solar or UMD or settle or compromise the CUF Claim or Delayed Interest Claim without prior written consent of such Project SPVs.</p> <p><b>Terralight Kanji/ TN Solar/ UMD Series A NCDs</b> shall become redeemable upon:</p>
3.	TN Solar	(a) TN Solar Series A NCDs: 6,000 number of 7% Unrated, Unlisted, Unsecured, Redeemable, Non-Convertible Debentures; (b) TN Solar Series B NCDs: 6,000 number of 7% Unrated,	Shapoorji Pallonji Solar Holdings Private Limited	(i) (a) the actual receipt by Terralight Kanji/UMD/TN Solar of the Revised Tariff Payment <sup>(8)</sup> from TANGEDCO, within the CUF Claim Period; and (b) subject to and only if the CUF Order has become final and non-appealable under applicable law; or

Sr. No.	Name of Project SPV	Type of Security Issued	Debenture Holder	Redemption Event
		Unlisted, Redeemable, Unsecured Non-Convertible Debentures; (c) TN Solar Series C NCDs: 6,000 number of 7% Unrated, Unlisted, Redeemable, Unsecured Non-Convertible Debentures; and (d) TN Solar Series D NCDs: 6,000 number of 7% Unrated, Unlisted, Redeemable, Unsecured Non-Convertible Debentures (collectively, <b>“TN Solar NCDs”</b> )		(ii) the actual receipt by the Terralight Kanji/TN Solar/UMD in full, of tariff payments for the entirety of financial years ending March 31, 2020, March 31, 2021 and March 31, 2022, such that the aggregate of the tariff payments received by Terralight Kanji, TN Solar, UMD from TANGEDCO for each such financial year, are computed for the units of electricity billed by the power plant to TANGEDCO in each such financial year without being subject to the 19% CUF limit;
4.	UMD	(a) UMD Series A NCDs: 6,000 number of 7% Unrated, Unlisted, Unsecured, Redeemable, Non-Convertible Debentures; (b) UMD Series B NCDs: 6,000 number of 7% Unrated, Unlisted, Redeemable, Unsecured Non-Convertible Debentures; (c) UMD Series C NCDs: 6,000 number of 7% Unrated, Unlisted, Redeemable, Unsecured Non-Convertible Debentures; and (d) UMD Series D NCDs: 6,000 number of 7% Unrated, Unlisted, Redeemable, Unsecured Non-Convertible Debentures (collectively, <b>“UMD NCDs”</b> )	Shapoorji Pallonji Solar Holdings Private Limited	<p>(iii) the actual receipt by Terralight Kanji, TN Solar, UMD in full, of tariff payments for the entirety of any three consecutive financial years (excluding a financial year ending March 31, 2020) on and from September 9, 2020 (but, subject to each such financial year being within the CUF Claim Period), such that the aggregate of the tariff payments received by Terralight Kanji, TN Solar, UMD from TANGEDCO for each such financial year, are computed for the units of electricity billed by the power plant to TANGEDCO in each such financial year without being subject to the 19% CUF limit.</p> <p>In the event the debenture holder (on behalf of Terralight Kanji, TN Solar and UMD) is unable to procure the CUF Order prior to the CUF Claim Period, then upon the expiry of such period, Terralight Kanji Series A NCDs, TN Solar Series A NCDs and UMD Series A NCDs shall be redeemed at an amount calculated in the manner specified in the debenture documents.</p> <p><b>Terralight Kanji/ TN Solar/ UMD Series B NCDs:</b></p> <p>Subject to and only if the CUF Order has become final and non-appealable under applicable law, (a) 50% of the Terralight Kanji/ TN Solar/ UMD Series B NCDs shall become redeemable immediately upon the actual receipt by Terralight Kanji/ TN Solar/ UMD of any portion of the Past CUF Receivables/ such other amount prescribed under the CUF Order, within the CUF Claim Period and (b) the outstanding Terralight Kanji/ TN Solar/ UMD Series B NCDs</p>

Sr. No.	Name of Project SPV	Type of Security Issued	Debenture Holder	Redemption Event
				<p>shall become redeemable upon the expiry of the first anniversary of the first Terralight Kanji/ TN Solar/ UMD Series B NCDs redemption.</p> <p>In the event the debenture holder (on behalf of Terralight Kanji, TN Solar and UMD) is unable to procure the CUF Order prior to the CUF Claim Period, or in case the first Series B redemption does not occur within the CUF Claim Period, then upon the expiry of such period, Terralight Kanji Series B NCDs, TN Solar Series B NCDs and UMD Series B NCDs shall be redeemed at an amount calculated in the manner specified in the debenture documents.</p> <p><b>Terralight Kanji/ TN Solar/ UMD Series C NCDs</b></p> <p>The Terralight Kanji/ TN Solar/ UMD Series C NCDs shall become redeemable upon, and to the extent of, the actual receipt by Terralight Kanji/ TN Solar/ UMD of, the entirety or a portion of, the December Receivables<sup>(9)</sup> from TANGEDCO without any deduction towards a rebate of 2% on such December Receivables from time to time (depending on the timing of receipt by Terralight Kanji/ TN Solar/ UMD of such amounts), but prior to the expiry of three years from the subscription date</p> <p>In the event Terralight Kanji, TN Solar and UMD does not receive the entirety or a portion of the December Receivables prior to the expiry of the redemption period, then upon the expiry of such period, the outstanding, Terralight Kanji Series C NCDs, TN Solar Series C NCDs and UMD Series C NCDs shall be redeemed at an amount calculated in the manner specified in the debenture documents.</p> <p><b>Terralight Kanji/ TN Solar/ UMD Series D NCDs:</b></p> <p>The Terralight Kanji/ TN Solar/ UMD Series D NCDs shall become redeemable upon, and to the extent of, the actual receipt by the Terralight Kanji/ TN Solar/ UMD of, the entirety or a portion of, the Delayed Interest Payments from TANGEDCO (as the case may be), from time to time (depending on the</p>

Sr. No.	Name of Project SPV	Type of Security Issued	Debenture Holder	Redemption Event
				<p>timing of receipt by Terralight Kanji/ TN Solar/ UMD of such amounts) within the Delayed Interest Claim Period, subject to and only if the Delayed Interest Claim Order has become final and non-appealable under applicable law.</p> <p>In case Terralight Kanji/ TN Solar/ UMD and TANGEDCO mutually agree to settle the Delayed Interest Claim for a particular sum to be paid by TANGEDCO, the debenture holder shall have the right to seek redemption of all or a proportionate number of Terralight Kanji/ TN Solar/ UMD Series D NCDs.</p> <p>In the event Terralight Kanji/ TN Solar/ UMD does not receive entirety or any portion of the Delayed Interest Payments within the period specified, then upon the expiry of such period, the outstanding, Terralight Kanji Series D NCDs, TN Solar Series D NCDs and UMD Series D NCDs shall be redeemed at an amount calculated in the manner specified in the debenture documents.</p> <p>Further, by way of a letter amendment agreement, an additional redemption event was included which specifies that in case Terralight Kanji/ TN Solar/ UMD agrees (in writing) to waive the Delayed Interest Claim against TANGEDCO in lieu of TANGEDCO making due tariff payments to Terralight Kanji/ TN Solar/ UMD for the period until June 30, 2020 (“<b>Settlement Payments</b>”), then within a period of five business days of receipt of such Settlement Payments or any portion(s) thereof (from time to time) by Terralight Kanji/ TN Solar/ UMD (provided such monies are received within the Delayed Interest Claim Period), the debenture holder shall have the right to seek redemption of all or, from time to time, of a proportionate number (pro-rated to the Settlement Payments received) of the Terralight Kanji Series D NCDs, TN Solar Series D NCDs and UMD Series D NCDs (depending on whether the entirety or portion of the Settlement Payments has been received), at the redemption amount calculated in the manner specified in the letter amendment agreement.</p>

Sr. No.	Name of Project SPV	Type of Security Issued	Debenture Holder	Redemption Event
5.	Terralight Rajapalayam	TR NCD 6,000 number of 7% Unrated, Unlisted, Redeemable, Unsecured Non-Convertible Debentures (collectively, “TR NCDs”)	Shapoorji Pallonji Solar Holdings Private Limited	In case of TR NCDs, upon the actual receipt by Terralight Rajapalayam of the TR December Receivables <sup>(10)</sup> from TANGEDCO without any deduction towards a rebate of 2% on such TR December Receivables, the TR NCDs were fully redeemed, as on the date of this Final Placement Memorandum.

- (1) *GST Order means the order within a period of three years and six months from the subscription date (“GST Claim Period”), directing the payment of the GST Receivables to Solar Edge, in relation to claims raised by Solar Edge before the CERC, in respect of change in law reliefs under the power purchase agreements, vide petition number 536/MP/2020. For details, see ‘Material Litigation and Regulatory Action – Litigation and Regulatory Actions involving the Asset SPVs’ on page 294.*
- (2) *GST Receivables means such amount, receivable by Solar Edge from SECI, after the refinancing date, whether as a lump-sum amount or from time to time, pursuant to the GST Order.*
- (3) *New Lender Discharge means full and final satisfaction or discharge of the dues outstanding to the refinancing lenders and the new working capital lenders.*
- (4) *CUF Claim means the claim(s) raised by Terralight Kanji, TN Solar and UMD, against TANGEDCO, in relation to all the cash receivables for electricity payments under the respective power purchase agreements executed with TANGEDCO on account of 19% CUF being imposed by TANGEDCO, along with interest as applicable. For details, see ‘Material Litigation and Regulatory Action – Litigation and Regulatory Actions involving the Asset SPVs’ on page 294.*
- (5) *Delayed Interest Claim means the claim(s) raised by Terralight Kanji, TN Solar and UMD, against TANGEDCO, in respect of payment of interest by TANGEDCO or reversal of any rebate charged by TANGEDCO to Terralight Kanji, TN Solar and UMD, on delayed tariff payments under the respective power purchase agreements executed with TANGEDCO, for the period ending on December 31, 2019.*
- (6) *CUF Order means order received within a period of five years from the subscription date (“CUF Claim Period”), directing TANGEDCO to (a) remove the 19% CUF limit on the purchase of power from the power plant; and/ or (b) make payment of such amount to be paid by TANGEDCO to Terralight Kanji, TN Solar or UMD, after the refinancing closing date, as differential tariff payments under the power purchase agreements for the period ending on 31 December 2019, for disputed receivables corresponding to revenues for such period, calculated without being subject to the 19% CUF limit (“Past CUF Receivables”). In the event the CUF Order is appealed by TANGEDCO, the CUF Claim Period shall stand automatically extended for an additional period of two and a half years from the date of expiry of the CUF Claim Period. For details, see ‘Material Litigation and Regulatory Action – Litigation and Regulatory Actions involving the Asset SPVs’ on page 294.*
- (7) *Delayed Interest Claim Order means order within a period of five years from the subscription date (“Delayed Interest Claim Period”), directing TANGEDCO to make payment to Terralight Kanji, TN Solar or UMD, after the refinancing closing date, whether as a lump-sum amount or from time to time, as interest in respect of delays in making due tariff payments, pursuant to the Delayed Interest Claim (“Delayed Interest Payments”). It is specified that notwithstanding the interest amounts received by Terralight Kanji, TN Solar or UMD from TANGEDCO, Delayed Interest Payments shall only include interest amounts paid in respect of delays until December 31, 2019 (and interest amounts paid in respect of delays for the period after December 31, 2019 shall not be considered as Delayed Interest Payments). In the event the Delayed Interest Claim Order is appealed by TANGEDCO, the Delayed Interest Claim Period shall stand automatically extended for an additional period of two and a half years from the date of expiry of the Delayed Interest Claim Period.*
- (8) *Revised Tariff Payment means the actual receipt by Terralight Kanji, TN Solar or UMD in full, of the tariff payments for the entirety of the financial year in which the CUF Order becomes final and non-appealable such that the aggregate tariff payments received by Terralight Kanji or TN Solar or UMD from TANGEDCO for such financial year, are computed for the units of electricity billed by the power plant to TANGEDCO in such financial year without being subject to the 19% CUF limit.*
- (9) *December Receivables means receivables accruing to Terralight Kanji, TN Solar and UMD from TANGEDCO under the power purchase agreements, as reflected in the financial statements of Terralight Kanji, TN Solar and UMD, for the period ending on December 31, 2019.*
- (10) *TR December Receivables means receivables accruing to Terralight Rajapalayam from TANGEDCO under the power purchase agreements, as reflected in the financial statements of Terralight Rajapalayam for the period ending on December 31, 2019.*

As mentioned above, the redemption event for the NCDs issued by the Project SPVs are dependent on outcome on the certain outstanding litigation involving our Project SPVs. However, in accordance with the relevant securities subscription and purchase agreements, the debenture holders hold the right to assume control of the defence and negotiation of such legal proceedings at its cost and expense. For additional details on NCDs, see **‘Risk Factors - The NCDs issued by our Project SPVs are subject to certain terms and conditions’** on page 32.

The descriptions above are indicative, and there may be additional terms and conditions with respect to security, financial or other covenants and events of default under the various borrowing arrangements entered into by the Asset SPVs and NCD documents entered into by the Project SPVs. The Asset SPVs are required to ensure that the aforementioned events of default and other events of default, as specified under the various documents and agreements entered into by such Asset SPV for the purpose of availing of loans, are not triggered.



### **Consents from the Lenders of the Asset SPVs**

As at the date of this Final Placement Memorandum, the Solar Edge re-financing facility agreement specifically permits to undertake the various activities that are proposed by way of the Formation Transactions and the Issue including permitted reorganization for any sale by the Sponsor of its shareholding in Solar Edge to Terra InvIT subject to the Terra InvIT being controlled by the Sponsor, Kohlberg Kravis Roberts & Co. L.P. (“**KKR**”) and/or KKR affiliates until final settlement date and Terra InvIT executes an undertaking as contemplated under the facility agreement.

Further, as at the date of this Final Placement Memorandum, all the Asset SPVs have intimated and obtained necessary consent from all its lenders, as required under the relevant facility documentations to undertake the various activities that are proposed by way of the Formation Transactions and the Issue, such as change in shareholding of the Asset SPVs, amendments to the charter documents of the Asset SPVs, transfer of shareholding of the Asset SPVs to Terra InvIT etc. subject to certain conditions such as prior review and approval by lenders of amendment to charter documents and all existing rights of lenders under facility documents continuing.

For additional details on indebtedness, see ‘*Risk Factors – The Asset SPVs are subject to restrictive covenants and undertakings under its financing agreements. Any non-compliance or default by the Asset SPVs could limit its flexibility in managing its business or to use cash or other assets.*’, and ‘*Background and Structure of the Terra InvIT*’ and ‘*Use of Proceeds*’ on pages 30, 94 and 73 respectively.

## SECTION VIII – LEGAL AND OTHER INFORMATION

### MATERIAL LITIGATION AND REGULATORY ACTION

*Except as stated in this section, there are no outstanding material litigation or non-ordinary course regulatory action involving the Asset SPVs and against the Terra InvIT, the Sponsor, the Investment Manager, the Project Manager or any of their Associates and the Trustee that are currently pending.*

*For purposes of this section, on the basis described below, details of all non-ordinary course regulatory actions and criminal matters that are currently pending, involving Asset SPVs or against the Terra InvIT, the Sponsor, the Investment Manager, the Project Manager or their respective Associates (collectively referred to as the “**Relevant Parties**”) and the Trustee have been disclosed. Further, all material litigations (on the basis described below) with respect to the Asset SPVs and against the Terra InvIT, the Sponsor, the Investment Manager, the Project Manager or each of their respective Associates and the Trustee have been disclosed. For this purpose, all civil litigation involving an amount equivalent to, or more than the amount as disclosed below, have been considered material.*

*Outstanding litigation against any of the Asset SPVs before any judicial forum involving a claim amount exceeding ₹516.36 lakhs, being 1.5% of revenue from operations of the Asset SPVs for the last completed audit period (i.e., Financial Year 2021), in accordance with the Combined Financial Statements shall be considered material. In relation to outstanding litigation and/or regulatory actions (which are outside the ordinary course) where the monetary liability is not quantifiable, such litigation shall be considered material in the event that the outcome of such litigation would have a material adverse effect on the position of the Asset SPVs.*

*The disclosures with respect to material litigations and non-ordinary course regulatory actions relating to the Sponsor and its Associates (other than the Terra InvIT and its Associates, the Asset SPVs and the Investment Manager, Project Manager and their Associates), have been made solely on the basis of the public disclosures made by KKR & Co. Inc., (“**KKR & Co.**”) in the most recent quarterly report on Form 10-Q filed with U.S. Securities and Exchange Commission on August 6, 2021 relating to the quarter ended June 30, 2021 with respect to all entities, which are consolidated for financial reporting purposes with KKR & Co., which is listed on the New York Stock Exchange. In accordance with applicable securities law and stock exchange rules, KKR & Co., is required to disclose material litigations through applicable securities filings and KKR & Co., has made no public filings after August 6, 2021 which materially changes the disclosures made in that regard in such quarterly report. The threshold for identifying material litigations in such disclosures is based on periodically reviewed thresholds applied by the independent auditor of KKR & Co., in expressing its opinion on the financial statements and is generally linked to various financial metrics of KKR & Co.*

*In relation to the Trustee, all litigation involving an amount equivalent to or exceeding ₹100.58 lakhs (being 5% of the profit after tax for Financial Year ended March 31, 2021 based on the audited standalone financial statements of the Trustee for Financial Year ended March 31, 2021).*

*Taxation proceedings against the Relevant Parties (and, in case of the Asset SPVs, involving the Asset SPVs) have been disclosed in a consolidated manner on the basis of the above.*

#### **I. Litigation and Regulatory Actions against the Terra InvIT and its Associates**

As at the date of this Final Placement Memorandum, there are no there are no outstanding criminal litigation, non-ordinary course regulatory actions or material civil litigation against the Terra InvIT and the Associates of the Terra InvIT, save as set out herein.

#### **II. Litigation and Regulatory Actions against the Sponsor and its Associates (other than the Terra InvIT and its Associates, the Asset SPVs and the Investment Manager, Project Manager and their Associates)**

In accordance with the abovementioned, except as stated below, there are no outstanding criminal litigation, non-ordinary course regulatory actions or material civil litigation against the Sponsor solely on the basis described above.

From time to time, KKR (including Global Atlantic) is involved in various legal proceedings, lawsuits, arbitration and claims incidental to the conduct of KKR's businesses. KKR's asset management and insurance businesses are also subject to extensive regulation, which may result in regulatory proceedings against them.

In December 2017, KKR & Co. L.P. (which is now KKR & Co. Inc.) and its Co-Chief Executive Officers were named as defendants in a lawsuit filed in Kentucky state court alleging, among other things, the violation of fiduciary and other duties in connection with certain separately managed accounts that Prisma Capital Partners LP, a former subsidiary of KKR, manages for the Kentucky Retirement Systems. Also named as defendants in the lawsuit are certain current and former trustees and officers of the Kentucky Retirement Systems, Prisma Capital Partners LP, and various other service providers to the Kentucky Retirement Systems and their related persons. KKR and other defendants' motions to dismiss were denied by the trial court in November 2018, but in April 2019 the Kentucky Court of Appeals vacated the trial court's opinion and order denying the motions to dismiss the case for lack of standing. The decision of the Court of Appeals was appealed by plaintiffs to the Supreme Court of Kentucky. On July 9, 2020, the Supreme Court of Kentucky reversed the trial court's order and remanded the case to the trial court with direction to dismiss the complaint for lack of constitutional standing. On July 20, 2020, the Office of the Attorney General, on behalf of the Commonwealth of Kentucky, filed a motion to intervene as a plaintiff in the lawsuit and on July 21, 2020 filed a new lawsuit in the same Kentucky trial court making essentially the same allegations against the defendants, including KKR & Co. Inc. and Messrs. Kravis and Roberts. On July 29, 2020, certain private plaintiffs in the original lawsuit filed a motion to further amend their original complaint and to add new plaintiffs. On July 30, 2020, KKR and other defendants filed objections to the Attorney General's motion to intervene. On December 28, 2020, the trial court dismissed the complaint filed by the original plaintiffs and denied their motion to amend their original complaint and add new plaintiffs, but granted the Office of the Attorney General's motion to intervene. In January 2021, some of the attorneys for the private plaintiffs in the original lawsuit filed a new lawsuit, and a motion to intervene in the original lawsuit, on behalf of a new set of plaintiffs, who claim to be "Tier 3" members of Kentucky Retirement Systems, alleging substantially the same allegations as in the original lawsuit. The motion to intervene in the original lawsuit was denied. In addition, the Kentucky Retirement Systems had commissioned an investigation into certain matters alleged in the Attorney General's complaint. The trial court ordered that this investigation be completed by May 17, 2021, and the Attorney General was permitted to amend its complaint after reviewing the investigation's report within ten days of the Attorney General's receipt of it. On May 24, 2021, the Attorney General filed a First Amended Complaint on behalf of the Commonwealth of Kentucky. This complaint continues to name KKR & Co. L.P. and its Co-Chief Executive Officers, as defendants, and makes similar allegations against them. KKR and the other defendants moved to dismiss the First Amended Complaint on July 30, 2021. On July 9, 2021, the individual plaintiffs served an amended complaint, which purports to assert, on behalf of a class of beneficiaries of Kentucky Retirement Systems, direct claims for breach of fiduciary duty and civil violations under the Racketeer Influenced and Corrupt Organizations Act. This complaint was removed to the U.S. District Court for the Eastern District of Kentucky.

KKR (including Global Atlantic) currently is and expects to continue to become, from time to time, subject to examinations, inquiries and investigations by various U.S. and non-U.S. governmental and regulatory agencies, including but not limited to the SEC, Department of Justice, U.S. state attorney generals, Financial Industry Regulatory Authority ("FINRA"), the U.K. Financial Conduct Authority, Central Bank of Ireland, Monetary Authority of Singapore, U.S. state insurance regulatory authorities, and the Bermuda Monetary Authority. Such examinations, inquiries and investigations may result in the commencement of civil, criminal or administrative proceedings or fines against KKR or its personnel.

Moreover, in the ordinary course of business, KKR (including Global Atlantic) is and can be both the defendant and the plaintiff in numerous lawsuits with respect to acquisitions, bankruptcy, insolvency and other events. Such lawsuits may involve claims that adversely affect the value of certain investments owned by KKR's funds and Global Atlantic's insurance companies.

KKR establishes an accrued liability for legal proceedings only when those matters present loss contingencies that are both probable and reasonably estimable. In such cases, there may be an exposure to loss in excess of any amounts accrued. No loss contingency is recorded for matters where such losses are either not probable or reasonably estimable (or both) at the time of determination. Such matters may be subject to many uncertainties, including among others: (i) the proceedings may be in early stages; (ii) damages sought may be unspecified, unsupported, unexplained or uncertain; (iii) discovery may not have been started or is incomplete; (iv) there may be uncertainty as to the outcome of pending appeals or motions; (v) there may be significant factual issues to be resolved or (vi) there may be novel legal issues or unsettled legal theories to be presented or a large number of parties. Consequently, management is unable to estimate a range of potential loss, if any, related to these matters. In addition, loss contingencies may be, in part or in whole, subject to insurance or other payments such as contributions and/or indemnity, which may reduce any ultimate loss. KKR has included in its financial statements the reserve for regulatory, litigation and related matters that Global Atlantic includes in its financial statements, including with respect to matters arising from the conversion of life insurance policies from systems previously managed by Athene Holdings Limited to the platform of one of Global Atlantic's third party service

providers, Alliance-One, a subsidiary of DXC Technology Company.

It is not possible to predict the ultimate outcome of all pending legal proceedings, and some of the matters discussed above seek or may seek potentially large and/or indeterminate amounts. Based on information known by management, management has not concluded that the final resolutions of the matters above will have a material effect upon the financial statements. However, given the potentially large and/or indeterminate amounts sought or may be sought in certain of these matters and the inherent unpredictability of investigations and litigations, it is possible that an adverse outcome in certain matters could, from time to time, have a material effect on KKR's financial results in any particular period.

### III. Litigation and Regulatory Actions involving the Asset SPVs

1. NSFI on behalf of Terralight Kanji, TN Solar and UMD has filed a petition dated December 1, 2018 before the TNERC against TANGEDCO, SLDC and TANTRANSCO regarding the non-payment by SLDC for the units of electricity supplied by Terralight Kanji, TN Solar and UMD, in excess of 19% of the annual CUF. The petition sought an interim stay on the operation of the circular issued by the SLDC dated June 14, 2016 ("**Circular**"), challenging it as being wholly arbitrary, illegal and contrary to the provisions of the Electricity Act 2003 and TNERC tariff orders. Further, the petition sought to direct the SLDC to adhere to the terms of the PPAs entered into with Terralight Kanji, TN Solar and UMD and not make deductions by applying CUF. By way of an order dated December 20, 2020, the TNERC has disallowed the petition and stated that payments made to the solar power generators shall be limited to the annual generation that corresponds to the annual CUF of 19%. An appeal has been filed by NSFI before APTEL on February 18, 2021 against the TNERC order. The matter is currently pending.

As part of acquisition of the Project SPVs from Shapoorji Pallonji Solar Holdings Private Limited and Shapoorji Pallonji Infrastructure Capital Company Private Limited, the Project SPVs have issued NCDs to Shapoorji Pallonji Solar Holdings Private Limited which are *inter alia* redeemable upon receipt of certain orders in connection with the above litigation. For details of redemption terms, please see '**Financial Indebtedness –NCD Terms (Terralight Kanji, TN Solar and UMD)**' on page 285. Further, as per the debenture subscription agreements with respect to Terralight Kanji, TN Solar and UMD, the debenture holder i.e. Shapoorji Pallonji Solar Holdings Private Limited has the right to assume control of the defense and negotiation of this litigation. However, the debenture holder shall not have the right to admit any liability on behalf of Terralight Kanji, TN Solar or UMD or settle or compromise the litigation without prior written consent of the concerned Project SPVs. For financial impact of this matter on Terralight Kanji, TN Solar and UMD, please see '**Financial Indebtedness –NCD Terms (Terralight Kanji, TN Solar and UMD)**' on page 285.

2. NSFI on behalf Terralight Kanji, TN Solar, UMD and Terralight Rajapalayam has filed petition dated August 10, 2016 before the TNERC against TANGEDCO, SLDC, TANTRANSCO and others seeking deemed generation charges on account of loss of power generation units due to unjustified and unlawful backing down instructions issued by SLDC verbally without any written confirmation and forceful disconnection and curtailment of supply by TANGEDCO and TANTRANSCO. The petition states that despite the possibility of maximum power production, since they are unable to evacuate such power, it is leading to wastage of power as well as impacting their revenue. TNERC by way of an order dated March 25, 2019 ("**TNERC Order**") held that the SLDC should not resort to back down instructions without recording a reason. On the issue of deemed generation benefits, TNERC observed that it has already instructed the SLDC to not to resort to back down instructions without reasons, and that there were no provisions in the PPA's which pertains to payment of deemed generation charges. Therefore, no deemed generation benefits were awarded. Subsequently, NSFI on behalf of the Terralight Kanji, TN Solar, UMD and Terralight Rajapalayam appealed before the ATE on May 7, 2019 to (i) provide a direction to TANGEDCO, SLDC, TANTRANSCO and MNRE to stop and implement 'must run' status on all solar power plants under regulation 5.2 of the Central Electricity Regulatory Commission (Indian Electricity Grid Code) Regulations 2010; and (ii) issue a direction to consider deemed generation benefits to the solar power plants for the loss of generation due to issuance of backing down instructions of SLDC under regulation 2(q) of the TNERC (Terms and Conditions for Determination of Tariff) Regulations, 2015. ATE by way of an order dated August 2, 2021 held that the issues raised in the appeal filed by NSFI have merits and hence, the appeal was allowed. Further, the TNERC Order was set aside to the extent of denial of deemed generation charges/ compensation for issuing backing down instructions. The matter is currently pending.
3. Solar Edge has filed a petition dated June 24, 2019 before the CERC, New Delhi against SECI and

MSEDCL, claiming the effect of 'change in law' as per the provisions of the PPA entered into between Solar Edge with SECI. The change in law claims are made as a consequence of additional tax burden on construction, operation and maintenance of the solar power generating system on account of imposition of Central Goods and Services Tax Act, 2017, the Integrated Goods and Services Tax Act, 2017, the State Goods and Services Tax Act, 2017 ("**GST Laws**"). The matter is currently pending. Subsequently, SECI has filed a petition dated June 4, 2020 before the CERC, New Delhi wherein various solar power developers ("**SPDs**") and distributor companies are made respondents to the matter, to seek directions from CERC to formulate a mechanism for payment of compensation to the SPDs in light of the above outstanding matter. SECI has sought this amount payable on account of GST Laws from distribution companies so that SECI may make this payment to the SPDs under the respective PPAs. Solar Edge has filed its written submission on the petition filed by SECI. The matter is currently pending.

As part of acquisition of the Project SPVs from Shapoorji Pallonji Solar Holdings Private Limited and Shapoorji Pallonji Infrastructure Capital Company Private Limited, the Project SPVs have issued NCDs to Shapoorji Pallonji Solar Holdings Private Limited which are *inter alia* redeemable upon receipt of certain orders in connection with the above litigation. For details of redemption terms, please see '**Financial Indebtedness –NCD Terms (Solar Edge)**' on page 285. Further, as per the debenture subscription agreement with respect to Solar Edge, the debenture holder i.e. Shapoorji Pallonji Solar Holdings Private Limited has the right to assume control of the defense and negotiation of this litigation at their own cost and expense. However, the debenture holder shall not have the right to admit any liability on behalf of Solar Edge or settle or compromise the litigation without prior written consent of Solar Edge. For financial impact of this matter on Solar Edge, please see '**Financial Indebtedness –NCD Terms (Solar Edge)**' on page 285.

4. Solar Edge has filed a writ petition dated December 15, 2020 before the Bombay High Court against the MERC and others challenging the MERC (Forecasting, Scheduling and Deviation Settlement for Solar and Wind Generation) Regulations, 2018 ("**Maharashtra F&S Regulations**") on grounds including, (i) the Maharashtra F&S Regulations being arbitrary, onerous in nature and hence violative of Article 14 of the Constitution of India, (ii) the charges levied on the renewables project having no nexus to the objective of grid security, leading to unjust charges being sought from the renewables energy generators. The matter is currently pending adjudication.
5. Terralight Kanji, TN Solar, UMD and Terralight Rajapalayam have filed a writ petition under Article 226 of the Constitution of India before the Madras High Court against TNERC, TANGEDCO and others on June 25, 2021 challenging the TNERC Forecasting Scheduling and Deviation Settlement and Related Matters for Wind and Solar Generation Regulations 2019 dated March 1, 2019 and Procedure for TNERC Forecasting Scheduling and Deviation Settlement and Related Matters for Wind and Solar Generation Regulations 2019 dated October 3, 2020 ("**TN F&S Regulations**") on grounds including, among others (i) the TN F&S Regulations seek to treat the renewable energy projects like wind and solar at par with conventional thermal power stations which is arbitrary since it is not possible to give accurate projections on how the weather condition will impact their generation at a given point of time of day; (ii) the TN F&S Regulations have sought to fix the absolute error band at (+/- 10%) which is a much narrower and tightened error band than compared to other similarly placed renewable energy generating rich states as well as the Forum of Regulators Model Regulations (at +/- 15%); and (iii) the TN F&S Regulations do not include provisions pertaining to aggregation of generation schedules among pooling substations at the state level. The matter was admitted by the Madras High Court on August 6, 2021 is currently pending.
6. A petition dated May 29, 2018 was filed by the group gram panchayat at Wadve (Maharashtra) and the *sarpanch* against Solar Edge before the Civil Court, Muktainagar, District Jalgaon alleging that Solar Edge does not possess a gram panchayat NOC with the sign and seal for setting up the solar power plant at Muktainagar, Jalgaon district and sought for an injunction. The matter is currently pending.
7. A petition dated November 5, 2015 was filed by Mehalingam and others before the District Munsif Cum Judicial Magistrate, Vilathikulam seeking permanent injunction to restrain TN Solar from erecting electrical polls and cause any interference to the peaceful enjoyment of their property. An ex parte decree was passed on September 6, 2018 ("**2018 Order**") in favour to Mehalingam and others. A petition dated December 11, 2019 was filed by TN Solar before the District Munsif Vilathikulam to set aside 2018 Order along with a petition dated December 11, 2019 for condonation of delay of filing the written statement in relation to the 2018 Order. The set aside petition and condonation of delay was allowed by the court, with cost imposed. The matter is currently pending.

8. Terralight Kanji has received a legal notice, on behalf of Mr. Baskaran, concerning a dispute on purchase of land at survey no. 7/1 measuring an extent of 3 acres, where the 30 MW solar power plant of Terralight Kanji is located. Terralight Kanji has responded to the legal notice maintaining that, *inter alia*, it purchased the property from legal heirs and it is in exclusive enjoyment and possession of the property. In furtherance of the legal notice, Terralight Kanji received legal summons from District and Sessions Court, Thiruvannamalai to appear before the court in relation to the case registered by Mr. Mr. Baskaran. The matter is currently pending.
9. Solar Edge purchased land for the 50MW Muktainagar solar power plant from Mr. Jeevan Ram Patel pursuant to sale deed dated May 16, 2017. Mrs. Surekha Patil (“**Plaintiff**”) has filed suit at the Court of Civil Judge, Junior Division at Muktainagar (“**Civil Court, Muktainagar**”), against Mr. Jeevan Ram Patel, Solar Edge and others (“**Defendants**”), stating that disputed land is in her ownership and occupation, the land was not sold to Mr. Jeevan Ram Patel and that it was provided as security for the purposes of loan availed from Mr. Jeevan Ram Patel. The Plaintiff, *inter alia*, has requested the court to transfer the sale deed of the property to her name and a permanent prohibitory order against the Defendants that there should not be any objection and obstruction to the Plaintiff and her family occupying the suit property. The Plaintiff has also made an application to Civil Court, Muktainagar to obtain a temporary prohibitory order to not allow any objection or obstruction by the Defendants for the Plaintiff’s possession of the suit property and the temporary prohibitory order should be kept permanent till the judgement is pronounced. The matter is currently pending.

Further, in terms of the indemnity provisions of the Amended and Restated Securities Subscription and Purchase Agreement for acquisition of the Solar Edge from Shapoorji Pallonji Solar Holdings Private Limited and Shapoorji Pallonji Infrastructure Capital Company Private Limited (“**SPICCL**”), SPICCL shall represent Solar Edge in this matter.

10. Solar Edge had bought the parcel of land (admeasuring 3 hectare and approx. 8.5 acres) situated at Gut No. 541, Village Hartale, Muktainagar, a critical part of the 50 MW power plant in Muktainagar, from Vinod Patel and Pushpa Patel (“**Sellers**”) pursuant to sale deed dated March 21, 2017. This parcel is subject to claim by an heir (“**Claimant**”) of the earlier land owner, Mr. Lalsingh Patil, who had sold the land to the Sellers, and mutation entry was recorded and certified. Upon Claimant challenging the mutation entry recording the names of the Sellers at various forums, the Maharashtra Revenue Tribunal (“**Revenue Tribunal**”) passed an order dated November 28, 2018 against the Sellers, pursuant to which, the Tahsildar called upon Solar Edge to hand over the possession of the subject land, vide notice dated June 2, 2021. Solar Edge filed a writ petition under Article 227 of the Constitution of India at the High Court of Bombay bench at Aurangabad (“**High Court**”), challenging the order by Revenue Tribunal and notice from Tahsildar. The High Court has stayed the operation of the notice issued by the Tahsildar, pursuant to order dated June 29, 2021. The matter is currently pending.
11. GERC, by way of its tariff order dated January 29, 2010 (“**GERC Tariff Order**”) determined the generic tariff for procurement of power from the solar energy developers by the discoms. The tariff for solar power projects for 25 years basis the capital cost of ₹16.50 crores per MW and debt-equity ratio of 70:30, was determined as two sub-periods: (a) ₹15 per unit for first 12 years starting from date of commercial operation; and (b) ₹5 per unit for the balance 13 years thereafter, and this tariff would apply only to the projects commissioned within two years from the date of the order. GUVNL filed a petition before the GERC for revisiting and revision of the tariff for the solar energy projects determined in the earlier tariff order dated January 29, 2010. The key contention, *inter alia*, was that at the time of passing the GERC Tariff Order, GERC assumed the project cost at ₹16.50 crores based on the representations made by the solar developers although the actual project cost incurred by many of the solar developers was much less than ₹16.50 crores. GERC, dismissed the petition as being not maintainable by its order dated August 8, 2013 (“**Impugned Order**”) as the petition filed by the GUVNL was a review of the earlier GUVNL Tariff Order filed after considerable lapse of time which was not maintainable. Therefore, GUVNL filed an appeal with APTEL, New Delhi for the setting aside of the Impugned Order and for issuing consequential directions. APTEL in its order dated August 22, 2014 (“**APTEL Order**”) upheld the Impugned Order and stated that GERC was correct in holding that the GUVNL petition for re-determination of tariff was not maintainable. Subsequently, GUVNL filed a civil appeal against APTEL’s order on October 27, 2014, against GERC and others (including TSEC and PLG) before the Supreme Court. The matter is currently pending.

#### **IV. Litigation and Regulatory Actions against the Investment Manager, Project Manager and their Associates**

As at the date of this Final Placement Memorandum, subject to the disclosures made in ‘*Litigation and Regulatory Actions against the Sponsor*’ above, there are no outstanding criminal litigation, non-ordinary course regulatory actions or material civil litigation against the Investment Manager, Project Manager and their Associates.

#### **V. Litigation and Regulatory Actions against the Trustee**

As at the date of this Final Placement Memorandum, there are no material litigation or any outstanding criminal litigation or regulatory actions against the Trustee.

#### **VI. Taxation Proceedings**

The details of all outstanding tax disputes involving the Asset SPVs and against the Terra InvIT, Sponsor, the Project Manager, the Investment Manager, their respective Associates and the Trustee, on the basis of abovementioned, are set forth below:

<b>Name of the entity</b>	<b>Number of Proceedings</b>	<b>Amount Involved</b>
<b><i>Direct tax</i></b>		
i. Terra InvIT	-	-
ii. Sponsor	-	-
iii. Investment Manager	-	-
iv. Project Manager	-	-
v. Associates of Sponsor / Project Manager / Investment Manager	-	-
vi. Asset SPVs	11	280.19 lakhs
vii. Trustee	-	-
<b><i>Indirect Tax</i></b>		
i. Terra InvIT	-	-
ii. Sponsor	-	-
iii. Investment Manager	-	-
iv. Project Manager	-	-
v. Associates of Sponsor / Project Manager / Investment Manager	-	-
vi. Asset SPVs	1	1,848.23 lakhs
vii. Trustee	-	-

## REGULATORY APPROVALS

*Provided below are the material approvals, consents, licenses, registrations and permissions from the government, various governmental agencies and other statutory and/or regulatory authorities with which the Terra InvIT can undertake the Issue and the Terra InvIT and the Asset SPVs can undertake their respective current business activities, as applicable. Unless otherwise stated, these approvals are valid as of the date of this Final Placement Memorandum. In the event that any of the approvals and licenses that are required for the Asset SPVs' business operations expire in the ordinary course of business, the relevant Asset SPV will apply for such renewal from time to time. For details in connection with the regulatory and legal framework within which the Terra InvIT and the Asset SPVs operate, see 'Regulations and Policies' on page 183.*

### **A. Approvals in relation to the Issue**

1. Resolution dated January 27, 2021 passed by the board of directors of Terra Asia Holdings II Pte. Ltd. approving the settlement of the Terra InvIT and to act as a sponsor of the Terra InvIT.
2. Resolutions dated January 27, 2021, March 3, 2021 and July 23, 2021 respectively, passed by the board of directors of the Investment Manager in relation to the Issue and other incidental matters.
3. In-principle listing approval from NSE dated August 6, 2021.

### **B. Approvals in relation to the Terra InvIT**

1. Certificate of registration dated February 25, 2021 bearing registration number IN/InvIT/20-21/0018 issued by SEBI under Regulation 3 of the SEBI InvIT Regulations, for registration of the Terra InvIT as an infrastructure investment trust. The registration certificate has been granted subject to the following conditions, *inter-alia*, as specified in Regulation 7 of the SEBI InvIT Regulations:
  - i. the Terra InvIT shall abide by the provisions of the SEBI Act and the SEBI InvIT Regulations;
  - ii. the Terra InvIT shall forthwith inform the SEBI in writing, if any information or particulars previously submitted to the SEBI are found to be false or misleading in any material particular or if there is any material change in the information already submitted;
  - iii. the Terra InvIT and the parties to the Terra InvIT shall satisfy with the conditions specified in Regulation 4 of the SEBI InvIT Regulations at all times;
  - iv. the Terra InvIT and the parties to the Terra InvIT shall comply, at all times, with the code of conduct as specified in Schedule VI of the SEBI InvIT Regulations, wherever applicable.

The certificate also states:

- i. that the investment conditions and other restrictions will apply to all investments, distributions etc. made;
- ii. that for issuance and listing of Units issued in terms of Chapter VIA of the SEBI InvIT Regulations, the Terra InvIT shall fulfill the conditions as may be prescribed by the SEBI from time to time;
- iii. that the transaction for transfer of the underlying assets/shares or interest in Asset SPVs to the Terra InvIT and the corresponding issue of the Terra InvIT's Units to the transferor entity shall happen only after the closure of the initial offer;
- iv. the minimum investment and lot size for an InvIT shall be as prescribed by SEBI from time to time;
- v. that the Terra InvIT shall keep and maintain the books of accounts, records and such other documents as may be required by the SEBI under the SEBI InvIT Regulations from time to time;
- vi. that the Terra InvIT shall ensure compliance with the guidelines/directives/instructions/circulars etc. as may be issued from time to time by the SEBI or the Government of India relating to the activities carried on by the Trust;



- vii. that the Terra InvIT shall not make use of its status as a SEBI registered InvIT in furtherance of unrelated activities or any other purpose which is not permitted under the SEBI InvIT Regulations;
- viii. that the Terra InvIT's actions shall be governed by the SEBI Act and the SEBI InvIT Regulations in respect of activities carried on as an InvIT;
- ix. that any material change in the information on the basis of which registration is granted must be communicated to SEBI immediately; and
- x. that the registration has been granted on the basis of information available with the SEBI at the relevant point of time and does not preclude the SEBI from cancelling the registration later if anything adverse is found against the Terra InvIT or in case of a conviction.

### **C. Approvals in Relation to the Asset SPVs**

#### ***Commissioning Certificates***

1. Commissioning certificate dated April 7, 2018 issued by MEDA, certifying successful commission of 30 MW (AC) solar power project (Beed) of Solar Edge on March 23, 2018.
2. Declaration of commercial operation dated August 1, 2018 issued by SECI, declaring commercial operation date of 30 MW(AC) solar power project (Beed) of Solar Edge on April 22, 2018.
3. Commissioning certificate dated April 7, 2018 issued by MEDA, certifying successful commission of 50 MW (AC) solar power project (Beed) of Solar Edge on March 9, 2018.
4. Declaration of commercial operation dated August 1, 2018 issued by SECI, declaring commercial operation date of 50 MW (AC) solar power project (Beed) of Solar Edge on April 8, 2018.
5. Commissioning certificate dated April 7, 2018 issued by MEDA, certifying successful commission of 50 MW (AC) solar power project (Jalgaon) of Solar Edge on March 27, 2018.
6. Declaration of commercial operation dated August 1, 2018 issued by SECI, declaring commercial operation date of 50 MW (AC) solar power project (Jalgaon) of Solar Edge on April 26, 2018.
7. Commissioning certificate dated March 29, 2016 issued by TANGEDCO, certifying successful commission of 30 MW (AC) solar power project of Terralight Kanji (formerly known as Solar PV) on March 26, 2016.
8. Commissioning certificate dated October 24, 2018 issued by TANGEDCO, certifying successful commission of 50 MW (AC) solar power project of Terralight Rajapalayam (formerly known as SP Suryaprakash) on September 26, 2018.
9. Letter dated May 30, 2016 issued by TANGEDCO, certifying successful synchronization of 5 MW (AC) solar power project of TN Solar on December 28, 2015.
10. Commissioning certificate dated October 19, 2015 issued by TANGEDCO, certifying successful commission of 8 MW (AC) solar power project of TN Solar on September 28, 2015.
11. Letter dated December 28, 2015 issued by TANGEDCO, certifying successful synchronization of 10 MW (AC) solar power project of TN Solar on November 2, 2015.
12. Commissioning certificate dated December 2, 2015 issued by TANGEDCO, certifying successful commission of 12 MW (AC) solar power project of UMD on November 16, 2015.
13. Letter dated May 7, 2016 issued by TANGEDCO, certifying successful synchronization of 13 MW (AC) solar power project of UMD on March 21, 2016.
14. Commissioning certificate dated February 23, 2012 issued by GEDA, certifying successful commission of 20 MW solar power project of PLG on January 26, 2012.
15. Commissioning certificate dated September 15, 2016 issued jointly by UPPTCL, UPNEDA and DVVNL

certifying successful commission of 30 MW solar power project of USUPL on September 15, 2016.

16. Commissioning certificate dated October 21, 2011 issued by RRECL, certifying successful commission of 5 MW solar power project of TSET on October 15, 2011.
17. Commissioning certificate dated April 17, 2012 issued by GEDA, certifying successful commission of TSEC solar power project, 4 MW (DC) plant on March 4, 2012, 6 MW (DC) plant on March 31, 2012, 4.92 MW (DC) plant on April 12, 2012.
18. Commissioning certificate dated November 7, 2012 issued by GEDA, certifying successful commission of 0.08 MW solar power plant of TSEC on October 31, 2012.

#### ***Approvals for continuing commercial operations***

The Asset SPVs are required to obtain and maintain certain approvals, consents, licenses, registrations and permissions during the operations stage of their respective projects, as listed below:

1. Power evacuation approval from the relevant authorities for evacuation of power from the solar power plant to the substation;
2. Energization approval under Central Electricity Authority (Measures relating to safely and Electrical supply) Regulations, 2010, for energizing the electrical equipment comprising of the solar power plant;
3. Certain Asset SPVs require no objection certificate from the relevant gram panchayat for establishment of the solar project;
4. The Asset SPVs require fire no objection certificates from the relevant fire department of the respective states;
5. Certain Asset SPVs have obtained a registration to employ certain number of workers in their respective power plants under the provisions of Factories Act. In relation to TSET, Factories Act is not applicable given that the number of workers at the site does not meet the threshold applicable;
6. Certain Asset SPVs have obtained Validation, Verification, Issuance & Trading registration under Verified Carbon Standard (VCS).
7. Letter of registration/allotment in favor of certain of the Asset SPV for setting up the solar power project issued by RRECL, UPNEDA or Energy and Petrochemicals Department, Gujarat, as the case may be.
8. Certain Asset SPVs have obtained interconnection approval for interconnecting the sub-station to the solar project;
9. Certain Asset SPVs require approval for drawal of groundwater from Central Ground Water Authority or the relevant local authority, as applicable;
10. The Asset SPVs had obtained consent to establish and consent to operate under the Air Act and Water Act, as applicable, from the relevant pollution control boards prior to commencement of operations. However, the Central Pollution Control Board vide its notification dated March 7, 2016 has exempted solar power projects from obtaining consent to establish and consent to operate under the Air Act and Water Act.

The Asset SPVs have, save as set out below, also obtained the necessary approvals, consents, licenses, registrations and permissions from the relevant governmental, statutory and regulatory authorities that are required for their respective businesses and operations.

Certain approvals and/or licenses may have expired in the normal course of business and the respective Asset SPVs have either made applications to the relevant authorities for renewal or are in the process of making such applications. For details related to risks involved, please see '***Risk Factors – We are required to maintain certain licenses, approvals, registrations, consents and permits in the ordinary course of business, and the failure to maintain them may materially and adversely affect our operations.***' on page 33.

**D. Approvals applied for, but not yet received**

As of the date of this Final Placement Memorandum, except as disclosed below, there are no approvals required to be obtained by the Terra InvIT and the Asset SPVs, for which applications have been made, but approvals have not been received:

- i. Application for renewal of fire NOC has been made to Station Officer, Rajapalayam by Terralight Rajapalayam on September 22, 2021;
- ii. Application for fire NOC has been made to Jodhpur Municipal Corporation by TSET on October 15, 2020;
- iii. Application for issue of no objection certificate to abstract ground water has been made to Central Ground Water Authority by USUPL on May 20, 2020; and
- iv. Application for issue of no objection certificate to abstract ground water has been made to Central Ground Water Authority by PLG on June 30, 2019.

**E. Approvals for which applications are yet to be made**

Terralight Kanji was issued a new certificate of incorporation on February 9, 2021 for change in its name from Solar PV, Terralight Rajapalayam was issued new certificate of incorporation on February 5, 2021, for change in its name from SP Suryaprakash, TSET was issued a new certificate of incorporation on July 16, 2021, for change in its name from Sindicatum Solar Energy Private Limited and TSEC was issued a new certificate of incorporation on July 16, 2021, for change in its name from Sindicatum Solar Energy Gujarat Private Limited. These Asset SPVs are in the process of applying for change in names in their material approvals obtained as specified in this section, as may be required.

Further, as on the date of this Final Placement Memorandum, one of the Asset SPVs' i.e., Solar Edge, is in the process of applying to receive the Fire NOC in relation to its projects i.e., 50 MW (AC) (Muktainagar), 50 MW(AC) (Parli) and 30 MW(AC) (Parli) Solar Edge power project. We cannot assure you that, our Asset SPV, Solar Edge will be successful in receiving this Fire NOC for its projects in a timely manner. For details related to risks involved, please see - ***Risk Factors – We are required to maintain certain licenses, approvals, registrations, consents and permits in the ordinary course of business, and the failure to maintain them may materially and adversely affect our operations.*** on page 33.

Apart from this, as of the date of this Final Placement Memorandum, there are no material approvals required to be obtained by the Terra InvIT or the Asset SPVs for which applications are yet to be made.

## SECTION IX – ISSUE INFORMATION

### ISSUE PROCEDURE

This section is a summary intended to provide a general outline of the procedures for the bidding, application, payment, allocation and Allotment of the Units to be offered pursuant to the Issue. The Eligible Investors are advised to inform themselves of any restrictions or limitations that may be applicable to them under applicable law to which they are subject, and are required to consult their respective advisors in this regard. The Eligible Investors that will apply in the Issue will be required to confirm, and will be deemed to have represented to the Trustee, the Investment Manager and their respective directors, officers, agents, affiliates and representatives, that they are eligible under all applicable law, rules, regulations and guidelines to acquire the Units. The Investment Manager, the Sponsor, the Trustee and their respective directors, officers, agents, affiliates and representatives accept no responsibility or liability for advising any investor on whether such investor is eligible to acquire the Units.

#### Authority for the Issue

The Terra InvIT is making this Issue in accordance with Regulation 14(2) of the SEBI InvIT Regulations. The Issue was authorised and approved by the Board on July 23, 2021. The Draft Placement Memorandum has been approved by the Board and InvIT Committee on July 23, 2021, the Placement Memorandum has been approved by the Board on September 20, 2021 and this Final Placement Memorandum has been approved by the Board on September 28, 2021.

The Terra InvIT has received in-principle approval of the NSE, pursuant to letter dated August 6, 2021. The Investment Manager has filed a copy of the Draft Placement Memorandum and the Placement Memorandum, and will file a copy of this Final Placement Memorandum, with the SEBI and the Stock Exchange, in compliance with the provisions of the SEBI InvIT Regulations.

Neither the Terra InvIT, Asset SPVs, Trustee, Sponsor, Project Manager, Investment Manager nor any of its directors have been declared as 'Fraudulent Borrowers' by the lending banks or financial institution or consortium, in terms of RBI master circular dated July 01, 2016, as amended.

**The Units have not been and will not be registered, listed or otherwise qualified in any jurisdiction outside India and may not be offered or sold, and Bids may not be made by persons in any such jurisdiction, except in compliance with the applicable law of such jurisdiction. The Units shall not be offered or sold where such offer or sale would require registration, qualification or listing. The Eligible Investor should note that Allotment will only be in the dematerialised form. Application Forms which do not have the details of the Bidders' demat accounts including DP ID, PAN and Client ID will be treated as incomplete and rejected. Bidders will not have the option of receiving Allotment in physical form. On Allotment, the Units will be traded only on the dematerialized segment of the Stock Exchange.**

#### Issue Procedure

1. The Lead Manager, in consultation with the Investment Manager shall electronically or physically circulate serially numbered copies of the Placement Memorandum and the Application Form to Eligible Investors. The Application Form will be specifically addressed to each Eligible Investor. The list of Eligible Investors to whom the serially numbered copies of the Placement Memorandum and the Application Form will be circulated shall be determined by the Investment Manager, in consultation with the Lead Manager.
2. Unless a serially numbered Placement Memorandum along with an Application Form is addressed to a particular Eligible Investor, no invitation to subscribe shall be deemed to have been made to such Eligible Investor. Even if such documentation were to come into the possession of any person other than the intended recipient, no offer or invitation to offer shall be deemed to have been made to such person and such person shall not be eligible to participate in the Issue.
3. Bidders may submit an Application Form to the Lead Manager only during the Bid/Issue Period.
4. Bidders will be required inter-alia, to indicate the following in the Application Form:
  - (a) name of the Bidder to whom the Units are to be Allotted;

- (b) number of Units Bid for;
- (c) the details of the Bid Amount deposited by the Bidder into the Designated Account;
- (d) details of the demat accounts to which the Units should be credited;
- (e) a representation that such person is an “Institutional Investor” or a “Body Corporate” in terms of the SEBI InvIT Regulations;
- (f) the details of Bidder’s bank account along with fund transfer details, in case of any refund;
- (g) that it is permitted to acquire the Units under the laws of any applicable jurisdiction and that it has necessary capacity and authority, and have obtained all necessary consents and authorisations to enable it to commit to this participation in the Issue and to perform its obligations in relation thereto (including, without limitation, on behalf of any person) and honor such obligations;
- (h) it is eligible to invest in India and in the Units under applicable law, including the FEMA Rules, and has not been prohibited by the SEBI or any regulatory authority from buying, selling or dealing in units or securities; and
- (i) any other information which may be relevant to the Bid.

Bids made by asset management companies or custodians of Mutual Funds, if permitted under applicable law, shall specifically state the names of the concerned schemes for which the Bids are made. In case of a Mutual Fund, a separate Bid can be made in respect of each scheme of the Mutual Fund registered with SEBI and such Bids in respect of more than one scheme of the Mutual Fund will not be treated as multiple Bids provided that the Bids clearly indicate the scheme for which the Bid has been made. Bidders are advised to ensure that any single Bid from them does not exceed the investment limits or maximum number of Units that can be held by them under applicable law.

5. Each Bidder shall be required to make payment of the entire Bid Amount for the Units at the Issue Price, only through electronic transfer to the Designated Account during the Bid/Issue Period, along with the Application Form.
6. No payment shall be made by Bidders in cash. Please note that any payment of Bid Amount for Units shall be made from the bank account of the relevant Bidder applying for Units. The Bid Amount payable on Units to be held by joint holders shall be paid from the bank account of the person whose name appears first in the Application Form. Pending Allotment, all Bid Amounts received from Bidders shall be kept by in the Designated Account.
7. Once a duly completed Application Form is submitted by a Bidder on the basis of disclosures in the Placement Memorandum, such Application Form constitutes an irrevocable offer and cannot be withdrawn, subject to terms contained therein and the Placement Memorandum.
8. Upon receipt of the Application Form and the receipt of Bid Amount in the Designated Account, the Investment Manager shall, after Bid/Issue Closing Date, determine the number of the Units to be Allotted pursuant to the Issue, in consultation with the Lead Manager.
9. Upon determination of the Bidders to whom Allocation shall be made, the Lead Manager, on behalf of the Investment Manager, will send the CANs to the Bidders who have been Allocated Units. The dispatch of a CAN shall be deemed a valid, binding and irrevocable contract in respect of the number of Units Allocated to the Bidder. Please note that the Allocation and Allotment will be at the absolute discretion of the Investment Manager, in consultation with the Lead Manager and in accordance with SEBI InvIT Regulations and any applicable contractual commitments.
10. Upon the dispatch of CAN to successful Bidders, the Investment Manager shall Allot Units of the Terra InvIT as per the details in the CAN sent to successful Bidders. The Investment Manager will intimate the Stock Exchange about the details of the Allotment and apply for approvals of the Units for listing and trading of the Units on the Stock Exchange after the credit of Units into the demat accounts of the successful Bidders.

11. Allottees are advised to instruct their respective Depository Participants' to accept the Units that may be Allotted to them pursuant to the Issue into their respective demat accounts.
12. In the event the Investment Manager is unable to Allot the Units or upon cancellation of the Issue, the Investment Manager shall be liable to refund the Bid Amounts with interest to the Bidders in accordance with applicable law. For each Bidder to whom any amounts are to be refunded, the refund shall be made to the same bank account from which the Bid Amount was remitted by such Bidder.
13. The Units that have been credited to the demat accounts of the Bidders shall be eligible for trading on the Stock Exchange only upon the receipt of final listing and trading approvals from the Stock Exchange. Bidders are advised to apprise themselves of the status of the receipt of the permissions from the Stock Exchange or the Investment Manager.
14. The Bid Amounts will be transferred to the account of the Terra InvIT from the Designated Account only after receipt of the final listing and trading approval for the Units from Stock Exchange.

#### **Who can Bid?**

Each Bidder should check if it is eligible to Bid under applicable law, including the FEMA Rules. Certain categories of Bidders may not be permitted to Bid in the Issue or hold Units in excess of the limits specified under applicable law.

Only Institutional Investors and Bodies Corporate are eligible to participate in the Issue.

**The Trustee, the Valuer and the employees of the Valuer who were involved in the valuation of the Asset SPVs are not permitted to Bid in the Issue.**

#### ***Bids by FPIs***

Foreign Portfolio Investors are permitted to participate in the Issue subject to compliance with Schedule 8 of the FEMA Rules. In case of Bids by FPIs, the payment should be made as inward remittance from abroad through banking channels or out of funds held in NRE or FCNR(B) accounts maintained in accordance with the Foreign Exchange Management (Deposit) Regulations, 2016, along with documentary evidence in support of the remittance. In case of Bids made by FPIs, a copy of the certificate of registration under the SEBI FPI Regulations is required to be attached with the Application Form.

#### ***Bids by SEBI registered VCFs and AIFs***

The SEBI VCF Regulations prescribe, amongst others, the investment restrictions on VCFs registered with SEBI. Further, the SEBI AIF Regulations prescribe, amongst others, the investment restrictions on AIFs. VCFs and AIFs are subject to certain investment restrictions, including with respect to the percentage of investible funds held in each investee entity. Allotments made in respect of Bids by VCFs and AIFs in the Issue shall be subject to the rules and regulations that are applicable to each of them respectively.

#### ***Bids by Banking Companies***

Bids may be made by banks as permitted by the RBI and is subject to conditions specified in the Prudential Guidelines – Banks' investment in units of REITs and InvITs dated April 18, 2017. In case of Bids made by banking companies registered with the RBI, certified copies of (i) the certificate of registration issued by the RBI, and (ii) the approval of such banking company's investment committee are required to be attached to the Application Form.

#### ***Bids by Provident Funds/Pension Funds***

On March 2, 2015, the Ministry of Finance issued a notification allowing investments by non-government provident funds, super-annuation funds and gratuity funds up to 5% in infrastructure investment trusts, as specified. On June 26, 2015, the Ministry of Labour and Employment issued a notification allowing investments by provident funds up to 5% in infrastructure investment trusts, as specified. The Pension Fund Regulatory and Development Authority issued circulars dated June 3, 2015, September 2, 2015, November 4, 2016 and May 4, 2017, respectively, allowing investments by national pension funds up to 5% in infrastructure investment trusts, as specified. However, such investments by provident funds and pension funds will be subject to, amongst others, the sponsor or in some cases the securities having a minimum of AA or equivalent rating from at least two credit

rating agencies registered with SEBI. In case of Bids made by provident funds/ pension funds, subject to applicable law, with minimum corpus of ₹2,500 lakhs, a certified copy of certificate from a chartered accountant certifying the corpus of the provident fund/pension fund must be attached to the Bid cum Application Form.

#### ***Bids by Mutual Funds***

Bids may be made by mutual funds under all its schemes, existing and future, subject to the investment conditions and other restrictions prescribed under the Securities and Exchange Board of India (Mutual Funds) Regulations, 1996 (including, the circular on mutual funds dated February 28, 2017 and any other circulars, notifications and guidelines issued thereunder).

#### ***Bids by Insurance Companies***

Bids may be made by insurance companies as permitted by the Insurance Regulatory and Development Authority of India in terms of the Master Circular – Investments, 2016 and the circular issued by the IRDAI entitled, Investment in Units of Real Estate Investment Trusts (REIT) & Infrastructure Investment Trusts (InvIT) dated March 14, 2017.

#### ***Bids under Power of Attorney***

In case of Bids made pursuant to a power of attorney by Institutional Investors or Bodies Corporate, a certified copy of the power of attorney or the relevant resolution or authority, as the case may be, along with a certified copy of the memorandum of association and articles of association and/or bye laws must be lodged along with the Application Form. The Investment Manager, in its absolute discretion, reserves the right to relax the above condition of simultaneous lodging of the power of attorney along with the Application Form.

**The Parties to the Terra InvIT are not liable for any amendment or modification or change to applicable law or regulations, which may occur after the date of this Final Placement Memorandum. Eligible Investors are advised to make their independent investigations and satisfy themselves that they are eligible to apply in the Issue. Eligible Investors are advised to ensure that any single application from them does not exceed the investment limits or maximum number of Units that can be held by them under applicable law or regulation or as specified the Placement Memorandum.**

#### ***Maximum and Minimum Bid Size***

- (i) Each Bidder is required to Bid for a Minimum Bid Size of ₹2,500 lakhs.
- (ii) No Bidder shall Bid for that number of Units which exceeds the Issue size.

#### **Application Process**

Bidders shall only use the Application Forms provided by the Investment Manager for the purpose of making a Bid in terms of the Placement Memorandum.

A Bidder applying for the Units to be issued pursuant to the Issue must have at least one beneficiary account with a Depository Participant of either NSDL or CDSL prior to making the Bid. Allotment to a successful Bidder will be credited in electronic form directly to the beneficiary account (with the Depository Participant) of such Bidder.

By making a Bid for the Units through Application Forms, Bidders will be deemed to have made the following representations and warranties, respectively:

1. The Bidder confirms that it is an Institutional Investor or a Body Corporate, and is eligible to participate in the Issue;
2. The Bidder has deposited the Bid Amount in the Designated Account;
3. Subject to the terms of the Application Form and the Placement Memorandum, the Bidder has no right to withdraw its Bid once such Bid is submitted to the Lead Manager;
4. The Bidder confirms that it is eligible to apply for, and hold, any Units that may be Allotted to the Bidder pursuant to the Issue. The Bidder further confirms that any such Allotment of Units to, and the holding of Units by, the Bidder does not, and shall not, exceed the level permissible as per any law applicable to the Bidder;

5. The Bidder understands and agrees that the Units offered hereby have not been registered with, or approved or disapproved by the SEC or any State securities commission in the U.S. or any other U.S. regulatory authority, and that the Units may not be offered, sold or resold or otherwise transferred within the U.S., except in a transaction exempt from the registration requirements of the Securities Act, and the Units are being offered and sold in an offshore transaction outside the U.S. in compliance with Regulation S to persons located in jurisdictions where such offer and sale of the Units is permitted under the laws of such jurisdiction. Accordingly, the Bidder confirms that it is outside the United States and it is purchasing the Units in an offshore transaction in reliance on Regulation S under the U.S. Securities Act.
6. The Bidder further confirms that no offer or sale of the Units is the result of any “directed selling efforts” in the United States (as such term is defined in Regulation S) and that Terra InvIT and the Lead Manager, and their respective affiliates and representatives (including legal counsels to each of the foregoing), will rely upon the truth and accuracy of the foregoing acknowledgements, representations, warranties and agreements and agree that, if at any time any of the acknowledgements, representations, warranties and agreements made in connection with the Units is no longer accurate, it shall immediately notify Terra InvIT and the Lead Manager in writing.

**ELIGIBLE INVESTORS MUST PROVIDE THEIR DEMAT ACCOUNT DETAILS, THEIR DEPOSITORY PARTICIPANT'S NAME, DEPOSITORY PARTICIPANT IDENTIFICATION NUMBER, BENEFICIARY ACCOUNT NUMBER AND BANK ACCOUNT DETAILS IN THE APPLICATION FORM. ELIGIBLE INVESTORS MUST ENSURE THAT THE NAME GIVEN IN THE APPLICATION FORM IS EXACTLY THE SAME AS THE NAME IN WHICH THE DEMAT ACCOUNT IS HELD.**

Demographic details such as address and bank account details will be obtained from the Depositories as per the demat account details given above.

#### ***Instructions for completing the Application Form***

Bidders may note that forms not filled completely or correctly as per instructions provided in the Placement Memorandum and the Application Form are liable to be rejected. The Bids should adhere to the following:

- (i) Bids must be made only in the prescribed application form;
- (ii) Application Form must be completed in full, in BLOCK LETTERS in ENGLISH and in accordance with the instructions contained herein and in the Application Form. Incomplete Application Forms are liable to be rejected. Bidders must provide details of valid and active DP ID, Client ID and PAN clearly and without error. Invalid accounts, suspended accounts or where such account is classified as invalid or suspended shall not be considered for Allotment. Bidders should note that the Registrar and the Investment Manager will not be liable for errors in data entry due to incomplete or illegible Application Forms; and
- (iii) Bidders are required to sign the Application Form. Bidders should ensure that the thumb impressions and signatures other than in the languages specified in the Eighth Schedule to the Constitution of India, are attested by a Magistrate or a Notary Public or a Special Executive Magistrate under official seal.

#### ***Submission of Application Form***

All Application Forms must be duly completed with information including the name of the Bidder, the number of the Units applied for and the Bid Amount deposited in the Designated Account, and include details of the bank account from which payment of the Bid Amount was made as well as a confirmation of funds transfer. The Application Form shall be submitted to the Lead Manager either through electronic form or through physical delivery at the following address:

#### **Axis Capital Limited**

1<sup>st</sup> Floor, Axis House  
C 2 Wadia International Centre  
P. B. Marg, Worli  
Mumbai 400 025  
Maharashtra, India  
**Tel:** +91 22 4325 5585  
**Email:** sanjay.kathale@axiscap.in



**Contact person:** Sanjay Kathale

The Lead Manager shall not be required to provide any written acknowledgement of the Application Form.

#### **PAN**

**Each Eligible Investor must mention its PAN allotted under the IT Act. Each Eligible Investor is required to submit a copy of its PAN card along with the Application Form.** Eligible Investors should not submit the general index registrar number (“GIR”) instead of the PAN. Applications without this information will be considered incomplete and are liable to be rejected, except from Eligible Investors which are not required to hold a PAN under applicable law.

#### ***Bank Account for Payment of Bid Amount***

The Investment Manager will open the Designated Account with Axis Bank Limited, acting as the Escrow Collection Bank in terms of the arrangement among the Terra InvIT, the Investment Manager, the Lead Manager and the Escrow Collection Bank. Bidders are required to deposit the entire Bid Amount during the Bid/Issue Period, together with the completed Application Form, in favour of “Virescent Renewable Energy Trust – Escrow Account”. If the payment of the Bid Amount is not made favouring the Designated Account within the Bid/Issue Period, the Application Form of the Bidder is liable to be rejected. The Trustee and the Investment Manager shall utilize the amount deposited in the Designated Account only for the purposes of: (i) adjustment against Allotment; or (ii) refund of application monies in case of any failure to allot Units in the Issue.

#### ***Payment Instructions***

The payment of Bid Amount shall be made by the Bidders in the name of the Designated Account as per the payment instructions provided in the Placement Memorandum and the Application Form. Payments are to be made only through electronic fund transfer. Payments through cheques or cash or any mode other than electronic mode shall be rejected.

#### ***Bidders’ Demat Account and Bank Account Details***

Bidders should not that on the basis of Bidders’ PAN, DP ID and Client ID provided by them in the Application Form, the Registrar will obtain from the Depository the demographic details including the Bidders’ address and bank account details (the “**Demographic Details**”), from the Depository. The Demographic Details will be used for giving refunds (including through direct credit, NECS, NEFT and RTGS) to the Bidders. It is mandatory to provide the bank account details in the space provided in the Application Form and Application Forms that do not contain such details are liable to be rejected. Hence, Bidders are advised to immediately update their bank account details, PAN and Demographic Details as appearing on the records of the Depository Participant and ensure that they are true and correct. Failure to do so could result in delays in credit of refunds to Bidders at their sole risk and none of the Registrar, the Investment Manager or the Trustee will have any responsibility or undertake any liability for this. Accordingly, Bidders should carefully fill in their demat account details in the Application Form.

By signing the Application Form, the Bidder is deemed to have authorised the Depositories to provide to the Investment Manager and the Registrar, on request, the required Demographic Details as available in their records.

The Trustee, the Investment Manager or the Lead Manager will not be responsible or liable for the delay in the credit of the Units to be issued and transferred pursuant to the Issue due to errors in the Application Form, delay in payment of Bid Amount or otherwise on part of the Bidders.

#### ***Method of Allocation***

The Investment Manager shall determine the Allocation in consultation with the Lead Manager on a discretionary basis. After finalization of the Allocation, the Investment Manager has updated the Placement Memorandum with the Issue details and proposes to file this Final Placement Memorandum with SEBI and the Stock Exchange, and dispatch the CAN, together with a serially numbered Final Placement Memorandum to each successful Bidder.

**THE DECISION OF THE INVESTMENT MANAGER, IN CONSULTATION WITH THE LEAD MANAGER IN RESPECT OF ALLOCATION SHALL BE FINAL AND BINDING ON ALL BIDDERS. BIDDERS MAY NOTE THAT ALLOCATION OF THE UNITS IS AT THE SOLE AND ABSOLUTE DISCRETION OF THE INVESTMENT MANAGER, IN CONSULTATION WITH THE LEAD MANAGER, AND BIDDERS MAY NOT RECEIVE ANY ALLOCATION EVEN IF THEY HAVE**

**SUBMITTED VALID APPLICATION FORMS. NEITHER THE INVESTMENT MANAGER NOR THE LEAD MANAGER ARE OBLIGED TO ASSIGN ANY REASON FOR ANY SUCH NON-ALLOCATION.**

**Confirmation of Allocation Note or CAN**

Based on the Application Forms and Bid Amounts received from Bidders, the Investment Manager, in consultation with the Lead Manager, in their sole and absolute discretion, will decide the Bidders to whom the serially numbered CANs shall be sent, pursuant to which the details of Units Allocated to them shall be notified to such Bidders. Further, details of the amounts payable for Allotment of the Units in their respective names shall be notified to such Bidders. Additionally, the CAN will include the probable designated date, being the date of credit of the Units to the respective Bidder's demat account ("Designated Date").

Bidders, who have been Allocated Units, would also be sent a serially numbered Final Placement Memorandum either in electronic form or by physical delivery along with the serially numbered CAN. The dispatch of the serially numbered Final Placement Memorandum and the CAN to Bidders shall be deemed a valid, binding and irrevocable contract in respect of the number of Units Allocated to each successful Bidder.

Bidders are advised to instruct their Depository Participant to accept the Units that may be Allotted to them pursuant to the Issue.

***Allotment of the Units***

In accordance with the SEBI InvIT Regulations, the Units will be issued and Allotment shall be made only in dematerialised form to the Allottees. The Investment Manager and the Registrar have entered into:

- (a) Agreement dated February 26, 2021 with NSDL; and
- (b) Agreement dated March 2, 2021 with CDSL.

After the Bid/Issue Closing Date, the Investment Manager has updated the Placement Memorandum with the Issue details and proposed to file this Final Placement Memorandum with the SEBI and the Stock Exchange, within the timelines specified under applicable law.

Following the Allotment of Units, the Investment Manager will apply for final listing and trading approval from the Stock Exchange. The Investment Manager and the Lead Manager shall endeavour to list the Units on the Stock Exchange within 30 Working Days from date of Allotment.

***Refunds***

In the event of non-receipt of listing permission from the Stock Exchange, the Units shall not be eligible for listing. The Terra InvIT will ensure that refunds are made to the Bidders, along with interest at the rate of 15% per annum from the date of Allotment, in accordance with and subject to applicable law.

**SECTION X – OTHER INFORMATION**

**PROJECTIONS OF REVENUE FROM OPERATIONS AND CASH FLOWS FROM OPERATING  
ACTIVITIES**

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To  
Virescent Renewable Energy Trust

The Board of Directors  
Axis Trustee Service Limited [As the Trustee of Trust]

The Board of Directors  
Virescent Infrastructure Investment Manager Private Limited (As the Investment Manager of the Trust)

Dear Sirs,

We have examined the accompanying Statement of projections of revenue from operations and cash flow from operating activities and the basis and notes to these projections (together referred to as “Projections”) along with significant assumptions underlying the Projections and other explanatory information (“Projection Assumptions”) of Virescent Renewable Energy Trust (the “Terra InvIT”) and the following subsidiaries, namely:

- a. TN Solar Power Energy Private Limited,
- b. Universal Mine Developers and Service Providers Private Limited,
- c. Terralight Kanji Solar Private Limited (formerly known as Shapoorji Pallonji Solar PV Private Limited),
- d. Terralight Rajapalayam Solar Private Limited (formerly known as Shapoorji Pallonji Suryaprakash Private Limited),
- e. Solar Edge Power and Energy Private Limited,
- f. PLG Photovoltaic Private Limited,
- g. Terralight Solar Energy Tinwari Private Limited (formerly known as Sindicatum Solar Energy Private Limited),
- h. Terralight Solar Energy Charanka Private Limited (formerly known as Sindicatum Solar Energy Gujarat Private Limited) and
- i. Universal Saur Urja Private Limited

(individually referred to as “Project SPV” or “SPV’s” and together referred to as “Project SPV Group”), which are proposed to be transferred from Terra Asia Holdings II Pte Limited, Singapore (hereinafter referred as ‘Sponsor’) to the Terra InvIT pursuant to the proposed private placement of Units which will be listed of the Terra InvIT (‘Private Placement’ or ‘Issue’), for the years ending March 31, 2022, March 31, 2023, March 31, 2024 and in accordance with Standard on Assurance Engagement 3400, ‘The Examination of Prospective Financial Information’, issued by the Institute of Chartered Accountants of India. The Terra InvIT and Project SPVs on a combined basis have been referred to as the “Terra InvIT Group”. The preparation and presentation of the projection including the underlying assumptions as set out in note 2 and 3 to the Projections is the responsibility of the Investment Manager (on behalf of the Terra InvIT) and has been approved by the Board of Directors of the Investment Manager (on behalf of the Terra InvIT). Our responsibility is to examine the evidence supporting the Projection Assumptions (excluding the hypothetical assumption) and other information in the Projections.

#### **Report of auditor on examination of prospective financial information**

Our responsibility does not include verification of Projections. Therefore, we do not vouch for the accuracy of the same.

These Projections have been prepared for the purpose of inclusion in the Draft Placement Memorandum, Placement Memorandum and Final Placement Memorandum in connection with the proposed Issue in accordance with the requirements of Securities and Exchange Board of India (Infrastructure Investment Trusts) Regulations, 2014 as amended from time to time including any guidelines and circulars issued thereunder (together referred to as ‘InvIT Regulations’). This projection has been prepared by the Investment Manager (on behalf of the Terra InvIT) using a set of assumptions that include hypothetical assumptions about future events and management’s

actions that are not necessarily expected to occur. Consequently, users are cautioned that this projection may not be appropriate for purposes other than that described above.

We have carried out our examination of the prospective financial information on test check basis. Based on our examination of the evidence supporting the assumptions, nothing has come to our attention which causes us to believe that the Projection Assumptions do not provide a reasonable basis for the Projections.

Further, in our opinion, the Projections are properly prepared on the basis of the assumptions as set out in note 2 and 3 to the Projections and on a consistent basis with the accounting policies used for the preparation of the historical combined financial statements of the Project SPVs required by InvIT regulations. Even if the events anticipated under the hypothetical assumptions described above occur, actual results are still likely to be different from the Projections since other anticipated events frequently do not occur as expected and the variation may be material. The actual results may therefore differ materially from those forecasted and projected. For the reasons set out above, we do not express any opinion as to the possibility of achievement of the Projections.

This report is required by InvIT Regulations requiring the independent auditor to issue a report on the Projections and is issued for the sole purpose of the proposed Private Placement in accordance with the InvIT Regulations. Our work has not been carried out in accordance with auditing or other standards and practices generally accepted in jurisdictions outside India, including in the United States of America, and accordingly should not be relied upon as if it had been carried out in accordance with those standards and practices. US securities regulations do not require profit forecasts to be reported on by a third party. The Issue will be made in India and outside the United States of America in offshore transactions in reliance on Regulation S under the U.S. Securities Act of 1933, as amended ("U.S. Securities Act"). We accept no responsibility and deny any liability to any person who seeks to rely on this report and who may seek to make a claim in connection with any offering of securities on the basis that they had acted in reliance on such information under the protections afforded by United States of America law and regulation.

We have no responsibility to update our report for events and circumstances occurring after the date of the report.

Our report is intended solely for inclusion in the Draft Placement Memorandum, Placement Memorandum and Final Placement Memorandum in connection with the proposed Issue. It should not be used by any other person or for any other purpose. Accordingly, we do not accept or assume any liability or any duty of care for any other purpose or to any other person to whom this report is shown or into whose hands it may come without our prior consent in writing.

**For MSKA & Associates**

Chartered Accountants

ICAI Firm Registration Number: 105047W

Ananthakrishnan Govindan

Partner

Membership Number: 205226

UDIN: 21205226AAAAFU8364

Hyderabad

July 23, 2021

**Virescent Renewable Energy Trust**  
**Projections of revenue from operations and cash flow from operations**  
**Summary of significant assumptions and other explanatory information**

**1. General information**

Virescent Renewable Energy Trust (the "Trust") is an irrevocable trust, pursuant to the Trust Deed dated January 28, 2021, under the provisions of the Indian Trusts Act, 1882 and registered with the Securities Exchange Board of India ("SEBI") vide Certificate of Registration dated February 25, 2021 as an Infrastructure Investment Trust under Regulation 3(1) of the Securities Exchange Board of India (Infrastructure Investment Trust) Regulations, 2014. The Trust is settled Virescent Infrastructure Investment Manager ("Investment Manager") on behalf of Terra Asia Holding II PTE Ltd., Singapore (referred as the "Sponsor"). The Trustee for the Trust is Axis Trustee Service Limited (the "Trustee"). The Investment Manager for the Trust is Virescent Infrastructure Investment Manager Pvt Ltd (the "Investment Manager" or the "Management").

**2. Basis of preparation of projections of revenue from operations and cash flow from operating activities**

The projections of revenue from operations and cash flow from operating activities of the Trust and the following subsidiaries of the Sponsor, namely:

- TN Solar Power Energy Private Limited (TN Solar),
- Universal Mine Developers and Service Providers Private Limited (UMD Project),
- Terralight Kanji Solar Private Limited (formerly known as Shapoorji Pallonji Solar PV Private Limited (Terralight Kanji),
- Terralight Rajapalayam Solar Private Limited (formerly known as Shapoorji Pallonji Suryaprakash Private Limited) (Terralight Rajapalayam)
- Solar Edge Power and Energy Private Limited (Solar Edge)
- Terralight Solar Energy Charanka Private Limited (Terralight Charanka)
- Terralight Solar Energy Tinwari Private Limited (Terralight Tinwari)
- PLG Photovoltaic Private Limited (PLG), and
- Universal Saur Urja Private Limited (USUPL)

(individually referred to as "Project SPV" or "SPV" and together referred to as "Project SPV Group") for the years ending March 31, 2022, March 31, 2023 and March 31, 2024 ("**Projection period**") have been prepared by the Investment Manager solely for inclusion in the Placement Document in connection with the proposed private placement memorandum of Units of the InvIT in accordance with the requirements of the Securities and Exchange Board of India (Infrastructure Investment Trusts) Regulations, 2014 issued by the Securities and Exchange Board of India ("**SEBI**") on September 26, 2014, as amended from time to time and any circulars issued thereunder (the "**InvIT Regulations**"). Therefore, the use of the Projections may not be appropriate and should not be used or relied upon for any purpose other than that described above.

The Projections are prepared based on the accounting policies used for preparation of the Special Purpose Combined Financial Statements as required by the InvIT Regulations, which are prepared in accordance with Indian Accounting Standards ("Ind-AS") as defined in Rule 2(1)(a) of the Companies (Indian Accounting Standards) Rules, 2015, as amended, prescribed under Section 133 of the Companies Act, 2013.

Though the aforesaid Projections are prepared under the Ind-AS framework, they do not provide for all the detailed disclosures as required under Ind-AS.

## Virescent Renewable Energy Trust

### Projections of revenue from operations and cash flow from operations

#### Summary of significant assumptions and other explanatory information

The Projections have been prepared and disclosed in INR lakhs, unless otherwise specifically mentioned.

The Projections contain forecasts and projections that relate to future events, which are, by their nature, subject to significant risks and uncertainties. The future events referred to involve risks, uncertainties and other factors which may cause the actual results or performance to be materially different from the Projections.

### 3. Significant assumptions for the Projections

The Projections have been prepared based on the significant assumptions summarized below. These have been prepared by the Investment Manager and are the Investment Manager's best estimate assumptions and hypothetical assumptions (about future events and actions) and have been prepared by the Investment Manager solely for inclusion in the Placement Documents in connection with the proposed private placement of Units of the Trust in accordance with the requirements of the SEBI InvIT Regulations. The Investment Manager considers the assumptions to be appropriate and reasonable as at the date of the report. The investors may consider these assumptions as the Projections, however, should make their own assessment of the future performance of the Trust Group.

The consolidated projections have been prepared by combining the projections of revenue and operating cash flows of the Trust and the Project SPVs, eliminating transactions between the Trust and the Project SPVs and after considering the following assumptions:

#### a. Revenue from Operations:

Revenue from operations of the InvIT Group and all the Project SPVs consists of income from sale of power. Revenue projections for InvIT Group and all the Project SPVs do not include any other income stream (operating as well as non-operating).

Each of the Project SPVs generate stable revenue from specified contracted tariffs under long term PPAs. The pre-determined tariff structure and the long-term nature of the PPAs ensure predictable and stable generation of revenue and long-term predictable cash flows. Details of the long-term PPAs executed by our Project SPVs are as follows:

Project Name	State	Commercial Operation Date *	Contracted Capacity (MW AC)	Capacity (MW DC)	Tariff (₹ per unit)	Off taker	Duration of PPA (years)
Solar Edge	Maharashtra	April, 2018	130.0	169.0	4.43	SECI	25
Terralight Kanji	Tamil Nadu	March, 2016	30.0	36.0	7.01	TANGEDCO	25
TN Solar	Tamil Nadu	November, 2015	23.0	27.6	7.01	TANGEDCO	25
UMD	Tamil Nadu	January, 2016	25.0	30.0	7.01	TANGEDCO	25
Terralight Rajapalayam	Tamil Nadu	September, 2018	50.0	54.0	3.47	TANGEDCO	25
PLG	Gujarat	January, 2012	20.0	20.0	₹ 15/kWh for the first 12 years and ₹ 5/kWh thereafter	GUVN	25
Terralight Tinwari	Rajasthan	October, 2011	5.0	5.75	₹ 17.91/kWh	NVVN	25
Terralight Charanka	Gujarat	March, 2012	13.0	15.0	In accordance	GUVN	25

## Virescent Renewable Energy Trust

### Projections of revenue from operations and cash flow from operations

#### Summary of significant assumptions and other explanatory information

Project Name	State	Commercial Operation Date *	Contracted Capacity (MW AC)	Capacity (MW DC)	Tariff (₹ per unit)	Off taker	Duration of PPA (years)
USUPL	Uttar Pradesh	September, 2016	30.0	37.0	₹ 9.33/kWh for the first 12 years and from the 13th year, tariff will be as determined in accordance with the USUPL PPA.	UPPCL	25

\*Weighted average commercial operation date based on commissioned capacity

<sup>1</sup> Tariff structure for Terralight Charanka is as stated below:

Capacity	Tariff 1 (₹ / kWh)	Tariff 1 End Date	Tariff 2 (₹ / kWh)	Tariff 2 End Date
4.0	15.00	March 3, 2024	5.00	March 3, 2037
6.0	9.98	March 30, 2024	7.00	March 30, 2037
4.9	9.98	October 30, 2024	7.00	April 11, 2037
0.1	9.98	October 30, 2024	7.00	October 30, 2037

All our Projects are operational and revenue generating. For the purpose for projecting annual units generated, we have considered the generation targets approved by the board.

Key variables for projections of revenues are actual irradiation, natural climatic conditions, machine availability, external and internal grid availability and losses on account of transmission lines.

In case of Terralight Charanka and PLG, while the realizable revenue will be based on the current applicable tariff rates, for the purpose of projections, we have considered the straight-line average tariff in line with applicable accounting standards under IndAS.

Rebate charges have been deducted from the gross revenue for projects wherever the power off-taker has levied such expenses while making payments against the billed amount.

#### b. Cash Flow from Operating Activities:

Cash flow from Operating activities for the InvIT Group and the Project SPVs have been calculated using the direct method under Ind AS 7 - Statement of Cash Flows and is computed by deducting the operating expenses and adjusted for working capital changes and non-cash expenses (if any). Cash flow from operating activities do not include any items pertaining to financing or investing nature.

#### Tax (in Project SPVs)

As the actual outflow on account of direct taxation would be dependent on various factors including but not limited to the final capital structure, prior period MAT credit and unabsorbed depreciation, we have estimated the cash flow from operations excluding payments for direct taxes.

#### c. Operating Expenses:



## **Virescent Renewable Energy Trust**

### **Projections of revenue from operations and cash flow from operations**

#### **Summary of significant assumptions and other explanatory information**

The operating expenses include routine maintenance, insurance, other operating expenses, Project Manager fees and Investment Manager fees. These costs are projected based on the base year expenses for the Project SPVs and projected annual increase based on inflation rates and/or based on agreements.

i. **Operation and Maintenance (O&M) expenses**

O&M expenses considered in the Projections are based on currently existing O&M contracts and their annual increment are considered in line with the terms of the O&M contracts

ii. **SPV Overheads**

These mainly include expenses not covered under the O&M contracts such as cost of spares, professional fees SPV-level overheads, SPV-level employee expenses, etc. These expenses have been considered in the Projections based on the management's expectations as to the extent to which these are recurring in nature along with management's expectations of annual increment.

iii. **Insurance**

Insurance expenses considered in the Projections are based on premiums currently being incurred by the Project SPVs. The Investment Manager does not foresee any increase in the insurance cost over the projection period of 3 years, hence the cost has been kept constant over the Projection period.

iv. **Import Charges**

In case of Solar Edge, charges levied for units utilized for auxiliary consumption are higher than the applicable tariff rate. Such additional costs incurred by Solar Edge have estimated based on current applicable rates.

v. **Deviation Settlement Mechanism (DSM) Penalty**

DSM penalties have been considered in the Projections based on management's estimates on the deviation in forecasting of units along with the applicable penalties.

vi. **Project Manager and Investment Manager fees**

Project Manager and Investment Manager fees have been considered based on the Investment Manager's expectations of the expenses that will be incurred during the course of next three years. These costs also include miscellaneous expenses that will be incurred by the Investment Manager on behalf of the Trust such as fees payable to the auditors, valuers, etc. Additionally, the management expects to further aggregate capacity to Terra InvIT, thereby reducing the allocation of Project Manager and Investment Manager to the current capacity in the future.

vii. **Operating Expenses (at InvIT level)**

Operating expense at InvIT level mainly include fees payable to Trustee based on the agreement executed with the Trustee.

d. **Working capital changes (in Project SPVs):**

Working capital changes have been considered based on current trends of working capital cycle and management's estimates of working capital cycle going forward.

## Annexure

### Projections of revenue from operations and cash flow from operations

S No	Particulars	Years ending March 31,		
		2022	2023	2024
A	<b><u>Virescent Renewable Energy Trust Group (Combined)</u></b>			
	Revenue from operations	35,618.59	35,621.07	35,536.07
	Cash flow from operating activities	29,619.76	30,605.40	31,083.06
B	<b><u>TNSEPL</u></b>			
	Revenue from operations	2,851.18	2,836.92	2,830.40
	Cash flow from operating activities*	1,963.65	2,362.79	2,400.20
C	<b><u>UMD</u></b>			
	Revenue from operations	3,094.30	3,078.83	3,071.75
	Cash flow from operating activities*	2,337.33	2,596.08	2,637.66
D	<b><u>Terralight Kanji Solar</u></b>			
	Revenue from operations	3,835.78	3,816.60	3,807.83
	Cash flow from operating activities*	2,712.77	3,138.67	3,189.27
E	<b><u>Terralight Rajapalayam Solar</u></b>			
	Revenue from operations	2,887.73	2,873.30	2,866.69
	Cash flow from operating activities*	1,605.99	2,341.03	2,396.02
F	<b><u>Solar Edge</u></b>			
	Revenue from operations	11,447.14	11,502.67	11,476.23
	Cash flow from operating activities*	10,605.74	9,587.98	9,763.93
G	<b><u>Terralight Solar Energy Charanka</u></b>			
	Revenue from operations	1,925.70	1,974.94	1,965.08
	Cash flow from operating activities*	1,618.11	1,725.09	1,743.50

S No	Particulars	Years ending March 31,		
		2022	2023	2024
H	<b><u>Terralight Solar Energy Tinwari</u></b>			
	Revenue from operations	1,608.47	1,609.37	1,600.76
	Cash flow from operating activities*	1,643.87	1,526.65	1,525.53
I	<b><u>PLG</u></b>			
	Revenue from operations	2,996.07	2,981.09	2,981.36
	Cash flow from operating activities*	2,663.40	2,754.96	2,825.07
J	<b><u>USUPL</u></b>			
	Revenue from operations	4,972.21	4,947.35	4,935.98
	Cash flow from operating activities*	4,468.90	4,572.15	4,601.88

\* Cashflow from operating activities are reported before taxes (Refer 3 b of Summary of significant assumptions and other explanatory information)

## MATERIAL CONTRACTS AND DOCUMENTS FOR INSPECTION

The following contracts, which are or may be deemed material have been entered or are to be entered into in due course. These contracts and also the documents for inspection referred to hereunder, may be inspected by the Eligible Investors at the office of the Terra InvIT at Mumbai, from 10:00 A.M. to 5:00 P.M., from the date of the Placement Memorandum until the Bid/Issue Closing Date, on Working Days.

### A. Material Contracts

1. The Trust Deed, between the Sponsor, Investment Manager (acting as the settlor) and the Trustee, dated January 28, 2021;
2. The Investment Management Agreement, amongst the Trustee, Investment Manager and Project SPVs, dated January 29, 2021 and deed of adherence to the Investment Management Agreement to be entered into, amongst the Trustee, Investment Manager, Project SPVs and Specified SPVs;
3. The Project Management Agreement, amongst the Trustee, Investment Manager, Project Manager and the Project SPVs dated March 3, 2021 and deed of adherence to the Project Management Agreement to be entered into, amongst the Trustee, Investment Manager, Project Manager, Project SPVs and Specified SPVs;
4. The Placement Agreement entered into between the Terra InvIT (acting through the Trustee), the Investment Manager, the Sponsor, the Project Manager and the Lead Manager, dated July 23, 2021;
5. The Cash Escrow Agreement entered into between the Terra InvIT (acting through the Trustee), the Investment Manager, the Sponsor, the Lead Manager and the Escrow Collection Bank, dated [•], 2021;
6. Power purchase agreements executed between Solar Edge and SECI, all dated February 10, 2017, together with any amendments or supplements thereto;
7. Energy purchase agreement executed between Terralight Kanji (formerly known as Solar PV) and TANGEDCO dated September 19, 2015, together with any amendments or supplements thereto;
8. Power purchase agreement executed between SPICCPPL and TANGEDCO dated September 27, 2017 which was further assigned to Terralight Suryaprakash (formerly known as SP Suryaprakash), together with any amendments or supplements thereto;
9. Energy purchase agreements executed between TN Solar and TANGEDCO dated March 5, 2015, March 17, 2015 and May 20, 2015, together with any amendments or supplements thereto;
10. Energy purchase agreements executed between UMD and TANGEDCO dated March 25, 2015 and May 20, 2015, together with any amendments or supplements thereto;
11. Power purchase agreement executed between PLG and GUVNL dated May 7, 2010, together with any amendments or supplements thereto;
12. Power purchase agreement executed between TSET (formerly known as Sindicatum Solar Energy Private Limited) and NVVN dated October 15, 2010, together with any amendments or supplements thereto;
13. Power purchase agreement executed between TSEC (formerly known as Sindicatum Solar Energy Gujarat Private Limited) and GUVNL dated May 29, 2010, together with any amendments or supplements thereto;
14. Power purchase agreement executed between USUPL and UPPCL dated April 6, 2015, together with any amendments or supplements thereto;
15. The amended and restated securities acquisition agreement to be executed between the Terra InvIT (acting through the Trustee), the Investment Manager, the Sponsor, and the Project SPVs;
16. The securities acquisition agreement to be executed between the Terra InvIT (acting through the Trustee), the Investment Manager, the Sponsor, and the Specified SPVs;

17. The operations and management agreements each dated February 1, 2021 entered amongst Solar Edge, Terralight Kanji, TN Solar, UMD and Terralight Rajapalayam, the Project Manager and O&M Contractors; and
18. The operations and management agreements each dated June 25, 2021 entered amongst PLG, TSET, TSEC and USUPL and O&M Contractors.

**B. Material Documents**

1. Certificate of registration of the Terra InvIT as an infrastructure investment trust dated February 25, 2021 issued by the SEBI;
2. The resolution of the Board dated July 23, 2021 authorising the Issue;
3. The resolutions of the Board and InvIT Committee each dated July 23, 2021 approving the Draft Placement Memorandum.
4. Consents received from (i) the Auditor; (ii) CRISIL; (iii) Valuer; (iv) Technical Consultant; (v) Lead Manager; (vi) Legal counsel to the Terra InvIT; (vii) Registrar; (viii) Escrow Collection Bank; (ix) Compliance Officer; (x) Trustee; (xi) Sponsor; and (xii) Investment Manager;
5. In-principle listing approval dated [•] from NSE;
6. Tripartite Agreement dated February 26, 2021, amongst the Investment Manager (on behalf of the Terra InvIT), NSDL and the Registrar; and
7. Tripartite Agreement dated March 2, 2021, amongst the Investment Manager (on behalf of the Terra InvIT), CDSL and the Registrar.

Any of the contracts or documents mentioned in this Draft Placement Memorandum may be amended or modified at any time if so required in the interest of the Terra InvIT or if required by the other parties, without reference to the Unitholders, subject to compliance with applicable law.

## **MATERIAL CONTRACTS AND DOCUMENTS FOR INSPECTION**

The following contracts, which are or may be deemed material have been entered or are to be entered into in due course. These contracts and also the documents for inspection referred to hereunder, may be inspected by the Eligible Investors at the office of the Terra InvIT at Mumbai, from 10:00 A.M. to 5:00 P.M., from the date of the Placement Memorandum until the Bid/Issue Closing Date, on Working Days.

### **A. Material Contracts**

1. The Trust Deed, between the Sponsor, Investment Manager (acting as the settlor) and the Trustee, dated January 28, 2021;
2. The Investment Management Agreement, amongst the Trustee, Investment Manager and Project SPVs, dated January 29, 2021 and deed of adherence to the Investment Management Agreement dated September 17, 2021, amongst the Trustee, Investment Manager, Project SPVs and Specified SPVs;
3. The Project Management Agreement, amongst the Trustee, Investment Manager, Project Manager and the Project SPVs dated March 3, 2021 and deed of adherence to the Project Management Agreement dated September 17, 2021, amongst the Trustee, Investment Manager, Project Manager, Project SPVs and Specified SPVs;
4. The Placement Agreement entered into between the Terra InvIT (acting through the Trustee), the Investment Manager, the Sponsor, the Project Manager and the Lead Manager, dated July 23, 2021;
5. The Cash Escrow Agreement entered into between the Terra InvIT (acting through the Trustee), the Investment Manager, the Sponsor, the Lead Manager and the Escrow Collection Bank, dated September 17, 2021;
6. Power purchase agreements executed between Solar Edge and SECI, all dated February 10, 2017, together with any amendments or supplements thereto;
7. Energy purchase agreement executed between Terralight Kanji (formerly known as Solar PV) and TANGEDCO dated September 19, 2015, together with any amendments or supplements thereto;
8. Power purchase agreement executed between SPICCPPL and TANGEDCO dated September 27, 2017 which was further assigned to Terralight Suryaprakash (formerly known as SP Suryaprakash), together with any amendments or supplements thereto;
9. Energy purchase agreements executed between TN Solar and TANGEDCO dated March 5, 2015, March 17, 2015 and May 20, 2015, together with any amendments or supplements thereto;
10. Energy purchase agreements executed between UMD and TANGEDCO dated March 25, 2015 and May 20, 2015, together with any amendments or supplements thereto;
11. Power purchase agreement executed between PLG and GUVNL dated May 7, 2010, together with any amendments or supplements thereto;
12. Power purchase agreement executed between TSET (formerly known as Sindicatum Solar Energy Private Limited) and NVVN dated October 15, 2010, together with any amendments or supplements thereto;
13. Power purchase agreement executed between TSEC (formerly known as Sindicatum Solar Energy Gujarat Private Limited) and GUVNL dated May 29, 2010, together with any amendments or supplements thereto;
14. Power purchase agreement executed between USUPL and UPPCL dated April 6, 2015, together with any amendments or supplements thereto;
15. The amended and restated securities acquisition agreement dated September 17, 2021 between the Terra InvIT (acting through the Trustee), the Investment Manager, the Sponsor, and the Project SPVs;
16. The securities acquisition agreement dated September 17, 2021 between the Terra InvIT (acting through the Trustee), the Investment Manager, the Sponsor, and the Specified SPVs;

17. The operations and management agreements each dated February 1, 2021 entered amongst Solar Edge, Terralight Kanji, TN Solar, UMD and Terralight Rajapalayam, the Project Manager and O&M Contractors; and
18. The operations and management agreements each dated June 25, 2021 entered amongst PLG, TSET, TSEC and USUPL and O&M Contractors.

**B. Material Documents**

1. Certificate of registration of the Terra InvIT as an infrastructure investment trust dated February 25, 2021 issued by the SEBI;
2. The resolution of the Board dated July 23, 2021 authorising the Issue;
3. The resolutions of the Board and InvIT Committee each dated July 23, 2021 approving the Draft Placement Memorandum;
4. The resolutions of the Board dated September 20, 2021, approving the Placement Memorandum;
5. The resolutions of the Board dated September 28, 2021, approving this Final Placement Memorandum
6. Consents received from (i) the Auditor; (ii) CRISIL; (iii) Valuer; (iv) Technical Consultant; (v) Lead Manager; (vi) Legal counsel to the Terra InvIT; (vii) Registrar; (viii) Escrow Collection Bank; (ix) Compliance Officer; (x) Trustee; (xi) Sponsor; and (xii) Investment Manager;
7. In-principle listing approval dated August 6, 2021 from NSE;
8. Tripartite Agreement dated February 26, 2021, amongst the Investment Manager (on behalf of the Terra InvIT), NSDL and the Registrar; and
9. Tripartite Agreement dated March 2, 2021, amongst the Investment Manager (on behalf of the Terra InvIT), CDSL and the Registrar.

Any of the contracts or documents mentioned in this Final Placement Memorandum may be amended or modified at any time if so required in the interest of the Terra InvIT or if required by the other parties, without reference to the Unitholders, subject to compliance with applicable law.

## **DECLARATION**

The Investment Manager hereby declares and certifies that all relevant provisions of the SEBI InvIT Regulations, regulations and guidelines issued by the GoI or SEBI (as the case may be) have been complied with and no statement made in this Final Placement Memorandum is contrary to the provisions of the SEBI InvIT Regulations, the SCRA, the SEBI Act, or rules, regulations, and guidelines issued thereunder (as the case may be). The Investment Manager further certifies that all the statements and disclosures in this Final Placement Memorandum are material, true, correct, not misleading and are adequate in order to enable the investors to make an informed decision.

### **SIGNED BY THE DIRECTOR OF THE INVESTMENT MANAGER**

Mr. Hardik Shah  
*Non-Executive Director*

**Date:** September 28, 2021

**Place:** Mumbai



## **DECLARATION**

The Investment Manager hereby declares and certifies that all relevant provisions of the SEBI InvIT Regulations, regulations and guidelines issued by the GoI or SEBI (as the case may be) have been complied with and no statement made in this Final Placement Memorandum is contrary to the provisions of the SEBI InvIT Regulations, the SCRA, the SEBI Act, or rules, regulations, and guidelines issued thereunder (as the case may be). The Investment Manager further certifies that all the statements and disclosures in this Final Placement Memorandum are material, true, correct, not misleading and are adequate in order to enable the investors to make an informed decision.

### **SIGNED BY THE DIRECTOR OF THE INVESTMENT MANAGER**

Mr. Sanjay Grewal  
*Executive Director*

**Date:** September 28, 2021

**Place:** New Delhi

## **DECLARATION**

The Investment Manager hereby declares and certifies that all relevant provisions of the SEBI InvIT Regulations, regulations and guidelines issued by the GoI or SEBI (as the case may be) have been complied with and no statement made in this Final Placement Memorandum is contrary to the provisions of the SEBI InvIT Regulations, the SCRA, the SEBI Act, or rules, regulations, and guidelines issued thereunder (as the case may be). The Investment Manager further certifies that all the statements and disclosures in this Final Placement Memorandum are material, true, correct, not misleading and are adequate in order to enable the investors to make an informed decision.

### **SIGNED BY THE DIRECTOR OF THE INVESTMENT MANAGER**

Mr. Vinay Pabba  
*Independent Non-executive Director*

**Date:** September 28, 2021

**Place:** Hyderabad

## **DECLARATION**

The Investment Manager hereby declares and certifies that all relevant provisions of the SEBI InvIT Regulations, regulations and guidelines issued by the GoI or SEBI (as the case may be) have been complied with and no statement made in this Final Placement Memorandum is contrary to the provisions of the SEBI InvIT Regulations, the SCRA, the SEBI Act, or rules, regulations, and guidelines issued thereunder (as the case may be). The Investment Manager further certifies that all the statements and disclosures in this Final Placement Memorandum are material, true, correct, not misleading and are adequate in order to enable the investors to make an informed decision.

### **SIGNED BY THE DIRECTOR OF THE INVESTMENT MANAGER**

Mr. Pradeep Kumar  
*Independent Non-executive Director*

**Date:** September 28, 2021

**Place:** Bengaluru

## **DECLARATION**

The Trustee (on behalf of the Terra InvIT) hereby declares and certifies that all relevant provisions of the SEBI InvIT Regulations, regulations and guidelines issued by the GoI or SEBI (as the case may be) have been complied with and no statement made in this Final Placement Memorandum is contrary to the provisions of the SEBI InvIT Regulations, the SCRA, the SEBI Act, or rules, regulations, and guidelines issued thereunder (as the case may be). The Trustee (on behalf of the Terra InvIT) further certifies that all the statements and disclosures in this Final Placement Memorandum are material, true, correct, not misleading and are adequate in order to enable the investors to make an informed decision.

**SIGNED BY THE TRUSTEE (ON BEHALF OF THE TERRA INVIT)**

For **AXIS TRUSTEE SERVICES LIMITED**

**Date:** September 28, 2021

**Place:** Mumbai

## **DECLARATION**

Terra Asia Holdings II Pte. Ltd hereby declares and certifies that all relevant provisions of the SEBI InvIT Regulations, regulations and guidelines issued by the GoI or SEBI (as the case may be) have been complied with and no statement made in this Final Placement Memorandum is contrary to the provisions of the SEBI InvIT Regulations, the SCRA, the SEBI Act, or rules, regulations, and guidelines issued thereunder (as the case may be). We further certify that all the statements and disclosures in this Final Placement Memorandum are material, true, correct, not misleading and are adequate in order to enable the investors to make an informed decision.

**SIGNED BY THE DIRECTOR OF TERRA ASIA HOLDINGS II PTE. LTD.**

Cecilio Velasco  
*Director*

**Date:** September 28, 2021

**Place:** Singapore

## **DECLARATION**

Terra Asia Holdings II Pte. Ltd hereby declares and certifies that all relevant provisions of the SEBI InvIT Regulations, regulations and guidelines issued by the GoI or SEBI (as the case may be) have been complied with and no statement made in this Final Placement Memorandum is contrary to the provisions of the SEBI InvIT Regulations, the SCRA, the SEBI Act, or rules, regulations, and guidelines issued thereunder (as the case may be). We further certify that all the statements and disclosures in this Final Placement Memorandum are material, true, correct, not misleading and are adequate in order to enable the investors to make an informed decision.

**SIGNED BY THE DIRECTOR OF TERRA ASIA HOLDINGS II PTE. LTD.**

Tang Jin Rong  
*Director*

**Date:** September 28, 2021

**Place:** Singapore

## **ANNEXURE I - VALUATION REPORT**

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**Prepared for:**  
**Virescent Renewable Energy Trust ("the Trust")**

**Virescent Infrastructure Investment Manager Private Limited**  
**("the Investment Manager")**

## **Valuation as per SEBI (Infrastructure Investment Trusts) Regulations, 2014 as amended**

**Fair Enterprise Valuation**

**Valuation Date: 31<sup>st</sup> March 2021**

**Mr. S Sundararaman,**  
**Registered Valuer,**  
IBBI Registration No - IBBI/RV/06/2018/10238



RV/SSR/R/2022/03

Date: 22<sup>nd</sup> July 2021

**Virescent Renewable Energy Trust**

*(acting through Axis Trustee Services Limited [in its capacity as “the Trustee” of the Trust])*

2<sup>nd</sup> Floor, Piramal Tower,  
Peninsula Corporate Park,  
Lower Parel, Mumbai – 400 013.

**Virescent Infrastructure Investment Manager Private Limited**

*(acting as the Investment Manager to Virescent Renewable Energy Trust)*

10<sup>th</sup> Floor, Parinee Crescenzo, C- 30,  
G Block, Bandra Kurla Complex,  
Bandra East, Mumbai – 400 051.

**Sub: Financial Valuation as per SEBI (Infrastructure Investment Trusts) Regulations, 2014, as amended (“the SEBI InvIT Regulations”)**

Dear Sir(s)/Madam(s),

I, Mr. S. Sundararaman (“**Registered Valuer**” or “**RV**” or “**I**” or “**My**” or “**Me**”) bearing IBBI registration number IBBI/RV/06/2018/10238, have been appointed vide letter bearing reference number RV/SSR//EL/0506/A# as an independent valuer, as defined as per Regulation 2(zzf) of the SEBI InvIT Regulations, by **Virescent Infrastructure Investment Manager Private Limited** (“**VIIMPL**” or “**the Investment Manager**”) acting as the investment manager for **Virescent Renewable Energy Trust** (“**the Trust**” or “**InvIT**”), an infrastructure investment trust, registered with the **Securities Exchange Board of India** (“**SEBI**”) with effect from 25<sup>th</sup> February 2021, bearing registration number IN/InvIT/20-21/0018 and **Axis Trustee Services Limited** (“**the Trustee**”) acting on behalf of the Trust for the purpose of the financial valuation of the special purpose vehicles (defined below and hereinafter together referred as “**the SPVs**”) of Terra Asia Holdings II Pte. Limited (“**the Sponsor**” or “**Terra Asia**”) as per the requirements of the Securities and Exchange Board of India (Infrastructure Investment Trusts) Regulations, 2014, as amended (“**SEBI InvIT Regulations**”). The SPVs to be valued are proposed to be transferred to the Trust created as set out in the SEBI InvIT Regulations, where VIIMPL is acting as the Investment Manager and Terra Asia is the Sponsor as per the extant provisions of the SEBI InvIT Regulations.

I am enclosing the Report providing opinion on the fair enterprise value of the SPVs as defined hereinafter on a going concern basis as at 31<sup>st</sup> March 2021 (“**Valuation Date**”).

Enterprise Value (“**EV**”) is described as the total value of the equity in a business plus the value of its debt and debt related liabilities, minus any cash or cash equivalents to meet those liabilities. The attached Report details the valuation methodologies used, calculations performed and the conclusion reached with respect to this valuation.

I was further requested by the Investment Manager to provide the adjusted enterprise value of the SPVs as at 31<sup>st</sup> March 2021, where the adjusted enterprise value (“**Adjusted EV**”) is derived as EV as defined above plus cash or cash equivalents of the SPVs as at 31<sup>st</sup> March 2021.

I have relied on explanations and information provided by the Investment Manager. Although, I have reviewed such data for consistency, those are not independently investigated or otherwise verified.

# effective from 6<sup>th</sup> May 2021

My team and I have no present or planned future interest in the Trust, the SPVs or the Investment Manager except to the extent of this appointment as an independent valuer and the fee for this Valuation Report (“**Report**”) which is not contingent upon the values reported herein. The valuation analysis should not be construed as investment advice, specifically, I do not express any opinion on the suitability or otherwise of entering into any financial or other transaction with the Trust.

This Report has been prepared solely for the purpose of inclusion as part of the Draft Placement Memorandum (“DPM”), Placement Memorandum (“PM”) and the Final Placement Memorandum (“FPM”) and such other documents as may be required in accordance with the independent valuation required as per the SEBI InvIT Regulations.

The SPVs are expected to be acquired by the Trust and are to be valued as per Regulation 21 read with Chapter V of the SEBI InvIT Regulations.

Following Special Purpose Vehicles are proposed to be transferred to the Trust:

Sr. No.	Name of the SPV	Term
1	TN Solar Power Energy Private Limited	TNSEPL
2	Universal Mine Developers & Service Providers Private Limited	UMD
3	Terralight Kanji Solar Private Limited	TKSPL
4	Terralight Rajapalayam Solar Private Limited	TRSPL
5	Solar Edge Power and Energy Pvt Ltd	Solar Edge
6	Terralight Solar Energy Charanka Private Limited	TSEC
7	PLG Photovoltaic Private Limited	PLG
8	Terralight Solar Energy Tinwari Private Limited	TSETPL
9	Universal Saur Urja Private Limited	USUPL

(Hereinafter all the 9 companies mentioned above are together referred to as “**the SPVs**”)

The analysis must be considered as a whole. Selecting portions of any analysis or the factors that are considered in this Report, without considering all factors and analysis together could create a misleading view of the process underlying the valuation conclusions. The preparation of a valuation is a complex process and is not necessarily susceptible to partial analysis or summary description. Any attempt to do so could lead to undue emphasis on any particular factor or analysis.

The information provided to me by the Investment Manager in relation to the SPVs included but not limited to historical financial statements, forecasts/projections, other statements and assumptions about future matters like forward-looking financial information prepared by the Investment Manager. The forecasts and projections as supplied to me are based upon assumptions about events and circumstances which are yet to occur.

By nature, valuation is based on estimates, however, considering the outbreak of COVID-19 pandemic and the consequent economic slowdown, the risks and uncertainties relating to the events occurring in the future, the actual figures in future may differ from these estimates and may have an impact on the valuation of the SPVs.

Further, considering the current crisis in relation to COVID-19 in India and across the globe, I have been informed by the Investment Manager, that the forecasts / projections provided for the valuation exercises are prepared after reasonably evaluating and incorporating the impact of outbreak of COVID-19 pandemic as per prevalent conditions as on date.

I have not tested individual assumptions or attempted to substantiate the veracity or integrity of such assumptions in relation to the forward-looking financial information, however, I have made sufficient enquiry to satisfy myself that such information has been prepared on a reasonable basis.

Notwithstanding anything above, I cannot provide any assurance that the forward looking financial information will be representative of the results which will actually be achieved during the cash flow forecast period.

The valuation provided by RV and the valuation conclusion are included herein and the Report complies with the SEBI InvIT Regulations and guidelines, circular or notification issued by the Securities and Exchange Board of India (“SEBI”) thereunder.

Please note that all comments in the Report must be read in conjunction with the caveats to the Report, which are contained in Section 11 of this Report. This letter, the Report and the summary of valuation included herein can be provided to Trust’s advisors and may be made available for the inspection to the public and with the SEBI, the stock exchanges and any other regulatory and supervisory authority, as may be required.

RV draws your attention to the limitation of liability clauses in Section 11 of this Report.

This letter should be read in conjunction with the attached Report.

Yours faithfully,

Swaminathan  
Sundaraman  
n

Digitally signed  
by Swaminathan  
Sundaraman  
Date: 2021.07.22  
21:40:37 +05'30'

**S. Sundaraman**

Registered Valuer

IBBI Registration No.: IBBI/RV/06/2018/10238

Asset Class: Securities or Financial Assets

Place: Chennai

UDIN: 21028423AAAALJ1145

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## Definition, abbreviation & glossary of terms

Abbreviations	Meaning
Capex	Capital Expenditure
CCIL	Clearing Corporation of India Limited
CCM	Comparable Companies Multiples
COD	Commercial Operation Date
CTM	Comparable Transactions Multiples
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortization
ERP	Equity Risk Premium
EV	Enterprise Value
FCFF	Free Cash Flow to the Firm
FDI	Foreign Direct Investment
FPM	Final Placement Memorandum
FY	Financial Year Ended 31 <sup>st</sup> March
GAAP	Generally Accepted Accounting Principles
GW	Giga Watts
Ind AS	Indian Accounting Standards
INR	Indian Rupee
Investment Manager/ VIIMPL	Virescent Infrastructure Investment Manager Private Limited
IVS	ICAI Valuation Standards 2018
kWh	Kilo Watt Hour
Mn	Million
NAV	Net Asset Value Method
NCA	Net Current Assets, Excluding Cash and Bank Balances
O&M	Operation & Maintenance
PLG	PLG Photovoltaic Private Limited
PM	Placement Memorandum
PPP	Public Private Partnership
RV	Registered Valuer
SEBI	Securities and Exchange Board of India
SEBI InvIT Regulations	SEBI (Infrastructure Investment Trusts) Regulations, 2014, as amended
Solar Edge	Solar Edge Power and Energy Private Limited
Sponsor/ Terra Asia	Terra Asia Holdings II Pte. Limited
SPV	Special Purpose Vehicle
the Trust or InvIT	Virescent Renewable Energy Trust
the Trustee	Axis Trustee Services Limited
TKSPL	Terralight Kanji Solar Private Limited
TRSPL	Terralight Rajapalayam Solar Private Limited
TNSEPL	TN Solar Power Energy Private Limited
TSETPL	Terralight Solar Energy Tinwari Private Limited
TSEC	Terralight Solar Energy Charanka Private Limited
UMD	Universal Mine Developers & Service Providers Private Limited
USUPL	Universal Saur Urja Private Limited
WACC	Weighted Average Cost of Capital

## 1. Executive Summary

### 1.1. Background

- 1.1.1. Terra Asia Holdings II Pte. Limited ("**the Sponsor**" or "**Terra Asia**") has floated an infrastructure investment trust under the SEBI InvIT Regulations called "**Virescent Renewable Energy Trust**" ("**the InvIT**" or "**the Trust**"). Terra Asia is an affiliate of Kohlberg Kravis Roberts & Co. L.P. (together with its affiliates, "**KKR**"). Founded in 1976, KKR is a leading global investment firm that offers alternative asset management and capital markets and insurance solutions with approximately US\$ 251 billion of assets under management as of 31<sup>st</sup> December 2020.
- 1.1.2. Axis Trustee Services Limited ("**the Trustee**") has been appointed as the Trustee of the Virescent Renewable Energy Trust. Virescent Infrastructure Investment Manager Private Limited ("**VIIMPL**" or "**the Investment Manager**") has been appointed as the Investment Manager to the Trust by the Trustee and will be responsible to carry out the duties of such person as mentioned under the SEBI InvIT Regulations.
- 1.1.3. Shareholding of the Investment Manager as on the Valuation Date is as under :

Sr. No.	Particulars	No. of shares	%
1	Terra Asia Holdings II Pte. Ltd.	11,009,999	100.0%
2	*Terra Asia Holdings I Pte. Ltd.	1	0.0%
<b>Total</b>		<b>11,010,000</b>	<b>100.0%</b>

Source: Investment Manager

\* Nominee Shareholder of Terra Asia Holdings II Pte. Ltd.

- 1.1.4. I understand that Virescent Renewable Energy Trust, acting through the Trustee, shall acquire the equity held by the Sponsor in the 9 SPVs mentioned in para 1.1.6, following which units will be issued to the Sponsor by the Trust, which are to be listed on one or more Indian stock exchanges consequent to the proposed private placement of the Trust ("**the Proposed Transaction**").
- 1.1.5. In this regard, the Investment Manager intends to undertake an independent valuation of the SPVs (as defined in para 1.1.6) as per the extant provisions of the SEBI InvIT Regulations issued by Securities and Exchange Board of India ("**SEBI**").
- 1.1.6. **Financial Assets to be Valued**

The financial assets under consideration are valued at Enterprise Value and Adjusted Enterprise Value of the following SPVs:

Sr. No.	Name of the SPV	Term
1	TN Solar Power Energy Private Limited	TNSEPL
2	Universal Mine Developers & Service Providers Private Limited	UMD
3	Terralight Kanji Solar Private Limited	TKSPL
4	Terralight Rajapalayam Solar Private Limited	TRSPL
5	Solar Edge Power and Energy Pvt Ltd	Solar Edge
6	Terralight Solar Energy Charanka Private Limited	TSEC
7	PLG Photovoltaic Private Limited	PLG
8	Terralight Solar Energy Tinwari Private Limited	TSETPL
9	Universal Saur Urja Private Limited	USUPL

(Together referred to as "**the SPVs**")

- 1.1.7. In this regard, the Investment Manager has appointed me, S. Sundararaman (“**Registered Valuer**” or “**RV**” or “**I**” or “**My**” or “**Me**”) bearing IBBI registration number IBBI/RV/06/2018/10238 to undertake fair valuation of the SPVs at the enterprise level as per the extant provisions of the SEBI InvIT Regulations issued by SEBI. Enterprise Value (“**EV**”) is described as the total value of the equity in a business plus the value of its debt and debt related liabilities, minus any cash or cash equivalents to meet those liabilities.
- 1.1.8. Further, on the request of the Investment Manager, I have calculated Adjusted Enterprise Value of the SPVs which is derived as the EV as defined above plus cash or cash equivalents of the SPVs as at the Valuation Date.
- 1.1.9. I declare that:
- i. I am competent to undertake the financial valuation in terms of the SEBI InvIT Regulations;
  - ii. I am not an associate of the Sponsor or the Investment Manager or the Trustee and I have not less than five years of experience in valuation of infrastructure assets;
  - iii. I am independent and have prepared the Report on a fair and unbiased basis;
  - iv. I have valued the SPVs based on the valuation standards as specified / applicable as per SEBI InvIT Regulations.
- 1.1.10. This Report covers all the disclosures required as per the SEBI InvIT Regulations and the Valuation of the SPVs is impartial, true and fair and in compliance with the SEBI InvIT Regulations.

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## 1.2. **Scope of Valuation**

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### 1.2.1. **Valuation Base**

Valuation Base means the indication of the type of value being used in an engagement. In the present case, I have determined the fair value of the SPVs at the enterprise level. Fair Value Bases defined as under:

#### **Fair Value**

Fair value is the price that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants at the valuation date. It is the price that would be received to sell an asset or paid to transfer a liability in an orderly transaction in the principal (or most advantageous) market at the measurement date under current market conditions (i.e. an exit price) regardless of whether that price is directly observable or estimated using another valuation technique. Fair value or Market value is usually synonymous to each other except in certain circumstances where characteristics of an asset translate into a special asset value for the party (ies) involved.

### 1.2.2. **Valuation Date**

Valuation Date is the specific date at which the value of the assets to be valued gets estimated or measured. Valuation is time specific and can change with the passage of time due to changes in the condition of the asset to be valued. Accordingly, valuation of an asset as at a particular date can be different from other date(s).

The Valuation Date considered for the fair enterprise valuation of the SPVs is 31<sup>st</sup> March 2021 (“**Valuation Date**”). The RV is not aware of any other events having occurred since 31<sup>st</sup> March 2021 till date of this Report which he deems to be significant for his valuation analysis.

### 1.2.3. **Premise of Value**

Premise of Value refers to the conditions and circumstances how an asset is deployed. In the present case, RV has determined the fair enterprise value of the SPVs on a Going Concern Value defined as under:

#### **Going Concern Value**

Going Concern value is the value of a business enterprise that is expected to continue to operate in the future. The intangible elements of going concern value result from factors such as having a trained work force, an operational plant, necessary licenses, systems, and procedures in place etc.

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### 1.3. Summary of Valuation

I have assessed the fair enterprise value of each of the SPVs on a stand-alone basis by using the Discounted Cash Flow (“**DCF**”) method under the income approach. Following table summarizes my explanation on the usage or non usage of different valuation methods:

Valuation Approach	Valuation Methodology	Used	Explanation
Cost Approach	Net Asset Value	No	NAV does not capture the future earning potential of the business.
Income Approach	Discounted Cash Flow	Yes	All the SPVs are generating income based on pre-determined power purchase agreements. Hence, the growth potential of the SPVs and the true worth of its business would be reflected in its future earnings potential and therefore, DCF Method under the income approach has been considered as an appropriate method for the present valuation exercise.
Market Approach	Market Price	No	The equity shares of the SPVs are not listed on any recognized stock exchange in India. Hence, I was unable to apply the market price method.
	Comparable Companies	No	In the absence of any exactly comparable listed companies with characteristics and parameters similar to that of the SPVs, I am unable to consider this method for the current valuation.
	Comparable Transactions	No	In the absence of adequate details about the Comparable Transactions, I was unable to apply the CTM method.

Under the DCF Method, the Free Cash Flow to Firm (“**FCFF**”) has been used for the purpose of valuation of each of the SPVs. In order to arrive at the fair EV of the individual SPVs under the DCF Method, I have relied on the audited financial statements as at 31<sup>st</sup> March 2021 prepared in accordance with the Indian Accounting Standards (Ind AS) and the financial projections of the respective SPVs prepared by the Investment Manager as at the Valuation Date based on their best judgement.

The discount rate considered for the respective SPVs for the purpose of this valuation exercise is based on the Weighted Average Cost of Capital (“**WACC**”) for each of the SPVs.

The term of the PPA is 25 years for majority of the SPVs. The ownership of the underlying assets (tangible assets) shall remain with the SPVs even after the expiry of PPA term. As the cash flows beyond 25 years are relatively uncertain on account of factors like degradation of panels, technology factor, tariff rate, extension of land lease (wherever applicable), etc., the terminal period value (i.e. value on account of cash flows to be generated after the expiry of PPA period) has been considered based on the salvage value of the plant & machinery, sale of freehold land and realisation of working capital at the end of their respective PPA term of 25 years.

Based on the methodology and assumptions discussed further, RV has arrived at the fair enterprise value of the SPVs as on the Valuation Date:

Sr. No.	SPVs	Approximate Projection Period (Balance Project Period)	WACC	Fair Value of EV* (INR Lacs)	Fair Value of Adjusted EV** (INR Lacs)
1	TNSEPL	~19 Years and 7 Months	8.37%	20,395	24,412
2	UMD	~19 Years and 10 Months	8.37%	22,471	26,431
3	TKSPL	~20 Years and 0 Months	8.37%	27,740	32,999
4	TRSPL	~22 Years and 6 Months	7.95%	19,169	24,478
5	Solar Edge	~22 Years and 0 Months	8.17%	86,656	88,966
6	TSEC	~16 Years and 0 Months	8.07%	11,849	13,665
7	PLG	~15 Years and 10 Months	8.36%	17,409	20,562
8	TSETPL	~15 Years and 7 Months	7.90%	10,798	11,978
9	USUPL	~20 Years and 6 Months	8.41%	26,526	29,856
<b>Total</b>				<b>2,43,013</b>	<b>2,73,346</b>

\* Enterprise Value ("EV") is described as the total value of the equity in a business plus the value of its debt and debt related liabilities, minus any cash or cash equivalents to meet those liabilities.

\*\* Further, on the request of the Investment Manager, I have calculated Adjusted Enterprise Value of the SPVs which is derived as the EV as defined above plus cash or cash equivalents of the SPVs as at the Valuation Date.

(Refer Appendix 1 & 2 for the detailed workings)

Further to above considering that present valuation exercise is based on the future financial performance and based on opinions on the future credit risk, cost of debt assumptions, etc., which represent reasonable expectations at a particular point of time, but such information, estimates or opinions are not offered as predictions or as assurances that a particular level of income or profit will be achieved, a particular event will occur or that a particular level of income or profit will be achieved, a particular event will occur or that a particular price will be offered or accepted. Actual results achieved during the period covered by the prospective financial analysis will vary from these estimates and variations may be material. Accordingly, a quantitative sensitivity analysis is considered on the following unobservable inputs:

1. WACC by increasing / decreasing it by 0.5%
2. WACC by increasing / decreasing it by 1.0%
3. PLF by increasing / decreasing it by 0.5%
4. PLF by increasing / decreasing it by 1.0%
5. Operating Expenses by increasing / decreasing it by 20%

#### 1. Fair Enterprise Valuation Range based on WACC parameter (0.5%)

							INR Lacs
Sr. No.	SPVs	WACC + 0.5%	EV	Base WACC	EV	WACC - 0.5%	EV
1	TNSEPL	8.87%	19,697	8.37%	20,395	7.87%	21,135
2	UMD	8.87%	21,709	8.37%	22,471	7.87%	23,279
3	TKSPL	8.87%	26,784	8.37%	27,740	7.87%	28,755
4	TRSPL	8.45%	18,506	7.95%	19,169	7.45%	19,874
5	Solar Edge	8.67%	83,356	8.17%	86,656	7.67%	90,191
6	TSEC	8.57%	11,569	8.07%	11,849	7.57%	12,142
7	PLG	8.86%	17,019	8.36%	17,409	7.86%	17,819
8	TSETPL	8.40%	10,502	7.90%	10,798	7.40%	11,108
9	USUPL	8.91%	25,921	8.41%	26,526	7.91%	27,160
<b>Total of all SPVs</b>			<b>2,35,063</b>		<b>2,43,013</b>		<b>2,51,463</b>

## 2. Fair Enterprise Valuation Range based on WACC parameter (1.0%)

INR Lacs							
Sr. No.	SPVs	WACC + 1.0%	EV	Base WACC	EV	WACC - 1.0%	EV
1	TNSEPL	9.37%	19,037	8.37%	20,395	7.37%	21,920
2	UMD	9.37%	20,989	8.37%	22,471	7.37%	24,136
3	TKSPL	9.37%	25,881	8.37%	27,740	7.37%	29,833
4	TRSPL	8.95%	17,883	7.95%	19,169	6.95%	20,625
5	Solar Edge	9.17%	80,272	8.17%	86,656	7.17%	93,983
6	TSEC	9.07%	11,303	8.07%	11,849	7.07%	12,449
7	PLG	9.36%	16,646	8.36%	17,409	7.36%	18,249
8	TSETPL	8.90%	10,220	7.90%	10,798	6.90%	11,433
9	USUPL	9.41%	25,345	8.41%	26,526	7.41%	27,827
Total of all SPVs			2,27,575		2,43,013		2,60,455

## 3. Fair Enterprise Valuation Range based on Plant Load Factor (PLF) parameter (0.5%)

INR Lacs							
Sr. No.	SPVs	PLF + 0.5%	EV	Base PLF for FY22	EV	PLF - 0.5%	EV
1	TNSEPL	17.4%	20,456	16.9%	20,395	16.4%	20,207
2	UMD	17.0%	22,624	16.5%	22,471	16.0%	22,120
3	TKSPL	17.6%	27,777	17.1%	27,740	16.6%	27,585
4	TRSPL	17.2%	19,856	16.7%	19,169	16.2%	18,394
5	Solar Edge	17.0%	89,239	16.5%	86,656	16.0%	84,066
6	TSEC	16.7%	12,209	16.2%	11,849	15.7%	11,490
7	PLG	18.4%	17,890	17.9%	17,409	17.4%	16,951
8	TSETPL	18.3%	11,087	17.8%	10,798	17.3%	10,509
9	USUPL	17.2%	27,332	16.7%	26,526	16.2%	25,720
Total of all SPVs			2,48,469		2,43,013		2,37,041

## 4. Fair Enterprise Valuation Range based on Plant Load Factor (PLF) parameter (1.0%)

INR Lacs							
Sr. No.	SPVs	PLF + 1.0%	EV	Base PLF for FY22	EV	PLF - 1.0%	EV
1	TNSEPL	17.9%	20,458	16.9%	20,395	15.9%	19,800
2	UMD	17.5%	22,662	16.5%	22,471	15.5%	21,479
3	TKSPL	18.1%	27,777	17.1%	27,740	16.1%	27,196
4	TRSPL	17.7%	20,487	16.7%	19,169	15.7%	17,467
5	Solar Edge	17.5%	91,822	16.5%	86,656	15.5%	81,433
6	TSEC	17.2%	12,567	16.2%	11,849	15.2%	11,131
7	PLG	18.9%	18,370	17.9%	17,409	16.9%	16,465
8	TSETPL	18.8%	11,375	17.8%	10,798	16.8%	10,220
9	USUPL	17.7%	28,137	16.7%	26,526	15.7%	24,914
Total of all SPVs			2,53,654		2,43,013		2,30,106

**5. Fair Enterprise Valuation Range based on Operating Expense parameter (20%)**

Sr. No.	SPVs	INR Lacs		
		EV at Expenses + 20%	EV at Base Expenses	EV at Expenses - 20%
1	TNSEPL	19,938	20,395	20,852
2	UMD	22,026	22,471	22,916
3	TKSPL	27,250	27,740	28,231
4	TRSPL	18,418	19,169	19,918
5	Solar Edge	83,901	86,656	89,402
6	TSEC	11,544	11,849	12,157
7	PLG	17,162	17,409	17,680
8	TSETPL	10,699	10,798	10,896
9	USUPL	26,000	26,526	27,018
<b>Total of all SPVs</b>		<b>2,36,939</b>	<b>2,43,013</b>	<b>2,49,071</b>

The above represents reasonable range of fair enterprise valuation of the SPVs.

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## 2. **Procedures adopted for current valuation exercise**

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- 2.1. I have performed the valuation analysis, to the extent applicable, in accordance with ICAI Valuation Standards 2018 (“**IVS**”) issued by the Institute of Chartered Accountants of India.
- 2.2. In connection with this analysis, I have adopted the following procedures to carry out the valuation analysis:
- 2.2.1. Requested and received financial and qualitative information relating to the SPVs;
  - 2.2.2. Obtained and analyzed data available in public domain, as considered relevant by me;
  - 2.2.3. Discussions with the Investment Manager on:
    - Understanding of the business of the SPVs – business and fundamental factors that affect its earning-generating capacity including strengths, weaknesses, opportunities and threats analysis and historical and expected financial performance;
  - 2.2.4. Undertook industry analysis:
    - Research publicly available market data including economic factors and industry trends that may impact the valuation;
    - Analysis of key trends and valuation multiples of comparable companies/comparable transactions, if any, using proprietary databases subscribed by me;
  - 2.2.5. Analysis of other publicly available information;
  - 2.2.6. Selection of valuation approach and valuation methodology/(ies), in accordance with IVS, as considered appropriate and relevant by me;
  - 2.2.7. Determination of fair value of the EV of the SPVs on a going concern basis till the end of PPA term as at the Valuation Date and determination of fair value of the Adjusted EV of the SPVs on a going concern basis till the end of PPA term as at the Valuation Date on request of the Investment Manager.

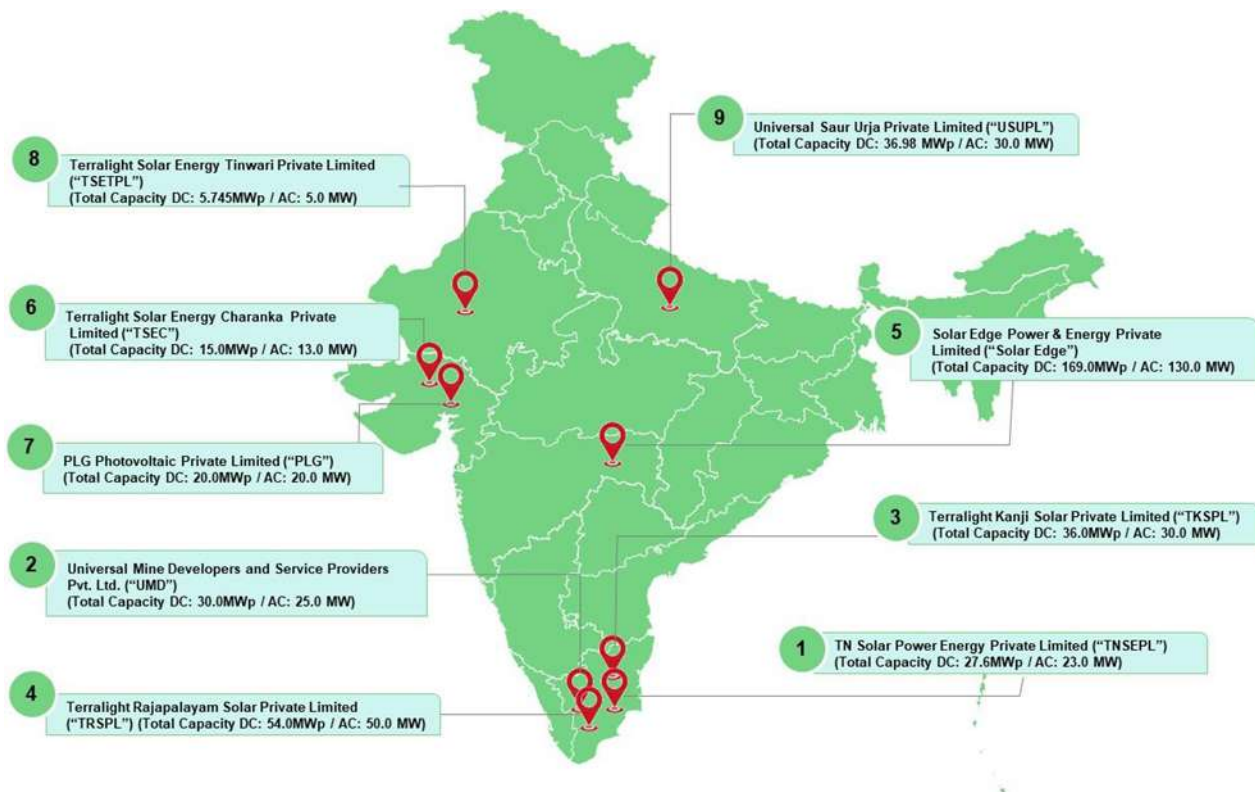
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### 3. Overview of Sponsor, InvIT and SPVs

#### 3.1. Sponsor / Terra Asia Holdings II Pte. Limited (Terra Asia)

- 3.1.1. Terra Asia is an affiliate of Kohlberg Kravis Roberts & Co. L.P. (together with its affiliates, “KKR”).
- 3.1.2. Founded in 1976, KKR is a leading global investment firm that offers alternative asset management and capital markets and insurance solutions with approximately US\$ 251 billion of assets under management as of 31<sup>st</sup> December 2020.
- 3.1.3. I understand that the proposed Virescent Renewable Energy Trust, acting through the Trustee, shall acquire the equity held by the Sponsor in the SPVs following which units will be issued to the Sponsor by the Trust, which are to be listed on one or more Indian stock exchanges consequent to the proposed private placement of the Trust.

#### 3.2. Following is a map of India showing the area covered by the proposed SPVs of the Trust:



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## Background of the SPVs

### 3.3. TN Solar Power Energy Private Limited (“TNSEPL”):

3.3.1. Summary of project details of TNSEPL are as follows:

Parameters	Details
Installed Capacity (DC)	27.60 MW
Plant Location	Thuthookudi, Tamil Nadu (12.00 MW) Virudhunagar, Tamil Nadu (9.60 MW) Dindigul, Tamil Nadu (6.00 MW)
Actual COD	01-Nov-2015 (Average)
Land Area	116.21 Acres
O&M Contractor	AVI Solar Energy Pvt. Ltd.
PPA Counterparty	Tamil Nadu Generation and Distribution Corporation Ltd.
PPA Date	12 <sup>th</sup> September 2014
PPA Term	25 years from Actual COD
PPA Tariff	INR 7.01 per Unit

*Source: Investment Manager*

3.3.2. TNSEPL is engaged in carrying on the business of setting up, generating and selling of renewable power from its ground mounted solar power plants located at Thuthookudi (12.00 MW), Virudhunagar (9.60 MW), and Dindigul (6.00 MW) in Tamil Nadu. The Company had entered into a PPA with Tamil Nadu Generation and Distribution Corporation Ltd. (“TANGEDCO”) on 12<sup>th</sup> September 2014 for implementation of a 27.60 MW Solar Photovoltaic Power Generation Unit in the State of Tamil Nadu, under which it has a commitment to sell electricity for a period of 25 years.

3.3.3. The equity shareholding of TNSEPL as on Valuation Date is as follows:

Sr. No.	Particulars	No. of shares	%
1	Terra Asia Holdings II Pte. Ltd.	4,34,99,999	100.0%
2	*Terra Asia Holdings I Pte. Ltd	1	0.0%
	<b>Total</b>	<b>4,35,00,000</b>	<b>100.0%</b>

*\* Nominee Shareholder of Terra Asia Holdings II Pte. Ltd.*

*Source: Investment Manager*

3.3.4. The CCPS Holding of TNSEPL as on Valuation Date is as follows:

Sr. No.	Particulars	No. of CCPS	%
1	Terra Asia Holdings II Pte. Ltd.	1,91,20,000	100.0%
	<b>Total</b>	<b>1,91,20,000</b>	<b>100.0%</b>

*Source: Investment Manager*

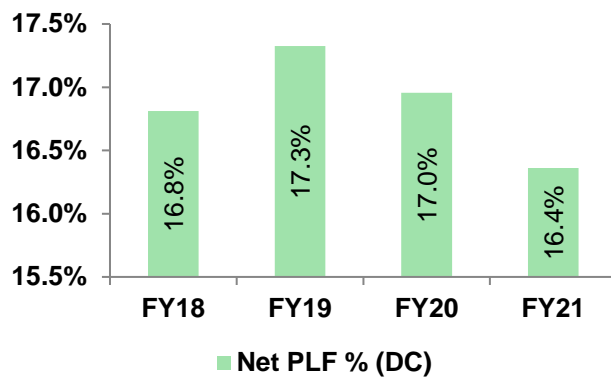
3.3.5. The CCD Holding of TNSEPL as on Valuation Date is as follows:

Sr. No.	Particulars	No. of CCDs	%
1	Terra Asia Holdings II Pte. Ltd.	13,44,58,559	100.0%
	<b>Total</b>	<b>13,44,58,559</b>	<b>100.0%</b>

*Source: Investment Manager*



3.3.6. Operating Efficiency history of TNSEPL:



Source: Investment Manager

3.3.7. Considering the restrictions on movement imposed by State Governments and various Local Bodies on account of COVID-19 pandemic, it was not possible to conduct physical site visit for the SPVs. My team had conducted virtual site visits over collaboration apps like Google Teams, Zoom App, Whatsapp Video Calling, etc. with the person on plant site on 10<sup>th</sup> July 2021, to the extent appropriate. Refer below for the pictures of TNSEPL, as provided by the Investment Manager.





### **3.4. Universal Mine Developers & Service Providers Private Limited (“UMD”)**

3.4.1. Summary of project details of UMD are as follows:

Parameters	Details
Installed Capacity (DC)	30.00 MW
Plant Location	Amathur, Tamil Nadu (14.40 MW) Kovilpatti, Tamil Nadu (15.60 MW)
Actual COD	20-Jan-2016 (Average)
Land Area	147.29 Acres
O&M Contractor	AVI Solar Energy Pvt. Ltd.
PPA Counterparty	Tamil Nadu Generation and Distribution Corporation Ltd.
PPA Date	12-Sept-14
PPA Term	25 years from Actual COD
PPA Tariff	INR 7.01 per Unit

Source: Investment Manager

3.4.2. UMD is engaged in carrying on the business of setting up, generating and selling of renewable power from its ground mounted solar power plants located at Amathur (14.40 MW) & Kovilpatti (15.60 MW) in Tamil Nadu. The Company had entered into a PPA with Tamil Nadu Generation and Distribution Corporation Ltd. (“TANGEDCO”) on 12<sup>th</sup> September 2014 for implementation of a 30 MW Solar Photovoltaic Power Generation Unit in the State of Tamil Nadu, under which it has a commitment to sell electricity for a period of 25 years.

3.4.3. The equity shareholding of UMD as on Valuation Date is as follows:

Sr. No.	Particulars	No. of shares	%
1	Terra Asia Holdings II Pte. Ltd.	4,69,00,999	100.0%
2	*Terra Asia Holdings I Pte. Ltd	1	0.0%
	<b>Total</b>	<b>4,69,01,000</b>	<b>100.0%</b>

\* Nominee Shareholder of Terra Asia Holdings II Pte. Ltd.

Source: Investment Manager

3.4.4. The CCPS Holding of UMD as on Valuation Date is as follows:

Sr. No.	Particulars	No. of CCPS	%
1	Terra Asia Holdings II Pte. Ltd.	2,01,00,000	100.0%
	<b>Total</b>	<b>2,01,00,000</b>	<b>100.0%</b>

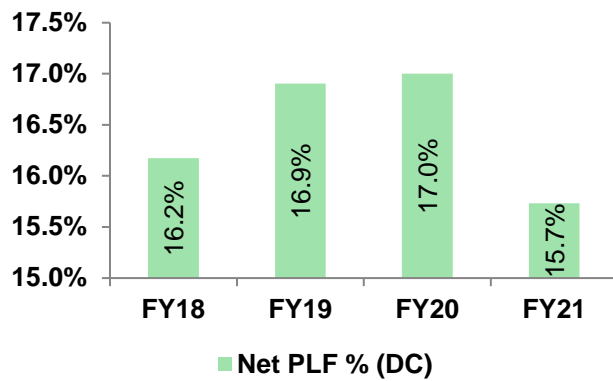
Source: Investment Manager

3.4.5. The CCD Holding of UMD as on Valuation Date is as follows:

Sr. No.	Particulars	No. of CCDs	%
1	Terra Asia Holdings II Pte. Ltd.	15,06,58,705	100.0%
	<b>Total</b>	<b>15,06,58,705</b>	<b>100.0%</b>

Source: Investment Manager

3.4.6. Operating Efficiency history of UMD:



Source: Investment Manager

3.4.7. Considering the restrictions on movement imposed by State Governments and various Local Bodies on account of COVID-19 pandemic, it was not possible to conduct physical site visit for the SPVs. My team had conducted virtual site visits over collaboration apps like Google Teams, Zoom App, Whatsapp Video Calling, etc. with the person on plant site on 10<sup>th</sup> July 2021, to the extent appropriate. Refer below for the pictures of UMD, as provided by the Investment Manager.



### 3.5. Terralight Kanji Solar Private Limited (“TKSPL”):

3.5.1. Summary of project details of TKSPL are as follows:

Parameters	Details
Installed Capacity (DC)	36.00 MW
Plant Location	Tiruvannamalai, Tamil Nadu
Actual COD	26-Mar-16
Land Area	160.03 Acres
O&M Contractor	AVI Solar Energy Pvt. Ltd.
PPA Counterparty	Tamil Nadu Generation and Distribution Corporation Ltd.
PPA Date	12-Sept-14
PPA Term	25 years from Actual COD
PPA Tariff	INR 7.01 per Unit

Source: Investment Manager

3.5.2. Terralight Kanji Solar Private Limited (earlier known as Shapoorji Pallonji Solar PV Private Limited) is engaged in carrying on the business of setting up, generating and selling of renewable power from its ground mounted solar power plants located at Tiruvannamalai, Tamil Nadu.

3.5.3. TKSPL had entered into a PPA with Tamil Nadu Generation and Distribution Corporation Ltd. (“TANGEDCO”) on 12<sup>th</sup> September 2014 for implementation of a 36 MW (DC) Solar Photovoltaic Power Generation Unit in the State of Tamil Nadu, under which it has a commitment to sell electricity for a period of 25 years.

3.5.4. The equity shareholding of TKSPL as on Valuation Date is as follows:

Sr. No.	Particulars	No. of shares	%
1	Terra Asia Holdings II Pte. Ltd.	4,05,00,799	100.0%
2	*Terra Asia Holdings I Pte. Ltd.	1	0.0%
	<b>Total</b>	<b>4,05,00,800</b>	<b>100.0%</b>

Source: Investment Manager

\* Nominee Shareholder of Terra Asia Holdings II Pte. Ltd.

3.5.5. The CCPS Holding of TKSPL as on Valuation Date is as follows:

Sr. No.	Particulars	No. of CCPS	%
1	Terra Asia Holdings II Pte. Ltd.	70,000	100.0%
	<b>Total</b>	<b>70,000</b>	<b>100.0%</b>

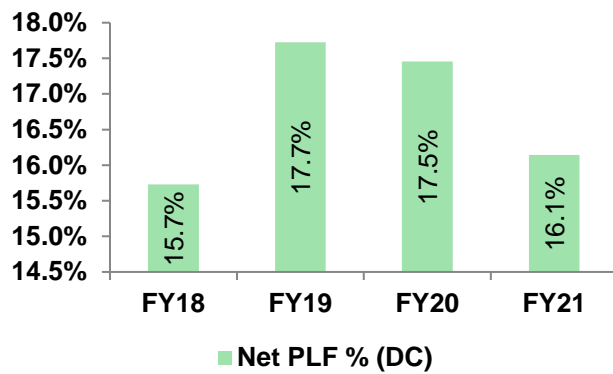
Source: Investment Manager

3.5.6. The CCD Holding of TKSPL as on Valuation Date is as follows:

Sr. No.	Particulars	No. of CCDs	%
1	Terra Asia Holdings II Pte. Ltd.	24,18,22,113	100.0%
	<b>Total</b>	<b>24,18,22,113</b>	<b>100.0%</b>

Source: Investment Manager

### 3.3.6 Operating Efficiency history of TKSPL:



Source: Investment Manager

3.3.7 Considering the restrictions on movement imposed by State Governments and various Local Bodies on account of COVID-19 pandemic, it was not possible to conduct physical site visit for the SPVs. My team had conducted virtual site visits over collaboration apps like Google Teams, Zoom App, Whatsapp Video Calling, etc. with the person on plant site on 10<sup>th</sup> July 2021, to the extent appropriate. Refer below for the pictures of TKSPL, as provided by the Investment Manager.



### 3.6. Terralight Rajapalayam Solar Private Limited ("TRSPL")

3.6.1. Summary of project details of TRSPL are as follows:

Parameters	Details
Installed Capacity (DC)	54.00 MW
Plant Location	Rajapalayam, Tamil Nadu
Scheduled Commercial Operation Date (SCOD)	26-Sept-18
Actual COD	26-Sept-18
Land Area	224.48 Acres
O&M Contractor	AVI Solar Energy Pvt. Ltd.
PPA Counterparty	Tamil Nadu Generation and Distribution Corporation Ltd. (TANGEDCO)
PPA Date	27-Sept-17
PPA Term	25 years from Actual COD
PPA Tariff	INR 3.47 per unit

Source: Investment Manager

3.6.2. Terralight Rajapalayam Solar Private Limited (earlier known as Shapoorji Pallonji Suryaprakash Private Limited) is engaged in carrying on the business of setting up, generating and selling of renewable power from its ground mounted solar power plants located at Rajapalayam, Tamil Nadu. The Company had entered into a PPA with TANGEDCO on 27<sup>th</sup> September 2017 for implementation of a 54.00 MW (DC) Solar Photovoltaic Power Generation Unit in the State of Tamil Nadu, under which it has a commitment to sell electricity for a period of 25 years.

3.6.3. The equity shareholding of TRSPL as on Valuation Date is as follows:

Sr. No.	Particulars	No. of shares	%
1	Terra Asia Holdings II Pte. Ltd.	109,999	100.0%
2	*Terra Asia Holdings I Pte. Ltd.	1	0.0%
<b>Total</b>		<b>110,000</b>	<b>100.0%</b>

\* Nominee Shareholder of Terra Asia Holdings II Pte. Ltd.

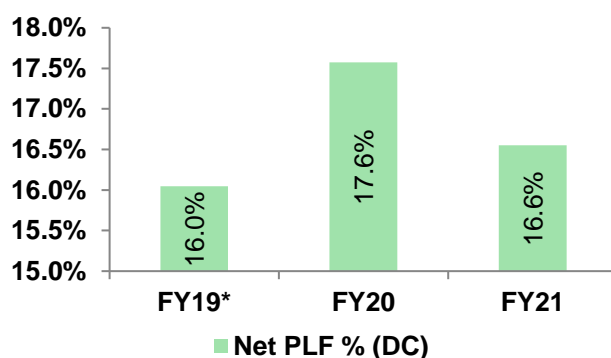
Source: Investment Manager

3.6.4. The CCD Holding of TRSPL as on Valuation Date is as follows:

Sr. No.	Particulars	No. of CCDs	%
1	Terra Asia Holdings II Pte. Ltd.	18,53,33,277	100.0%
<b>Total</b>		<b>18,53,33,277</b>	<b>100.0%</b>

Source: Investment Manager

3.6.5. Operating Efficiency history of TRSPL:



\*from October 2018

Source: Investment Manager



- 3.6.6. Considering the restrictions on movement imposed by State Governments and various Local Bodies on account of COVID-19 pandemic, it was not possible to conduct physical site visit for the SPVs. My team had conducted virtual site visits over collaboration apps like Google Teams, Zoom App, Whatsapp Video Calling, etc. with the person on plant site on 10<sup>th</sup> July 2021, to the extent appropriate. Refer below for the pictures of TRSPL, as provided by the Investment Manager.



### 3.7. Solar Edge Power and Energy Private Limited (“Solar Edge”)

3.7.1. Summary of project details of Solar Edge are as follows:

Parameters	Details
Installed Capacity (DC)	169 MW
Plant Location	Beed, Maharashtra (104 MW) Jalgaon, Maharashtra (65 MW)
Scheduled Commercial Operation Date (SCOD)	23-Dec-17
Actual COD	18-April-18 (Average)
Land Area	718.99 Acres
O&M Contractor	Solar OM Global Services India Pvt. Ltd.
PPA Counterparty	Solar Energy Corporation of India Ltd. (SECI)
PPA Date	10-Feb-17
PPA Term	25 years from Actual COD
PPA Tariff	INR 4.43 per unit

Source: Investment Manager

3.7.2. Solar Edge is engaged in carrying on the business of setting up, generating and selling of renewable power from its ground mounted solar power plants located at Beed (104 MW) & Jalgaon (65 MW) in Maharashtra. It had entered into a Power Purchase Agreement (“PPA”) with Solar Energy Corporation of India Ltd. (“SECI”) on 10<sup>th</sup> February 2017 for implementation of a 169.00 MW (DC) Solar Photovoltaic Power Generation Unit in the State of Maharashtra, under which it has a commitment to sell electricity for a period of 25 years.

3.7.3. The equity shareholding of Solar Edge as on Valuation Date is as follows:

Sr. No.	Particulars	No. of Shares	%
1	Terra Asia Holdings II Pte. Ltd.	14,89,99,999	100.0%
2	*Terra Asia Holdings I Pte. Ltd.	1	0.0%
	<b>Total</b>	<b>14,90,00,000</b>	<b>100.0%</b>

\* Nominee Shareholder of Terra Asia Holdings II Pte. Ltd.

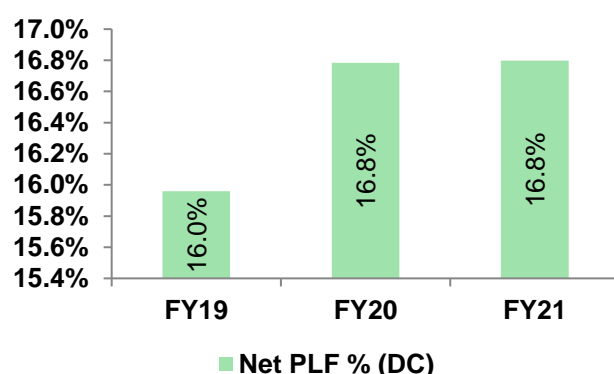
Source: Investment Manager

3.7.4. The CCD holding of Solar Edge as on Valuation Date is as follows:

Sr. No.	Particulars	No. of CCDs	%
1	Terra Asia Holdings II Pte. Ltd.	12,15,32,667	100.0%
	<b>Total</b>	<b>12,15,32,667</b>	<b>100.0%</b>

Source: Investment Manager

3.7.5. Operating Efficiency history of Solar Edge:



Source: Investment Manager

- 3.7.6. Considering the restrictions on movement imposed by State Governments and various Local Bodies on account of COVID-19 pandemic, it was not possible to conduct physical site visit for the SPVs. My team had conducted virtual site visits over collaboration apps like Google Teams, Zoom App, Whatsapp Video Calling, etc. with the person on plant site on 10<sup>th</sup> July 2021, to the extent appropriate. Refer below for the pictures of Solar Edge, as provided by the Investment Manager.





### **3.8. Terralight Solar Energy Charanka Private Limited (“TSEC”)**

3.8.1. Summary of project details of TSEC are as follows:

Parameters	Details
Installed Capacity (DC)	15.00 MW (Existing) 15.50 MW* (Projected from October 2021)
Plant Location	Patan, Gujarat
Scheduled Commercial Operation Date (SCOD)	30-Jun-11 for 3.00 MW 31-Dec-11 for 12.00 MW
Actual COD	28-Mar-12 (Average)
Land Area	78.52 Acres
O&M Contractor	Mitrash Energy Private Limited
PPA Counterparty	Gujarat Urja Vikas Nigam Limited
PPA Date	29-May-10
PPA Term	25 years from Actual COD
PPA Tariff (Weighted average)	INR 11.32 till FY 23 INR 11.11 during FY 24 INR 6.99 during FY 25 INR 6.47 from FY 26 till FY 37

*\*Subject to receipt of requisite approvals*

*Source: Investment Manager*

3.8.2. Terralight Solar Energy Charanka Private Limited (earlier known as Sindicatum Solar Energy Gujarat Private Limited ) is engaged in carrying on the business of setting up, generating and selling of renewable power from its ground mounted solar power plants located at Patan, Gujarat. The Company had entered into a PPA with Gujarat Urja Vikas Nigam Limited (“GUVNL”) on 29<sup>th</sup> May 2010 for implementation of a 15.00 MW Solar Photovoltaic Power Generation Unit in the State of Gujarat, under which it has a commitment to sell electricity for a period of 25 years.

3.8.3. The equity shareholding of TSEC as on Valuation Date is as follows:

Sr. No.	Particulars	No. of shares	%
1	Sindicatum Captive Energy Singapore Pte. Ltd.	98,322,740	100.0%
2	Sindicatum Renewable Energy Company Pte. Ltd.	1	0.0%
<b>Total</b>		<b>98,322,741</b>	<b>100.0%</b>

*Source: Financials of TSEC*

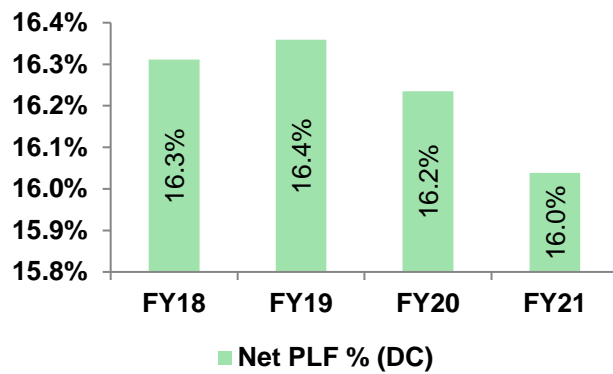
3.8.4. The equity shareholding of TSEC as on Report Date is as follows:

Sr. No.	Particulars	No. of shares	%
1	Terra Asia Holdings II Pte. Ltd.	9,83,22,740	100.0%
2	*TN Solar Power Energy Pvt. Ltd.	1	0.0%
<b>Total</b>		<b>98,322,741</b>	<b>100.0%</b>

*Source: Investment Manager*

*\* Nominee Shareholder of Terra Asia Holdings II Pte. Ltd.*

3.8.5. Operating Efficiency history of TSEC:



Source: Investment Manager

3.8.6. Considering the restrictions on movement imposed by State Governments and various Local Bodies on account of COVID-19 pandemic, it was not possible to conduct physical site visit for the SPVs. My team had conducted virtual site visits over collaboration apps like Google Teams, Zoom App, Whatsapp Video Calling, etc. with the person on plant site on 11<sup>th</sup> July 2021, to the extent appropriate. Refer below for the pictures of the TSEC, as provided by the Investment Manager.



### **3.9. PLG Photovoltaic Private Limited (“PLG”)**

3.9.1. Summary of project details of PLG are as follows:

Parameters	Details
Installed Capacity (DC)	20.00 MW
Plant Location	Sami, Patan, Gujarat
Scheduled Commercial Operation Date (SCOD)	31-May-11 for 10 MW 30-Jun-11 for 10 MW
Actual COD	26-Jan-12
Land Area	107 Acres
O&M Contractor	Mitrash Energy Private Limited
PPA Counterparty	Gujarat Urja Vikas Nigam Limited
PPA Date	20-May-10
PPA Term	25 years from Actual COD
PPA Tariff	INR 15 per unit for first 12 years INR 5 per unit from 13 <sup>th</sup> year

Source: Investment Manager

3.9.2. PLG is engaged in carrying on the business of setting up, generating and selling of renewable power from its ground mounted solar power plants located at Sami, Patan, Gujarat. The Company had entered into a PPA with Gujarat Urja Vikas Nigam Limited (“GUVNL”) on 20<sup>th</sup> May 2010 for implementation of a 20.00 MW Solar Photovoltaic Power Generation Unit in the State of Gujarat, under which it has a commitment to sell electricity for a period of 25 years.

3.9.3. The equity shareholding of PLG as on Valuation Date is as follows:

Sr. No.	Particulars	No. of shares	%
1	Sindicatum Renewable Energy India Private Limited	37,113,445	90.0%
2	Sindicatum Captive Energy Singapore Pte. Ltd.	4,123,711	10.0%
3	Sindicatum Renewable Energy Company Pte. Ltd.	1	0.0%
<b>Total</b>		<b>4,12,37,157</b>	<b>100.0%</b>

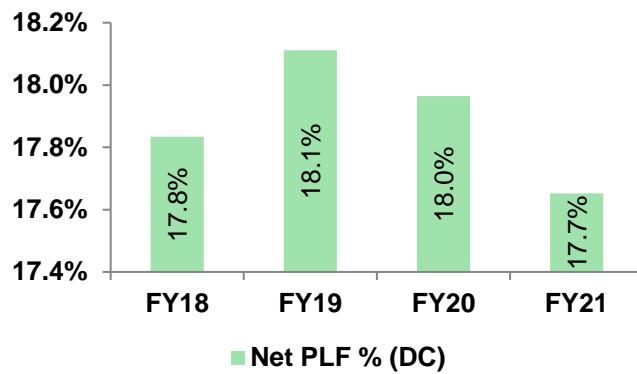
Source: Financials of PLG

3.9.4. The equity shareholding of PLG as on Report Date is as follows:

Sr. No.	Particulars	No. of shares	%
1	Universal Saur Urja Private Limited (USUPL)	4,01,47,710	97.3%
2	Terra Asia Holdings II Pte. Ltd.	10,89,447	2.7%
<b>Total</b>		<b>4,12,37,157</b>	<b>100.0%</b>

Source: Investment Manager

3.9.5. Operating Efficiency history of PLG:



Source: Investment Manager

3.9.6. Considering the restrictions on movement imposed by State Governments and various Local Bodies on account of COVID-19 pandemic, it was not possible to conduct physical site visit for the SPVs. My team had conducted virtual site visits over collaboration apps like Google Teams, Zoom App, Whatsapp Video Calling, etc. with the person on plant site on 11<sup>th</sup> July 2021, to the extent appropriate. Refer below for the pictures of PLG, as provided by the Investment Manager.





### **3.10. Terralight Solar Energy Tinwari Private Limited (“TSETPL”)**

3.10.1. Summary of project details of TSETPL are as follows:

Parameters	Details
Installed Capacity (DC)	5.75 MW (Existing) 5.85 MW* (Projected from October 2021)
Plant Location	Jodhpur, Rajasthan
Scheduled Commercial Operation Date (SCOD)	15-Oct-11
Actual COD	15-Oct-11
Land Area	37.06 Acres
O&M Contractor	Meera Corporation
PPA Counterparty	NTPC Vidyut Vyapar Nigam Ltd.
PPA Date	15-Oct-10
PPA Term	25 years from Actual COD
PPA Tariff	INR 17.91 per unit

*\*Subject to receipt of requisite approvals*

*Source: Investment Manager*

3.10.2. Terralight Solar Energy Tinwari Private Limited (earlier known as Sindicatum Solar Energy Private Limited) is engaged in carrying on the business of setting up, generating and selling of renewable power from its ground mounted solar power plants located at Jodhpur, Rajasthan. The Company had entered into a PPA with NTPC Vidyut Vyapar Nigam Ltd. (“NVVN”) on 15<sup>th</sup> October 2010 for implementation of a 5.75 MW Solar Photovoltaic Power Generation Unit in the State of Rajasthan, under which it has a commitment to sell electricity for a period of 25 years.

3.10.3. The equity shareholding of TSETPL as on Valuation Date is as follows:

Sr. No.	Particulars	No. of shares	%
1	Terralight Solar Energy Charanka Private Limited (TSEC)	16,625,000	89.6%
2	Sindicatum Captive Energy Singapore Pte. Limited	1,929,612	10.4%
	<b>Total</b>	<b>18,554,612</b>	<b>100.0%</b>

*Source: Financials of TSETPL*



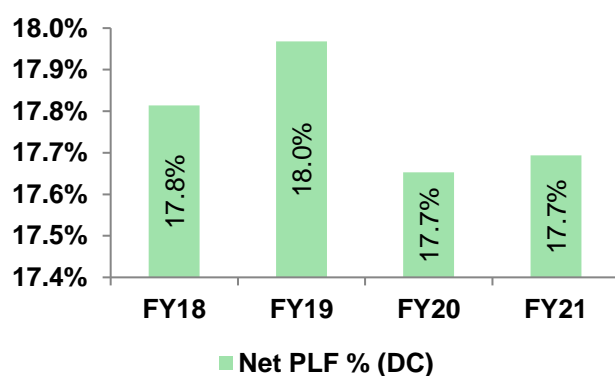
3.10.4. The equity shareholding of TSETPL as on Report Date is as follows:

Sr. No.	Particulars	No. of shares	%
1	Terralight Solar Energy Charanka Private Limited (TSEC)	1,85,54,611	100.0%
2	*TN Solar Power Energy Private Limited	1	0.0%
<b>Total</b>		<b>1,85,54,612</b>	<b>100.0%</b>

Source: Investment Manager

\* Nominee Shareholder of Terralight Solar Energy Charanka Private Limited

3.10.5. Operating Efficiency history of TSETPL:



Source: Investment Manager

3.10.6. Considering the restrictions on movement imposed by State Governments and various Local Bodies on account of COVID-19 pandemic, it was not possible to conduct physical site visit for the SPVs. My team had conducted virtual site visits over collaboration apps like Google Teams, Zoom App, Whatsapp Video Calling, etc. with the person on plant site on 10<sup>th</sup> July 2021, to the extent appropriate. Refer below for the pictures of TSETPL, as provided by the Investment Manager.





### **3.11. Universal Saur Urja Private Limited (“USUPL”)**

3.11.1. Summary of project details of USUPL are as follows:

Parameters	Details
Installed Capacity (DC)	36.98 MW
Plant Location	Mahoba District, Uttar Pradesh
Actual COD	15-Sept-16
Land Area	37.06 Acres
O&M Contractor	Meera Corporation
PPA Counterparty	Uttar Pradesh Power Corporation Ltd.
PPA Date	06-April-15
PPA Term	25 years from Actual COD
PPA Tariff	INR 9.33 per unit for first 12 years Est. INR 2.40 per unit from 13 <sup>th</sup> year (Fixed Tariff till for first 12 years, then RoE based tariff will be as determined by the state commission in the 11 <sup>th</sup> year)

Source: Investment Manager

3.11.2. USUPL is engaged in carrying on the business of setting up, generating and selling of renewable power from its ground mounted solar power plants located at Mahoba District, Uttar Pradesh. The Company had entered into a PPA with Uttar Pradesh Power Corporation Ltd. on 6<sup>th</sup> April 2015 for implementation of a 35.24 MW (capacity now augmented to 36.98 MW DC) Solar Photovoltaic Power Generation Unit in the State of Uttar Pradesh, under which it has a commitment to sell electricity for a period of 25 years.

3.11.3. The equity shareholding of USUPL as on Valuation Date is as follows:

Sr. No.	Particulars	No. of shares	%
1	Sindicatum Captive Energy Singapore Pte. Ltd.	16,733,984	100.0%
2	Sindicatum Renewable Energy Company Pte. Ltd.	1	0.0%
<b>Total</b>		<b>16,733,985</b>	<b>100.0%</b>

Source: Financials of USUPL

3.11.4. The equity shareholding of USUPL as on Report Date is as follows:

Sr. No.	Particulars	No. of shares	%
1	Terra Asia Holdings II Pte. Ltd.	1,67,33,984	100.0%
2	*TN Solar Power Energy Pvt. Ltd.	1	0.0%
<b>Total</b>		<b>1,67,33,985</b>	<b>100.0%</b>

Source: Investment Manager

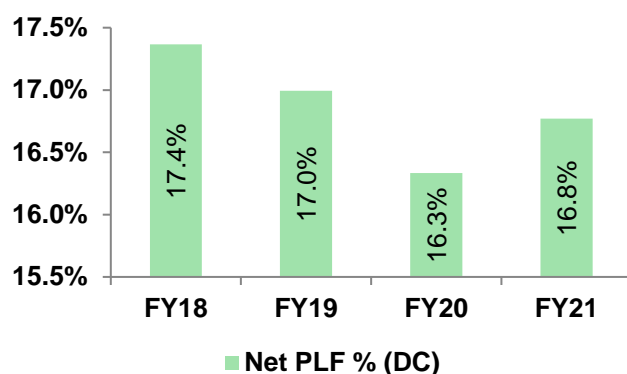
\* Nominee Shareholder of Terra Asia Holdings II Pte. Ltd.

3.11.5. The CCPS holding of USUPL as on Report Date is as follows:

Sr. No.	Particulars	No. of CCPS	%
1	Terralight Solar Energy Tinwari Pvt. Ltd. (TSETPL)	11,45,000	100.0%
<b>Total</b>		<b>11,45,000</b>	<b>100.0%</b>

Source: Investment Manager

3.11.6. Operating Efficiency history of USUPL:



Source: Investment Manager

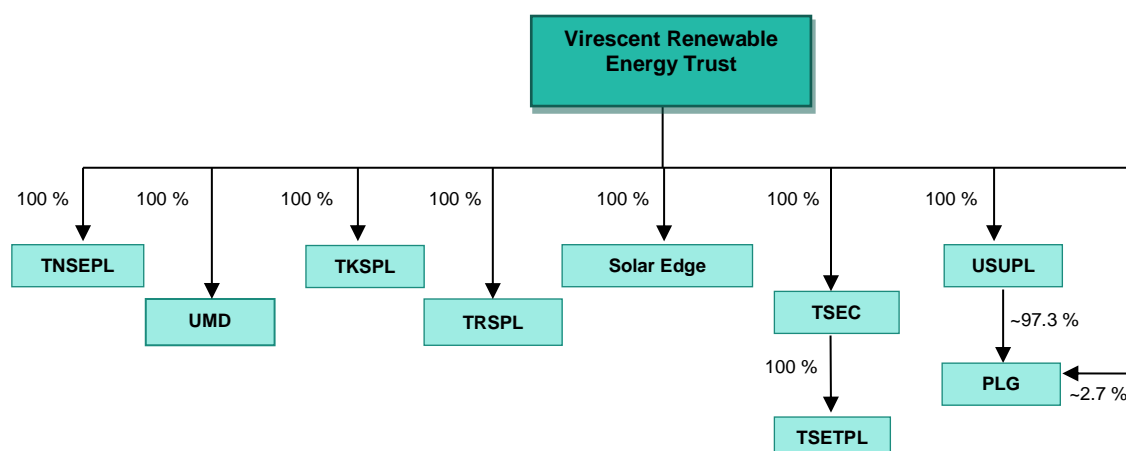
3.11.7. Considering the restrictions on movement imposed by State Governments and various Local Bodies on account of COVID-19 pandemic, it was not possible to conduct physical site visit for the SPVs. My team had conducted virtual site visits over collaboration apps like Google Teams, Zoom App, Whatsapp Video Calling, etc. with the person on plant site on 10<sup>th</sup> July 2021, to the extent appropriate. Refer below for the pictures of USUPL, as provided by the Investment Manager.





#### 4. Proposed Transaction

- 4.1. Following is the proposed structure of Virescent Renewable Energy Trust after the completion of the Proposed Transaction:



Source: Investment Manager

- 4.2. Proposed Acquisition of stake in the SPVs by the Trust:

Sr. No.	SPV	As on Report Date	Post Proposed Transaction
		Sponsor Holding*	Equity Stake proposed to be acquired by Trust prior to listing*
1	TNSEPL	100.0%	100.0%
2	UMD	100.0%	100.0%
3	TKSPL	100.0%	100.0%
4	TRSPL	100.0%	100.0%
5	Solar Edge	100.0%	100.0%
6	TSEC	100.0%	100.0%
7	PLG	100.0%	100.0%
8	TSETPL	100.0%	100.0%
9	USUPL	100.0%	100.0%

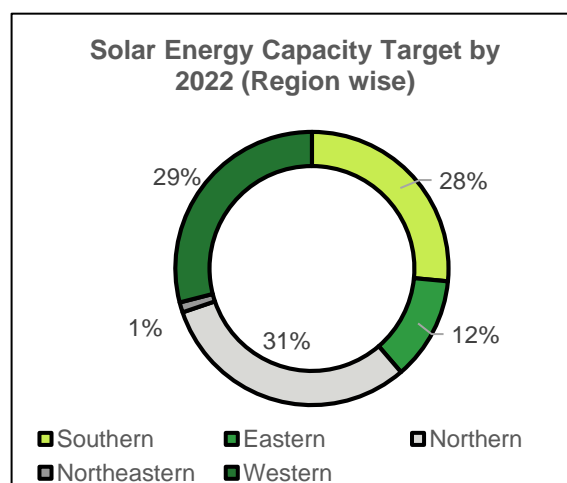
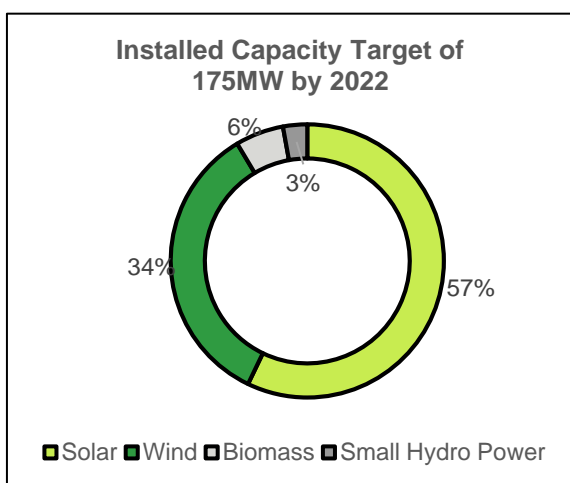
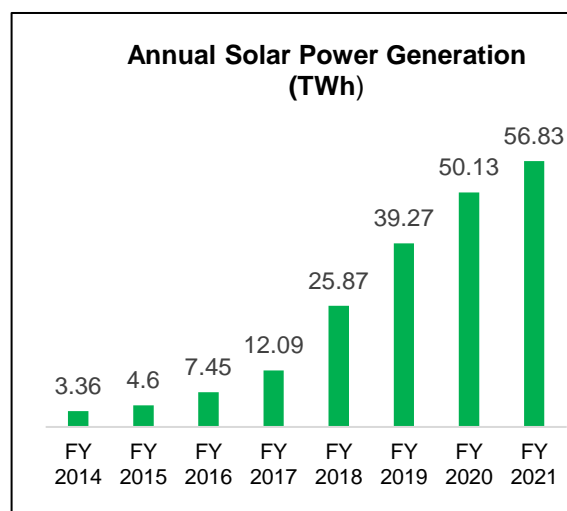
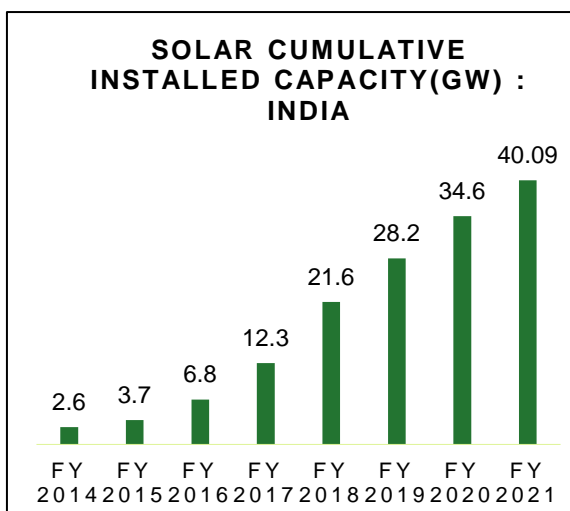
\* Total economic interest, held directly or through subsidiaries

Source: Investment Manager

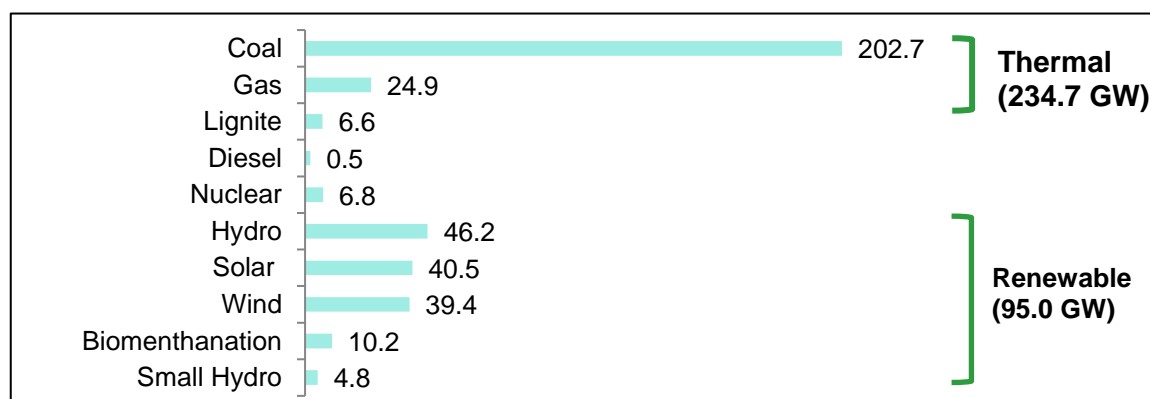
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## 5. Overview of the Industry

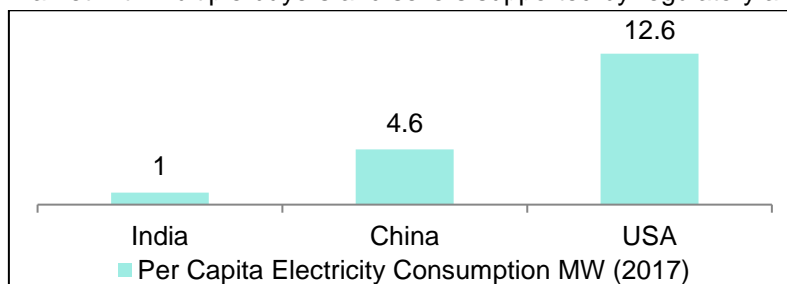
- 5.1 Indian solar installed capacity reached 40.09 GW as of 31 March 2021, with a target to achieve 100 GW of installed solar capacity by 2022. Keeping in view India's commitment for a healthy planet with a less carbon intensive economy, in 2015 the Government of India (the "Government" or "GOI") targeted that 175 GW of renewable energy capacity will be installed by the year 2022. This includes 100 GW from solar, 60 GW from wind, 10 GW from biomass and 5 GW from small hydro power of this 94.43 GW of renewable energy capacity has been installed in March 2021.



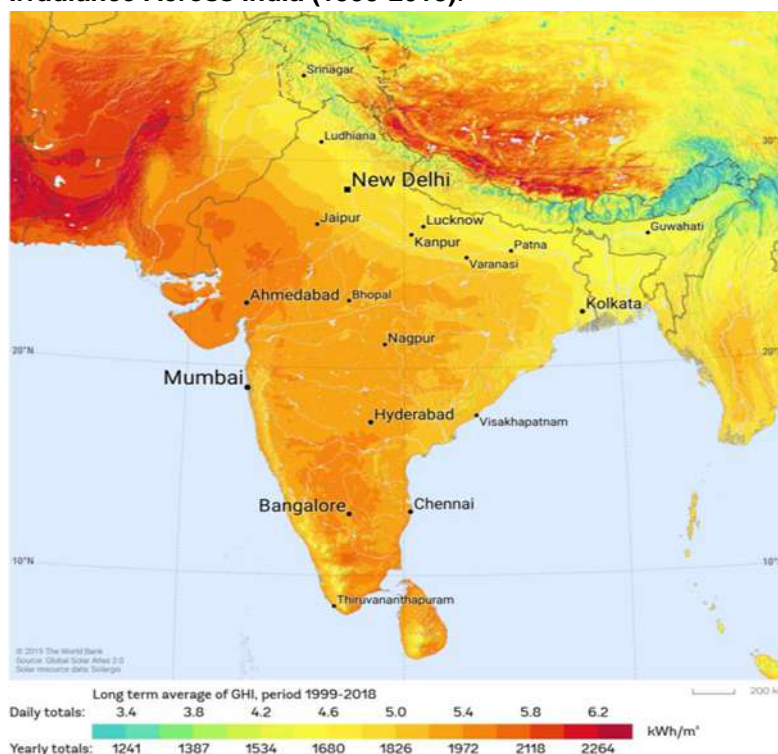
## 5.2 India's Total Installed Power Capacity as on 30<sup>th</sup> April 2021 (in GW):



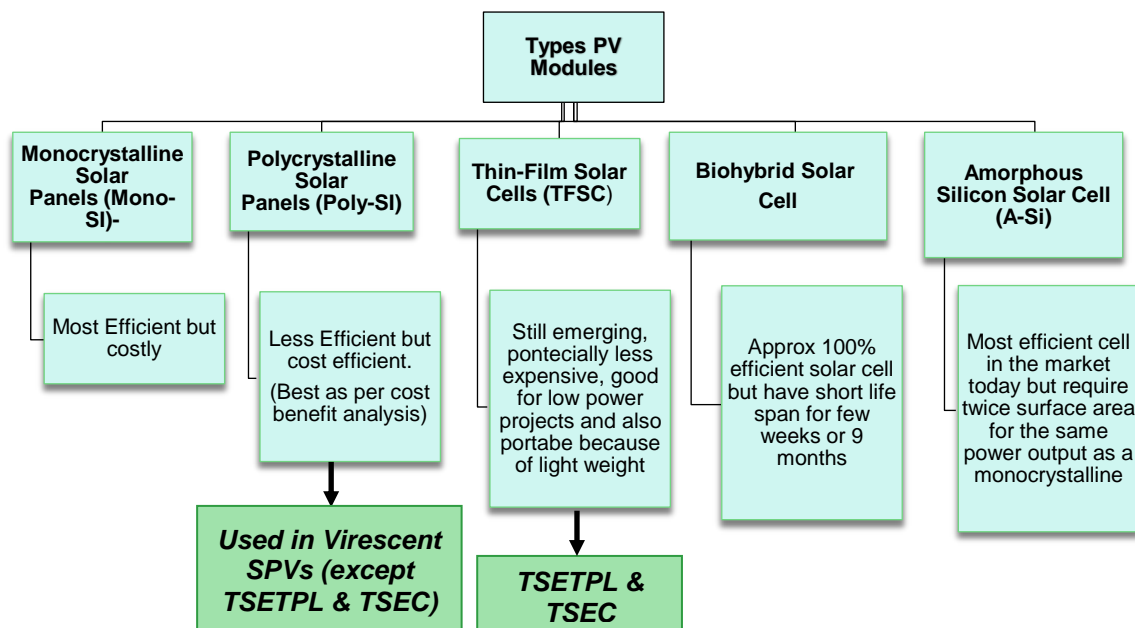
- 5.3 In 2019, Prime Minister of India announced that India's renewable energy capacity should exceed 400 GWs by year 2030. The substantial higher capacity target will ensure greater energy security, improved energy access and enhanced employment opportunities. With the accomplishment of these ambitious targets, India will become one of the largest Green Energy producers in the world, surpassing several developed countries.
- 5.4 National Institute of Solar Energy has assessed the Country's solar potential of about 748 GW assuming 3% of the waste land area to be covered by Solar PV modules. Solar energy has taken a central place in India's National Action Plan on Climate Change with National Solar Mission as one of the key Missions.
- 5.5 India is the most populous democracy in the world with a population of more than 1.3 billion. India's GDP grew 4.7% in the third quarter of fiscal year 2020. An efficient, resilient, and financially robust power sector is essential for the growth of the Indian economy. A series of reforms in the 1990s and the Electricity Act 2003 have moved the Indian power sector towards being a competitive market with multiple buyers and sellers supported by regulatory and oversight bodies.



- 5.6 India's annual per capita electricity consumption reached 1.2 MWh in fiscal year 2019. There are various factors such as electrification rates, purchasing power, market saturation and electrical heating or cooling requirements, which impacts the per capita consumption levels globally.
- 5.7 India receives an average sunshine (5.1 hrs / day) across the country that is higher compared with other major solar markets. (The top two in the solar market are the United States with 4.7 hrs/day and China with 3.6 hrs/day on average.) This equates to a ~21% capacity factor (or plant load factor).
- 5.8 **Irradiance Across India (1999-2018):**

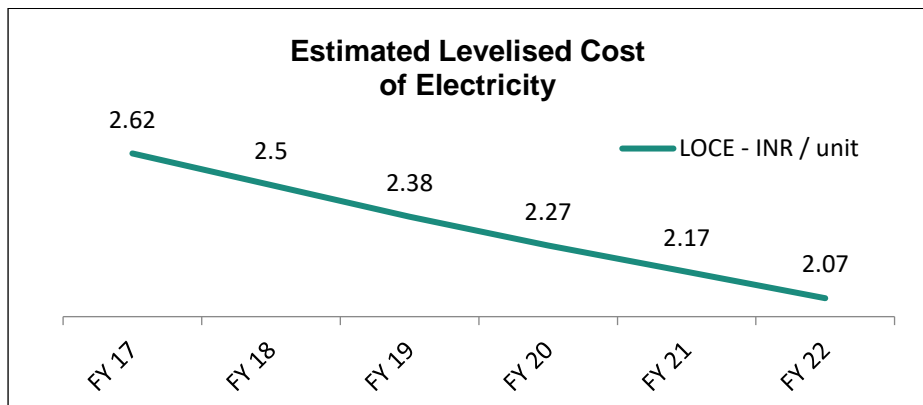


- 5.9 Energy in the country is predominantly sourced from fossil fuels, which represent ~70% of the total installed capacity base that generates ~74% total electricity. Solar represents only ~3% of installed capacity today and generates ~1% of total electricity. The country plans to increase its renewable mix to reduce pollution levels and reduce its fuel import bill. Under the Paris Climate Change Agreement signed in September 2016, the country has agreed to produce ~40% of electricity with non-fossil fuel sources by 2030.
- 5.10 Recently, India achieved 5<sup>th</sup> global position in solar power deployment by surpassing Italy. In India, renewable energy has started playing an increasingly important role in the augmentation of grid power, providing energy access, reducing the consumption of fossil fuels and helping India pursue its low carbon development path. Ahead of COP 21, India submitted its Intended Nationally Determined Contribution (INDC) to the UNFCCC, outlining the country's post-2020 climate actions. India's INDC builds on its goal of installing 175 gigawatts (GW) of renewable power capacity by 2022 by setting a new target to increase the country's share of non-fossil-based installed electric capacity to 40 percent by 2030.
- 5.11 As per Central Electricity Authority's National Electricity Plan, contribution of renewable energy sources is estimated to be around 21% of the total electricity demand of the country in the year 2021-22 and 24% by 2026-27. The share of solar energy of overall RE installed capacity has increased from 7.5% in 2014 to around 39.7% in 2020, growing at a CAGR of 53.7%.
- 5.12 **Various Technologies for Solar PV Modules:**



- 5.13 The As the project sizes in the country have increased from a couple of MWs in 2011 to hundreds of MWs as project economics have improved due to declining system costs. Solar PPAs have declined by 46% in the past five years, while benchmark solar system prices have declined 75% in the same duration. Solar tariffs today are cheaper than other technologies for a new build project. Variable cost of energy produced from low-cost imported natural gas projects is ~INR 3-5/kWh, while the all-in tariff for solar projects is already at INR 2/kWh in higher sunshine states today. Solar tariffs are also cheaper compared with recent coal tariffs signed at INR 4.9/kWh.

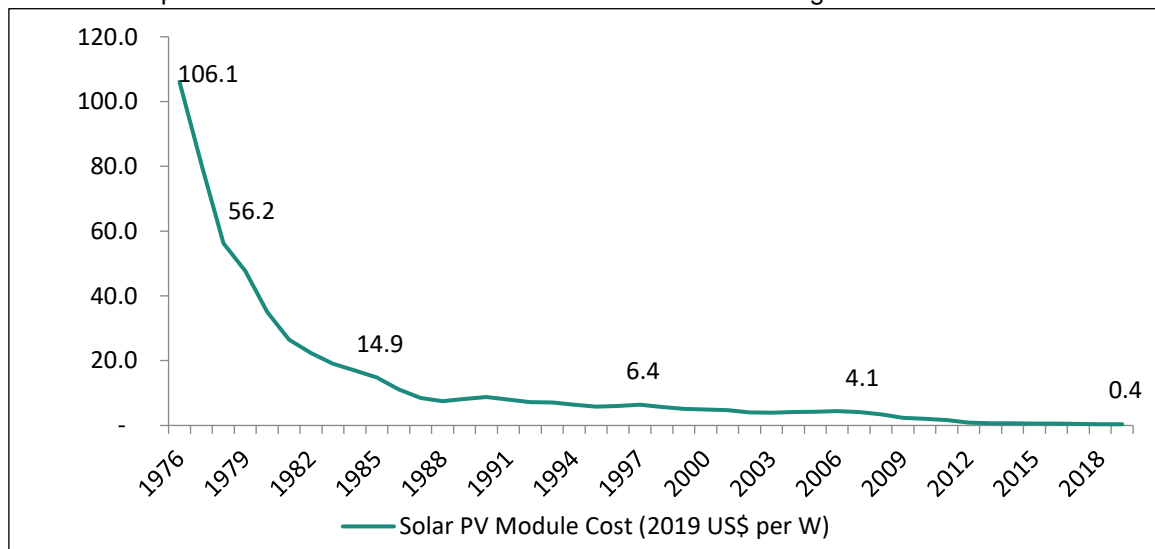
#### 5.14 Decline in Tariff Rates:



Source: ADB Group

5.15 In the current financial year 2020-21, solar power tariffs declined to ₹ 2.36/kWh between June-July 2020 and ₹ 2.0/kWh in November 2020. In the latest bidding, while the winning bids were at ₹ 2/kWh. According to a recent research report released by India Ratings, the decline in solar tariffs is being driven by:

i. Lower capital cost/MW of around ₹ 40million/MW due to declining Panel costs.



Source: ourworldindata.org

- ii. Advancement in panel designs enabling a higher capacity utilisation factor (CUF)
- iii. Lower financing costs due to declining interest rates.

The Tariff rates are expected to plunge down further in the coming future due to abovementioned factors.

#### 5.16 Challenges:

There are several challenges to overcome, including regulatory and policy inconsistencies, changes in duties, and payment delays by distribution companies (DISCOMs), among others.

- Payment disputes by DISCOMs were also rampant, slowing down any progress made by developers. The government's introduction of credit mechanisms and amendments to policies has done little in the way of negating these issues.
- A 25% safeguard duty was announced on solar cell and module imports from China and Malaysia between July 30, 2018, and July 29, 2019. The duty was set at 25% for the

first year, followed by a phased down approach for the second year, with the rate set to be lowered by 5% every six months until July 2020.

- Manufacturers of solar modules, ancillary products, system integrators, and raw material suppliers in the solar photovoltaic space complained that the government's protectionist policies were increasing costs for smaller local manufacturers and had loopholes.
- Tender cancellations, tariff re-negotiations by a few states had increased the uncertainty of some of the large-scale projects and hence delayed their executions.

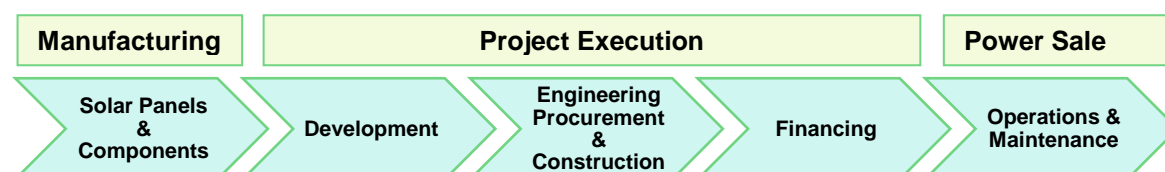
The outlook for 2020 remains mostly positive. Hope remains for the government to achieve its ambitious target of 100 GW of solar capacity by 2022 as long as it works in tandem with the industry to create a more conducive and consistent policy environment.

### 5.17 Solar PV Value Chain

Solar power projects depend on solar radiation, also called insolation, to generate electricity, and face lower fuel availability risk than conventional sources of power. India expects diverse climatic conditions in different regions and hence the performance varies due to not only quality issues of modules, but also the design framework and the Operations & Maintenance (O&M) techniques used at project site. Various stages involved with construction of solar plant are Feasibility study, site development, detailed design, installation, commissioning and operations & maintenance.

In most regions, PV projects are primarily affected by a few climatic stress factors, such as salt in the air, high UV radiation, high humidity, heat, sand or strong winds. In several areas of India PV Projects often face a large number of these factors at the same time.

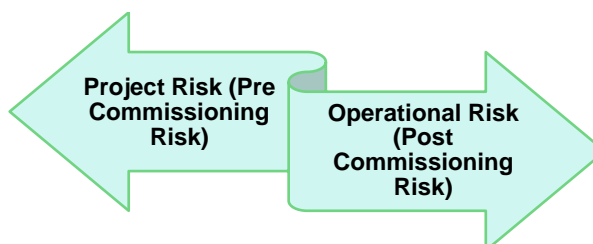
Example: Rajasthan faces problems due to the high level of solar radiation leading to damaging of solar PV modules because of climatic stress factors. India has some of the highest solar irradiation rates in the world but that can also lead to faster component degradation.



For the projects that have commissioned, there is lower risk pertaining to Operations & Maintenance than the projects that are yet to be commissioned. The Risk Aspect is explained in detail in the upcoming sub-section.

### 5.18 Risks Associated with the Solar Industry

Solar power projects face risks such as variation in radiation levels, new technology, solar panel quality, and counterparty payment risk. While vulnerable to climatic changes, the inter-annual variability in solar radiation, unlike wind speed, is relatively low. There are significant technology risks involved in solar power projects because, barring some exceptions such as crystalline silicon, the technology is new, evolving rapidly, and often owned by companies with moderate-to-weak credit quality.



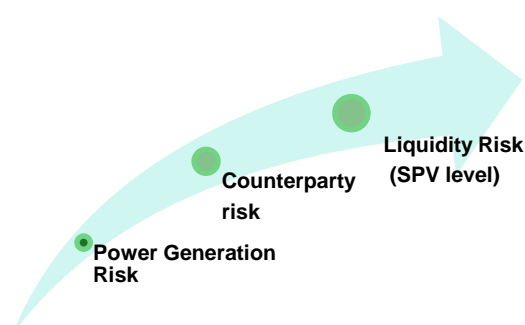
## A. Project risk (Pre-Commissioning Risk)

Solar power projects are relatively less challenging to set up than thermal power plants and have an established track record of timely completion. That said, the projects face risks related to land availability and evacuation infrastructure which play a key role in determining debt servicing ability. Nevertheless, these risks are usually lower for projects set up in solar parks and this is factored in the credit rating.

Key Project Risks	Explanation
<b>Implementation risk</b>	Solar power projects face fewer implementation risks. However, issues related to land availability and power evacuation because of delays in commissioning of transmission lines could be a major hindrance to timely completion of projects.
<b>Funding risk</b>	Availability of funding, both debt and equity, is critical for timely completion of the project. Availability of funding, both debt and equity, is critical for timely completion of the project.
<b>Offtake and pricing risk</b>	PPA with a distribution company or captive power consumers reduces the market risk once the solar power project is commissioned.

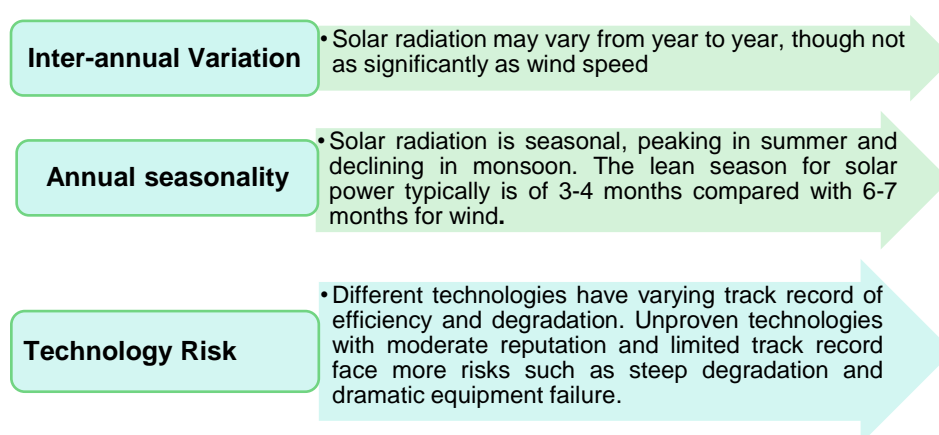
Solar power projects face stabilisation risks after construction is complete. It is only when the operations have stabilised that the operational metrics may be tested for base-case assumptions. The stabilisation phase may vary from one to two years.

## B. Operational risk (Post-Commissioning Risk)



### i. Power generation risk

A solar power project SPV will depend on cash flow generated by the asset for servicing debt. The cash flow will depend on electricity generated, which is vulnerable to inter- or intra-annual variability in solar radiation.



## ii. Counterparty risk

Solar power projects usually have PPAs with discoms or captive consumers. While PPAs tend to reduce the demand risk, operational solar power projects continue to face counterparty payment risk.

Even if the SPV generates adequate power and supplies to a buyer, any delay in payment by the buyer can significantly impact the SPV's credit quality. Payment risk varies from buyer to buyer.

The payment risk is not the same as the counterparty's credit quality. Often, state discoms with weak credit risk profiles continue to make payments to power generation companies, albeit with delays. That's because discoms may get support from the respective state government. Some discoms have a better payment track record for their purchases of renewable power.

Risk Factor	Explanation
<b>Business profile</b>	<ul style="list-style-type: none"><li>• Track record of recent increases in tariff</li><li>• Aggregate technical and commercial losses</li><li>• Profit gap</li></ul>
<b>Funding risk</b>	<ul style="list-style-type: none"><li>• Networth</li><li>• Debt</li><li>• Losses</li></ul>
<b>State government's ability to support</b>	<ul style="list-style-type: none"><li>• Release of subsidy</li><li>• State government rating</li></ul>
<b>Payment track record</b>	<ul style="list-style-type: none"><li>• Payment track record in the past few years</li></ul>

## iii. Liquidity at the SPV level

Adequate liquidity at the SPV level is critical to mitigate counterparty payment risk and seasonality. The more the delay from counterparties, the higher will be the liquidity that the SPV needs to maintain to mitigate counterparty payment risk. Also, seasonal deficit in a typical project is about two months of debt obligation.

The liquidity requirement varies with counterparty risk and the extent of seasonality. Given the sector's inherent risks, and the economic considerations where the developer may want to generate reasonable returns on investment, project DSCR and liquidity are unlikely to be substantially high.

## C. Other Risks:

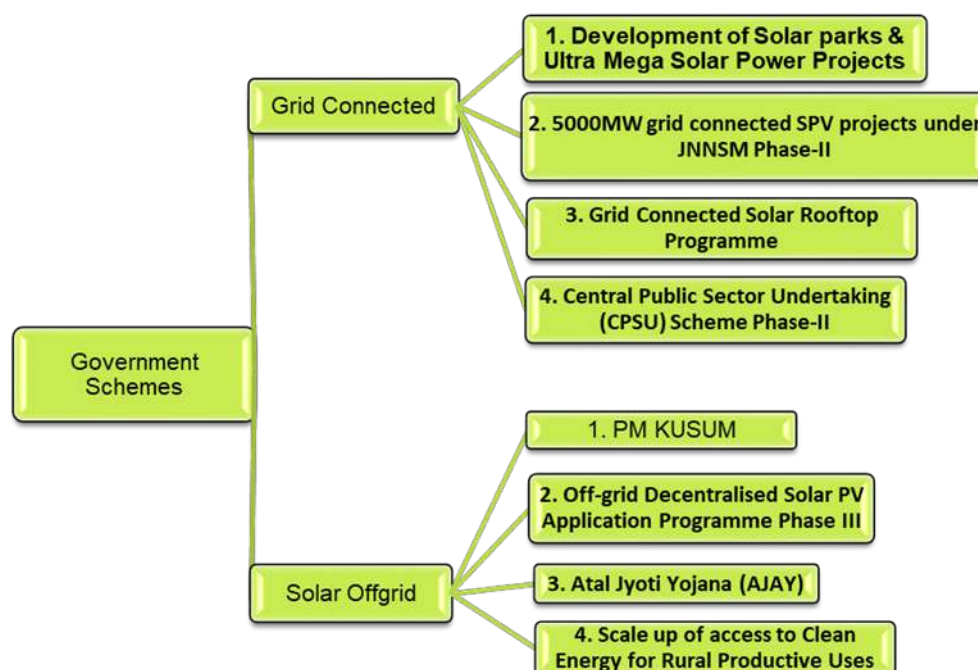
Other Risks	Explanation
<b>Political Risks</b>	<ul style="list-style-type: none"><li>• High costs and unfavorable power pricing rules</li><li>• Frequent changes in government policy</li><li>• Problems in obtaining clearances and certifications</li><li>• Payment guarantee mechanisms are not reliable</li></ul>
<b>Environment Risk</b>	<ul style="list-style-type: none"><li>• Biodiversity protection issues</li><li>• Debt</li><li>• Workers Health and Safety issues</li><li>• Environmental legislation Changes</li></ul>
<b>Land Feasibility</b>	<ul style="list-style-type: none"><li>• Selection of appropriate site</li><li>• Land acquisition issues</li></ul>
<b>Procurement Risk</b>	<ul style="list-style-type: none"><li>• Indigenization percentage in reference with project cost and its impact on project cost</li></ul>



- 5.19 Electricity demand is expected to rise in the future due to increased electrification. Major efforts are being taken by the Government to meet the targets of renewable energy in the country, including:
- Permitting Foreign Direct Investment up to 100 percent under the automatic route,
  - Strengthening the terms of PPAs; introduction of guidelines on power curtailments, policies on tariff adoption, force majeure event guidelines etc.
  - Mandating the requirement of Letter of Credit (“LC”) as payment security mechanism by distribution licensees for ensuring timely payments to renewable energy generators,
  - Setting up of Ultra Mega Renewable Energy Parks to provide land and transmission on plug and play basis to investors,
  - Waiver of Inter State Transmission System (“ISTS”) charges and losses for inter-state sale of solar and wind power for projects to be commissioned by December 31, 2022,
  - Notification of standard bidding guidelines to enable distribution licensee to procure solar and wind power at competitive rates in cost effective manner,
  - Declaration of trajectory of Renewable Purchase Obligation (“RPO”) for Solar as well as Non-solar, uniformly for all States/ Union Territories, reaching 21% of RPO by 2022 with 10.5% for solar based electricity,
  - Laying of transmission lines under the Green Energy Corridor Scheme for evacuation of Power in renewable rich states,
  - Launching of new schemes, such as, Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (“PM-KUSUM”), for farmers to install solar pumps and grid connected solar and other renewable power plants in the country,
  - Launching the new Solar Rooftop Phase II scheme for achieving cumulative capacity of 40,000 MWs from Rooftop Solar (“RTS”) Projects by the year 2022, and
  - Setting up 12,000 MWs of grid connected solar photovoltaic (“PV”) power projects for use by the Government and Government entities as part of the Central Public Sector Undertaking (“CPSU”) Scheme Phase II to facilitate national energy security and environment sustainability for Government purposes.
- 5.20 The sector is supported by a well-established institutional framework with specific roles and responsibilities assigned to various stakeholders. For example, the MNRE devises key policies in the solar sector. Power from solar projects can be sold to DISCOMs under central or state schemes or to end consumers through open access or captive route. Further, large scale adoption of solar capacity additions in India is primarily driven by various fiscal and regulatory incentives provided by the Government of India. Some of these measures are:
- **National Solar Mission (“NSM”):** A major initiative of the Indian government is to promote ecologically sustainable growth while addressing India’s energy security challenge. NSM was introduced as part of India’s National Action Plan on Climate Change (“NAPCC”) in 2010 with a view to deploy 20 GW of solar capacity by fiscal year 2022. The targets were subsequently revised to 100 GW by 2022 in June 2015.
  - **Solar Renewable Purchase Obligation (“RPO”):** RPO was one of the important instruments of the MOP to achieve the goal of installing 175 GW of renewable energy by fiscal year 2022. The MNRE, Government of India, along with all the State Nodal Agencies (SNAs) have taken appropriate policy initiatives for achieving the target of 175 GW of renewable energy by 2022, with solar capacity of 100 GW. SERCs are required to fix a minimum percentage of the total consumption of electricity in the area of a distribution licensee for purchase of energy from renewable energy sources. With the amendment of Tariff Policy in January, 2016, the SERCs are required to reserve a minimum percentage for purchase of solar energy which shall be such that it reaches 8% of total consumption of energy, excluding Hydro Power, by March 2022 or as notified by the Central Government from time to time. The Government of India in July 2018 notified the Long-Term growth trajectory of RPOs for Solar as well as Non-solar, uniformly for all States/ Union Territories, reaching 21% of RPO by 2022 with 10.5% for solar based electricity.

- **Waiver of interstates transmission system charges and losses for solar and wind energy projects:** There are no interstate charges and losses for the sale of solar and wind power for projects commissioned by December 31, 2022. The waiver will apply for a period of 25 years from the date of commissioning. The waiver is applicable for only those projects awarded through competitive bidding under the guidelines issued by the Government and projects entering into PPAs with entities for compliance of their RPO.
- **Ultra-Mega Renewable Energy Power Parks (“UMREPPS”):** The Ministry has undertaken a scheme to develop Ultra Mega Renewable Energy Power Parks (UMREPPs) under the existing Solar Park Scheme. The objective of the UMREPP is to provide land upfront to the project developer and facilitate transmission infrastructure for developing renewable energy based UMREPPs with solar/wind/hybrid and also with storage systems, if required.
- **Standard Bidding Guidelines:** The MNRE has issued Guidelines for Tariff Based Competitive Bidding Process for Procurement of Power from Grid Connected Solar & Wind Power Projects with an objective to provide a framework for procurement of solar & wind power through a transparent process of bidding including standardization of the process and defining of roles and responsibilities of various stakeholders.
- **Dispute Resolution Mechanism:** The MNRE has set up a Dispute Resolution Mechanism for wind and solar projects to consider the unforeseen disputes between solar and wind power developers and SECI/NTPC, beyond contractual agreement. This mechanism will help in the smooth implementation of solar/wind energy projects in India by expeditiously resolving unforeseen disputes that may arise beyond the scope of contractual agreements.

5.21 Following are the different schemes launched by government:



5.22 The solar energy sector has also benefited from tariffs that are the lowest cost source of new electricity capacity driven by continued declines in PV module costs, improvement in efficiency due to greater scale of projects, access to long tenure financing and a drop in interest rates to finance solar projects.

### 5.23 **Government Policies and Targets:**

- 5.23.1 As a part of its Paris Agreement commitments, the Government of India has set an ambitious target of achieving 175 GW of renewable energy capacity by 2022. This includes 100 GW of solar capacity and 60 GW of wind power capacity.
- 5.23.2 Moreover, Government of India is now aiming to achieve 225 GW of renewable energy capacity by 2022, much ahead of its target of 175 GW as per the Paris Agreement.
- 5.23.3 Government plans to establish renewable energy capacity of 500 GW by 2030.
- 5.23.4 The share of renewable energy is likely to more than double from current generation by FY 22 and will require substantial investment in grid infrastructure. The Government is already taking steps in this direction by constructing green energy corridors and modernizing or augmenting transmission infrastructure to evacuate the planned 175 GW by 2022. A network upgrade for Solar and Wind Energy zones of the country to evacuate ~66.5 GW of renewable energy capacity is already under plans of the Central Electricity Authority (CEA) with portion of it already under implementation in Phase 1.
- 5.23.5 60 solar cities will be developed in India as part of Ministry of New and Renewable Energy's Solar Cities program.
- 5.23.6 The government plans to set-up the world's biggest solar project in Leh with a capacity of 7,500 MW at an investment of INR 45,000 crore, which is expected to be completed by 2023.

*(Sources: IBEF report on Renewable Energy in India- January, 2021 and Tata Power Renewable Energy Limited and Adani Green Energy Limited Annual Reports, Ministry of New and Renewable Energy, Central Electricity Authority of India)*

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## 6. Valuation Methodology and Approach

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- 6.1. The present valuation exercise is being undertaken in order to derive the fair EV of the SPVs.
- 6.2. The valuation exercise involves selecting a method suitable for the purpose of valuation, by exercise of judgment by the valuers, based on the facts and circumstances as applicable to the business of the company to be valued.
- 6.3. There are three generally accepted approaches to valuation:
  - (a) "Cost" approach
  - (b) "Market" approach
  - (c) "Income" approach

### 6.4. **Cost Approach**

The cost approach values the underlying assets of the business to determine the business value. This valuation method carries more weight with respect to holding companies than operating companies. Also, cost value approaches are more relevant to the extent that a significant portion of the assets are of a nature that could be liquidated readily if so desired.

#### Net Asset Value ("NAV") Method

The NAV Method under Cost Approach considers the assets and liabilities, including intangible assets and contingent liabilities. The Net Assets, after reducing the dues to the preference shareholders, if any, represent the value of a company.

The NAV Method is appropriate in a case where the main strength of the business is its asset backing rather than its capacity or potential to earn profits. This valuation approach is also used in cases where the firm is to be liquidated, i.e. it does not meet the "Going Concern" criteria.

As an indicator of the total value of the entity, the NAV method has the disadvantage of only considering the status of the business at one point in time.

Additionally, NAV does not properly take into account the earning capacity of the business or any intangible assets that have no historical cost. In many aspects, NAV represents the minimum benchmark value of an operating business.

### 6.5. **Market Approach**

Under the Market approach, the valuation is based on the market value of the company in case of listed companies, and comparable companies' trading or transaction multiples for unlisted companies. The Market approach generally reflects the investors' perception about the true worth of the company.

#### Comparable Companies Multiples ("CCM") Method

The value is determined on the basis of multiples derived from valuations of comparable companies, as manifest in the stock market valuations of listed companies. This valuation is based on the principle that market valuations, taking place between informed buyers and informed sellers, incorporate all factors relevant to valuation. Relevant multiples need to be chosen carefully and adjusted for differences between the circumstances.

#### Comparable Transactions Multiples ("CTM") Method

Under the CTM Method, the value is determined on the basis of multiples derived from valuations of similar transactions in the industry. Relevant multiples need to be chosen carefully and adjusted for differences between the circumstances. Few of such multiples are EV/Earnings before Interest, Taxes, Depreciation & Amortization ("EBITDA") multiple and EV/Revenue multiple.

#### Market Price Method

Under this method, the market price of an equity share of the company as quoted on a recognized stock exchange is normally considered as the fair value of the equity shares of that company where such quotations are arising from the shares being regularly and freely traded. The market value generally reflects the investors' perception about the true worth of the company.

6.6. **Income Approach**

The income approach is widely used for valuation under "Going Concern" basis. It focuses on the income generated by the company in the past as well as its future earning capability. The Discounted Cash Flow Method under the income approach seeks to arrive at a valuation based on the strength of future cash flows.

**DCF Method**

Under DCF Method value of a company can be assessed using the Free Cash Flow to Firm Method ("FCFF") or Free Cash Flow to Equity Method ("FCFE"). Under the DCF method, the business is valued by discounting its free cash flows for the explicit forecast period and the perpetuity value thereafter. The free cash flows represent the cash available for distribution to both, the owners and creditors of the business. The free cash flows in the explicit period and those in perpetuity are discounted by the WACC. The WACC, based on an optimal vis-à-vis actual capital structure, is an appropriate rate of discount to calculate the present value of future cash flows as it considers equity-debt risk by incorporating debt-equity ratio of the firm.

The perpetuity (terminal) value is calculated based on the business' potential for further growth beyond the explicit forecast period. The "Constant Growth Model" is applied, which implies an expected constant level of growth for perpetuity in cash flows over the last year of forecast period.

The discounting factor (rate of discounting the future cash flows) reflects not only the time value of money, but also the risk associated with the business' future operations. The EV (aggregate of the present value of explicit period and terminal period cash flows) so derived, is further reduced by the value of debt, if any, (net of cash and cash equivalents) to arrive at value to the owners of the business.

**Conclusion on Valuation Approach**

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- 6.7. It is pertinent to note that the valuation of any company or its assets is inherently imprecise and is subject to certain uncertainties and contingencies, all of which are difficult to predict and are beyond my control. In performing my analysis, I have made numerous assumptions with respect to industry performance and general business and economic conditions, many of which are beyond the control of the SPVs. In addition, this valuation will fluctuate with changes in prevailing market conditions, and prospects, financial and otherwise, of the SPVs, and other factors which generally influence the valuation of companies and their assets.
- 6.8. The goal in selection of valuation approaches and methods for any business is to find out the most appropriate method under particular circumstances on the basis of available information. No one method is suitable in every possible situation. Before selecting the appropriate valuation approach and method, I have considered various factors, inter-alia, the basis and premise of current valuation exercise, purpose of valuation exercise, respective strengths and weaknesses of the possible valuation approach and methods, availability of adequate inputs or information and its reliability and valuation approach and methods considered by the market participants.

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### **Cost Approach**

The existing book value of EV of the SPVs comprising of the value of its Net fixed assets, Net intangible assets and working capital based on the audited financial statements as at 31<sup>st</sup> March 2021 prepared as per Indian Accounting Standards (Ind AS) are as under:

	<b>Book EV</b>	<b>Adjusted EV</b>
<b>In INR Lacs</b>	<b>31<sup>st</sup> March 2021</b>	<b>31<sup>st</sup> March 2021</b>
TNSEPL	12,781	16,798
UMD	13,951	17,910
TKSPL	19,851	25,109
TRSPL	13,526	18,835
Solar Edge	64,488	66,797
TSEC	2,829	4,645
PLG	(1,371)	1,781
TSETPL	4,055	5,235
USUPL	16,587	19,917
<b>Total of all SPVs</b>	<b>1,46,696</b>	<b>1,77,029</b>

*\* Enterprise Value ("EV") is described as the total value of the equity in a business plus the value of its debt and debt related liabilities, minus any cash or cash equivalents to meet those liabilities.*

*\*\* Further, on the request of the Investment Manager, I have calculated Adjusted Enterprise Value of the SPVs which is derived as the EV as defined above plus cash or cash equivalents of the SPVs as at the Valuation Date.*

In the present case, the future earnings of SPVs are represented by the PPA signed by the SPVs with their respective PPA counterparties. Further, on account of such signed PPA, there are regulatory or legal restrictions to create assets of substantially the same level of utility. In such scenario, the true worth of the business is reflected in its future earning capacity rather than the cost of the project. Accordingly, since the NAV does not capture the future earning potential of the business, I have not considered the cost approach for the current valuation exercise.

### **Market Approach**

The present valuation exercise is to arrive at the fair EV of the SPVs engaged in the solar power generation business for a specific tenure. Further, the tariff revenue & expenses are very specific to the SPVs depending on the nature of their geographical location & stage of project.

For renewable energy projects, the challenge will likely be and is, that each solar project is unique and the added financial value of any financial or technical parameter may differ substantially. Due to the rapidly changing tariff rates and technology, two projects on two almost identical sites, with identical output, built within a month of each other but under different tariff regimes or different technology or both, could have significantly different values. Further, the analysis of the market based transactions is depended on unique factors specific to the project under consideration which is relatively unknown. Accordingly, on account of limitation on the data availability, I am unable to consider the CCM Method. In the absence of adequate details about the Comparable Transactions, I was unable to apply the CTM method. Currently, the equity shares of the SPVs are not listed on any recognized stock exchange of India. Hence, I was unable to apply market price method.

### **Income Approach**

Currently, each of the SPVs are completed and are revenue generating SPVs. The cash flows of the SPVs for the projected period are driven by the contracts entered by the SPVs as on date like the PPA, O&M Agreements, etc. Accordingly, since all the SPVs are generating income based on pre-determined agreements and since the Investment Manager has provided me with the financial projections of the SPVs for the balance tenor of such, DCF Method under the income approach has been considered as the appropriate method for the present valuation exercise.

## 7. Valuation of the SPVs

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- 7.1. I have estimated the fair EV of the SPVs using the DCF Method. While carrying out this engagement, I have relied extensively on the information made available to me by the Investment Manager. I have considered projected financial statements of the SPVs as provided by the Investment Manager.

### Valuation

- 7.2. The key assumptions of the projections provided to us by the Investment Manager are:

#### Key Assumptions:

##### 7.2.1. Revenue:

The revenues generated by the SPVs are correlated to the amount of electricity generated, which in turn is dependent upon available irradiance and weather conditions generally. Irradiance and weather conditions have natural variations from season to season and from year to year and may also change permanently because of climate change or other factors.

The total kilowatt hour units expected to be generated annually during the tenure of PPA are estimated using budgeted plant load factors. The contractual tariff rates are applied to this annual estimate to determine the total estimated revenue over the term of the PPA.

The Plant Load Factor ("PLF") is the ratio of the actual output of a solar power plant over the reporting period to their potential output if it were possible for them to operate at full rated capacity. The PLF is not the same as the availability factor. The variability in the PLF is a result of seasonality, cloud covers, air pollution, and daily rotation of the earth, equipment efficiency losses, breakdown of transmission system and grid availability.

The plant load factor is effective in measuring the performance of the power plants. Higher plant load factor at a plant indicates increased electricity generation. Monitoring plant load factor on real time allows the Investment Manager to respond rapidly to potential generation anomalies.

Projections of solar resources depend on assumptions about weather patterns, shading and irradiance, which are inherently uncertain and may not be consistent with actual conditions at the site.

The projected PLF of the SPVs has been estimated on the basis of the historical performance of the SPVs.

##### 7.2.2. Expenses:

I have relied on the projections provided by the Investment Manager for expenses and have checked the reasonableness of the same, by analysing the past trend in expenses and the expenses projected by the SPVs.

- **Operations & Maintenance ("O&M"):** O&M expenditure is estimated by the Investment Manager for the projected period on the basis of the O&M Agreements entered into by the SPVs.
- **Insurance Expenses:** I understand from the Investment Manager that the insurance expenses of the SPVs are not reasonably expected to inflate for the projected period. I have relied on the projections provided by the Investment Manager on the insurance expenses for the projected period, which are based on the existing insurance costs of the SPVs.

- 7.2.3. **Capital Expenditure ("Capex"):** I understand that the SPVs has sourced majority of its components such as solar panels and inverters directly from multiple manufacturers with industry standard warranty and guarantee terms. I understand that the SPVs are not expected to incur any major Capex in the projected period. Minor maintenance Capex including replacement of inverters and other minor improvements in the plants of the SPVs have been projected by the Investment Manager, which I have incorporated in my models.

- 7.2.4. **Taxes and Tax Incentive:** There have been changes in tax regime pursuant to introduction of Taxation Laws (Amendment) Ordinance 2019 made on 20<sup>th</sup> September 2019 which was enacted to make certain amendments in the Income Tax Act, 1961 and the Finance (No. 2) Act, 2019. As per the discussions with the Investment Manager, the old provisions of Income Tax Act have been considered for the projected period of all SPVs (except TRSPL) for the current valuation exercise, which inter alia provide benefits of additional depreciation, section 115JB and section 80-IA. New provision of Income Tax Act (with base corporate tax rate of 22%) have been considered for such SPVs (except for TNSEPL, UMD, TKSPL & USUPL) after utilization/ lapse of such benefits. As per the discussions with the Investment Manager, the new provision of Income Tax Act has been considered for the entire projected period of TRSPL for the current valuation exercise, which inter alia does not provide benefits of additional depreciation and section 80-IA and Sec 115JB and accordingly, the base corporate tax rate of 22% (with applicable surcharge and cess) have been considered for TRSPL.
- 7.2.5. **Working Capital:** The Investment Manager has represented the working capital requirement of the SPVs for the projected period in terms of trade payables days and trade receivables (Debtors & Unbilled revenue) days. The operating working capital assumptions for the projections as provided by the Investment Manager comprises of trade payables and trade receivables related to the operating revenue and expenses. The trade payables days are 30 days (of annual expenses), and trade receivables days vary between 30-180 days (of annual revenue), based on the PPA counterparty and the historical collection trends.
- 7.2.6. **Terminal Value:** Terminal value represents the present value at the end of explicit forecast period of all subsequent cash flows till the end of the life of the asset or into perpetuity if the asset has an indefinite life. The term of the PPA is 25 years for majority of the SPVs. The ownership of the underlying assets (tangible assets) shall remain with the SPVs even after the expiry of PPA term. As the cash flows beyond 25 years are relatively uncertain on account of factors like degradation of panels, technology factor, tariff rate, extension of land lease (wherever applicable), etc., the terminal period value (i.e. value on account of cash flows to be generated after the expiry of PPA period) has been considered based on the salvage value of the plant & machinery, sale of freehold land and realisation of working capital at the end of their respective PPA term of 25 years.

### 7.3. **Impact of Ongoing Material Litigation on Valuation**

As on 31<sup>st</sup> March 2021, there are ongoing litigations as shown in Appendix 4. Further, Investment Manager has informed us that majority of the cases are low to medium risk and accordingly no material outflow is expected against the litigations.

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#### 7.4. **Calculation of Weighted Average Cost of Capital for the SPVs**

##### 7.4.1. **Cost of Equity:**

Cost of Equity (CoE) is a discounting factor to calculate the returns expected by the equity holders depending on the perceived level of risk associated with the business and the industry in which the business operates.

For this purpose, I have used the Capital Asset Pricing Model (CAPM), which is a commonly used model to determine the appropriate cost of equity for the SPVs.

$$K(e) = R_f + (ERP * \text{Beta}) + \text{CSRP}$$

Wherein:

K(e) = cost of equity

R<sub>f</sub> = risk free rate

ERP = Equity Risk Premium

Beta = a measure of the sensitivity of assets to returns of the overall market

CSRP = Company Specific Risk Premium (In general, an additional company-specific risk premium will be added to the cost of equity calculated pursuant to CAPM).

For valuation exercise, I have arrived at adjusted cost of equity of the SPVs based on the above calculation (Refer Appendix 2).

##### 7.4.2. **Risk Free Rate:**

I have applied a risk free rate of return of 6.71% on the basis of the zero coupon yield curve as on 31<sup>st</sup> March 2021 for government securities having a maturity period of 10 years, as quoted on the website of Clearing Corporation of India Limited ("CCIL").

##### 7.4.3. **Equity Risk Premium ("ERP"):**

Equity Risk Premium is a measure of premium that investors require for investing in equity markets rather than bond or debt markets. The equity risk premium is estimated based on consideration of historical realised returns on equity investments over a risk-free rate as represented by 10 year government bonds. Based on the aforementioned, a 7% equity risk premium for India is considered appropriate.

##### 7.4.4. **Beta:**

Beta is a measure of the sensitivity of a company's stock price to the movements of the overall market index. In the present case, I find it appropriate to consider the beta of companies in similar business/ industry to that of the SPVs.

For the valuation of the SPVs, I find it appropriate to consider the beta of NTPC Limited, NLCC and Tata Power Limited for an appropriate period. The beta so arrived, is further adjusted based on advantageous factors of mentioned SPVs like completion of projects, revenue certainty, past collection trend, lack of execution uncertainty etc. to arrive at the adjusted unlevered beta appropriate to the SPVs.

I have further unlevered the beta of such companies based on market debt-equity of the respective company using the following formula:

$$\text{Unlevered Beta} = \text{Levered Beta} / [1 + (\text{Debt} / \text{Equity}) * (1-T)]$$

Further I have re-levered it based on debt-equity at 70:30 based on the industry Debt: Equity ratio using the following formula:

$$\text{Re-levered Beta} = \text{Unlevered Beta} * [1 + (\text{Debt} / \text{Equity}) * (1-T)]$$

Accordingly, as per above, I have arrived at re-levered betas of the SPVs. (Refer Appendix 2)

**7.4.5. Company Specific Risk Premium (“CSRP”):**

Discount Rate is the return expected by a market participant from a particular investment and shall reflect not only the time value of money but also the risk inherent in the asset being valued as well as the risk inherent in achieving the future cash flows. In the present case, considering the length of the explicit period, the basis of deriving the underlying cash flows and basis my discussion with Investment Manager, I found it appropriate to consider 0% CSRP in the present case.

**7.4.6. Cost of Debt:**

The calculation of Cost of Debt post-tax can be defined as follows:

$$K(d) = K(d) \text{ pre-tax} * (1 - T)$$

Wherein:

K(d) = Cost of debt

T = tax rate as applicable

For the current valuation exercise, pre-tax cost of debt has been considered as 8.00%, as represented by the Investment Manager.

**7.4.7. Weighted Average Cost of Capital (WACC):**

The discount rate, or the WACC, is the weighted average of the expected return on equity and the cost of debt. The weight of each factor is determined based on the company's optimal capital structure.

Formula for calculation of WACC:

$$WACC = [K(d) * \text{Debt} / (\text{Debt} + \text{Equity})] + [K(e) * (1 - \text{Debt} / (\text{Debt} + \text{Equity}))]$$

Accordingly, as per above, I have arrived the WACC for the explicit period of the SPVs.

*(Refer Appendix 2 for detailed workings).*

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## 8. Valuation Conclusion

- 8.1. The current valuation has been carried out based on the discussed valuation methodology explained herein earlier. Further, various qualitative factors, the business dynamics and growth potential of the business, having regard to information base, management perceptions, key underlying assumptions and limitations were given due consideration.
- 8.2. I have been represented by the Investment Manager that there is no potential devolvement on account of the contingent liability as of valuation date; hence no impact has been factored in to arrive at fair EV of the SPVs.
- 8.3. Based on the above analysis, the fair EV as on the Valuation Date of the SPVs is as mentioned below:

Sr. No.	SPVs	End of Projected Period	Approximate Balance Period	Enterprise Value	INR Lacs
					Adjusted Enterprise Value
1	TNSEPL	01-Nov-40	~19 Years and 7 Months	20,395	24,412
2	UMD	20-Jan-41	~19 Years and 10 Months	22,471	26,431
3	TKSPL	26-Mar-41	~20 Years and 0 Months	27,740	32,999
4	TR SPL	25-Sep-43	~22 Years and 6 Months	19,169	24,478
5	Solar Edge	18-Apr-43	~22 Years and 0 Months	86,656	88,966
6	TSEC	28-Mar-37	~16 Years and 0 Months	11,849	13,665
7	PLG	31-Jan-37	~15 Years and 10 Months	17,409	20,562
8	TSETPL	15-Oct-36	~15 Years and 7 Months	10,798	11,978
9	USUPL	15-Sep-41	~20 Years and 6 Months	26,526	29,856
<b>Total of all SPVs</b>				<b>2,43,013</b>	<b>2,73,346</b>

(Refer Appendix 1 for detailed workings)

- 8.4. EV is described as the total value of the equity in a business plus the value of its debt and debt related liabilities, minus any cash or cash equivalents to meet those liabilities.
- 8.5. Adjusted Enterprise Value is derived as EV as defined above plus cash or cash equivalents of the SPVs as at 31<sup>st</sup> March 2021.
- 8.6. The fair EV of the SPVs is estimated using DCF method. The valuation requires Investment Manager to make certain assumptions about the model inputs including forecast cash flows, discount rate, and credit risk.
- 8.7. Valuation is based on estimates of future financial performance or opinions, which represent reasonable expectations at a particular point of time, but such information, estimates or opinions are not offered as predictions or as assurances that a particular level of income or profit will be achieved, a particular event will occur or that a particular price will be offered or accepted. Actual results achieved during the period covered by the prospective financial analysis will vary from these estimates and the variations may be material.
- 8.8. Accordingly, I have conducted sensitivity analysis on certain model inputs, the results of which are as indicated below:
1. Weighted Average Cost of Capital (WACC) by increasing / decreasing it by 0.5%
  2. WACC by increasing / decreasing it by 1.0%
  3. PLF by increasing / decreasing it by 0.5%
  4. PLF by increasing / decreasing it by 1.0%
  5. Operating Expenses by increasing / decreasing it by 20%

**1. Fair Enterprise Valuation Range based on WACC parameter (0.5%)**

INR Lacs							
Sr. No.	SPVs	WACC + 0.5%	EV	Base WACC	EV	WACC - 0.5%	EV
1	TNSEPL	8.87%	19,697	8.37%	20,395	7.87%	21,135
2	UMD	8.87%	21,709	8.37%	22,471	7.87%	23,279
3	TKSPL	8.87%	26,784	8.37%	27,740	7.87%	28,755
4	TRSPL	8.45%	18,506	7.95%	19,169	7.45%	19,874
5	Solar Edge	8.67%	83,356	8.17%	86,656	7.67%	90,191
6	TSEC	8.57%	11,569	8.07%	11,849	7.57%	12,142
7	PLG	8.86%	17,019	8.36%	17,409	7.86%	17,819
8	TSETPL	8.40%	10,502	7.90%	10,798	7.40%	11,108
9	USUPL	8.91%	25,921	8.41%	26,526	7.91%	27,160
<b>Total of all SPVs</b>			<b>2,35,063</b>		<b>2,43,013</b>		<b>2,51,463</b>

**2. Fair Enterprise Valuation Range based on WACC parameter (1.0%)**

INR Lacs							
Sr. No.	SPVs	WACC + 1.0%	EV	Base WACC	EV	WACC - 1.0%	EV
1	TNSEPL	9.37%	19,037	8.37%	20,395	7.37%	21,920
2	UMD	9.37%	20,989	8.37%	22,471	7.37%	24,136
3	TKSPL	9.37%	25,881	8.37%	27,740	7.37%	29,833
4	TRSPL	8.95%	17,883	7.95%	19,169	6.95%	20,625
5	Solar Edge	9.17%	80,272	8.17%	86,656	7.17%	93,983
6	TSEC	9.07%	11,303	8.07%	11,849	7.07%	12,449
7	PLG	9.36%	16,646	8.36%	17,409	7.36%	18,249
8	TSETPL	8.90%	10,220	7.90%	10,798	6.90%	11,433
9	USUPL	9.41%	25,345	8.41%	26,526	7.41%	27,827
<b>Total of all SPVs</b>			<b>2,27,575</b>		<b>2,43,013</b>		<b>2,60,455</b>

**3. Fair Enterprise Valuation Range based on Plant Load Factor (PLF) parameter (0.5%)**

INR Lacs							
Sr. No.	SPVs	PLF + 0.5%	EV	Base PLF for FY22	EV	PLF - 0.5%	EV
1	TNSEPL	17.4%	20,456	16.9%	20,395	16.4%	20,207
2	UMD	17.0%	22,624	16.5%	22,471	16.0%	22,120
3	TKSPL	17.6%	27,777	17.1%	27,740	16.6%	27,585
4	TRSPL	17.2%	19,856	16.7%	19,169	16.2%	18,394
5	Solar Edge	17.0%	89,239	16.5%	86,656	16.0%	84,066
6	TSEC	16.7%	12,209	16.2%	11,849	15.7%	11,490
7	PLG	18.4%	17,890	17.9%	17,409	17.4%	16,951
8	TSETPL	18.3%	11,087	17.8%	10,798	17.3%	10,509
9	USUPL	17.2%	27,332	16.7%	26,526	16.2%	25,720
<b>Total of all SPVs</b>			<b>2,48,469</b>		<b>2,43,013</b>		<b>2,37,041</b>

**4. Fair Enterprise Valuation Range based on Plant Load Factor (PLF) parameter (1.0%)**

INR Lacs							
Sr. No.	SPVs	PLF + 1.0%	EV	Base PLF for FY22	EV	PLF - 1.0%	EV
1	TNSEPL	17.9%	20,458	16.9%	20,395	15.9%	19,800
2	UMD	17.5%	22,662	16.5%	22,471	15.5%	21,479
3	TKSPL	18.1%	27,777	17.1%	27,740	16.1%	27,196
4	TRSPL	17.7%	20,487	16.7%	19,169	15.7%	17,467
5	Solar Edge	17.5%	91,822	16.5%	86,656	15.5%	81,433
6	TSEC	17.2%	12,567	16.2%	11,849	15.2%	11,131
7	PLG	18.9%	18,370	17.9%	17,409	16.9%	16,465
8	TSETPL	18.8%	11,375	17.8%	10,798	16.8%	10,220
9	USUPL	17.7%	28,137	16.7%	26,526	15.7%	24,914
<b>Total of all SPVs</b>			<b>2,53,654</b>		<b>2,43,013</b>		<b>2,30,106</b>

**5. Fair Enterprise Valuation Range based on Operating Expense parameter (20%)**

INR Lacs				
Sr. No.	SPVs	EV at Expenses + 20%	EV at Base Expenses	EV at Expenses - 20%
1	TNSEPL	19,938	20,395	20,852
2	UMD	22,026	22,471	22,916
3	TKSPL	27,250	27,740	28,231
4	TRSPL	18,418	19,169	19,918
5	Solar Edge	83,901	86,656	89,402
6	TSEC	11,544	11,849	12,157
7	PLG	17,162	17,409	17,680
8	TSETPL	10,699	10,798	10,896
9	USUPL	26,000	26,526	27,018
<b>Total of all SPVs</b>		<b>2,36,939</b>	<b>2,43,013</b>	<b>2,49,071</b>

The above represents reasonable range of fair enterprise valuation of the SPVs.

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## 9. Additional Procedures to be complied with in accordance with InvIT regulations

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### Scope of Work

- 9.1 The Schedule V of the SEBI InvIT Regulations prescribes the minimum set of mandatory disclosures to be made in the valuation report. In this reference, the minimum disclosures in valuation report may include following information as well, so as to provide the investors with the adequate information about the valuation and other aspects of the underlying assets of the InvIT.

The additional set of disclosures, as prescribed under Schedule V of InvIT Regulations, to be made in the valuation report of the SPVs are as follows:

- List of one-time sanctions/approvals which are obtained or pending;
- List of up to date/overdue periodic clearances;
- Statement of assets;
- Estimates of already carried as well as proposed major repairs and improvements along with estimated time of completion;
- Revenue pendencies including local authority taxes associated with InvIT asset and compounding charges, if any;
- On-going material litigations including tax disputes in relation to the assets, if any;
- Vulnerability to natural or induced hazards that may not have been covered in town planning/ building control.

### Limitations

- 9.2 This Report is based on the information provided by the representatives of the Investment Manager. The exercise has been restricted and kept limited to and based entirely on the documents, records, files, registers and information provided to me. I have not verified the information independently with any other external source.
- 9.3 I have assumed the genuineness of all signatures, the authenticity of all documents submitted to me as original, and the conformity of the copies or extracts submitted to me with that of the original documents.
- 9.4 I have assumed that the documents submitted to me by the representatives of Investment Manager in connection with any particular issue are the only documents related to such issue.
- 9.5 I have reviewed the documents and records from the limited perspective of examining issues noted in the scope of work and I do not express any opinion as to the legal or technical implications of the same.

### Analysis of Additional Set of Disclosures for the SPVs

- A. List of one-time sanctions/approvals which are obtained or pending:

The list of applications for government sanctions/ licenses required by the SPVs related to the power plants for which approval is pending as on the date of this Report is provided in Appendix 3.10. The list of sanctions/ approvals obtained by the SPVs till the date of this Report is provided in Appendix 3.1 to Appendix 3.09.

- B. List of up to date/ overdue periodic clearances:

The list of clearances obtained by the SPVs till the date of this Report is provided in Appendix 3.1 to Appendix 3.09. The list of applications for licenses required by the SPVs for which approval is pending as on the date of this Report is provided in Appendix 3.10. Investment Manager has confirmed that the SPVs are not required to take any periodic clearances other than those mentioned in Appendix 3.1 to Appendix 3.09.

C. Statement of assets included:

The details of assets of the SPVs as at 31<sup>st</sup> March 2021 are as mentioned below:

INR Lacs				
Sr. No.	SPVs	Net Fixed Assets	Non-Current Assets	Current Assets
1	TNSEPL	11,134	93	2,528
2	UMD	12,538	12	2,425
3	TKSPL	17,846	17	3,071
4	TRSPL	12,985	17	1,370
5	Solar Edge	60,770	63	4,050
6	TSEC	7,487	4,533	621
7	PLG	12,774	4,008	558
8	TSETPL	3,713	1,156	369
9	USUPL	14,240	2,138	2,603
<b>Total of all SPVs</b>		<b>1,53,487</b>	<b>12,037</b>	<b>17,594</b>

D. Estimates of already carried as well as proposed major repairs and improvements along with estimated time of completion:

I have been informed that maintenance is regularly carried out by the SPVs in order to maintain the working condition of the assets.

E. Revenue pendencies including local authority taxes associated with InvIT asset and compounding charges, if any:

Investment Manager has informed me that there are no material dues including local authority taxes (such as Municipal Tax, Property Tax, etc.) pending to be payable to the government authorities with respect to the SPVs (proposed InvIT assets).

F. On-going material litigations including tax disputes in relation to the assets, if any:

As informed by the Investment Manager, the status of ongoing litigations and tax assessments are updated in Appendix 4 and 5 respectively.

Investment Manager has informed us that it expects majority of the cases to be settled in favour of the SPVs. Further, Investment Manager has informed us that majority of the cases are having low to medium risk and accordingly no material outflow is expected against the litigations.

I was not been provided with the documents for the following cases:

Sr. No.	SPVs	No. of Cases	Remarks
1	TKSPL, TNSEPL, UMD and TRSPL ("TN Assets")	1	Case Involving TN Assets appealing for Deemed Generation Benefits
2	Solar Edge	1	Sale deed pending (Dispute on Land)
3	TNSEPL	1	Back up Document pending for the Right of Way
4	TKSPL	1	Dispute on Land

Hence, I have relied on the Investment Manager with respect to the current status of the abovementioned cases.

G. Vulnerability to natural or induced hazards that may not have been covered in town planning/ building control:

Investment Manager has confirmed to me that there are no such natural or induced hazards which have not been considered in town planning/ building control.

## 10. Sources of Information

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For the purpose of undertaking this valuation exercise, I have relied on the following sources of information provided by the Investment Manager:

- 10.1. Audited financial Statement of the SPVs for the Financial Year ("FY") ended 31<sup>st</sup> March 2018, 31<sup>st</sup> March 2019, 31<sup>st</sup> March 2020 and 31<sup>st</sup> March 2021;
- 10.2. Projected financial information for the remaining project life for each of the SPVs;
- 10.3. Details of projected Capital Expenditure (Capex);
- 10.4. Details of brought forward losses and MAT credit (as per Income Tax Act) of the SPVs as at 31<sup>st</sup> March 2021;
- 10.5. Independent Fair Valuation Report for freehold land owned by Solar Edge;
- 10.6. Details of Written Down Value (WDV) (as per Income Tax Act) of SPVs as at 31<sup>st</sup> March 2021;
- 10.7. Shareholding pattern of the equity shares, the CCDs and the CCPS (if any) of the SPVs and other entities mentioned in this Report as at 31<sup>st</sup> March 2021 and as at the date of this report;
- 10.8. Power Purchase Agreements (PPA) entered into by the SPVs with its respective customer;
- 10.9. List of licenses / approvals, details of tax litigations, civil proceeding and arbitrations of the SPVs;
- 10.10. Management Representation Letter by the Investment Manager dated 21<sup>st</sup> July 2021;
- 10.11. Relevant data and information about the SPVs provided to us by the Investment Manager either in written or oral form or in the form of soft copy;
- 10.12. Information provided by leading database sources, market research reports and other published data.

The information provided to me by the Investment Manager in relation to the SPVs included but not limited to historical financial statements, forecasts/projections, other statements and assumptions about future matters like forward-looking financial information prepared by the Investment Manager. The forecasts and projections as supplied to me are based upon assumptions about events and circumstances which are yet to occur.

By nature, valuation is based on estimates, however, considering the outbreak of COVID-19 Pandemic and the consequent economic slowdown, the risks and uncertainties relating to the events occurring in the future, the actual figures in future may differ from these estimates and may have a significant impact on the valuation of the SPVs.

I have not tested individual assumptions or attempted to substantiate the veracity or integrity of such assumptions in relation to the forward-looking financial information, however, I have made sufficient enquiries to satisfy myself that such information has been prepared on a reasonable basis.

Notwithstanding anything above, I cannot provide any assurance that the forward looking financial information will be representative of the results which will actually be achieved during the cash flow forecast period.

Further, considering the current crisis in relation to COVID-19 in India and across the globe, I have been informed by the Investment Manager, that the forecasts / projections provided for the valuation exercises are prepared after reasonably evaluating and incorporating the impact of outbreak of COVID-19 pandemic as per prevalent conditions as on date.

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## 11. Exclusions and Limitations

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- 11.1. My Report is subject to the limitations detailed hereinafter. This Report is to be read in totality, and not in parts, in conjunction with the relevant documents referred to herein.
- 11.2. Valuation analysis and results are specific to the purpose of valuation and is not intended to represent value at any time other than the valuation date of 31<sup>st</sup> March 2021 ("Valuation Date") mentioned in the Report and as per agreed terms of my engagement. It may not be valid for any other purpose or as at any other date. Also, it may not be valid if done on behalf of any other entity.
- 11.3. This Report, its contents and the results are specific to (i) the purpose of valuation agreed as per the terms of my engagements; (ii) the Valuation Date; and (iii) are based on the financial information of the SPVs till 31<sup>st</sup> March 2021 . The Investment Manager has represented that the business activities of the SPVs have been carried out in normal and ordinary course between 31<sup>st</sup> March 2021 and the Report Date and that no material changes have occurred in the operations and financial position between 31<sup>st</sup> March 2021 and the Report date.
- 11.4. I have been informed by the Investment Manager that there will be limited impact of the on-going COVID-19 pandemic outbreak on the operations of the SPVs and the projections provided to me are after considering the same.
- 11.5. The scope of my assignment did not involve me performing audit tests for the purpose of expressing an opinion on the fairness or accuracy of any financial or analytical information that was provided and used by me during the course of my work. The assignment did not involve me to conduct the financial or technical feasibility study. I have not done any independent technical valuation or appraisal or due diligence of the assets or liabilities of the SPVs or any of other entity mentioned in this Report and have considered them at the value as disclosed by the SPVs in their regulatory filings or in submissions, oral or written, made to me.
- 11.6. In addition, I do not take any responsibility for any changes in the information used by me to arrive at my conclusion as set out herein which may occur subsequent to the date of my Report or by virtue of fact that the details provided to me are incorrect or inaccurate.
- 11.7. I have assumed and relied upon the truth, accuracy and completeness of the information, data and financial terms provided to me or used by me; I have assumed that the same are not misleading and do not assume or accept any liability or responsibility for any independent verification of such information or any independent technical valuation or appraisal of any of the assets, operations or liabilities of the SPVs or any other entity mentioned in the Report. Nothing has come to my knowledge to indicate that the material provided to me was misstated or incorrect or would not afford reasonable grounds upon which to base my Report.
- 11.8. This Report is intended for the sole use in connection with the purpose as set out above. It can however be relied upon and disclosed in connection with any statutory and regulatory filing in connection with the provision of SEBI InvIT Regulations. However, I will not accept any responsibility to any other party to whom this Report may be shown or who may acquire a copy of the Report, without my written consent.
- 11.9. It is clarified that this Report is not a fairness opinion under any of the stock exchange/ listing regulations. In case of any third party having access to this Report, please note this Report is not a substitute for the third party's own due diligence/ appraisal/ enquiries/ independent advice that the third party should undertake for his purpose.
- 11.10. Further, this Report is necessarily based on financial, economic, monetary, market and other conditions as in effect on, and the information made available to me or used by me up to, the date hereof. Subsequent developments in the aforementioned conditions may affect this Report and the

assumptions made in preparing this Report and I shall not be obliged to update, revise or reaffirm this Report if information provided to me changes.

- 11.11. This Report is based on the information received from the sources as mentioned in Section 9 of this Report and discussions with the Investment Manager. I have assumed that no information has been withheld that could have influenced the purpose of my Report.
- 11.12. Valuation is not a precise science and the conclusions arrived at in many cases may be subjective and dependent on the exercise of individual judgment. There is, therefore, no indisputable single value. I have arrived at an indicative EV based on my analysis. While I have provided an assessment of the value based on an analysis of information available to me and within the scope of my engagement, others may place a different value on this business.
- 11.13. Any discrepancies in any table / appendix between the total and the sums of the amounts listed are due to rounding-off.
- 11.14. Valuation is based on estimates of future financial performance or opinions, which represent reasonable expectations at a particular point of time, but such information, estimates or opinions are not offered as predictions or as assurances that a particular level of income or profit will be achieved, a particular event will occur or that a particular price will be offered or accepted. Actual results achieved during the period covered by the prospective financial analysis will vary from these estimates and the variations may be material.
- 11.15. I do not carry out any validation procedures or due diligence with respect to the information provided/extracted or carry out any verification of the assets or comment on the achievability and reasonableness of the assumptions underlying the financial forecasts, save for satisfying ourselves to the extent possible that they are consistent with other information provided to me in the course of this engagement.
- 11.16. My conclusion assumes that the assets and liabilities of the SPVs, reflected in their respective latest balance sheets remain intact as of the Report date, except for changes occurring due to ordinary course of business.
- 11.17. Whilst all reasonable care has been taken to ensure that the factual statements in the Report are accurate, neither myself, nor any of my associates, officers or employees shall in any way be liable or responsible either directly or indirectly for the contents stated herein. Accordingly, I make no representation or warranty, express or implied, in respect of the completeness, authenticity or accuracy of such factual statements. I expressly disclaim any and all liabilities, which may arise based upon the information used in this Report. I am not liable to any third party in relation to the issue of this Report.
- 11.18. The scope of my work has been limited both in terms of the areas of the business & operations which I have reviewed and the extent to which I have reviewed them. There may be matters, other than those noted in this Report, which might be relevant in the context of the transaction and which a wider scope might uncover.
- 11.19. For the present valuation exercise, I have also relied on information available in public domain; however the accuracy and timelines of the same has not been independently verified by me.
- 11.20. In the particular circumstances of this case, my liability (in contract or under any statute or otherwise) for any economic loss or damage arising out of or in connection with this engagement, however the loss or damage caused, shall be limited to the amount of fees actually received by me from the Investment Manager, as laid out in the engagement letter for such valuation work. However, such cap shall not be applicable to damages arising from fraud or wilful default or gross negligence as established in civil or criminal proceedings.
- 11.21. In rendering this Report, I have not provided any legal, regulatory, tax, accounting or actuarial advice and accordingly I do not assume any responsibility or liability in respect thereof.

- 11.22. This Report does not address the relative merits of investing in InvIT as compared with any other alternative business transaction, or other alternatives, or whether or not such alternatives could be achieved or are available.
- 11.23. I am not an advisor with respect to legal, tax and regulatory matters for the proposed transaction. No investigation of the SPVs' claim to title of assets has been made for the purpose of this Report and the SPVs' claim to such rights have been assumed to be valid. No consideration has been given to liens or encumbrances against the assets, beyond the loans disclosed in the accounts. Therefore, no responsibility is assumed for matters of a legal nature.
- 11.24. I have no present or planned future interest in the Trustee, Investment Manager or the SPVs and the fee for this Report is not contingent upon the values reported herein. My valuation analysis should not be construed as investment advice; specifically, I do not express any opinion on the suitability or otherwise of entering into any financial or other transaction with the Investment Manager or SPVs.
- 11.25. I have submitted the draft valuation report to the Trust & Investment Manager for confirmation of accuracy of factual data used in my analysis and to prevent any error or inaccuracy in this Report.
- 11.26. **Limitation of Liabilities**
- i. It is agreed that, having regard to the RV's interest in limiting the personal liability and exposure to litigation of its personnel, the Sponsor, the Investment Manager and the Trust will not bring any claim in respect of any damage against the RV personally.
  - ii. In no circumstances RV shall be responsible for any consequential, special, direct, indirect, punitive or incidental loss, damages or expenses (including loss of profits, data, business, opportunity cost, goodwill or indemnification) in connection with the performance of the services whether such damages are based on breach of contract, tort, strict liability, breach of warranty, or otherwise, even if the Investment Manager had contemplated and communicated to RV the likelihood of such damages. Any decision to act upon the deliverables (including this Report) is to be made by the Investment Manager and no communication by RV should be treated as an invitation or inducement to engage the Investment Manager to act upon the deliverable(s).
  - iii. It is clarified that the Investment Manager will be solely responsible for any delays, additional costs, or other liabilities caused by or associated with any deficiencies in their responsibilities, misrepresentations, incorrect and incomplete information including information provided to determine the assumptions.
  - iv. RV will not be liable if any loss arises due to the provision of false, misleading or incomplete information or documentation by the Investment Manager.
- 11.27. **Limitation on account of COVID-19 and Uncertainty in Valuation**
- i. It is important to highlight that the COVID-19 pandemic has created uncertainty in valuation. The mitigation in the spread of COVID-19 and commencement of vaccination process has led to relaxation of restrictions and consequent opening up of the economy. However, the second wave and consequent lockdown in many parts of the country continues to impact the economy and consequent business recovery. Accordingly, the impact assessment of COVID-19 is a continuing process given the uncertainties associated with its nature and durations.
  - ii. I have been informed by the Investment Manager, that the forecasts / projections provided for the valuation exercises are prepared after reasonably evaluating and incorporating the impact of outbreak of COVID-19 pandemic as per prevalent conditions as on date. The estimates and judgement made by the Investment Manager, could vary on future developments, including,

among other things, any new information concerning the impact created by the COVID-19 pandemic on the economy and consequent effect on the business and on the customer's ability to make the payment. The Investment Manager continues to monitor any material changes to future economic conditions, which will be given effect, where relevant, in the respective future period.

- iii. Accordingly, I would recommend a degree of caution to the values arrived under current circumstances. Further, this Report is necessarily based on financial, economic, monetary, market and other conditions as in effect on, and the information made available to me or used by me up to, the date hereof. Subsequent developments in the aforementioned conditions may affect this Report and the assumptions made in preparing this Report and I shall not be obliged to update, revise or reaffirm this Report if information provided to me changes.

Yours faithfully,

Swaminathan  
n  
Sundararaman  
an

Digitally signed  
by Swaminathan  
Sundararaman  
Date: 2021.07.22  
21:41:34 +05'30'

**S. Sundararaman**

Registered Valuer

IBBI Registration No.: IBBI/RV/06/2018/10238

Asset Class: Securities or Financial Assets

Place: Chennai

UDIN: 21028423AAAALJ1145

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## Appendix 1 – Valuation of SPVs as on 31<sup>st</sup> March 2021

Abbreviations	Meaning
EBITDA	Operating Earnings Before Interest, Taxes, Depreciation and Amortization
Capex	Capital Expenditure
WC	Working Capital
FCFF	Free Cash Flow to the Firm
CAF	Cash Accrual Factor
PV	Present value

### Appendix 1.1 – Valuation of TNSEPL as on 31<sup>st</sup> March 2021

WACC 8.37%											INR Lacs
Year	Net PLF % (DC)	Revenue	EBITDA	EBITDA Margin	Capex	Changes in WC	Taxation	FCFF	CAF	Discounting Factor	PV of Cash Flows
FY22	16.9%	2,691	2,468	92%	39	692	258	1,478	0.50	0.96	1,420
FY23	16.8%	2,691	2,460	91%	-	(1)	257	2,204	1.50	0.89	1,954
FY24	16.7%	2,737	2,499	91%	-	(1)	264	2,235	2.50	0.82	1,828
FY25	16.6%	2,684	2,439	91%	12	(1)	253	2,174	3.50	0.75	1,641
FY26	16.5%	2,684	2,431	91%	52	(1)	251	2,129	4.50	0.70	1,482
FY27	16.5%	2,684	2,423	90%	53	(1)	249	2,121	5.50	0.64	1,363
FY28	16.4%	2,691	2,421	90%	55	(1)	281	2,086	6.50	0.59	1,237
FY29	16.3%	2,684	2,405	90%	43	(1)	375	1,988	7.50	0.55	1,088
FY30	16.2%	2,684	2,395	89%	-	(1)	373	2,023	8.50	0.50	1,021
FY31	16.1%	2,684	2,385	89%	-	(1)	371	2,015	9.50	0.47	939
FY32	16.0%	2,691	2,383	89%	-	(1)	371	2,012	10.50	0.43	865
FY33	16.0%	2,684	2,365	88%	-	(1)	368	1,998	11.50	0.40	792
FY34	15.9%	2,684	2,354	88%	-	(1)	366	1,989	12.50	0.37	728
FY35	15.8%	2,675	2,334	87%	-	(5)	362	1,976	13.50	0.34	667
FY36	15.7%	2,668	2,315	87%	-	(8)	359	1,964	14.50	0.31	612
FY37	15.6%	2,647	2,281	86%	-	(8)	353	1,936	15.50	0.29	557
FY38	15.5%	2,632	2,254	86%	-	(8)	348	1,913	16.50	0.27	508
FY39	15.4%	2,618	2,226	85%	-	(8)	344	1,890	17.50	0.24	463
FY40	15.4%	2,611	2,205	84%	-	(8)	340	1,873	18.50	0.23	423
FY41*	15.3%	1,525	1,278	84%	-	(8)	197	1,089	19.29	0.21	231
Present Value of Explicit Period Cash Flows											19,818
Present Value of Terminal Cash Flows											576
<b>Enterprise Value</b>											<b>20,395</b>
(+ ) Closing cash or cash equivalents as at the Valuation Date											4,017
<b>Adjusted Enterprise Value</b>											<b>24,412</b>

\* November 1, 2040

## Appendix 1.2 – Valuation of UMD as on 31<sup>st</sup> March 2021

WACC		8.37%									INR Lacs
Year	Net PLF % (DC)	Revenue	EBITDA	EBITDA Margin	Capex	Changes in WC	Taxation	FCFF	CAF	Discounting Factor	PV of Cash Flows
FY22	16.5%	2,925	2,709	93%	47	661	277	1,724	0.50	0.96	1,656
FY23	16.5%	2,925	2,702	92%	-	(1)	276	2,426	1.50	0.89	2,151
FY24	16.4%	2,975	2,745	92%	-	(1)	284	2,461	2.50	0.82	2,013
FY25	16.3%	2,917	2,681	92%	-	(1)	273	2,409	3.50	0.75	1,818
FY26	16.2%	2,917	2,673	92%	56	(1)	271	2,347	4.50	0.70	1,634
FY27	16.1%	2,917	2,665	91%	58	(1)	269	2,339	5.50	0.64	1,503
FY28	16.1%	2,925	2,664	91%	60	(1)	268	2,337	6.50	0.59	1,386
FY29	16.0%	2,917	2,648	91%	61	(1)	410	2,177	7.50	0.55	1,191
FY30	15.9%	2,917	2,638	90%	-	(1)	409	2,231	8.50	0.50	1,126
FY31	15.8%	2,911	2,623	90%	-	(4)	406	2,221	9.50	0.47	1,035
FY32	15.7%	2,904	2,606	90%	-	(8)	403	2,211	10.50	0.43	951
FY33	15.6%	2,881	2,572	89%	-	(8)	397	2,184	11.50	0.40	866
FY34	15.6%	2,865	2,546	89%	-	(8)	393	2,162	12.50	0.37	791
FY35	15.5%	2,850	2,520	88%	-	(8)	388	2,140	13.50	0.34	723
FY36	15.4%	2,843	2,501	88%	-	(8)	385	2,125	14.50	0.31	662
FY37	15.3%	2,820	2,466	87%	-	(9)	378	2,096	15.50	0.29	603
FY38	15.2%	2,804	2,438	87%	-	(9)	374	2,073	16.50	0.27	550
FY39	15.1%	2,789	2,409	86%	-	(9)	369	2,049	17.50	0.24	502
FY40	15.1%	2,781	2,388	86%	-	(9)	365	2,032	18.50	0.23	459
FY41*	15.0%	2,230	1,900	85%	-	(9)	290	1,619	19.40	0.21	340
Present Value of Explicit Period Cash Flows											21,960
Present Value of Terminal Cash Flows											511
<b>Enterprise Value</b>											<b>22,471</b>
(+ ) Closing cash or cash equivalents as at the Valuation Date											3,959
<b>Adjusted Enterprise Value</b>											<b>26,431</b>

\*January 20, 2041

### Appendix 1.3 – Valuation of TKSPL as on 31<sup>st</sup> March 2021

WACC		8.37%										INR Lacs	
Year	Net PLF % (DC)	Revenue	EBITDA	EBITDA Margin	Capex	Changes in WC	Taxation	FCFF	CAF	Discounting Factor	PV of Cash Flows		
FY22	17.1%	3,510	3,274	93%	48	769	317	2,139	0.50	0.96	2,055		
FY23	17.0%	3,510	3,266	93%	-	(1)	315	2,951	1.50	0.89	2,616		
FY24	16.9%	3,570	3,318	93%	-	(1)	324	2,994	2.50	0.82	2,449		
FY25	16.8%	3,500	3,242	93%	-	(1)	311	2,931	3.50	0.75	2,213		
FY26	16.8%	3,500	3,233	92%	68	(1)	309	2,857	4.50	0.70	1,990		
FY27	16.7%	3,500	3,224	92%	70	(1)	307	2,849	5.50	0.64	1,831		
FY28	16.6%	3,510	3,225	92%	72	(1)	306	2,847	6.50	0.59	1,689		
FY29	16.5%	3,500	3,205	92%	74	(1)	492	2,640	7.50	0.55	1,445		
FY30	16.4%	3,500	3,195	91%	-	(1)	490	2,706	8.50	0.50	1,366		
FY31	16.3%	3,500	3,184	91%	-	(1)	488	2,697	9.50	0.47	1,257		
FY32	16.3%	3,510	3,183	91%	-	(1)	488	2,696	10.50	0.43	1,159		
FY33	16.2%	3,500	3,162	90%	-	(1)	484	2,679	11.50	0.40	1,063		
FY34	16.1%	3,500	3,150	90%	-	(1)	482	2,669	12.50	0.37	977		
FY35	16.0%	3,500	3,137	90%	-	(1)	480	2,658	13.50	0.34	898		
FY36	15.9%	3,510	3,134	89%	-	(1)	479	2,656	14.50	0.31	828		
FY37	15.8%	3,498	3,109	89%	-	(2)	475	2,636	15.50	0.29	758		
FY38	15.7%	3,479	3,076	88%	-	(10)	469	2,617	16.50	0.27	695		
FY39	15.7%	3,460	3,042	88%	-	(11)	463	2,589	17.50	0.24	634		
FY40	15.6%	3,451	3,017	87%	-	(10)	459	2,569	18.50	0.23	581		
FY41*	15.5%	3,375	2,933	87%	-	(11)	523	2,420	19.49	0.21	505		
Present Value of Explicit Period Cash Flows											27,009		
Present Value of Terminal Cash Flows											732		
<b>Enterprise Value</b>											<b>27,740</b>		
(+ ) Closing cash or cash equivalents as at the Valuation Date											5,258		
<b>Adjusted Enterprise Value</b>											<b>32,999</b>		

\* March 26, 2041

## Appendix 1.4 – Valuation of TRSPL as on 31<sup>st</sup> March 2021

WACC 7.95%											INR Lacs
Year	Net PLF % (DC)	Revenue	EBITDA	EBITDA Margin	Capex	Changes in WC	Taxation	FCFF	CAF	Discounting Factor	PV of Cash Flows
FY22	16.7%	2,761	2,410	87%	65	816	-	1,530	0.50	0.96	1,472
FY23	16.6%	2,747	2,385	87%	-	(8)	95	2,297	1.50	0.89	2,048
FY24	16.6%	2,819	2,445	87%	-	(8)	279	2,174	2.50	0.83	1,795
FY25	16.5%	2,704	2,321	86%	-	(8)	298	2,030	3.50	0.77	1,553
FY26	16.4%	2,690	2,294	85%	-	(8)	334	1,968	4.50	0.71	1,394
FY27	16.3%	2,676	2,267	85%	-	(8)	364	1,911	5.50	0.66	1,254
FY28	16.2%	2,670	2,246	84%	60	(8)	388	1,807	6.50	0.61	1,099
FY29	16.1%	2,649	2,211	83%	123	(8)	401	1,695	7.50	0.56	955
FY30	16.1%	2,635	2,182	83%	127	(8)	412	1,651	8.50	0.52	862
FY31	16.0%	2,622	2,152	82%	130	(8)	420	1,610	9.50	0.48	778
FY32	15.9%	2,615	2,129	81%	67	(8)	430	1,640	10.50	0.45	734
FY33	15.8%	2,594	2,091	81%	-	(8)	436	1,663	11.50	0.41	690
FY34	15.7%	2,578	2,057	80%	-	(9)	441	1,625	12.50	0.38	624
FY35	15.6%	2,555	2,015	79%	-	(13)	442	1,586	13.50	0.36	565
FY36	15.6%	2,539	1,980	78%	-	(13)	443	1,549	14.50	0.33	511
FY37	15.5%	2,508	1,929	77%	-	(13)	439	1,504	15.50	0.31	459
FY38	15.4%	2,485	1,885	76%	-	(13)	434	1,464	16.50	0.28	414
FY39	15.3%	2,462	1,840	75%	-	(13)	429	1,424	17.50	0.26	373
FY40	15.2%	2,445	1,800	74%	-	(13)	424	1,389	18.50	0.24	337
FY41	15.1%	2,416	1,746	72%	-	(14)	415	1,345	19.50	0.22	302
FY42	15.1%	2,392	1,698	71%	-	(13)	407	1,305	20.50	0.21	272
FY43	15.0%	2,369	1,649	70%	-	(14)	397	1,265	21.50	0.19	244
FY44*	14.9%	1,144	780	68%	-	(14)	181	612	22.24	0.18	112
Present Value of Explicit Period Cash Flows											18,849
Present Value of Terminal Cash Flows											320
<b>Enterprise Value</b>											<b>19,169</b>
(+ ) Closing cash or cash equivalents as at the Valuation Date											5,310
<b>Adjusted Enterprise Value</b>											<b>24,478</b>

\* September 25, 2043



## Appendix 1.5 – Valuation of Solar Edge as on 31<sup>st</sup> March 2021

WACC	8.17%										INR Lacs
Year	Net PLF % (DC)	Revenue	EBITDA	EBITDA Margin	Capex	Changes in WC	Taxation	FCFF	CAF	Discounting Factor	PV of Cash Flows
FY22	16.5%	10,879	9,645	89%	939	(645)	1,051	8,300	0.50	0.96	7,980
FY23	16.4%	10,825	9,545	88%	-	(56)	1,034	8,567	1.50	0.89	7,615
FY24	16.3%	11,043	9,716	88%	-	(18)	1,064	8,671	2.50	0.82	7,125
FY25	16.3%	10,668	9,305	87%	-	(18)	992	8,331	3.50	0.76	6,328
FY26	16.2%	10,614	9,200	87%	-	(19)	973	8,245	4.50	0.70	5,790
FY27	16.1%	10,560	9,092	86%	-	(19)	955	8,157	5.50	0.65	5,295
FY28	16.0%	10,534	9,011	86%	324	(19)	939	7,768	6.50	0.60	4,661
FY29	15.9%	10,451	8,871	85%	336	(20)	911	7,643	7.50	0.55	4,240
FY30	15.9%	10,397	8,756	84%	349	(20)	888	7,539	8.50	0.51	3,866
FY31	15.8%	10,343	8,640	84%	362	(20)	864	7,433	9.50	0.47	3,524
FY32	15.7%	10,317	8,548	83%	-	(20)	1,276	7,292	10.50	0.44	3,196
FY33	15.6%	10,235	8,398	82%	-	(21)	1,249	7,169	11.50	0.41	2,905
FY34	15.5%	10,180	8,272	81%	-	(21)	1,227	7,066	12.50	0.37	2,646
FY35	15.4%	10,126	8,144	80%	-	(21)	1,205	6,960	13.50	0.35	2,410
FY36	15.4%	10,100	8,040	80%	-	(21)	1,548	6,513	14.50	0.32	2,085
FY37	15.3%	10,018	7,877	79%	-	(22)	1,794	6,105	15.50	0.30	1,806
FY38	15.2%	9,964	7,739	78%	-	(22)	1,788	5,973	16.50	0.27	1,634
FY39	15.1%	9,910	7,597	77%	-	(22)	1,776	5,843	17.50	0.25	1,478
FY40	15.0%	9,883	7,478	76%	-	(22)	1,767	5,734	18.50	0.23	1,340
FY41	14.9%	9,801	7,302	74%	-	(23)	1,739	5,585	19.50	0.22	1,207
FY42	14.9%	9,747	7,148	73%	-	(23)	1,715	5,455	20.50	0.20	1,090
FY43	14.8%	9,693	6,990	72%	-	(23)	1,688	5,325	21.50	0.18	983
FY44*	14.7%	449	318	71%	-	(24)	20	322	21.50	0.18	59
Present Value of Explicit Period Cash Flows											79,264
Present Value of Terminal Cash Flows											7,392
Enterprise Value											86,656
(+) Closing cash or cash equivalents as at the Valuation Date											2,310
Adjusted Enterprise Value											88,966

\* April 18, 2043

## Appendix 1.6 – Valuation of TSEC as on 31<sup>st</sup> March 2021

WACC		8.07%										INR Lacs
Year	Net PLF % (DC)	Revenue	EBITDA	EBITDA Margin	Capex	Changes in WC	Taxation	FCFF	CAF	Discounting Factor	PV of Cash Flows	
FY22	16.8%	2,506	2,311	92%	443	(325)	206	1,987	0.50	0.96	1,912	
FY23	16.6%	2,526	2,328	92%	27	1	209	2,091	1.50	0.89	1,862	
FY24	16.5%	2,466	2,264	92%	28	(48)	197	2,087	2.50	0.82	1,719	
FY25	16.4%	1,536	1,331	87%	28	(76)	180	1,199	3.50	0.76	914	
FY26	16.2%	1,409	1,200	85%	-	(11)	244	967	4.50	0.71	682	
FY27	16.1%	1,397	1,184	85%	-	(1)	240	945	5.50	0.65	617	
FY28	16.0%	1,390	1,172	84%	-	(1)	237	936	6.50	0.60	565	
FY29	15.8%	1,374	1,152	84%	-	(1)	232	921	7.50	0.56	515	
FY30	15.7%	1,362	1,136	83%	-	(1)	228	909	8.50	0.52	470	
FY31	15.6%	1,351	1,119	83%	-	(1)	224	896	9.50	0.48	429	
FY32	15.4%	1,343	1,106	82%	-	(1)	221	886	10.50	0.44	393	
FY33	15.3%	1,328	1,085	82%	-	(1)	216	871	11.50	0.41	357	
FY34	15.2%	1,316	1,068	81%	-	(1)	219	851	12.50	0.38	323	
FY35	15.0%	1,304	1,051	81%	-	(1)	246	806	13.50	0.35	283	
FY36	14.9%	1,296	1,037	80%	-	(1)	243	795	14.50	0.32	258	
FY37*	14.8%	1,278	1,013	79%	-	(2)	238	777	15.50	0.30	233	
Present Value of Explicit Period Cash Flows											11,531	
Present Value of Terminal Cash Flows											318	
<b>Enterprise Value</b>											<b>11,849</b>	
(+ ) Closing cash or cash equivalents as at the Valuation Date											1,816	
<b>Adjusted Enterprise Value</b>											<b>13,665</b>	

\* March 28, 2037

## Appendix 1.7 – Valuation of PLG as on 31<sup>st</sup> March 2021

WACC		8.36%										INR Lacs
Year	Net PLF % (DC)	Revenue	EBITDA	EBITDA Margin	Capex	Changes in WC	Taxation	FCFF	CAF	Discounting Factor	PV of Cash Flows	
FY22	17.9%	4,648	4,489	97%	1,209	65	428	2,787	0.50	0.96	2,677	
FY23	17.8%	4,625	4,461	96%	41	(2)	422	4,000	1.50	0.89	3,546	
FY24	17.7%	4,060	3,891	96%	42	(111)	322	3,637	2.50	0.82	2,976	
FY25	17.6%	1,526	1,355	89%	44	(208)	136	1,383	3.50	0.75	1,044	
FY26	17.6%	1,519	1,342	88%	-	(1)	134	1,210	4.50	0.70	843	
FY27	17.5%	1,511	1,330	88%	-	(1)	132	1,199	5.50	0.64	771	
FY28	17.4%	1,507	1,321	88%	-	(1)	130	1,192	6.50	0.59	707	
FY29	17.3%	1,495	1,304	87%	-	(1)	127	1,178	7.50	0.55	645	
FY30	17.2%	1,488	1,291	87%	-	(1)	125	1,167	8.50	0.51	590	
FY31	17.1%	1,480	1,278	86%	-	(1)	123	1,156	9.50	0.47	539	
FY32	17.0%	1,476	1,268	86%	-	(1)	121	1,148	10.50	0.43	494	
FY33	16.9%	1,464	1,251	85%	-	(1)	118	1,133	11.50	0.40	450	
FY34	16.8%	1,457	1,237	85%	-	(1)	116	1,122	12.50	0.37	411	
FY35	16.7%	1,449	1,223	84%	-	(1)	145	1,079	13.50	0.34	365	
FY36	16.7%	1,445	1,212	84%	-	(1)	304	909	14.50	0.31	284	
FY37*	16.6%	1,182	984	83%	-	(1)	247	739	15.41	0.29	214	
Present Value of Explicit Period Cash Flows											16,554	
Present Value of Terminal Cash Flows											855	
<b>Enterprise Value</b>											<b>17,409</b>	
(+ ) Closing cash or cash equivalents as at the Valuation Date											3,152	
<b>Adjusted Enterprise Value</b>											<b>20,562</b>	

\* January 31, 2037

## Appendix 1.8 – Valuation of TSETPL as on 31<sup>st</sup> March 2021

WACC		INR Lacs									
7.90%											
Year	Net PLF % (DC)	Revenue	EBITDA	EBITDA Margin	Capex	Changes in WC	Taxation	FCFF	CAF	Discounting Factor	PV of Cash Flows
FY22	17.8%	1,583	1,520	96%	33	(123)	182	1,427	0.50	0.96	1,374
FY23	17.6%	1,584	1,520	96%	10	(0)	239	1,271	1.50	0.89	1,134
FY24	17.5%	1,576	1,510	96%	11	(73)	333	1,239	2.50	0.83	1,025
FY25	17.3%	1,559	1,491	96%	11	(1)	328	1,153	3.50	0.77	884
FY26	17.2%	1,546	1,477	96%	8	(1)	324	1,145	4.50	0.71	813
FY27	17.1%	1,533	1,462	95%	-	(1)	321	1,143	5.50	0.66	752
FY28	16.9%	1,525	1,452	95%	-	(1)	318	1,135	6.50	0.61	692
FY29	16.8%	1,508	1,433	95%	-	(1)	313	1,121	7.50	0.57	634
FY30	16.6%	1,495	1,418	95%	-	(1)	311	1,109	8.50	0.52	581
FY31	16.5%	1,482	1,404	95%	-	(1)	307	1,098	9.50	0.49	533
FY32	16.3%	1,473	1,393	95%	-	(1)	304	1,090	10.50	0.45	490
FY33	16.2%	1,457	1,374	94%	-	(1)	299	1,076	11.50	0.42	449
FY34	16.1%	1,444	1,359	94%	-	(1)	297	1,063	12.50	0.39	411
FY35	15.9%	1,431	1,344	94%	-	(1)	335	1,010	13.50	0.36	362
FY36	15.8%	1,422	1,333	94%	-	(1)	333	1,001	14.50	0.33	332
FY37*	15.6%	762	713	93%	-	(1)	177	537	15.27	0.31	168
Present Value of Explicit Period Cash Flows											10,635
Present Value of Terminal Cash Flows											163
<b>Enterprise Value</b>											<b>10,798</b>
(+ ) Closing cash or cash equivalents as at the Valuation Date											1,181
<b>Adjusted Enterprise Value</b>											<b>11,978</b>

\* October 15, 2036

## Appendix 1.9 – Valuation of USUPL as on 31<sup>st</sup> March 2021

WACC 8.41%											INR Lacs
Year	Net PLF % (DC)	Revenue	EBITDA	EBITDA Margin	Capex	Changes in WC	Taxation	FCFF	CAF	Discounting Factor	PV of Cash Flows
FY22	16.7%	4,997	4,737	95%	44	121	586	3,986	0.50	0.96	3,828
FY23	16.6%	4,972	4,705	95%	-	(3)	608	4,100	1.50	0.89	3,632
FY24	16.5%	4,960	4,686	94%	-	(3)	628	4,060	2.50	0.82	3,318
FY25	16.4%	4,922	4,643	94%	-	(3)	642	4,003	3.50	0.75	3,018
FY26	16.4%	4,897	4,610	94%	34	(3)	655	3,924	4.50	0.70	2,729
FY27	16.3%	4,872	4,577	94%	70	(3)	665	3,845	5.50	0.64	2,467
FY28	16.2%	4,860	4,557	94%	72	(3)	675	3,813	6.50	0.59	2,256
FY29	16.1%	2,879	2,567	89%	74	(163)	339	2,316	7.50	0.55	1,264
FY30	16.0%	1,234	912	74%	38	(136)	59	952	8.50	0.50	479
FY31	15.9%	1,227	897	73%	-	(1)	66	831	9.50	0.46	386
FY32	15.9%	1,224	884	72%	-	(1)	74	811	10.50	0.43	348
FY33	15.8%	1,215	864	71%	-	(1)	78	787	11.50	0.40	311
FY34	15.7%	1,208	846	70%	-	(1)	83	765	12.50	0.36	279
FY35	15.6%	1,202	829	69%	-	(1)	87	744	13.50	0.34	250
FY36	15.5%	1,199	814	68%	-	(1)	90	726	14.50	0.31	225
FY37	15.4%	1,189	792	67%	-	(2)	91	703	15.50	0.29	201
FY38	15.4%	1,182	774	65%	-	(2)	93	682	16.50	0.26	180
FY39	15.3%	1,176	754	64%	-	(2)	94	662	17.50	0.24	161
FY40	15.2%	1,173	737	63%	-	(2)	94	644	18.50	0.22	145
FY41	15.1%	1,163	713	61%	-	(2)	94	622	19.50	0.21	129
FY42*	15.0%	532	319	60%	-	(2)	42	279	20.23	0.20	55
Present Value of Explicit Period Cash Flows											25,661
Present Value of Terminal Cash Flows											865
<b>Enterprise Value</b>											<b>26,526</b>
(+ ) Closing cash or cash equivalents as at the Valuation Date											3,330
<b>Adjusted Enterprise Value</b>											<b>29,856</b>

\* September 15, 2042

## Appendix 2 – Weighted Average Cost of Capital of the SPVs (1/2)

Particulars	TNSEPL	UMD	TKSPL	TRSPL	Solar Edge	Remarks
Risk Free Rate (Rf)	6.71%	6.71%	6.71%	6.71%	6.71%	Risk Free Rate has been considered based on zero coupon yield curve as at 31 <sup>st</sup> March 2021 of Government Securities having maturity period of 10 years, as quoted on CCIL's website.
Equity Risk Premium (ERP)	7.00%	7.00%	7.00%	7.00%	7.00%	Based on the historical realized returns on equity investments over a risk free rate of as represented by 10 year government bonds, a 7% equity risk premium is considered appropriate for India.
Beta (relevered)	0.83	0.83	0.83	0.79	0.81	Beta has been considered based on the beta of companies operating in the similar kind of business in India.
Base Cost of Equity	12.50%	12.50%	12.50%	12.23%	12.37%	Base Ke = Rf + ( $\beta$ x ERP)
Company Specific Risk Premium (CSRP)	0.00%	0.00%	0.00%	0.00%	0.00%	Risk Premium/ Discount Specific to the SPVs
<b>Adjusted Cost of Equity (Ke)</b>	<b>12.50%</b>	<b>12.50%</b>	<b>12.50%</b>	<b>12.23%</b>	<b>12.37%</b>	<b>Adjusted Ke = Rf + (<math>\beta</math> x ERP) + CSRP</b>
Pre-tax Cost of Debt	8.00%	8.00%	8.00%	8.00%	8.00%	As represented by the Investment Manager
Effective tax rate of SPV	17.47%	17.47%	17.52%	23.49%	20.33%	Average tax rate for the life of the SPVs have been considered
<b>Post-tax Cost of Debt</b>	<b>6.60%</b>	<b>6.60%</b>	<b>6.60%</b>	<b>6.12%</b>	<b>6.37%</b>	<b>Effective cost of debt. Kd = Pre tax Kd * (1-Effective Tax Rate)</b>
Debt/(Debt+Equity)	70.00%	70.00%	70.00%	70.00%	70.00%	The debt - equity ratio computed as [D/(D+E)] is considered as 70% as per industry standard.
<b>WACC Adopted</b>	<b>8.37%</b>	<b>8.37%</b>	<b>8.37%</b>	<b>7.95%</b>	<b>8.17%</b>	<b>WACC = [Ke*(1-D/(D+E))]+[Kd*(1-t)*(D/(D+E))]</b>

## Appendix 2 – Weighted Average Cost of Capital of the SPVs (2/2)

Particulars	TSEC	TSETPL	PLG	USUPL	Remarks
Risk Free Rate (Rf)	6.71%	6.71%	6.71%	6.71%	Risk Free Rate has been considered based on zero coupon yield curve as at 31 <sup>st</sup> March 2021 of Government Securities having maturity period of 10 years, as quoted on CCIL's website.
Equity Risk Premium (ERP)	7.00%	7.00%	7.00%	7.00%	Based on the historical realized returns on equity investments over a risk free rate of as represented by 10 year government bonds, a 7% equity risk premium is considered appropriate for India.
Beta (relevered)	0.80	0.78	0.83	0.83	Beta has been considered based on the beta of companies operating in the similar kind of business in India.
Base Cost of Equity	12.30%	12.19%	12.50%	12.53%	Base Ke = Rf + ( $\beta$ x ERP)
Company Specific Risk Premium (CSRP)	0.00%	0.00%	0.00%	0.00%	Risk Premium/ Discount Specific to the SPVs
<b>Adjusted Cost of Equity (Ke)</b>	<b>12.30%</b>	<b>12.19%</b>	<b>12.50%</b>	<b>12.53%</b>	<b>Adjusted Ke = Rf + (<math>\beta</math> x ERP) + CSRP</b>
Pre-tax Cost of Debt	8.00%	8.00%	8.00%	8.00%	As represented by the Investment Manager
Effective tax rate of SPV	21.88%	24.23%	17.66%	16.99%	Average tax rate for the life of the SPVs have been considered
<b>Post-tax Cost of Debt</b>	<b>6.25%</b>	<b>6.06%</b>	<b>6.59%</b>	<b>6.64%</b>	<b>Effective cost of debt. Kd = Pre tax Kd * (1-Effective Tax Rate)</b>
Debt/(Debt+Equity)	70.00%	70.00%	70.00%	70.00%	The debt - equity ratio computed as $[D/(D+E)]$ is considered as 70% as per industry standard.
<b>WACC Adopted</b>	<b>8.07%</b>	<b>7.90%</b>	<b>8.36%</b>	<b>8.41%</b>	<b>WACC = <math>[Ke*(1-D/(D+E))]+[Kd*(1-t)*(D/(D+E))]</math></b>

### Appendix 3.1 – TNSEPL: Summary of approvals and licences (1/2)

Sr. No	Approvals	Date of Issue	Validity (in years)	Issuing Authority
1	Consent to Establish - Air, required u/s 21 of Air Act 1981			
	5 MW Solar Power Plant	10-Aug-15	NA	Tamilnadu Pollution Control Board
	8 MW Solar Power Plant	3-Nov-15	NA	Tamilnadu Pollution Control Board
	10 MW Solar Power Plant	12-Feb-16	NA	Tamilnadu Pollution Control Board
2	Consent to Establish - Water, required u/s 25 of Water Act, 1974			
	5 MW Solar Power Plant	10-Aug-15	NA	Tamilnadu Pollution Control Board
	8 MW Solar Power Plant	3-Nov-15	NA	Tamilnadu Pollution Control Board
	10 MW Solar Power Plant	12-Feb-16	NA	Tamilnadu Pollution Control Board
3	Consent to Operate - Air, required u/s 21 of Air Act 1981			
	8 MW Solar Power Plant	15-Sep-15	NA	Tamilnadu Pollution Control Board
	10 MW Solar Power Plant	12-Feb-16	NA	Tamilnadu Pollution Control Board
4	Consent to Operate - Water, required u/s 25 of Water Act, 1974			
	8 MW Solar Power Plant	3-Nov-16	NA	Tamilnadu Pollution Control Board
	10 MW Solar Power Plant	12-Feb-16	NA	Tamilnadu Pollution Control Board
5	CEIG Safety Certificate required under Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010 for energization of the electrical equipment comprising the project			
	5 MW Solar Power Plant	26-Nov-15	Valid	Electrical Inspector
	8 MW Solar Power Plant	25-Sep-15	Valid	Electrical Inspector
	10 MW Solar Power Plant	25-Sep-15	Valid	Electrical Inspector
6	Power Evacuation Approval for evacuation of power from the solar power plant to TANGEDCO Substation			
	5 MW Solar Power Plant	26-Dec-15	Valid	TANGEDCO
	8 MW Solar Power Plant	26-Sep-15	Valid	TANGEDCO
	10 MW Solar Power Plant	28-Oct-15	Valid	TANGEDCO

Source: Investment Manager



### Appendix 3.1 – TNSEPL: Summary of approvals and licences (2/2)

Sr. No	Approvals	Date of Issue	Validity (in years)	Issuing Authority
7	Commissioning Certificate (COD) for evidencing commissioning of the entire capacity of the project			
	5 MW Solar Power Plant	19-Oct-15	Valid	Superintending Engineer, TANGEDCO
	8 MW Solar Power Plant	30-May-16	Valid	Superintending Engineer, TANGEDCO
	10 MW Solar Power Plant	28-Dec-15	Valid	Superintending Engineer, TANGEDCO
8	Fire License required u/s 13 of Tamil Nadu Fire Service Act 1985			
	10 MW Solar Power Plant	25-Jun-20	1	District Officer-Fire & Rescue Service
9	Factory License obtained under Form No.4 Registration and License to work a factory			
	5 MW Solar Power Plant	24-Jan-20	Valid	Joint Director
	8 MW Solar Power Plant	23-Jan-20	Valid	Joint Director
	10 MW Solar Power Plant	31-Dec-20	Valid	Joint Director
10	NOC from Gram Panchayat for undertaking construction on any land falling within the jurisdiction of the gram panchayat			
	5 MW Solar Power Plant	6-Jul-15	Valid	Village Panchayat
	8 MW Solar Power Plant	21-May-15	Valid	Village Panchayat
	10 MW Solar Power Plant	25-Mar-15	Valid	Village Panchayat

Source: Investment Manager

### Appendix 3.2 – UMD: Summary of approvals and licences

Sr. No	Approvals	Date of Issue	Validity (in years)	Issuing Authority
1	Consent to Establish - Air, required u/s 21 of Air Act 1981			
	12 MW Solar Power Plant	25-Jun-15	NA	Tamilnadu Pollution Control Board
	13 MW Solar Power Plant	29-Sep-15	NA	Tamilnadu Pollution Control Board
2	Consent to Establish - Water, required u/s 25 of Water Act, 1974			
	12 MW Solar Power Plant	25-Jun-15	NA	Tamilnadu Pollution Control Board
	13 MW Solar Power Plant	29-Sep-15	NA	Tamilnadu Pollution Control Board
3	Consent to Operate - Air, required u/s 21 of Air Act 1981			
	12 MW Solar Power Plant	20-Dec-15	NA	Tamilnadu Pollution Control Board
4	Consent to Operate - Water, required u/s 25 of Water Act, 1974			
	12 MW Solar Power Plant	20-Dec-15	NA	Tamilnadu Pollution Control Board
5	CEIG Safety Certificate required under Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010 for energization of the electrical equipment comprising the project			
	12 MW Solar Power Plant	4-Nov-15	Valid	Electrical Inspector
	5 MW (out of 13 MW) Solar Power Plant	21-Mar-16	Valid	Electrical Inspector
	8 MW (out of 13 MW) Solar Power Plant	21-Mar-16	Valid	Electrical Inspector
6	Power Evacuation Approval for evacuation of power from the solar power plant to TANGEDCO Substation			
	12 MW Solar Power Plant	12-Nov-15	Valid	TANGEDCO
	13 MW Solar Power Plant	17-Mar-16	Valid	TANGEDCO
7	Commissioning Certificate (COD) for evidencing commissioning of the entire capacity of the project			
	12 MW Solar Power Plant	2-Dec-15	Valid	Superintending Engineer, TANGEDCO
	13 MW Solar Power Plant	7-May-16	Valid	Superintending Engineer, TANGEDCO
8	Fire License required u/s 13 of Tamil Nadu Fire Service Act 1985			
	13 MW Solar Power Plant	25-Jun-20	1	District Officer-Fire & Rescue Service
9	Factory License obtained under Form No.4 Registration and License to work a factory			
	13 MW Solar Power Plant	22-Dec-20	Valid	Joint Director
10	NOC from Gram Panchayat for undertaking construction on any land falling within the jurisdiction of the gram panchayat			
	12 MW Solar Power Plant	11-Apr-15	Valid	Village Panchayat
	13 MW Solar Power Plant	NA	Valid	Village Panchayat

Source: Investment Manager

### Appendix 3.3 – TKSP: Summary of approvals and licences

Sr. No	Approvals	Date of Issue	Validity (in years)	Issuing Authority
1	Consent to Establish - Air, required u/s 21 of Air Act 1981	13-Jan-16	NA	Tamilnadu Pollution Control Board
2	Consent to Establish - Water, required u/s 25 of Water Act, 1974	13-Jan-16	NA	Tamilnadu Pollution Control Board
3	Consent to Operate - Air, required u/s 21 of Air Act 1981	24-Jun-16	NA	Tamilnadu Pollution Control Board
4	Consent to Operate - Water, required u/s 25 of Water Act, 1974	24-Jun-16	NA	Tamilnadu Pollution Control Board
5	CEIG Safety Certificate required under Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010 for energization of the electrical equipment comprising the project	21-Mar-16	Valid	Electrical Inspector
6	Power Evacuation Approval for evacuation of power from the solar power plant to TANGEDCO Substation	16-Mar-16	Valid	TANGEDCO
7	Commissioning Certificate (COD) for evidencing commissioning of the entire capacity of the project	29-Mar-16	Valid	Superintending Engineer, TANGEDCO
8	Fire License required u/s 13 of Tamil Nadu Fire Service Act 1985	27-Nov-20	1	District Officer-Fire & Rescue Service
9	Factory License obtained under Form No.4 Registration and License to work a factory	3-Dec-18	Valid	Joint Director
10	NOC from Gram Panchayat for undertaking construction on any land falling within the jurisdiction of the gram panchayat	NA	NA	Village Panchayat

Source: Investment Manager

#### Appendix 3.4 – TRSPL: Summary of approvals and licences

Sr. No	Approvals	Date of Issue	Validity (in years)	Issuing Authority
1	CEIG Safety Certificate required under Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010	24-Sep-18	Valid	Electrical Inspector
2	Power Evacuation Approval for evacuation of power from the solar power plant to TANGEDCO Substation	24-Sep-18	Valid	TANGEDCO
3	Commissioning Certificate (COD) for evidencing commissioning of the entire capacity of the project	24-Oct-18	Valid	Superintending Engineer, TANGEDCO
4	Fire License required u/s 13 of Tamil Nadu Fire Service Act 1985	23-Sep-20	1	District Officer-Fire & Rescue Service
5	Factory License obtained under Form No.4 Registration and License to work a factory	30-Aug-19	Valid	Joint Director
6	NOC from Gram Panchayat for undertaking construction on any land falling within the jurisdiction of the gram panchayat	25-Sep-20	NA	Village Panchayat
7	Registration under the Clean Development Mechanism of United Nations Framework Convention on Climate Change	13-Aug-19	Valid	NA

Source: Investment Manager

### Appendix 3.5 – Solar Edge: Summary of approvals and licences

Sr. No	Approvals	Date of Issue	Validity (in years)	Issuing Authority
1	CEIG Safety Certificate required under Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010			
	80 MW Solar Power Plant, Parli	12-Jan-18	Valid	Electrical Inspector
	50 MW Solar Power Plant, Muktainagar	17-May-18	Valid	Electrical Inspector
2	Power Evacuation Approval for evacuation of power from the solar power plant to Maharashtra State Electricity Transmission Co. Ltd. ("MSETCL") Substation			
	80 MW Solar Power Plant, Parli	1-Feb-18	Valid	MSETCL
	50 MW Solar Power Plant, Muktainagar	21-Mar-18	Valid	MSETCL
3	Commissioning Certificate (COD) for evidencing commissioning of the entire capacity of the project			
	50 MW Solar Power Plant, Parli	1-Aug-18	Valid	General Manager
	30 MW Solar Power Plant, Parli	1-Aug-18	Valid	General Manager
	50 MW Solar Power Plant, Muktainagar	1-Aug-18	Valid	General Manager
4	NOC from Gram Panchayat for undertaking construction on any land falling within the jurisdiction of the gram panchayat			
	50 MW Solar Power Plant, Parli	1-May-17	Valid	Village Panchayat
	30 MW Solar Power Plant, Parli	2-May-17	Valid	Village Panchayat
	50 MW Solar Power Plant, Muktainagar	3-Jun-17	Valid	Village Panchayat
5	Borewell/Ground water permission from Central Ground Water Authority			
	50 MW Solar Power Plant, Muktainagar	28-May-18	Valid	Senior Geologist
6	Factory License obtained to work a factory			
	50 MW Solar Power Plant, Parli	12-Jul-21	Valid	Joint Director
	30 MW Solar Power Plant, Parli	13-Jul-21	Valid	Joint Director
	50 MW Solar Power Plant, Muktainagar	17-Feb-21	Valid	Joint Director
7	Registration under the Clean Development Mechanism of United Nations Framework Convention on Climate Change (if any)	13-Aug-19	Valid	NA

Source: Investment Manager

### Appendix 3.6 – TSEC: Summary of approvals and licences

Sr. No	Approvals	Date of Issue	Validity (in years)	Issuing Authority
1	Consent to Establish - Air, required u/s 21 of Air Act 1981	9-Nov-12	NA	Gujarat Pollution Control Board
2	Consent to Establish - Water, required u/s 25 of Water Act, 1974	9-Nov-12	NA	Gujarat Pollution Control Board
3	Consent to Operate - Air, required u/s 21 of Air Act 1981	30-Aug-13	NA	Gujarat Pollution Control Board
4	Consent to Operate - Water, required u/s 25 of Water Act, 1974	30-Aug-13	NA	Gujarat Pollution Control Board
5	Letter of Registration/Allotment for the allotment of a 15 MW project in favour of TSEC, being developed in Charanka Solar Park, Gujarat.	28-May-10	Valid	Energy and Petrochemicals Department, Government of Gujarat
6	CEIG Safety Certificate required under Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010 for energization of the electrical equipment comprising the project	31-Jan-12 and 15-Mar-12	Valid	Chief Electrical Inspector, Government of Gujarat
7	Power Evacuation Approval for evacuation of power from the solar power plant to the 66kV Dahisar substation of Gujarat Energy Transmission Corporation Limited ("GETCO")	4-Jul-11	Valid	GETCO
8	Commissioning Certificate (COD) for evidencing commissioning of the entire capacity of the project			
	14.92 MW Solar Power Plant	17-Apr-12	Valid	Gujarat Energy Development Authority
	0.08 MW Solar Power Plant	7-Nov-12	Valid	Gujarat Energy Development Authority

Source: Investment Manager

### Appendix 3.7 – PLG: Summary of approvals and licences

Sr. No	Approvals	Date of Issue	Validity (in years)	Issuing Authority
1	Consent to Establish - Air, required u/s 21 of Air Act 1981	18-Nov-11	NA	Gujarat Pollution Control Board
2	Consent to Establish - Water, required u/s 25 of Water Act, 1974	18-Nov-11	NA	Gujarat Pollution Control Board
3	Consent to Operate - Air, required u/s 21 of Air Act 1981	14-Mar-12	NA	Gujarat Pollution Control Board
4	Consent to Operate - Water, required u/s 25 of Water Act, 1974	14-Mar-12	NA	Gujarat Pollution Control Board
5	Letter of Registration/Allotment for the allotment of a 20 MW solar power project in favour of PLG, being developed at Patan, Gujarat	16-Oct-10	Valid	Energy and Petrochemicals Department, Government of Gujarat
6	CEIG Safety Certificate required under Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010 for energization of the electrical equipment comprising the project	20-Jan-12	Valid	Chief Electrical Inspector, Government of Gujarat
7	Power Evacuation Approval for evacuation of power from the solar power plant to 220/400 kV substation of GETCO	20-Aug-11	Valid	GETCO
8	Commissioning Certificate (COD) for evidencing commissioning of the entire capacity of the project	23-Feb-12	Valid	Gujarat Energy Development Authority
9	NOC from Gram Panchayat for undertaking construction on any land falling within the jurisdiction of the gram panchayat	3-Sep-11	Valid	Dahisar Village Panchayat

Source: Investment Manager

### Appendix 3.8 – TSETPL: Summary of approvals and licences

Sr. No	Approvals	Date of Issue	Validity (in years)	Issuing Authority
1	Consent to Establish - Water, required u/s 25 of Water Act, 1974	23-Feb-10	NA	Rajasthan State Pollution Control Board
2	Consent to Operate - Water, required u/s 25 of Water Act, 1974	3-Nov-15	NA	Rajasthan State Pollution Control Board
3	Letter of Registration/Allotment for allotment of a 5 MW solar power project in favour of TSETPL, being developed at village Tinwari, district Jodhpur, Rajasthan.	2-Mar-09	Valid	Rajasthan Renewable Energy Corporation Limited
4	CEIG Safety Certificate required under Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010 for energization of the electrical equipment comprising the project	22-Nov-11	Valid	Electrical Inspector, Government of Rajasthan
5	Power Evacuation Approval for evacuation of power from the solar power plant to 220 kV Tinwari grid substation through a 33 kV line	24-Dec-10	Valid	Rajasthan Rajya Vidyut Prasaran Nigam Limited
6	Interconnection Approval for interconnection of the project to the 220kV grid substation	11-Oct-11	Valid	Rajasthan Rajya Vidyut Prasaran Nigam Limited
7	Commissioning Certificate (COD) for evidencing commissioning of the entire capacity of the project	21-Oct-11	Valid	Rajasthan Renewable Energy Corporation Limited

Source: Investment Manager



### Appendix 3.9 – USUPL: Summary of approvals and licences

Sr. No	Approvals	Date of Issue	Validity (in years)	Issuing Authority
1	Letter of Registration/Allotment for the allotment of 30 MW solar project in favour of Sukhbir Agro Energy Limited (the erstwhile sellers)	2-Feb-15	Valid	Uttar Pradesh New & Renewable Energy Development Agency ("UPNREDA")
2	CEIG Safety Certificate required under Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010 for energization of the electrical equipment comprising the project	14-Sep-16	Valid	Chief Electrical Inspector, Government of Uttar Pradesh
3	Power Evacuation Approval for evacuation of power from the solar power plant to the 132 kV Panwari substation	10-Nov-15	Valid	Uttar Pradesh Power Transmission Corporation Limited ("UPPTCL")
4	NOC from Gram Panchayat for undertaking construction on any land falling within the jurisdiction of the gram panchayat	16-Nov-15	Valid	Village Panchayat
5	Commissioning Certificate (COD) for evidencing commissioning of the entire capacity of the project	15-Sep-16	Valid	UPPTCL, UPNREDA and Dakshinanchal Vidyut Vitran Nigam Limited

Source: Investment Manager

### Appendix 3.10: Summary of pending applications for licences

Sr. No	Applications	Date of Application
1	Renewal application for factories license made for 50 MW (AC) (Parli) Solar Edge power project	31-Jan-21
2	Renewal application for factories license made for 30 MW(AC) (Parli) Solar Edge power project	31-Jan-21
3	Application for issue of no objection certificate to abstract ground water made to Central Ground Water Authority by USUPL	20-May-20
4	Application for issue of no objection certificate to abstract ground water made to Central Ground Water Authority by PLG	30-Jun-19
5	Renewal application for fire license made for 13 MW(AC) UMD power project	15-Jun-21
6	Renewal application for fire license made for 10 MW(AC) TNSEPL power project	23-Jun-21
7	Application for fire NOC made to Jodhpur Municipal Corporation by TSETPL	15-Oct-20
8	<b>Applications yet to be made:</b>	
	Fire NOC Application yet to made by Solar Edge	
	50 MW Solar Power Plant, Parli	
	30 MW Solar Power Plant, Parli	
	50 MW Solar Power Plant, Muktainagar	

Source: Investment Manager

## Appendix 4 – Summary of Ongoing Litigations (1/3)

Sr. No	Matter	Pending Before	SPVs Involved	Particulars	Amount Involved (INR Lacs)
1	Civil Suit	Supreme Court of India	PLG & TSEC	<p><b>Background:</b> GUVNL had filed a petition before the GERC praying for the revision of the tariff for the solar energy projects determined in the GERC Tariff Order on the ground that the capital cost considered by the GERC in the GERC Tariff Order was much higher than the actual project cost incurred by many of the solar developers on account of sufficient reduction in capital cost on account of exemption in excise duty and customs duty. The GERC, however, dismissed the petition as not being maintainable as it was filed after a considerable lapse of time. Following this, an appeal was filed by GUVNL against the GERC's order before the APTEL. The APTEL dismissed GUVNL's petition on similar grounds and subsequently an appeal was filed by GUVNL against the APTEL's order in the Supreme Court.</p> <p><b>Current Status:</b> Hearing is pending before Supreme Court of India</p>	Not Quantifiable
2	Appeal	Tamil Nadu Electricity Regulatory Commission ("TNERC")	TKSPL, TNSEPL and UMD	<p><b>Background of the case:</b> National Solar Federation of India ("NSFI") on behalf of TKSPL, TNSEPL and UMD filed a petition before the TNERC against TANGEDCO, State Load Dispatch Centre ("SLDC") and Tamil Nadu Transmission Corporation Limited ("TANTRANSCO") regarding the non-payment of units for electricity supplied by TKSPL, TNSEPL and UMD and excess of units corresponding to 19% CUF availed by the SLDC. The petition challenged the circular issued by the SLDC dated June 14, 2016 ("Circular") as being wholly arbitrary and illegal and contrary to the provisions of the Electricity Act 2003 and TNERC tariff orders. The petition sought to set aside the Circular stay the operation of the Circular and refund the amount wrongly deducted. By way of an order dated December 20, 2020, the TNERC has disallowed the petition and stated that payments made to the solar power generators shall be limited to the annual generation that corresponds to the annual CUF of 19%. An appeal has been filed by NSFI before APTEL on February 18, 2021 against the TNERC order</p> <p><b>Current Status:</b> The matter is currently pending.</p>	2,440
3	Appeal	Appellate Tribunal for Electricity (APTEL)	TKSPL, TNSEPL, UMD and TRSPL ("TN Assets")	<p><b>Background of the case:</b> SLDC issued certain backing down instructions to TN Assets. The same were challenged by the NSFI on behalf of Solar Entities before the TNERC. The TNERC by way of an order dated March 25, 2019 ("TNERC Order") held that the SLDC should not resort to back down instructions without recording a reason. On the issue of deemed generation benefits, TNERC observed that it has already instructed the SLDC to not to resort to back down instructions without reasons and that no provision in the purchase agreements pertains to payment of deemed generation charges. Therefore, no deemed generation benefits were awarded. The TNERC Order was challenged by NSFI before the ATE to (i) provide a direction to the TANGEDCO, SLDC, TANTRANSCO and MNRE to implement 'must run' status on all solar power plants under regulation 5.2 of the CERC (Indian Electricity Grid Code) Regulations 2010; and (ii) issue a direction to consider deemed generation benefits to the solar power plants for the loss of generation due to backing down instructions of the respondents under regulation 2(q), TNERC (terms and conditions for determination of tariff) Regulations, 2015.</p> <p><b>Current Status:</b> Arguments regarding Load shedding have concluded. However, the matter is going to be re-heard on July 2, 2021 and July 5, 2021.</p>	Not Quantifiable

Source: Investment Manager

## Appendix 4 – Summary of Ongoing Litigations (2/3)

Sr. No	Matter	Pending Before	SPVs Involved	Particulars	Amount Involved (INR Lacs)
4	Petition	Central Electricity Regulatory Commission (CERC)	Solar Edge	<p><b>Background of the case:</b> Solar Edge has filed a petition dated June 24, 2019 before the CERC, New Delhi against SECI and MSEDCL, claiming the effect of 'change in law' as per the provisions of the PPA entered into between Solar Edge with SECI. The change in law claims are made as a consequence of additional tax burden on construction, operation and maintenance of the solar power generating system on account of imposition of Central Goods and Services Tax Act, 2017, the Integrated Goods and Services Tax Act, 2017, the State Goods and Services Tax Act, 2017 ("GST Laws").</p> <p>Subsequently, SECI has filed a petition dated June 4, 2020 before the CERC, New Delhi wherein various solar power developers ("SPDs") and distributor companies are made respondents to the matter, to seek directions from CERC to formulate a mechanism for payment of compensation to the SPDs in light of the above outstanding matter. SECI has sought this amount payable on account of GST Laws from distribution companies so that SECI may make this payment to the SPDs under the respective PPAs.</p> <p><b>Current Status:</b> Both the matters are pending.</p>	2,100
5	Petition	Taluka Court at Muktainagar	Solar Edge	<p><b>Background of the case:</b> According to the petition filed against Solar Edge and Sarpanch of Wadhve, Solar Edge is not having the grampanchayat NOC for setting up of Plant with sign and seal of sarpanch. The case has been filed by the previous sarpanch himself.</p> <p><b>Current Status:</b> Next hearing yet to be notified by the Taluk Court.</p>	Not Quantifiable
6	Petition	Court of Muktainagar Civil Judge (Jr. Divi.)	Solar Edge	<p><b>Background of the case:</b> Solar Edge, under erstwhile management, had purchased land in gut 169 of Wadve for the 50MW Muktainagar solar power plant from Mr. Jeevan Ram Patel pursuant to sale deed dated May 16, 2017. Mrs. Surekha Patil ("Plaintiff") has filed suit at the Court of Civil Judge, Junior Division at Muktainagar ("Civil Court, Muktainagar"), against Mr. Jeevan Ram Patel, Solar Edge and others ("Defendants"), stating that disputed land is in her ownership and occupation, the land was not sold to Mr. Jeevan Ram Patel and that it was provided as security for the purposes of loan availed from Mr. Jeevan Ram Patel. The Plaintiff, inter alia, has requested the court to transfer the sale deed of the property to her name and a permanent prohibitory order against the Defendants that there should not be any objection and obstruction to the Plaintiff and her family occupying the suit property. The Plaintiff has also made an application to Civil Court, Muktainagar to obtain a temporary prohibitory order to not allow any objection or obstruction by the Defendants for the Plaintiff's possession of the suit property and the temporary prohibitory order should be kept permanent till the judgement is pronounced.</p> <p>Further, in terms of the indemnity provisions of the Amended and Restated Securities Subscription and Purchase Agreement for acquisition of the Solar Edge from Shapoorji Pallonji Solar Holdings Private Limited and Shapoorji Pallonji Infrastructure Capital Company Private Limited ("SPICCPCL"), SPICCL shall represent Solar Edge in this matter.</p> <p><b>Current Status:</b> The matter is currently pending.</p>	Not Quantifiable
7	Petition	District munsif cum Judicial court/Vilathikulam	TNSEPL	<p><b>Background of the case:</b> A petition dated November 5, 2015 was filed by Mehalingam and others before the District Munsif Cum Judicial Magistrate, Vilathikulam seeking permanent injunction to restrain TNSEPL from erecting electrical polls and cause any interference to the peaceful enjoyment of their property. An ex parte decree was passed on September 6, 2018 ("2018 Order") in favour of Mehalingam and others. A petition dated December 11, 2019 was filed by TN Solar before the District Munsif Vilathikulam to set aside 2018 Order along with a petition dated December 11, 2019 for condonation of delay of filing the written statement in relation to the 2018 Order.</p> <p><b>Current Status:</b> Petitions have been filed but hearing is not decided.</p>	Not Quantifiable

## Appendix 4 – Summary of Ongoing Litigations (3/3)

Sr. No	Matter	Pending Before	SPVs Involved	Particulars	Amount Involved (INR Lacs)
8	Petition	Bombay High Court	Solar Edge	<p><b>Background of the case:</b> Solar Edge has filed a writ petition dated December 15, 2020 before the Bombay High Court against the MERC and others challenging the MERC (Forecasting, Scheduling and Deviation Settlement for Solar and Wind Generation) Regulations, 2018 ("F&amp;S Regulations") on grounds including, (i) the F&amp;S Regulations being arbitrary, onerous in nature and hence violative of Article 14 of the Constitution of India, (ii) the charges levied on the renewables project having no nexus to the objective of grid security, leading to unjust charges being sought from the renewables energy generators.</p> <p><b>Current Status:</b> The matter is currently pending adjudication.</p>	Not Quantifiable
9	Petition	Bombay High Court, Aurangabad	Solar Edge	<p><b>Background of the case:</b> Solar Edge had bought a parcel of land (admeasuring 3 hectare or ~8.5 acres) situated at Gut No 541, Village Hartale, Muktainagar and currently a part of the solar project is operational on this parcel. This parcel is subject to claim by an heir of an earlier land owner ("Claimant"). As on date the 7/12 extract reflects the borrower as the owner of the parcel.</p> <p>Ex-parte order was passed by Maharashtra Revenue Tribunal ("MRT") in an application by the Claimant challenging the mutation order passed to record the names of the Sellers. It may be noted that MRT order was passed on technical grounds of jurisdiction and at no stage the ownership of Claimant has been upheld.</p> <p><b>Current Status:</b> Solar Edge filed a writ petition with Aurangabad High Court and the Court has stayed the MRT award in favor of the heir. Next hearing date is July 27, 2021</p>	Not Quantifiable
10	Petition	District & Session Court, Tiruvannamalai	TKSPL	<p><b>Background of the case:</b> A Legal Summon from District &amp; Session Court, Tiruvannamalai was received on March 12, 2021 in the matter of purchase of 3.0 acres of land in Survey No. 7/1 at 30 MW Tiruvannamalai site of the Company. TKSPL has responded to the legal notice maintaining that , it purchased the property from legal heirs and it is in exclusive enjoyment and possession of the property</p> <p><b>Current Status:</b> Next hearing yet to be notified.</p>	Not Quantifiable
11	Petition	Madras High Court	TKSPL, TNSEPL, UMD and TRSPL ("TN Assets")	<p><b>Background of the case:</b> TN Assets have filed a writ petition under Article 226 of the Constitution of India before the Madras High Court against TNERC, TANGEDCO and others on June 15, 2021 challenging the TNERC Forecasting Scheduling and Deviation Settlement and Related Matters for Wind and Solar Generation Regulations 2019 dated March 1, 2019 and Procedure for TNERC Forecasting Scheduling and Deviation Settlement and Related Matters for Wind and Solar Generation Regulations 2019 dated October 3, 2020 ("TN F&amp;S Regulations") on grounds including, among others (i) the TN F&amp;S Regulations seek to treat the renewable energy projects like wind and solar at par with conventional thermal power stations which is arbitrary since it is not possible to give accurate projections on how the weather condition will impact their generation at a given point of time of day; (ii) the TN F&amp;S Regulations have sought to fix the absolute error band at (+/- 10%) which is a much narrower and tightened error band than compared to other similarly placed renewable energy generating rich states as well as the Forum of Regulators Model Regulations (at +/- 15%); and (iii) the TN F&amp;S Regulations do not include provisions pertaining to aggregation of generation schedules among pooling substations at the state level.</p>	Not Quantifiable

Source: Investment Manager

## Appendix 5 – Summary of Tax Notices

Date of Notice	SPV	Pertaining to AY	Notice u/s (Income Tax Act, 1961)	Date of Reply	Pending Before	Remarks
23-Sep-19	Solar Edge	AY 18-19	Sections 143(2), 143(3)	13-Mar-20	Jurisdictional Officer	Regular Assessment
9-Nov-19	Solar Edge	AY 18-19	Sections 142(1), 143(3)	13-Mar-20	Jurisdictional Officer	Regular Assessment
25-Feb-20	Solar Edge	AY 18-19	Section 279(1)	Adjournment	CIT(TDS)-2	Default amount INR 260 Lacs: Delay in deposit of TDS as per notice. Penalty yet to be determined
15-Jan-21	Solar Edge	AY 18-19	Sections 142(1)	01-Feb-21 & 17-Feb-21	Jurisdictional Officer	Regular Assessment
8-Apr-21	Solar Edge	AY 18-19	Sections 143(3), Penalty Notice u/s 274 read with 270A	31-May-21	Jurisdictional Officer	The Company has filed an appeal against the Assessment Order on 31st May 2021
4-Feb-20	Solar Edge	AY 19-20	Sections 143(i)a	NA	Jurisdictional Officer	Regular Assessment
21-Jan-21	Solar Edge	AY 18-19	Sections 143(i)a	NA	Jurisdictional Officer	Regular Assessment
21-Jan-19 & 11-Oct-19	TKSPL	AY 16-17	Sections 148	8-Jun-21	DCIT	The Company intimated the Department vide mail dated 8th Jun 2021 in this regard and also sought the basis for initiation of the reassessment proceedings
20-Dec-19	UMD	AY 16-17	Section 271(1)(c)	Not Available	Jurisdictional Officer	The assessing officer made an addition u/s 68 amounting INR 22.2 Lacs considering a portion of dividend, which was to be exempted, as unexplained cash credit. UMD has filed appealed against the same

Source: Investment Manager

<<End of Report>>

## **ANNEXURE II - TECHNICAL REPORT**

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Virescent Infrastructure

5MW(AC) Dindigul Solar PV Plant

TN Solar Power Energy Pvt Ltd

Technical Assessment Report

May 2021





## Report Details

<b>Prepared for:</b>	Virescent Infrastructure
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<b>Report Classification:</b>	Confidential

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<b>Reviewed by</b>	Ahmed Dalvi	Sr. Project Engineer	
<b>Authorised by</b>	Arif Aga	Director	
<b>Date of Issue</b>	28 May 2021		



**Amendment Records**

Revision Number	Date	Purpose of Revision	Summary of Amendments
A1	09 February 2021	Draft Issue	-
B1	09.02.2021	For Client Issue	-
B2	19.02.2021	For Client Issue	Minor Changes
B3	22.02.2021	For Client Issue	Finalisation of Report
B4	28.05.2021	For Client Issue	Generation Analysis updated

SF/04/023

**NOTICE**

This document entitled “5MW Dindigul Solar PV plant Technical Assessment Report”, document number 6.21/6001/006/PUN/B4 has been prepared solely for Virescent Infrastructure in connection with the 5MW Solar PV Plant. This document in whole or in part may not be used by any person for any purpose other than that specified, without the express written permission of SgurrEnergy.

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## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 13MW<sub>AC</sub> Universal Mine Developers and Service Providers Pvt Ltd (the Project). The Project is located near Kovilpatti village, in Thoothukudi district of Tamil Nadu.

The summary of the technical assessment is captured in the below table.

**Table 1-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	<p>The project site lies around the coordinates 10°29'29.84"N and 78° 3'45.68"E and is located near the Vendasandur village, in Dindigul district of Tamil Nadu.</p> <p>Project is contracted for generating 5MW<sub>AC</sub> power. The Owner has utilised approximately 22 acres of land for the project.</p> <p>Project is implemented with poly-crystalline modules (JA Solar) and central inverters (ABB). The module mounting structure is implemented with a tilt of 8° for a pitch of 6m.</p> <p>The power generated from the TNSPEPL 5MW<sub>AC</sub> PV plant is fed to Eriyodu substation, through a single circuit transmission line.</p> <p>The total DC installed capacity stands at 6MW<sub>p</sub>. The AC installed capacity stands at 5MW<sub>AC</sub> with 5 inverters of capacity 1,000kW each.</p>
2	PV Module	<p>SgurrEnergy has conducted a desktop review of JA Solar assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard. SgurrEnergy considers the warranty period to be in line with the industry standards. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.</p>
3	Inverter	<p>ABB is considered to have good track record for supplying central inverters. Certificates mentioned in the technical specification datasheet indicate ABB to hold adequate certifications. Technical characteristics are acceptable, with a good efficiency level for central inverters. Standard warranty of five years is provided for the inverters, which is in line with the industry requirement. Overall, SgurrEnergy does not raise any concern on the utilization of ABB inverters for the Project.</p>
4	Inverter Transformer	<p>The inverter transformers (2200kVA) used within the project are manufactured by Voltamp Transformers Limited. The manufacturers have a good track record of supplying transformers to distinguished customers in Indian as well as in the global market. SgurrEnergy has reviewed the transformers based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with</p>



Sr. No.	Parameter	Comment
		industry standards and raises no concerns over its use in the project
5	String Sizing	The VOC does not exceed the inverter input voltage for the site, and therefore, SgurrEnergy considers the number of modules in series to be acceptable for the PV Project.
6	Permits and Approvals	PPA signed between TN Solar Power Energy Ltd and Tamil Nadu Generation and Distribution Corporation Limited PPA term is 25 years from the Commercial Operation Date. Documents such as CEIG certificate, commissioning certificate, consent to operate etc. have not been provided.
7	Resource Assessment	For resource analysis, SEI has compared various satellite datasets. For the satellite databases, SEI has compared Meteonorm 7, NASA, SWERA and SolarGIS data to find the most suitable solar resource for long-term energy yield prediction. Owing to low uncertainty and high resolution, SEI considers SolarGIS dataset to be the most representative satellite database among all the satellite databases for long-term energy yield assessment.
8	Operational Analysis and Generation Comparison	<p>SgurrEnergy was provided with plant and grid availability records from February 2016 to December 2020 for the solar PV plant. In addition, the irradiation measurement records were also provided from April 2016 to December 2020.</p> <p>SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer for the period from April 2016 to December 2020.</p> <p>Overall the average grid availability experienced on site for the operational period was calculated to be 98.13% which is considered to be lower than the expected range. Correspondingly the average plant availability is noted to be 99.9% which is considered to be within expected range.</p> <p>Furthermore, SgurrEnergy observed that the overall recorded generation is approximately 1.47% higher than the generation predicted on site. Overall SgurrEnergy considers the PV plant to be performing in line with SgurrEnergy's prediction.</p>
9	Allied Components and Systems	<p>The 5MW<sub>AC</sub> solar PV plant is designed with JA solar (310/315Wp) solar PV modules and ABB 1000kW central inverter.</p> <p>The 5MW<sub>AC</sub> solar PV plant has been configured with 5 ABB 1000kW central inverters and two inverter stations. One inverter station of 4MW<sub>AC</sub> capacity contains four inverters of 1000MW capacities and two 3-winding transformers of 2.2MVA capacities. While one inverter station of 1MW<sub>AC</sub> capacity consists of one inverter of 1000kW capacity and one two-winding, 1.1MVA transformer.</p> <p>The 11kV output of each inverter station combined at 11kV main HT panel located within Main control room (MCR). Further the power is fed from main HT panel to 11kV plant end metering yard.</p>



Sr. No.	Parameter	Comment	
		Further the power from the metering yard is then evacuated to the substation located approximately 1.9kms from the Project site through ACSR dog conductor overhead transmission line.	
10	Energy Yield Assessment	Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for third year of plant operation for the 5 MWAC PV plant.	
		Global Horizontal Irradiation (kWh/m2)	1,986.50
		Global Inclined Irradiation (kWh/m2)	2,011.90
		Sixth Year P50 Energy Yield (MWh/annum)	9,283.12
		Specific Yield (kWh/kWp)	1547.18
		Performance Ratio (PR)	76.90%
		PLF on Contracted Capacity (5 MWAC)	21.19%





## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
m	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon



MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation



## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 258MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of six projects, as presented within Table 1-1.

**Table 1-1: Project Key Summary**

Project Name	SEPEPL – 80MW <sub>AC</sub>	SEPEPL – 50MW <sub>AC</sub>	SPSPL – 50MW <sub>AC</sub>	SPSPPL – 30MW <sub>AC</sub>	TNSPEPL – 5MW <sub>AC</sub> + 8MW <sub>AC</sub> + 10MW <sub>AC</sub>	UMD- 12MW <sub>AC</sub> + 13MW <sub>AC</sub> +
Site Location	18.926°N, 76.395°E, Parli, Maharash- tra, India	21.028°N, 75.985°E, Muktainagar Maharashtra ,India	9.324°N, 77.594°E. Rajapalyam, Tamil Nadu,India	12.344°N, 78.945°E Tiruvannam- alai, Tamil Nadu, India.	5MW <sub>AC</sub> – 10.480°N, 78.061°E Dindigul, Tamil Nadu, India 8MW <sub>AC</sub> – 9.437°N, 78.172°E Aruppukkotai Tamil Nadu, India 10MW <sub>AC</sub> – 9.118°N, 78.107°E Vilathikulam, Tamil Nadu, India	12MW <sub>AC</sub> - 9.554°N, 77.884°E Amathur, Tamil Nadu, India 13MW <sub>AC</sub> - 9.093°N, 77.780°E Kovilpatti, Tamil Nadu, India
Owner	Solar Edge Power and Energy Private Limited (SEPEPL)		Shapoorji Pallonji Suryaprakas h Private Limited (SPSPL)	Shapoorji Pallonji Solar PV Private Limited	TN Solar Power Energy Private Limited	Universal Mine Developers and Service Providers Private Limited
DC / AC Capacity	104.0MW <sub>P</sub> / 80.0MW <sub>AC</sub>	65.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	54.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	36.0MW <sub>P</sub> / 30.0MW <sub>AC</sub>	5MW <sub>AC</sub> – 6.0MW <sub>P</sub> / 5.0MW <sub>AC</sub> 8MW <sub>AC</sub> – 9.6MW <sub>P</sub> / 8.0MW <sub>AC</sub> 10MW <sub>AC</sub> – 12.0MW <sub>P</sub> / 10.0MW <sub>AC</sub>	12MW <sub>AC</sub> - 14.4MW <sub>P</sub> / 12MW <sub>AC</sub> 13MW <sub>AC</sub> - 15.6MW <sub>P</sub> / 13MW <sub>AC</sub>
Commissioning date	50MW <sub>AC</sub> – 08.04.2018 30MW <sub>AC</sub> – 22.04.2018	26.04.2018	26.09.2018	26.03.2016	5MW <sub>AC</sub> – 28.12.2015 8MW <sub>AC</sub> – 28.09.2015 10MW <sub>AC</sub> – 31.10.2015	12MW <sub>AC</sub> – 16.11.2015 13MW <sub>AC</sub> – 21.03.2016

This report presents the evaluation of the 5MW<sub>AC</sub> TNSPEPL Solar PV plant developed by TN Solar Power Energy Private Limited (TNSPEPL). The Solar PV plant under evaluation is located in *Perumpalli* village, *Vedasandur* taluk, *Dindigul* district in Tamil Nadu state. The purpose of this report is to provide a technical appraisal of PV plant under evaluation.



The report focuses on the following key parameters:

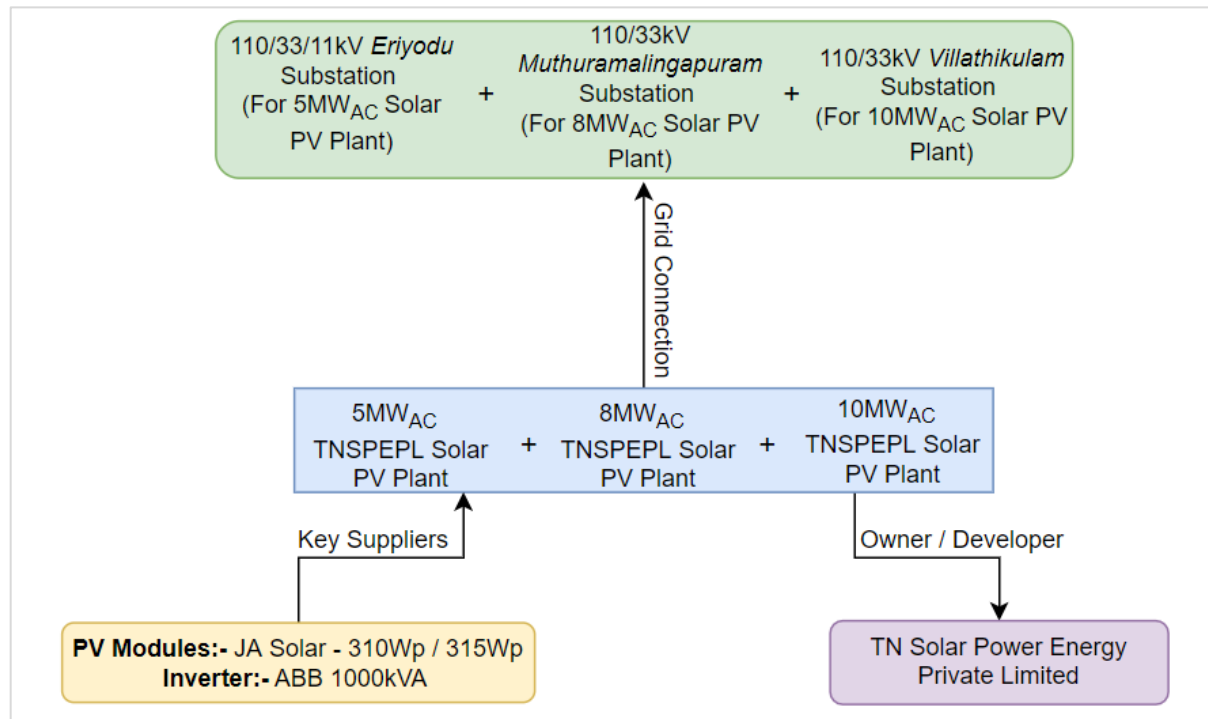
- System Design.
- Major Components.
- Engineering Design.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Plant Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project and is based on information made available by the Client through online dataroom. The main Project characteristic is summarised in



**Table 1-2.**

Figure 1-1 illustrates the project structure indicating key project participants for the 5MW<sub>AC</sub> Solar PV plant.



**Figure 1-1: Project Structure for 5MW<sub>AC</sub> Solar PV Plant**

**Table 1-2: Project Key Summary**

<b>Project Information</b>	
<b>Project Name</b>	5MW <sub>AC</sub> Solar PV plant
<b>Location</b>	5MW <sub>AC</sub> - <i>Dindigul</i> , Tamil Nadu
<b>Developer</b>	TN Solar Power Energy Private Limited
<b>DC/ AC capacity</b>	5MW <sub>AC</sub> PV Plant – 6.0MW <sub>P</sub> / 5.0MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: JA Solar Inverters: ABB
<b>MMS Configuration</b>	Fixed Tilt: 8°, Azimuth: 0°
<b>Commissioning Status</b>	– Commissioning for 5MW <sub>AC</sub> PV Plant was achieved on 28 December 2015.



## 2 5 MW<sub>AC</sub> Solar PV Plant Overview

The project site lies around the coordinates 10°29'29.84"N and 78° 3'45.68"E. Satellite imageries of 5MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1. The Owner has utilised approximately 22 acres of land project. The Project site is located near the Vendasandur village, in Dindigul district of Tamil Nadu.

Project is contracted for generating 5MW<sub>AC</sub> power; SgurrEnergy therefore interprets 5MW<sub>AC</sub> as the maximum AC installed capacity for the solar PV plant.



**Figure 2-1: Satellite image of 5MW<sub>AC</sub> plant**

### 2.1 5MW<sub>AC</sub> Project Summary

Solar PV plant is modular in nature; therefore, TNSPEPL 5MW<sub>AC</sub> solar PV plants is implemented by adopting modularity in designs. 4MW<sub>AC</sub> is the typical inverter station considered for implementing TNSPEPL 5MW<sub>AC</sub> solar PV plant.

Table 2-1 presents the summary of 5MW<sub>AC</sub> PV plant

**Table 2-1: Summary of 5MW<sub>AC</sub> Plant Configurations**

General	
PV Module Technology	Poly-crystalline
Inverter Technology	Central Inverters
Installed DC Peak Capacity (MW <sub>p</sub> )	6
Installed AC Capacity (MW)	5.0
Mounting Type	Fixed Tilt



General	
Tilt Angle (°)	8°
Pitch (m)	6
PV Modules	
PV Module Manufacturer	JA Solar
Model	JAP6-72-310/3BB JAP6-72-315/3BB
Wattage (W <sub>p</sub> )	310W <sub>p</sub> / 315W <sub>p</sub>
Number of Modules per String	21
Inverter	
Inverter Manufacturer / Model	ABB / PVS-800
Inverter Nominal AC Output	1,000kW
Number of Inverters	5
Mounting Structure	
Mounting Structure Details (rows x columns)	2 x 21
Orientation of Modules	Portrait

The 5MW<sub>AC</sub> plant is implemented with two (2) inverter station blocks, one inverter station of capacity 4MW<sub>AC</sub>. Inverter station is comprising of three winding transformers to accommodate 4 x 1,000kVA inverters, taking the individual inverter station size to 4MW<sub>AC</sub>. Inverter station is comprising of a physical block connecting to 4.8MW<sub>p</sub> of installed photovoltaic array. The output of 4MW<sub>AC</sub> inverter station is connected to 0.400/0.400/11kV three winding transformer of 2.2MVA for stepping up the voltage to 11kV.

While, there is one inverter of capacity 1MW<sub>AC</sub> is placed in the main control room. This inverter is comprising of two winding transformers to accommodate 1 x 1,000kVA inverter, taking the individual inverter size to 1MW<sub>AC</sub>. Inverter is comprising of a physical block connecting to 1.2MW<sub>p</sub> of installed photovoltaic array. The output of 1MW<sub>AC</sub> inverter station block is connected to 0.400/11kV two winding transformer of 1.1MVA for stepping up the voltage to 11kV.

The low voltage 11kV output of the inverter stations are placed in main control room (MCR), these are combined to form a solar PV plant of 5MW<sub>AC</sub>. The 11kV output is evacuated using a 11kV DP structure located in the plant premises.

The power generated by the TNSPEPL 5MW<sub>AC</sub> PV plant is fed to *Eriyodu* substation located approximately 2km from the Project site, through a Dog ACSR single circuit conductor. The point of interconnection is at the *Eriyodu* substation.

ABT / revenue metering is at *Eriyodu* substation; therefore, transmission line losses are accounted in the Owner's scope.





### 3 Review of Major plant components

SgurrEnergy has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions.

#### 3.1 PV modules

The PV modules selected for the Project are supplied by JA Solar Holding Co., Ltd., Canadian Solar and Astronergy. SgurrEnergy has conducted a technical review of the suppliers and proposed module specifications with regard to their suitability for use on the Project.

##### 3.1.1 Company Profile – JA Solar Holding Co., Ltd

JA Solar Holding Company Ltd. listed on NASDAQ (NASDAQ: JASO), was found in the year 2005 and started operation in 2006. The Company has 12 manufacturing bases and has production capacity of more than 11.5GW, 11GW, and 11GW for silicon wafer, solar cells, and solar modules, respectively.

JA solar has 20 branches around the world and employs more than 22,000 employees worldwide. As of December 2019, JA solar provides services in more than 135 countries and to more than 33,000 clients worldwide. As of second quarter 2020, JA solar had a cumulative shipment of more than 50GW. As of December 2019, JA solar had more than 779 authorized patents of independent R&D and 107 invention patents under its name. The Company's net revenue was RMB 21.16 billion in 2019.

Few of the commissioned solar power plants using JA modules are listed in Table 3-1.

**Table 3-1: Project References of JA Solar**

Sr. No.	Project and Location	Capacity (MW)
1	Bahia, Brazil	255.0
2	Northern Cooks, Australia	172.8
3	Cadiz, Philippines	132.5
4	Maharashtra, India	130.0
5	Three Gorges, Datong	100.0
6	Bahawalpur, Pakistan	100.0
7	Lincheng Country, Xingtai City, Hebei Province	100.0
8	Dunhuang, Gansu Province	100.0
9	Utah, USA	80.0
10	New South Wales, Australia	70.0
11	Maharashtra, India	70.0
12	Telangana, India	69.0
13	Bole, Xinjiang	60.0
14	San Carlos, Philippines	59.0
15	MP, India	57.0
16	Charanka Gujrat, India	53.0
17	Datong, Shanxi Province	50.0
18	Southwark, UK	49.0
19	Karnataka, India	43.0



Sr. No.	Project and Location	Capacity (MW)
20	Xiayu, Hebei Province	42.0
21	Yinchuan, Ningxia Province	40.0
22	Georgia, USA	38.7
23	Arawa Desert and Negev Desert, Israel	35.0
24	Hefeng, Tacheng, Xinjiang	30.0
25	Karnataka, India	23.0
26	Bulgaria	21.0
27	Haryana, India	21.0
28	Campania, Italy	20.0
29	Corp 184, Xinjiang	20.0
30	Telengana, India	18.0
31	Toshka, Egypt	10.1
32	Volkswagen Chattanooga Plant, USA	9.6
33	Antalya, Turkey	6.7
34	Kenitra, Morocco	2.0
35	ABC Bank, Jordan	1.5

JA is considered a Tier 1 supplier by Bloomberg (Q4, 2020). A Tier 1 supplier is defined as a module manufacturer who has *provided products to five different projects, which have been financed non-recourse by five different (non-development) banks, in the past two years.*

Whilst the Bloomberg tiering system does not reflect on a product's technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers JA solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

### 3.1.1.1 Main Technical Characteristics of JAP6-72/3BB

JA Solar, JAP6-72/3BB modules of 310W<sub>P</sub> and 315W<sub>P</sub> capacity have been utilized for the Project. These modules have an efficiency of 15.99% and 16.25% for 310W<sub>P</sub> and 315W<sub>P</sub> capacity modules, respectively, and a peak power tolerance of 0~+5W. The modules have a temperature coefficient (P<sub>max</sub>) of -0.41%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy's expectation for c-Si technology. The technical characteristics of JAP6-72/3BB are presented in Table 3-2.

**Table 3-2: Technical specifications of JAP6-72/3BB**

Specifications	JAP6-72-310/3BB	JAP6-72-315/3BB
Technology	Polycrystalline	
Nominal power (P <sub>MPP</sub> )	310W <sub>P</sub>	315W <sub>P</sub>
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	37.00V	37.28V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	8.38A	8.45A
Open circuit voltage (V <sub>OC</sub> )	45.45V	45.60V
Short circuit current (I <sub>SC</sub> )	8.85A	8.91A
Efficiency (%)	15.99%	16.25%



Specifications	JAP6-72-310/3BB	JAP6-72-315/3BB
Maximum System Voltage	1,000V (DC)	
Power tolerance (%)	0~+5W	
Dimensions (length × breadth × width) (mm)	1956 × 991 × 45	
Module area (m²)	1.94m²	
Weight (kg)	~26kg	
Temperature coefficient at P <sub>MAX</sub>	-0.41%/°C	
Operating temperature	-40°C to +85°C	
Maximum reverse current	15A	
Maximum mechanical load	5400Pa	
Maximum snow load	2400Pa	
Product warranty	10 years	
Power output guarantee	25 years	
Module technical characteristics are given at STC (1,000W/m² irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet)		

The maximum system voltage is 1,000V. The maximum reverse current is 15A. Overall, the module characteristics can be considered to be in line with market standard and JA Solar is listed as Tier 1 suppliers by Bloomberg since 2014.

### NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>1</sup> characteristics of selected JAP6-72/3BB modules of 310W<sub>P</sub> and 315W<sub>P</sub> is given in Table 3-3 corresponding to realistic operating conditions as compared to STC. It is affected by module materials used as well as the packing density of module materials. The NOCT for the module is 45±2°C. This is comparable with other manufacturers and demonstrates the module is effective at heat dissipation.

**Table 3-3: PV Module NOCT Characteristics of JAP6-72/3BB**

Model	JAP6-72-310/3BB	JAP6-72-315/3BB
Maximum Power (P <sub>MAX</sub> )	225.06W <sub>P</sub>	228.69W <sub>P</sub>
Max Power Voltage (V <sub>MPP</sub> )	34.05V	34.08V
Max Power Current (I <sub>MPP</sub> )	6.61A	6.71A
Open Circuit Voltage (V <sub>OC</sub> )	42.58V	42.63V
Short Circuit Current (I <sub>SC</sub> )	6.99A	7.06A

#### 3.1.1.2 Certification of Modules

General review of datasheet indicates JA Solar PV modules manufactured in facilities with the following certifications:

- ISO 14001 certification for environmental management systems

<sup>1</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C.



- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certifications available in public domain for the modules under evaluation within Table 3-4.

**Table 3-4: Certification for PV Module- JA Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
UL 1703	Standard for safety for flat-plate photovoltaic modules

### 3.1.1.3 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of six months from the dispatch from the JA solar factory or the delivery date to site.

### 3.1.1.4 Product Warranty

JA Solar provides a limited product warranty of 10 years, beginning on the earlier of module purchase date or one-year anniversary from the production date. If module fail to conform to this warranty, during the period ending of 10 years from the date of sale to the customer of the JA solar product, JA solar will at its opinion, either repair or replace the product, or refund the purchase price as paid by the customer. The repair or replacement or refund the customer at the current comparable market price of such module.

SgurrEnergy considers twelve-year product warranty provided by JA solar to be in line with the industry standard.

### 3.1.1.5 Linear Power-Output Warranty

According to the datasheet JA solar warrants that the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.7% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 80.7% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, JA solar will either repair, replace or provide additional modules to make up for the loss in power output.

## 3.2 Inverters – ASEA Brown Boveri (ABB)

The project has utilized ABB PVS800-57-1000kW central inverter for the project under evaluation.

### 3.2.1 Company background

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, ABB is one of the largest engineering companies as well as one of the largest conglomerates in the world. ABB has operations in around 100 countries, with



approximately 147,000 employees<sup>2</sup>. Company reported global revenue of around \$34,312 million for 2017.<sup>3</sup>

The firm's shares are traded on the stock exchanges of Zurich, Stockholm, and New York. ABB is a multinational corporation headquartered in Zurich, Switzerland, operating mainly in robotics and power and automation technology.

On July 9, 2019 the Italian company FIMER acquired ABB's solar inverter business. The takeover of ABB's solar inverter business included 800 employees in 26 countries as well as two manufacturing plants, in Italy and in India, and a R&D facility in Finland.

FIMER was founded in 1942, headquartered in Vimercate, Italy, has been actively working in inverter technology since 1983. As of 2020, the company employs more than 1,100 employees across its three manufacturing facilities and three R&D centres across the globe. As a result of acquisition of ABB's PV inverter line, FIMER ranked the fifth-largest PV inverter globally in 2019.

### 3.2.2 Track Record

ABB India commenced local manufacturing of solar inverters in 2012 and partnered with several customers. ABB is the solar inverter market leader in India holding approximately 24% market share in 2018. ABB has approximately 3,590MW in operation across more than 350 sites in India. ABB India manages close to 40% of the installed bases in India. As on 30 August 2017, ABB India crossed the 5GW threshold for the supply of inverters in the country.

Table 3-5 lists the state-wise installed capacity of ABB inverters in India. However, it is to be noted that the table below doesn't not comprise of the installed capacities till date.

**Table 3-5: ABB Inverter Track Record**

Location	Capacity (MW)
Tamil Nadu	747
Andhra Pradesh	647
Rajasthan	371
Karnataka	305
Madhya Pradesh	271
Maharashtra	261
Punjab	227
Bihar	225
Uttar Pradesh	106
Haryana	62
Kerala	50
Chhattisgarh	28
Odisha	20

ABB India has strategically located its headquarter in Bangalore and offices in other cities Pune, Ahmedabad, Jaipur, Faridabad, Hyderabad, Tamil Nadu, and Bhopal in order to

<sup>2</sup> <https://new.abb.com/news/detail/26838/abb-to-exit-solar-inverter-business>

<sup>3</sup> <https://new.abb.com/investorrelations/company-profile/facts-figures>



facilitate quick spare part availability and minimal response time. ABB aims to provide first response to its customers within 4 hours on weekdays and within 24 hours on weekends and holidays. ABB also provides a Turn-Around-Time of 48 and 72 hours on weekdays and weekends respectively, hence maintaining an average uptime of over 99%.

### 3.2.3 Technical Characteristics

ABB PVS800-57-1000kW inverter has been selected for technical feasibility of the Project. The technical specification of 1000kW ABB inverter is listed in Table 3-6.

The PVS800-57-1000kW Series of central inverters designed ideal for large PV Power Plants. PVS800 inverters are designed for fast and easy installation. These inverters are designed to operate with DC inputs up to 1,100 V. They incorporate maximum power point tracking (MPPT) and grid management features to meet utility requirements.

PVS800-57-1000kW inverter is designed for outdoor use with an IP42 ingress protection class. They are protected against solid objects over 1mm and against direct sprays of water up to 15° from the vertical. They perform optimally at ambient air temperatures between -15°C to 50°C and relative humidity in the range of 15% to 95% with maximum noise level of 75dBA.

The PVS800-57-1000kVA inverter has peak efficiency of 98.8% and a European efficiency of 98.6%.

The main technical characteristics of these inverters are illustrated in Table 3-6.

**Table 3-6: ABB inverter specifications**

<b>ABB Central Inverter Specifications</b>	
Inverter	ABB PVS800-57-1000kW
Type	Central Inverter
<b>Input Data</b>	
Maximum Input Power (kW <sub>p</sub> )	1200kW <sub>p</sub>
PV voltage range, MPP (V)	600 to 850V
Maximum DC voltage (V)	1100V
Maximum input current (A)	1710A
<b>Output Data</b>	
Nominal AC power (kW)	1000kW
Maximum AC current (A)	1445A
Nominal AC voltage(V)	400V
AC grid frequency (Hz)	50Hz -5%+3%
Maximum THD	< 3%
<b>Operating Performance</b>	
Maximum efficiency (%)	98.80%
Euro efficiency (%)	98.60%
<b>Power consumption</b>	
Own consumption in operation(W)	730W
Standby operation consumption (W)	70W
<b>Other</b>	



<b>ABB Central Inverter Specifications</b>	
Dimensions (W × H × D) (mm)	3630mm x 2130mm x 610mm
Weight (kg)	2600kg
Environmental Protection Rating	IP42
Operating temperature range (°C)	-15 to +50°C
Relative humidity (%)	15% to 95%

The following protection devices are included within the inverter design:

- Ground fault monitoring
- Grid Monitoring
- Anti-islanding protection
- DC reverse-polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection
- Remote monitoring solutions

ABB inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components.

### 3.2.4 Certification

ABB is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. ABB inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information available in public domain, SgurrEnergy has summarized the certification of the ABB inverter within Table 3-7.

**Table 3-7: Description of Certification of ABB inverters**

<b>Certification</b>	<b>Description</b>
IEC 60068-2-6/29	Environmental testing of inverters to assess their ability to perform and survive under conditions such as transportation, storage, operational environments, extreme cold and heat
IEC61683:1999	Measurement of the efficiency of power conditioners
IEC 62109-2:2011	Safety of Power Converters
IEC 62116:2014	Test procedure of islanding prevention measures

### 3.2.5 Warranties

SgurrEnergy referred the warranty documents available in public domain. Given the industry standard warranty of 60 months, SgurrEnergy does not raise any concern over the use of inverter for the project.





### 3.3 Inverter Transformer – Voltamp Transformers Limited

The power at low voltage from inverters is stepped up to 33kV using 2200kVA transformers of Voltamp Transformers Limited make.

#### 3.3.1 Company Profile

The inverter transformer used is manufactured by Voltamp Transformers limited (Voltamp).

Voltamp was founded in 1963 in Vadodara, Gujarat and now has a PAN India presence. The company initially started off by manufacturing small transformers by 1975 the largest transformer manufactured was for 132kV networks. This limit rose to 220kV class of transformers in 2008. The company employs more than 300 personnel (including 60 engineers) and has branch offices in Mumbai, New Delhi, Chennai, Bangalore, Secundrabad, Pune, Bhubaneshwar, etc.

The company has four manufacturing plants and the current manufacturing capacity totals to 13000 MVA per year. These facilities boast of manufacturing Oil filled Power and Distribution Transformers up to 160MVA, 220kV. The company got its ISO 9001 certification in 1998 and was listed on the NSE and BSE stock exchange in 2006.

Notable designs include:

- 75MVA 11/138kv GT
- 20MVA 33-22/11kV (DZ10)
- 50MVA 132-110/33kV transformer
- 6 MVA 1-ph transformer
- 15MVA 11/1.3-1.3kV (24 pulse)
- 100MVA 22kV

The company also manufacturers two types of dry transformers, i.e. resin impregnated (25KVA-5000KVA up to 11kV) and cast resin transformers (50kVA-12500kVA up to 33kV). Prominent clients include ABB, Exide, Adani, BHEL, BPCL, Suzlon etc.

#### 3.3.2 Technical Specifications

The 2200kVA Power transformers used in the project are outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 3-8.

**Table 3-8: Technical Specification of Voltamp Transformers**

Technical Parameters	Description
Rated Power	2200kVA
Rated HV	33kV
Rated LV	400-400V
Tapping on HV	-5% to +5% (steps of 2.5%)
Phases	3
Frequency	50Hz





Technical Parameters	Description
Vector group	Dy11y11
Impedance	5.93%
Cooling Strategy	ONAN
Oil temperature rise	50°C
Winding temperature rise	55°C
Winding material	Copper

SgurrEnergy considers the overall the technical specification to be adequate for the PV projects and in line with the industry accepted standards.

### 3.3.3 Temperature Rise Detection and Protection

Inverter transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.4 Warranties and Guaranties

Based on the information available in public domain, SgurrEnergy understands the Shilchar transformers have been provided with a warranty of 60 months from date of dispatch. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards.

## 3.4 Conclusion on Major Plant Components

### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of JA Solar, Canadian Solar and Astronergy assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.

Further, according to the warranty documents available in public domain for all three module manufacturers, SgurrEnergy considers the warranty terms and conditions offered by all three manufacturers to be in-line with the industry standard and raises no major concern regarding the warranties offered. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.

### Inverters

SgurrEnergy has conducted review of the ABB PVS800-57-1000kW central inverter ABB PVS800-57-1000kW central inverter has the required certification for use in solar PV plants. In-house testing of the inverter and individual components is relatively extensive during the R&D phase with functional and temperature cycling testing of each manufactured inverter. ABB offers a product warrant of 5 years which is in line with the current industry standards.

In conclusion, ABB can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters.



ABB inverters have more than 3GW of installation worldwide. These inverters are quite known to the Indian market and have installed capacity of more than 1.3GW which demonstrates a good track record in the Indian solar PV market.

### Transformers

Voltamp has a track record of more than 53,000 transformer installation across India, Nepal, Sri Lanka, Bhutan, Indonesia, Middle East Asia, South East, and African Countries<sup>4</sup>. The accreditations for manufacturing facility gained by the company are considered fair and satisfactory.

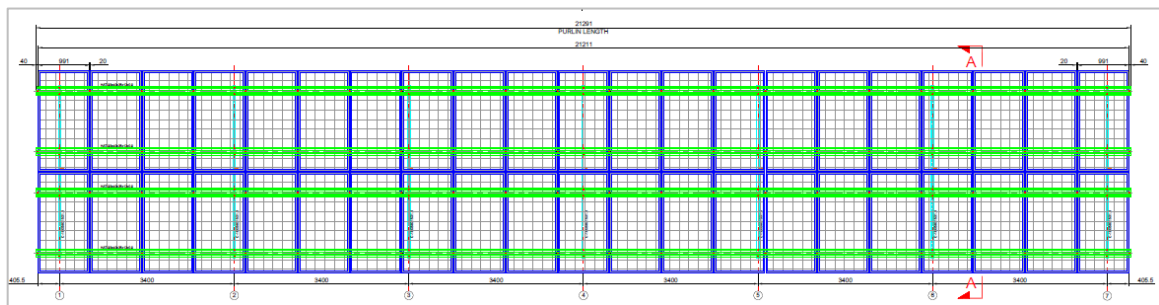
The inverter transformers (2200kVA) used within the project are manufactured by Voltamp Transformer Limited. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.

### 3.5 Module support structures

The Array Layout provided by the Client for the Talesun modules indicates the fixed tilt module mounting structure is inclined at 8° tilt angle.

Following the review of as-built MMS GA drawing dated 12.06.2015, SgurrEnergy observed that the structure has been designed with two rows of modules placed in portrait orientation with 21 modules in each row. In total there are 42 modules in one mounting structure. The layout is designed with a pitch of 6m.

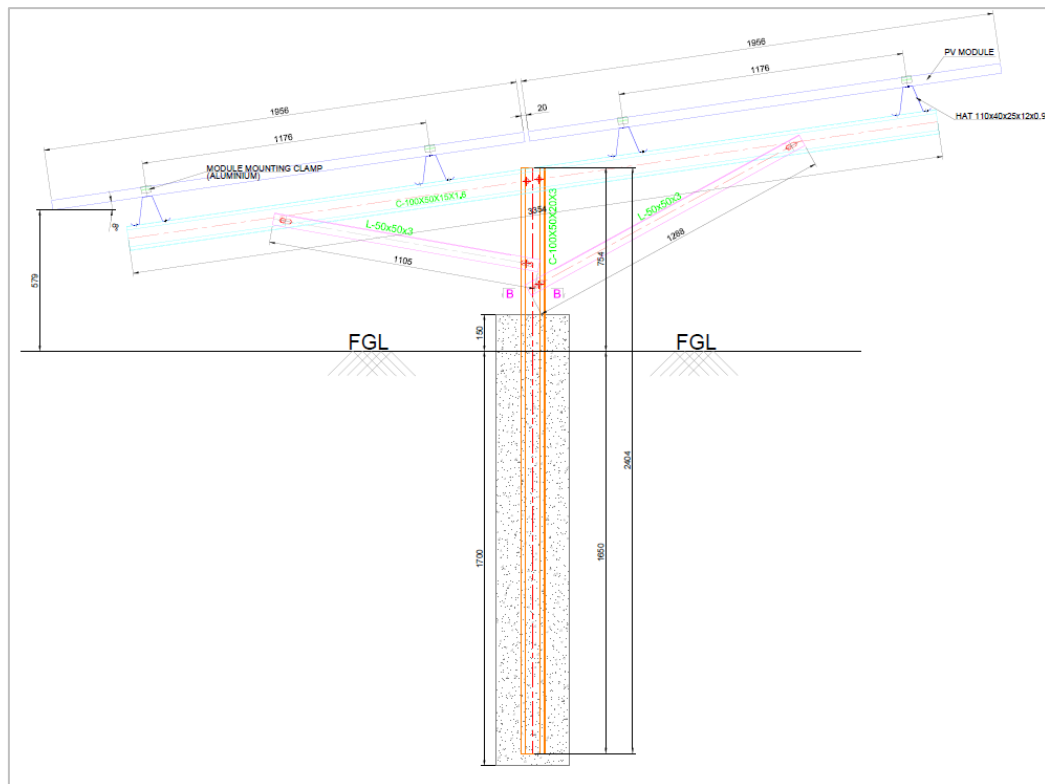
Figure 3-1 and Figure 3-2 illustrate the module mounting structure configuration provided by the Client for the JA PV modules.



**Figure 3-1: Two in portrait module mounting structure with 21 modules in a row**

<sup>4</sup> <http://www.voltampttransformers.com/index.php/dashboard/infrastructure>





**Figure 3-2: Side view of the module mounting structure configuration**

Based on the information provided in the GA drawing of the MMS, the technical specification has been summarized below.

Table 3-9 summarizes the technical specification of the module mounting structure.

**Table 3-9: Specification of MMS**

MMS Part	Material	Grades - Standard	Thickness (mm)	Minimum Yield Stress (MPa)
Rafter	Cold Formed	ASTM A 653-340-1	1.6	350
Purlin	Cold Formed	ASTM A 792/_2010/ G_80_550_CLASS_1	0.9	550
Leg	Cold Formed	E350- IS 5986-2011	3.0	350
Bracing	Cold Formed	E350- IS: 10262, IS 2911, IS 456, IS 800	3.0	350

Material used is a combination of hot-dipped galvanised mild steel and pre-galvanised cold rolled sheets sheared to form structural members for module mounting. The pre-galvanised sheets post process is appropriately coated with anti-corrosion compounds for the project life cycle. SgurrEnergy was not provided with the information regarding type of pile used in the project.



## 4 Allied Components and Systems

### 4.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

### 4.2 PV Power Transfer

SgurrEnergy has reviewed the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear, and plant substation as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

- “SWLB-SP-TN-05MW-E-DWG-SLD-100”, revision 1, dated 18.11.2015.
- “SWLB-SP-TN-05MW-E-DWG-SLD-100B”, revision 1, dated 23.11.15.
- “SWLB-SP-TN-05MW-E-DWG-AL-101”, revision 1, dated 21.11.15.

The 5MW<sub>AC</sub> solar PV Plant is designed with 310W<sub>P</sub> and 315W<sub>P</sub> JA solar PV modules and 1000kW ABB inverters. Modules are interconnected to form a string of 21 modules. Each string forms a single output that feeds as a single input to the 12 input combiner boxes. Eight string combiner boxes are further connected to the inverter.

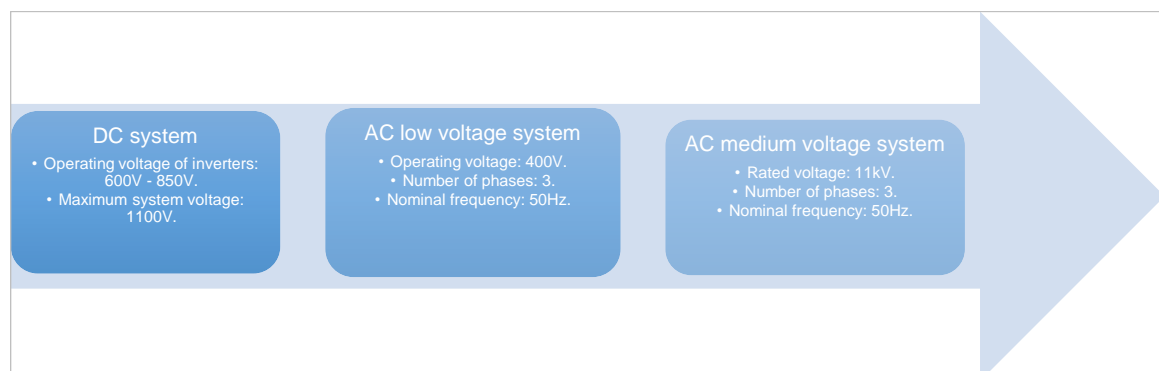
The 5MW<sub>AC</sub> solar PV plant has been configured with 5 ABB 1000kW central inverters and two inverter stations. One inverter station of 4MW<sub>AC</sub> capacity contains four inverters of 1000kW capacities and two 3-winding transformers of 2.2MVA capacities. While one inverter station of 1MW<sub>AC</sub> capacity consists of one inverter of 1000kW capacity and one two-winding, 1.1MVA transformer.

The 4MW<sub>AC</sub> capacity inverter station consists of 2-sets of two 1000kW inverters connected to 0.400/0.400/11kV three-winding, 2.2MVA transformer, while the inverter station of 1MW<sub>AC</sub> capacity consists of one 1000kW inverters connected to 0.400/11kV two-winding, 1.1MVA transformer. The voltage is stepped up to 11kV for all inverter stations by 2.2MVA and 1.1MVA transformers. The power from the HV side of the 11kV inverter transformer is transferred to 11kV HT panel.

The output power of each 11kV HT panel is connected to 11kV main HT panel located in the main control room. Further power from main control room is fed to 11kV metering yard through 11kV Double pole (DP) structure.

Power from 11kV metering yard is evacuated to the substation situated at a distance of 1.9km from the project site at 11kV voltage level through ACSR dog conductor overhead transmission line.

Figure below illustrates a power flow summary for the 5MW<sub>AC</sub> Solar PV plant.



**Figure 4-1: Power flow of 5MW<sub>AC</sub> PV plant**



### 4.3 Cabling

#### 4.3.1 DC Cabling

DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. Modules are interconnected in series with solar grade cables that are tied along with the module mounting structures. Modules are interconnected in leap-frog scheme to form a string of 21 PV modules connected in series.

The Y harness equipped with 30A fuse has been used to pre-combine the string of PV module. Single core 6mm<sup>2</sup> multi-stranded copper PV cables connect Y- harness output to String Combiner Box (SCB).

These combiner boxes are equipped with 30A fuse for each of the string connection and a 315A disconnect switch on output side. Power from string combiner box is further transferred to the inverter using 2 runs, 1C, 185/240/300mm<sup>2</sup>, 1.1kV aluminium XLPE ((2R X 1C X 185/240/300Sqmm, 1.1kV AL. XLPE Armoured) cables.

#### 4.3.2 AC Cabling

Three phase AC output from inverter is connected to the LV winding of a three-winding 2.2MVA transformers and two-winding 1.1MVA transformers, using 12 Runs single core 630mm<sup>2</sup> Aluminium Armoured XLPE (12R (4R/Ph) X1C x 630mm<sup>2</sup> Al. Ar. XLPE) cable. The inverter transformers step up the voltage to 11kV.

Power is fed from the high voltage side of each transformers using 1R,3C, 240mm<sup>2</sup>, 11kV Al XLPE armoured cable to the 11kV HT panel in the 4MW<sub>AC</sub> inverter stations using a radial feeder arrangement.

The 11kV output of both the inverter stations is transmitted to 11kV main HT panel located within Main control room using 1R,3C, 240mm<sup>2</sup>, 11kV(E) Al XLPE armoured HT cables.

The power from the Main HT panel is transferred to 11kV DP structure and 11kV metering yard through triple core, 300mm<sup>2</sup>, 11kV Aluminium XLPE Armoured (1R x 3C x 300sqmm/Phase 11kV[E], Al, XLPE, Ar.) cable.

Further the power from the solar PV plant is feed to the 11kV substation through ACSR dog conductor overhead transmission line.

### 4.4 Inverter Station

The 5MW<sub>AC</sub> solar PV plant has been configured with 5 inverters and two inverter stations. One inverter station of 4MW<sub>AC</sub> capacity consists of four inverters of 1000kW capacity while one inverter station of 1MW<sub>AC</sub> capacity consists of one inverter of 1000kW capacity.

The 4MW<sub>AC</sub> inverter station consists of two-sets of two inverters connected to a 2,200kVA three-winding transformer whereas one inverter is connected to a 1,100kVA two-winding transformer located in 1MW<sub>AC</sub> inverter station.

Each transformer, along with allied switchgears, steps up the voltage to 11kV for all inverter stations. Further the power from the HV side of the transformer is fed to the 11kV outdoor type HT panel through radial feeder arrangement.

11kV outdoor type HT panel comprises of 130/5A current transformer, 11kV EDO TP, 630A Vacuum Circuit Breaker and other electrical protection system. The power from inverter duty transformer is transferred to aforesaid MV panel.

### 4.5 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed 2.2MVA, 11kV/2x0.400kV, Dy11y11 three-winding transformers and 1.1MVA, 11kV/0.400kV, Dy11 two-winding transformer have been used in the project. These inverter duty transformers step up the voltage to 11kV.



The 2.2MVA inverter duty transformers output is connected to 11kV HT panels located within inverter station. The energy from 4MW<sub>AC</sub> inverter station 11kV HT panel and 1MW<sub>AC</sub> inverter station is radially combined at 11kV main HT panel located within main control room.

#### 4.6 11kV Main HT Panel

A 11kV main HT panel comprises of inverter station incoming feeders and one outgoing feeder. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class. All feeders have been provided with relay and metering unit. The 11kV main HT panel outgoing and incoming feeders are provided with instantaneous and IDMT (50/51) O/C relay instantaneous and IDMT (50N/51N) E/F relay protections. The 11kV outgoing feeders are provided with 0.2S class instrument transformers.

Power is fed from 11kV main HT panel to and metering yard using 11kV DP structure further power from 11kV DP structure is transferred to metering yard through overhead line.

#### 4.7 11kV Metering Yard

The 11kV main HT panel outgoing feeders are connected to 11kV DP structure and 11kV Metering yard.

The 11kV metering yard is observed to be equipped with instrument transformers, isolator, and lightning arrestor with metering & protection cores. The 10kV, 10kA lightning arrestor is provided at 11kV incoming feeders to discharge surge currents caused by lightning strokes.

Subsequently energy from 11kV plant end metering yard is evacuated to the substation located at the distance of 1.9km from the project site at 11kV level through dog ACSR single circuit overhead transmission line.

#### 4.8 Auxiliary Power Supply

SgurrEnergy had reviewed the electrical schematics shared for the projects to evaluate auxiliary system. The 4MW<sub>AC</sub> capacity block is equipped with 20kVA and 1MW<sub>AC</sub> block is equipped with 40kVA auxiliary transformers.

#### 4.9 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are normally mounted on individual structures.

Following the review of 11kV SLD, SgurrEnergy observed 11kV, 630A, 25kA/1sec load break switch has been used in the project.

#### 4.10 Isolators

Isolators are used to transfer load from one bus to another and also to isolate equipment for maintenance.

Based on the review of 11kV SLD, SgurrEnergy observed 11kV, 630A isolator with earth switch has been used in the project.

#### 4.11 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the



values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.

The current transformers with accuracy class of 0.2s for metering and class 5P and PS for protection has been used in 5MW<sub>AC</sub> solar PV plant. The potential transformers with accuracy class of 0.2 for metering and class 3P for protection has been used in the project.

#### 4.12 Surge Arresters and Lightning Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes on the lines entering the substation. The apparatus most commonly used for this purpose is the surge arrester. Transformer is the costliest equipment in substation, and it is normal practice to install surge arrester near to the transformer. Additional surge arresters shall be provided either on bus or on various lines for protection of the equipment.

Following the review, SgurrEnergy observed 10kV, 10kA, surge arrester and 10kV, 10kA lightning arrester has been used in 11kV main HT panel and 11kV metering yard, respectively.

#### 4.13 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy will be provided at the medium voltage switchboards for each of the feeder sections. These meters will be digital with an RS 485 port for remote monitoring. These usually have an accuracy class of 0.5.

Similarly, HV side shall also be equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point shall be 0.2S.





## 5 System Design Appraisal

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

### 5.1 Plant Layout Design

SgurrEnergy was provided with as built plant layout and electrical schematics. SgurrEnergy has verified the plant configuration with electrical schematics provided by the Client. The PV plant is JA Solar (310W<sub>p</sub> and 315W<sub>p</sub>) PV modules. The total DC installed capacity stands at 6MW<sub>p</sub>. The AC installed capacity stands at 5MW<sub>AC</sub> with 5 inverters of capacity 1,000kW each. Overall 5MW<sub>AC</sub> PV plant is illustrated below in the Figure 5-1.

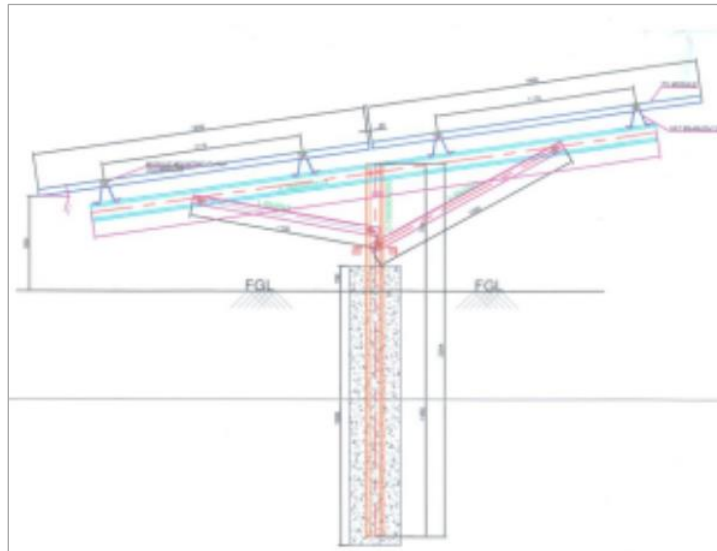


**Figure 5-1: Plant layout of 5MW<sub>AC</sub>**

All the PV modules are orientated towards South. The mounting structure provides support for two rows of panels in portrait orientation.







**Figure 5-2: Side view of typical module mounting structure configuration**

The selected tilt for the 5MW<sub>AC</sub> plant is 8°. The 5MW<sub>AC</sub> plant is designed with a pitch of 6m.

Based on regional experience of detail designing, SgurrEnergy considers the selected tilt angle and pitch is optimized for maximum irradiation on the collector plane, minimum loss due to inter row shading, minimum ohmic losses and ease of maintenance.

21 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.2. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.

## 5.2 String Sizing

The plant layout provided by the Developer indicate thirty 310W<sub>p</sub> and 315W<sub>p</sub> JA Solar polycrystalline modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage ( $V_{OC}$ ) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum  $V_{OC}$  of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy in validating string configuration. Subsequent to calculating open circuit voltage ( $V_{OC\ max}$ ), maximum power voltage ( $V_{mp\ min}$ ) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 40°C and 15°C respectively for system design validation to be fair and representative for the PV plants' site.

The results of string sizing validation are presented in Table 5-1. Results indicate that  $V_{OC\ max}$  at the minimum ambient temperature is within the maximum system voltage of 1,000V for the selected ABB inverters.

**Table 5-1: String Sizing for JA Solar PV Modules**

Parameters	JA 310W <sub>p</sub>	JA 315W <sub>p</sub>
PV module power (W <sub>p</sub> )	310	315



Modules per string	21	
Inverters	ABB (PVS-800-57-1000kW)	
Maximum Open-circuit voltage ( $V_{oc}$ max) at minimum ambient temperature of 15°C	987V	991V
Minimum power voltage ( $V_{mp}$ min) at maximum ambient temperature of 40°C	905.1V	907V

### 5.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with JA Solar and ABB inverter is presented in Table 5-2. SgurrEnergy has selected the highest rated JA Solar module (315W<sub>p</sub>) their compatibility with ABB inverters, as SgurrEnergy considers this to be representative for all the JA Solar PV modules installed on site.

**Table 5-2: Inverter Compatibility with JA Solar 315W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>JA Solar 315W<sub>p</sub></b>	
Modules per string	21	Acceptable
Strings per inverter	182	Acceptable
Maximum power, $P_{mpp}$ at STC (kW <sub>p</sub> )	1,203.9	Nominal power ratio is 1.20, this is within the inverter bus current carrying capacity.
Maximum power voltage, $V_{mpp}$ at STC (V)	782.8	Acceptable.
Maximum power current, $I_{mpp}$ at STC (A)	1,537.9	Acceptable
Open-circuit voltage, $V_{oc}$ at STC (V)	957.6	Acceptable.
Minimum MPP voltage at 40°C ambient temperature (V)	730.8	Acceptable: Inverter MPPT ranges 600 - 850V.
Maximum MPP voltage at 15°C ambient temperature (V)	814.8	Acceptable: Inverter MPPT ranges 600 - 850V.
Maximum open circuit voltage, $V_{oc}$ at 15°C (V)	991	Acceptable: Maximum inverter voltage 1000V.

Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.



## 6 Resource assessment

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SEI has sourced monthly horizontal plane irradiation data for the Project site from:

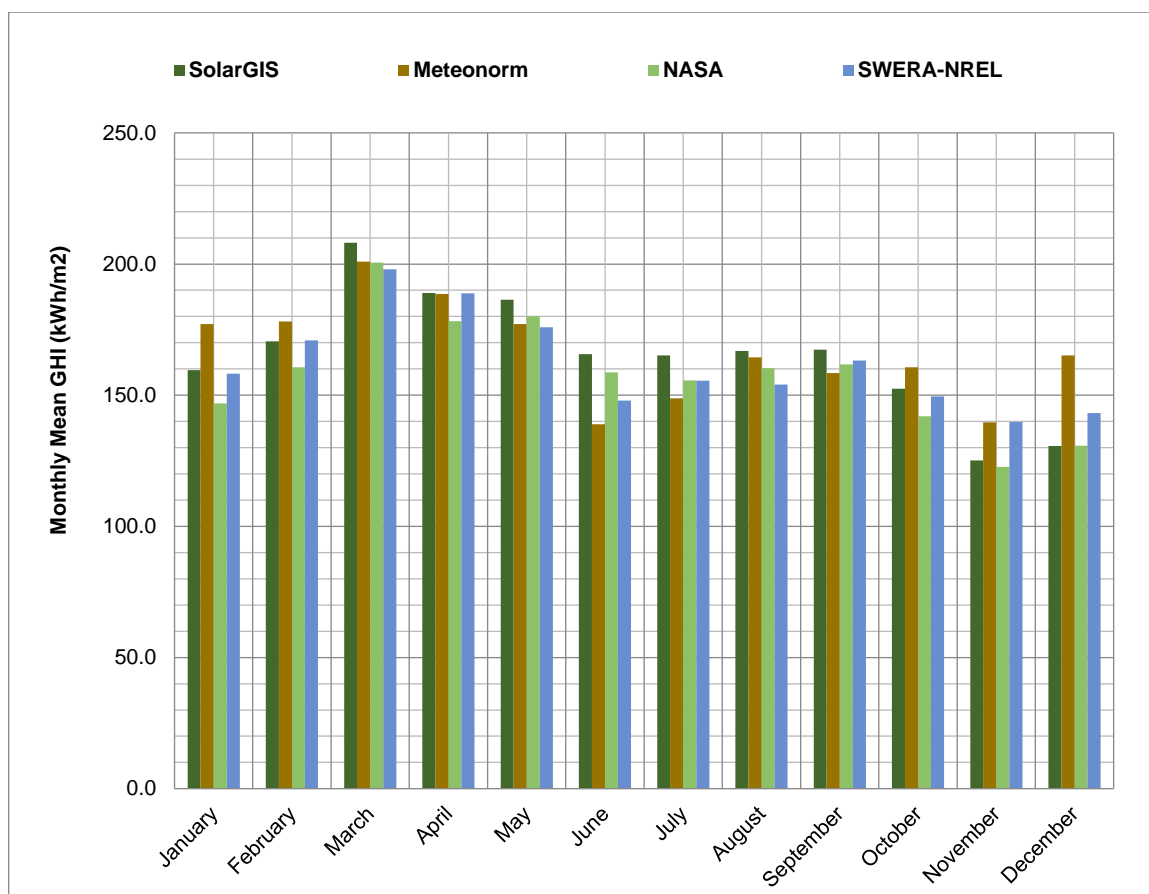
- **NASA's Surface Meteorology and Solar Energy data set**; holds satellite derived monthly data for a grid of 0.5° × 0.5° covering the globe for a thirty-four-year period (1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.



- The **METEONORM (version 7.3)** *global climatological database and synthetic weather generator*; contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.
- **SolarGIS:** SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km × 4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by *IEA (International Energy Agency) SHC Collaboration Agreement, and EU FP6 project MESoR* in terms of bias and RMSE.

SEI has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS data for the site. The comparison is graphically illustrated Table6-1





**Figure 6-1: Monthly Global Horizontal Irradiation**

**Table6-1: Comparison of Solar Irradiation Datasets for the site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	1,986.5
Meteonorm 7.3	14km × 14km	4.0%	1,997.9
NASA	55km × 55km	Unknown	1,898.3
NREL (SWERA)	40km × 40km	Unknown	1,945.0

The comparison of solar data for Project site location illustrated in Table6-1 indicates NASA dataset to give the highest irradiation levels. The next highest irradiation is given by Meteonorm 7.3 followed by SolarGIS and NREL (SWERA).

The irradiation values given by Meteonorm 7.3 typically provide a combination of ground and satellite measured data. Meteonorm 7.3 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as 7% for the proposed site.

The NASA-SSE data source provides purely satellite measured data for a grid covering 0.5° × 0.5° on the earth's surface and generally more suited for initial site selection.

The NREL (SWERA) data illustrated has been obtained for a location approximately 4.18 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data

The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also



been compared with other data sources globally. The IEA (International Energy Agency) validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>5</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)
- Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 6%.

SEI is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 6.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 6-2 and shown graphically in Figure 6-2. Diffuse irradiation accounts for 47.74% of the total irradiation. Table 6-2 illustrates direct and diffuse daily irradiation on a horizontal plane for the proposed site. SolarGIS irradiation data is presented in Table 6-2.

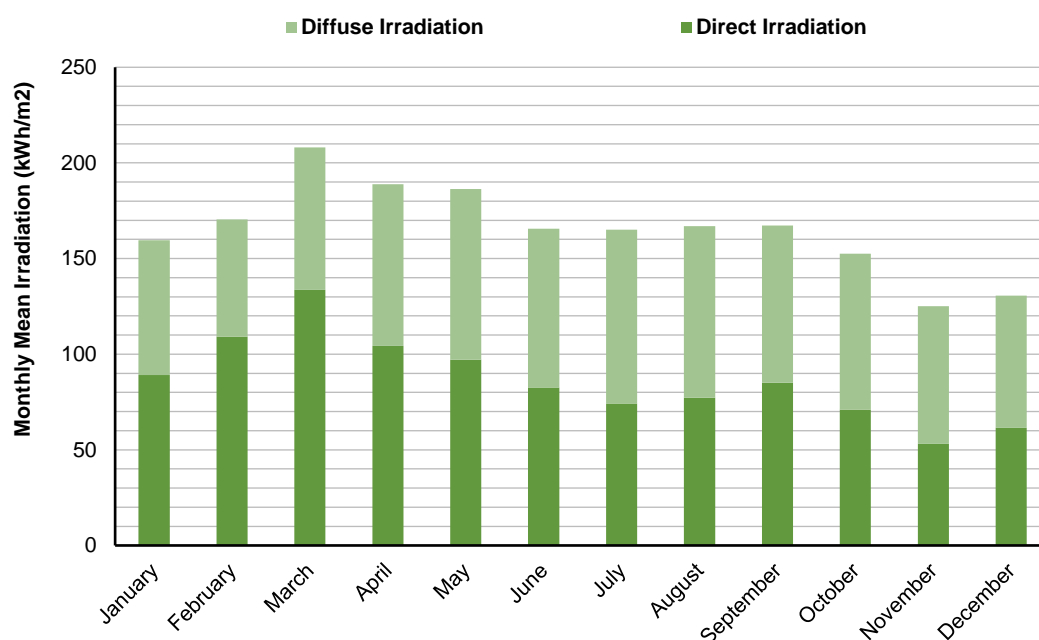
**Table 6-2: SolarGIS Irradiation Data for the Project sites**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	159.5	70.4	8.0%
February	170.5	61.3	8.6%
March	208.1	74.4	10.5%
April	188.9	84.6	9.5%
May	186.4	89.3	9.4%
June	165.6	83.1	8.3%
July	165.1	90.8	8.3%
August	166.9	89.6	8.4%
September	167.3	82.2	8.4%
October	152.5	81.5	7.7%

<sup>5</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>



Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
November	125.1	72.0	6.3%
December	130.6	69.1	6.6%
<b>Annual Sum</b>	<b>1,986.5</b>	<b>948.4</b>	<b>-</b>



**Figure 6-2: Monthly Direct and Diffuse Irradiation on a horizontal plane for the project site**

## 6.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.1.1), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -6-3 represents the monthly GTI profile.

**Table -6-3: Monthly Global Tilted Irradiation Data**

Month	GTI (kWh/m <sup>2</sup> )
January	171.50
February	180.30
March	212.90
April	187.40
May	180.70
June	159.10
July	159.50
August	164.10





Month	GTI (kWh/m <sup>2</sup> )
September	168.70
October	157.20
November	131.10
December	139.40
<b>Annual Sum</b>	<b>2,011.90</b>

### 6.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 6-4 below. The average wind speed of 3.7 m/s was measured at 10m height from ground level for the proposed project site location.

**Table 6-4: Simulated Wind Speed for site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	3.1
February	2.9
March	2.6
April	2.5
May	4.1
June	5.3
July	5.9
August	5.2
September	3.9
October	2.8
November	2.9
December	3.2
<b>Yearly Average</b>	<b>3.7</b>

### 6.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.



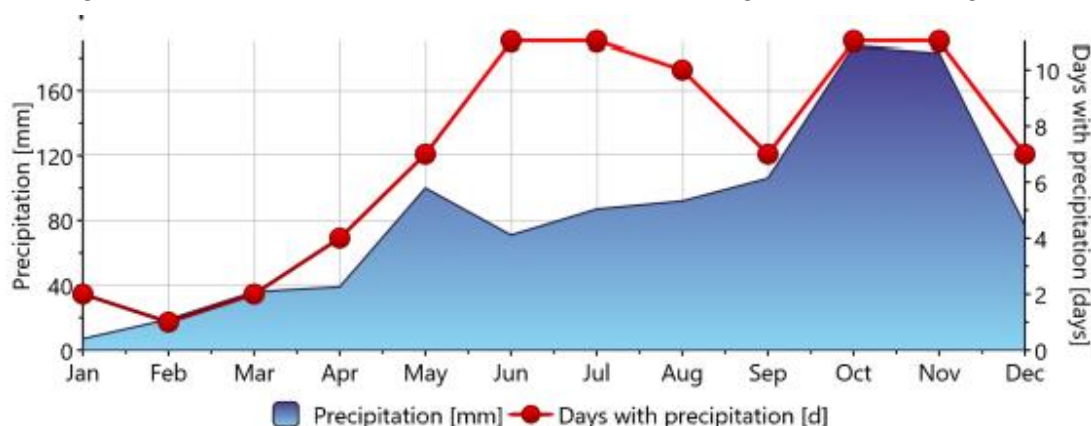


**Table 6-5: SolarGIS Temperature Data for Site (1999 – 2018)**

Months	Average Monthly Temperature (°C)
January	22.8
February	24.9
March	27.9
April	30.3
May	30.6
June	28.7
July	28.0
August	28.0
September	27.7
October	25.9
November	23.6
December	22.4
<b>Annual Average</b>	<b>26.7</b>

### 6.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.3 as illustrated in Figure 6-3. These figures show that the identified site is situated in a region that has marginal rainfall.

**Figure 6-3 Meteonorm Predicted Precipitation for the site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

Frequency of module cleaning depends on the rainfall frequency and the prevalence of dust and pollution in the local vicinity. Typical cleaning techniques include water cleaning, dry brushes or vehicle-based mechanical cleaning.

The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 1.5% has been considered by considering cleaning frequency of twice a month.



## 7 Energy Yield Analysis

SgurrEnergy has computed the annual energy yields for the 5 MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

Parameter	Description
Modules	JA Solar (JAP6-72-310/3BB, JAP6-72-315/3BB)
Inverters	ABB Central Inverters – 1.0MW <sub>AC</sub> (PVS800-57-1000kW-C)
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	6

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 7.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in Table 7-1 below.

**Table 7-1: Description of Energy Yield Losses**

Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.



Loss	Description
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 5 MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 7.2 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 5 MW<sub>p</sub> solar PV Plant with JA solar modules and ABB inverters. Table 7-2 summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.



**Table 7-2: Energy Yield for the 5 MW<sub>AC</sub> Solar PV Plant**

Parameters	Description
PV Module Technology	Polycrystalline
DC Capacity (MW <sub>p</sub> )	6
AC Capacity (MVA)	5
Contracted Capacity (MW)	5
P <sub>NOM</sub> Ratio	1.20
Tilt (°)	8
Pitch (m)	6
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1,986.50
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	2,011.90
Transposition Factor	1.01
<b>Losses</b>	
Horizon Shading	0.00%
Incident Irradiation Below Threshold	0.00%
Near Shading	0.52%
Incident Angle	2.51%
Soiling	1.50%
Low Irradiance	0.40%
Module Temperature	9.06%
Electrical Shadings	0.00%
Module Quality	0.00%
First year Degradation	1.50%
Module Mismatch	1.00%
DC Ohmic	1.06%
Inverter Performance	1.76%
Availability	1.00%
AC Ohmic	0.55%
Transformer (LV/MV)	1.07%
Transformer (MV/HV)	-
Transmission Line	1.50%
Auxiliary Consumption	0.60%
Curtailment	
<b>Total Annual Loss Factor</b>	<b>0.789</b>
<b>Sixth Year P50 Energy Yield (MWh/annum)</b>	<b>9,283.12</b>
<b>Sixth Year Specific Yield (kWh/kW<sub>p</sub>)</b>	<b>1547.18</b>
<b>Sixth Year CUF on AC Installed Capacity</b>	<b>21.19%</b>



Parameters	Description
Sixth Year CUF on Contracted Capacity	21.19%
Sixth Year CUF on DC Installed Capacity	17.66%
Sixth Year Performance Ratio	76.90%

Graphical representation of the monthly generation, performance ratio and CUF for 5 MW<sub>AC</sub> evaluated is illustrated graphically in the Figure 7-1.

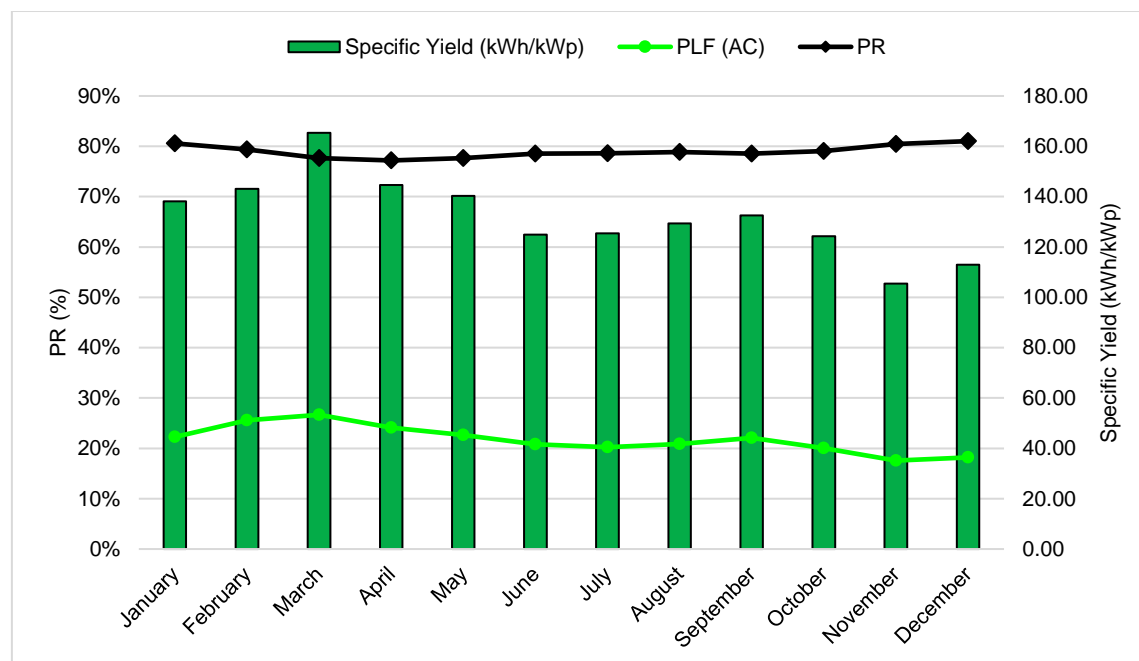


Figure 7-1: Monthly Energy Yield for 5 MW<sub>AC</sub>

### 7.3 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 7.3.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

#### 7.3.2 Inter – Annual Variation in the Solar Resource

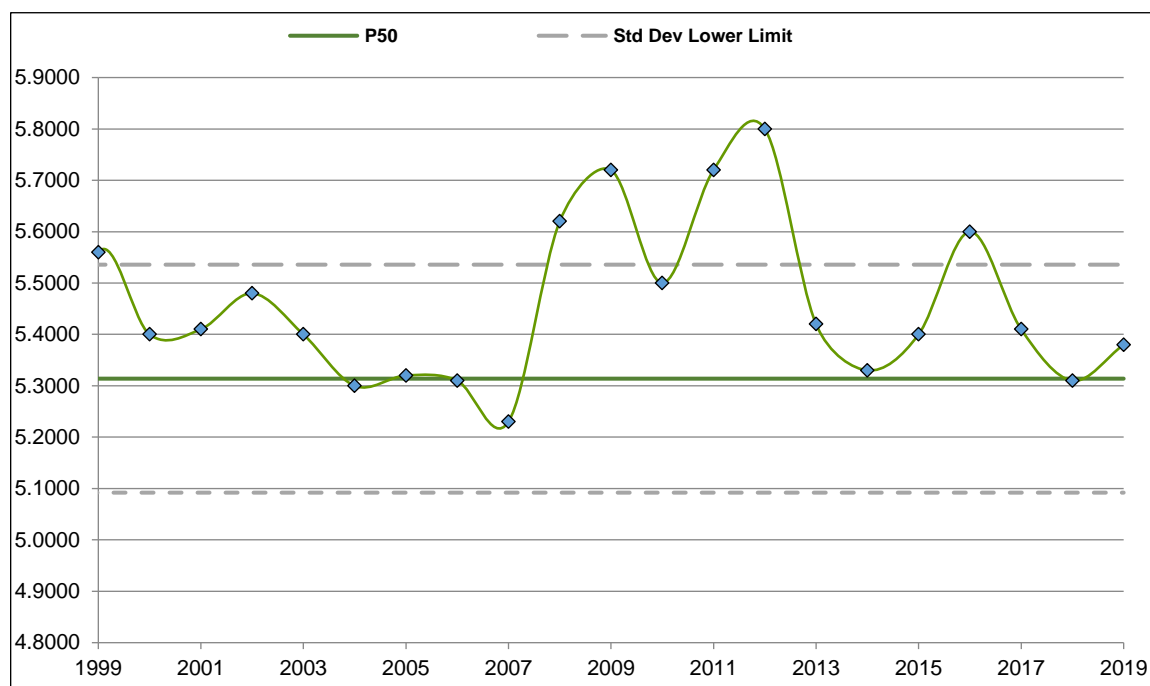
Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.



The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database for the proposed site location which is used to estimate the standard deviation of variation in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 7-3.

**Table 7-3: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	4.18



**Figure 7-2: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in Figure 7-2.

SgurrEnergy uses a coefficient of variation of 4.18% to quantify the inter-annual variation in the solar resource.

### 7.3.3 Modelling Uncertainty

The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

### 7.3.4 Total Uncertainty (P75, P90 and P99 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.



**Table 7-4: Life Cycle P50, P75 and P90 Generation Prediction for 5 MW<sub>AC</sub>**

Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>6</sup> (MWh/annum)	P90 Generation Prediction <sup>7</sup> (MWh/annum)
6	9,283.12	8,887.27	8,530.99
7	9,236.71	8,842.84	8,488.34
8	9,190.52	8,798.62	8,445.90
9	9,144.57	8,754.63	8,403.67
<b>10</b>	<b>9,098.85</b>	<b>8,710.86</b>	<b>8,361.65</b>
11	9,053.35	8,667.30	8,319.84
12	9,008.09	8,623.96	8,278.24
13	8,963.05	8,580.84	8,236.85
14	8,918.23	8,537.94	8,195.67
15	8,873.64	8,495.25	8,154.69
16	8,829.27	8,452.77	8,113.91
17	8,785.13	8,410.51	8,073.35
18	8,741.20	8,368.46	8,032.98
19	8,697.49	8,326.62	7,992.81
<b>20</b>	<b>8,654.01</b>	<b>8,284.98</b>	<b>7,952.85</b>
21	8,610.74	8,243.56	7,913.09
22	8,567.68	8,202.34	7,873.52
23	8,524.84	8,161.33	7,834.15
24	8,482.22	8,120.52	7,794.98
<b>25</b>	<b>8,439.81</b>	<b>8,079.92</b>	<b>7,756.01</b>

<sup>6</sup> The P75 values have been calculated over 10-year averages<sup>7</sup> The P90 values have been calculated over 10-year averages

## 8 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 0.6% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) and henceforth. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Developer, SgurrEnergy understands that the 5MW TNS solar PV plant was commissioned on 28<sup>th</sup> December 2015. SgurrEnergy was provided with plant and grid availability records from February 2016 to March 2021<sup>8</sup> for the solar PV plant. However, the irradiation measurement records were provided from April 2016 to March 2021.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from April 2016 to March 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Developers control.

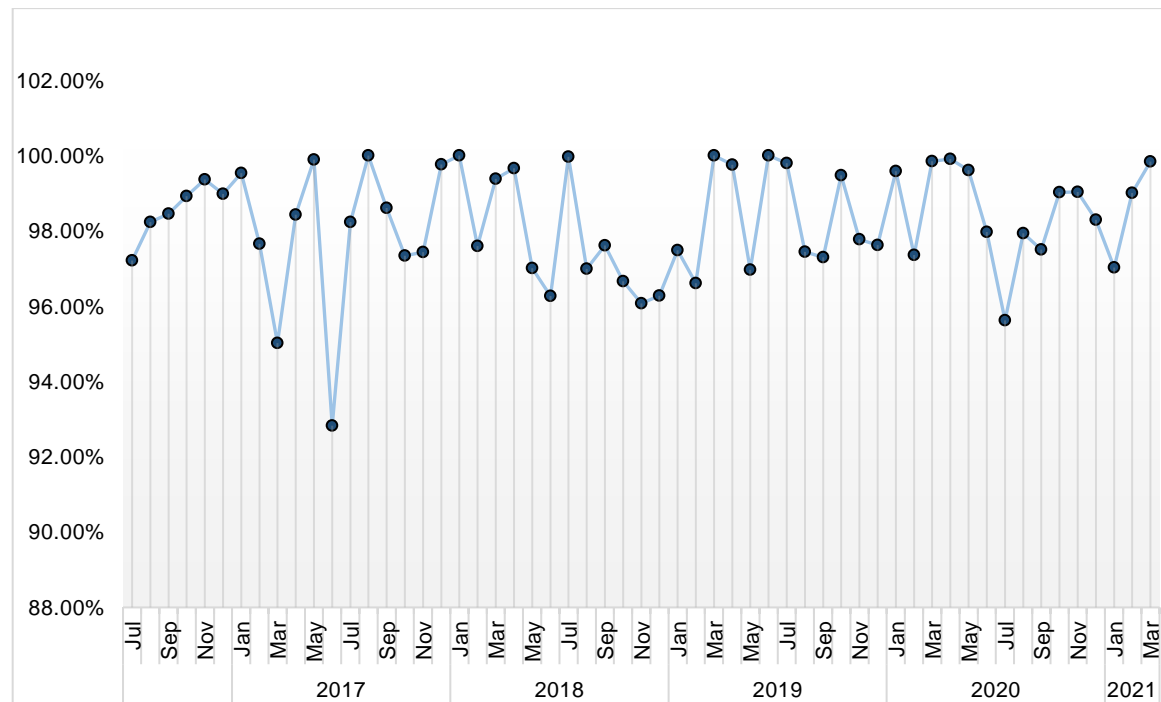
The monthly records of the grid availability from April 2016 to March 2021 have been graphically illustrated in Figure 8-1 below.

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<sup>8</sup> SgurrEnergy was provided with both the plant and grid availability records until March 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.







**Figure 8-1: Grid Availability**

Based on the above illustration, SgurrEnergy notes the grid availability for the TNS 5MW solar PV plant is notably inconsistent for all the months ranging between 92.82% to 100%.

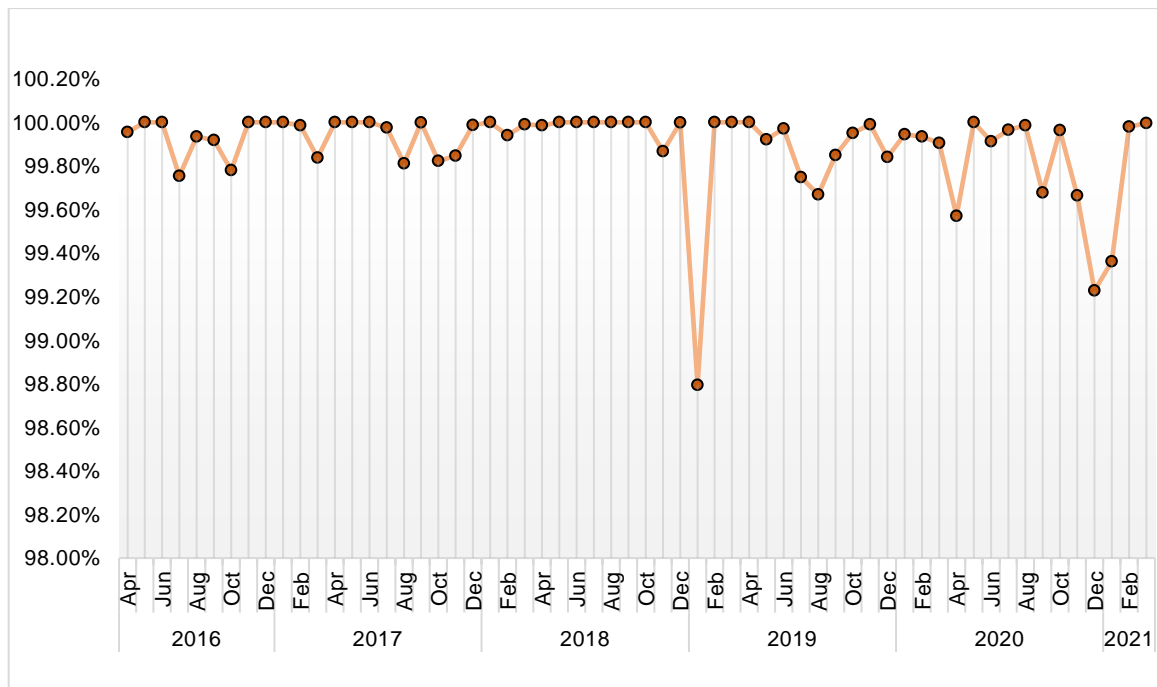
The resultant overall grid availability of the PV plant for the period evaluated was 98.15%. SgurrEnergy considers that the unavailability loss experienced due to grid anomalies for the operational period is higher than the expected range.

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the TNS 5MW solar PV plant is graphically illustrated below in Figure 8-2.





**Figure 8-2: Plant Availability**

Based on the above illustrations, SgurrEnergy notes the plant availability for the SPSPL solar PV plant was above 99.23% for substantial amount of time over the operational period of the plant. However, for the month of January 2019 the plant unavailability was slightly higher when compared to other months.

The resultant average plant availability of the PV plant for the period evaluated was 99.89% which is considered to be within expected range.

## 1.2 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer. To make the operational energy yield predictions more representative, SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Developer. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Developer.

The yearly comparison of the generation data is illustrated below in Figure 8-3.



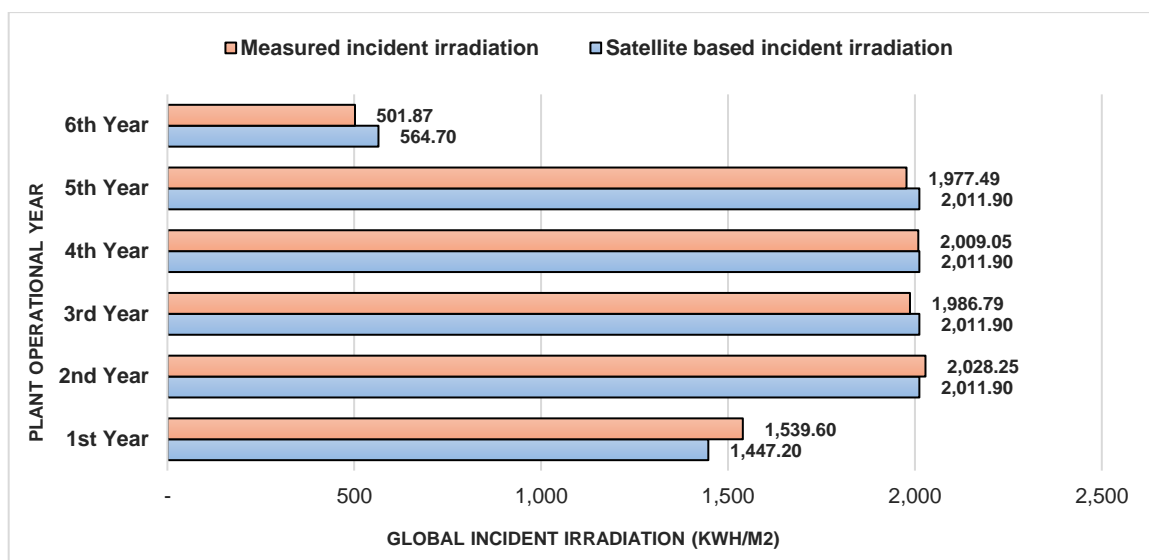


Figure 8-3: Generation Comparison

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 8-1

Table 8-1: PV Plant Performance – TNS 5MW

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>9</sup> (%)
April 2016 -Dec 2016	6,770.28	7,225.68	6.73%
Jan 2017 -Dec 2017	9,346.96	9,418.56	0.77%
Jan 2018 -Dec 2018	9,298.25	9,310.50	0.13%
Jan 2019 -Dec 2019	9,271.98	9,365.21	1.01%
Jan 2020 -Dec 2020	9,230.87	9,244.83	0.15%
Jan 2021- Mar 2021	2,587.07	2,325.13	-10.12
<b>Cumulative Period</b>	<b>46,505.41</b>	<b>46,889.91</b>	<b>0.83%</b>

Based on the above presented comparisons, SgurrEnergy notes the plant to be performing higher than SEI's predictions. Generation of the plant was 0.83% higher than SgurrEnergy's prediction for the period under evaluation. In order to validate the higher generation, SgurrEnergy has compared the monthly incident irradiation data provided by the Developer with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation. The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 8-4.

Table 8-2: Irradiation Comparison– TNS 5MW

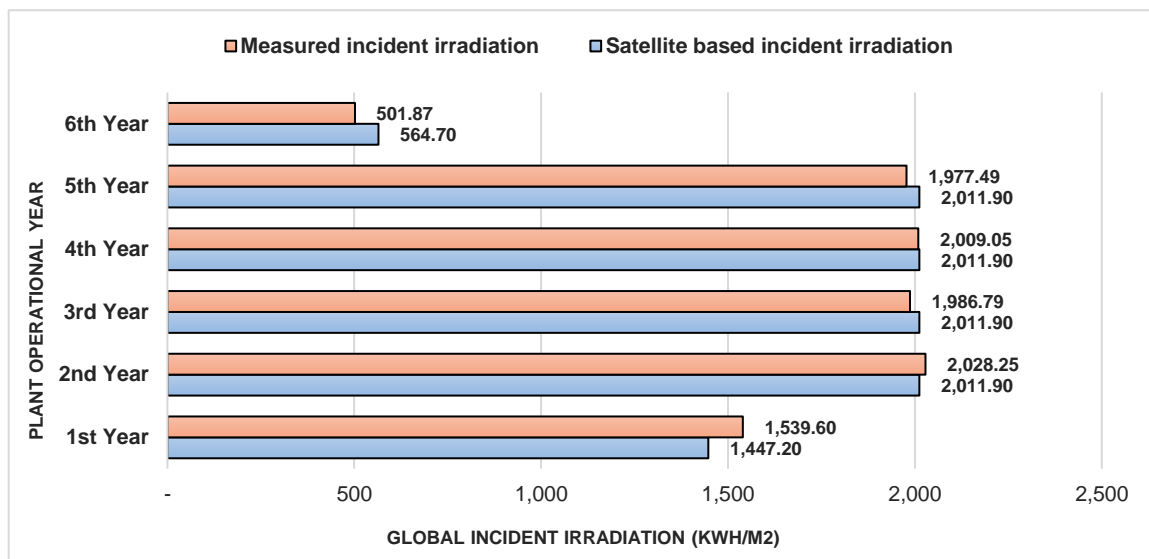
PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>10</sup> (%)
April 2016 -Dec 2016	1,447.20	1,539.60	6.38%
Jan 2017 -Dec 2017	2,011.90	2,028.25	0.81%
Jan 2018 -Dec 2018	2,011.90	1,986.79	-1.25%

<sup>9</sup> Positive values indicate higher generation, while negative values indicate lower generation

<sup>10</sup> Positive values indicate higher irradiation, while negative values indicate lower irradiation



PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>10</sup> (%)
Jan 2019 -Dec 2019	2,011.90	2,009.05	-0.14%
Jan 2020 -Dec 2020	2,011.90	1,977.49	-1.71%
Jan 2021- Mar 2021	564.70	501.87	-11.13%
<b>Cumulative Period</b>	<b>10,059.50</b>	<b>10,043.04</b>	<b>-0.16%</b>



**Figure 8-4: Irradiation Comparison**

Based on the above illustration, it is observed that the overall recorded generation is approximately 0.83% higher than the generation predicted. Correspondingly, it has also been observed that the recorded irradiation is approximately 0.16% lower than the predicted irradiation.

Overall, the comparative analysis indicates the PV plant to be performing in line with SgurrEnergy's prediction.



## 9 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar PV plants as having a lifetime of 25-40 years<sup>11</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>12</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the PV plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement.

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<sup>11</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>12</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>



Virescent Infrastructure

8MW(AC) Aruppukotai Solar PV Plant

TN Solar Power Energy Pvt Ltd

Technical Assessment Report

May 2021



## Report Details

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### Amendment Records

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B3	22.02.2021	For Client Issue	Finalisation of Report
B4	28.05.2021	For Client Issue	Generation Analysis updated

SF/04/023

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## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 13MW<sub>AC</sub> Universal Mine Developers and Service Providers Pvt Ltd (the Project). The Project is located near Kovilpatti village, in Thoothukudi district of Tamil Nadu.

The summary of the technical assessment is captured in the below table.

**Table 1-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	<p>The project site lies around the coordinates 9°26'48.93"N and 78°8'58.40"E and is located near the Aruppukotai village, in Virudhunagar district of Tamil Nadu.</p> <p>Project is contracted for generating 8MW<sub>AC</sub> power. The Owner has utilised approximately 38 acres of land for the project.</p> <p>Project is implemented with poly-crystalline modules (JA Solar) and central inverters (ABB). The module mounting structure is implemented with a tilt of 8° for a pitch of 6m.</p> <p>The power generated from the TNSPEPL 8MW<sub>AC</sub> PV plant is fed to Muthuramalingapuram substation substation, through a single circuit transmission line.</p> <p>The total DC installed capacity stands at 9.6MWP. The AC installed capacity stands at 8MW<sub>AC</sub> with 8 inverters of capacity 1,000kW each.</p>
2	PV Module	<p>SgurrEnergy has conducted a desktop review of JA Solar assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard. SgurrEnergy considers the warranty period to be in line with the industry standards. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.</p>
3	Inverter	<p>ABB is considered to have good track record for supplying central inverters. Certificates mentioned in the technical specification datasheet indicate ABB to hold adequate certifications. Technical characteristics are acceptable, with a good efficiency level for central inverters. Standard warranty of five years is provided for the inverters, which is in line with the industry requirement. Overall, SgurrEnergy does not raise any concern on the utilization of ABB inverters for the Project.</p>
4	Inverter Transformer	<p>The inverter transformers (2200kVA) used within the project are manufactured by Voltamp Transformers Limited. The manufacturers have a good track record of supplying transformers to distinguished customers in Indian as well as in the global market. SgurrEnergy has reviewed the transformers based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with</p>



Sr. No.	Parameter	Comment						
		industry standards and raises no concerns over its use in the project						
5	String Sizing	The VOC does not exceed the inverter input voltage for the site, and therefore, SgurrEnergy considers the number of modules in series to be acceptable for the PV Project.						
6	Permits and Approvals	PPA signed between TN Solar Power Energy Ltd and Tamil Nadu Generation and Distribution Corporation Limited PPA term is 25 years from the Commercial Operation Date. Documents such as CEIG certificate, commissioning certificate, consent to operate etc. have not been provided.						
7	Resource Assessment	For resource analysis, SEI has compared various satellite datasets. For the satellite databases, SEI has compared Meteornorm 7, NASA, SWERA and SolarGIS data to find the most suitable solar resource for long-term energy yield prediction. Owing to low uncertainty and high resolution, SEI considers SolarGIS dataset to be the most representative satellite database among all the satellite databases for long-term energy yield assessment.						
8	Operational Analysis and Generation Comparison	Review presented in Section 8.						
9	Allied Components and Systems	<p>The 8MWAC solar PV plant is designed with JA solar (310/315Wp) solar PV modules and ABB 1000kW central inverter.</p> <p>The 8MWAC solar PV plant has been configured with 8 ABB 1000kW central inverters and four inverter stations. Each inverter station is of 2MWAC capacity contain two inverters of 1000kW capacity, which is further connected to 0.400/0.400/33kV three-winding, 2.2MVA transformer, that steps up the voltage up to 33kV for all inverter stations.</p> <p>The 33kV output of each inverter station combined at 33kV main HT panel located within Main control room (MCR). Further the power is fed from main HT panel to 33kV plant end metering yard.</p> <p>Further the power from the metering yard is then evacuated to the substation located approximately 6.5kms from the Project site through ACSR dog conductor overhead transmission line.</p>						
10	Energy Yield Assessment	<p>Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for third year of plant operation for the 8 MWAC PV plant.</p> <table><tr><td>Global Horizontal Irradiation (kWh/m2)</td><td>1,929.80</td></tr><tr><td>Global Inclined Irradiation (kWh/m2)</td><td>1,951.40</td></tr><tr><td>Sixth Year P50 Energy Yield (MWh/annum)</td><td>14,341.03</td></tr></table>	Global Horizontal Irradiation (kWh/m2)	1,929.80	Global Inclined Irradiation (kWh/m2)	1,951.40	Sixth Year P50 Energy Yield (MWh/annum)	14,341.03
Global Horizontal Irradiation (kWh/m2)	1,929.80							
Global Inclined Irradiation (kWh/m2)	1,951.40							
Sixth Year P50 Energy Yield (MWh/annum)	14,341.03							



Sr. No.	Parameter	Comment	
		Specific Yield (kWh/kWp)	1492.75
		Performance Ratio (PR)	76.49%
		PLF on Contracted Capacity (8 MWAC)	20.46%



## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
m	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon



MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation





## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 258MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of six projects, as presented within Table 1-1.

**Table 1-1: Project Key Summary**

Project Name	SEPEPL – 80MW <sub>AC</sub>	SEPEPL – 50MW <sub>AC</sub>	SPSPL – 50MW <sub>AC</sub>	SPSPPL – 30MW <sub>AC</sub>	TNSPEPL – 5MW <sub>AC</sub> + 8MW <sub>AC</sub> + 10MW <sub>AC</sub>	UMD- 12MW <sub>AC</sub> + 13MW <sub>AC</sub>
Site Location	18.926°N, 76.395°E, Parli, Maharash- tra, India	21.028°N, 75.985°E, Muktainagar Maharashtra ,India	9.324°N, 77.594°E. Rajapalyam, Tamil Nadu,India	12.344°N, 78.945°E Tiruvannam- alai, Tamil Nadu, India.	5MW <sub>AC</sub> – 10.480°N, 78.061°E Dindigul, Tamil Nadu, India 8MW <sub>AC</sub> – 9.437°N, 78.172°E Aruppukkotai Tamil Nadu, India 10MW <sub>AC</sub> – 9.118°N, 78.107°E Vilathikulam, Tamil Nadu, India	12MW <sub>AC</sub> - 9.554°N, 77.884°E Amathur, Tamil Nadu, India 13MW <sub>AC</sub> - 9.093°N, 77.780°E Kovilpatti, Tamil Nadu, India
Owner	Solar Edge Power and Energy Private Limited (SEPEPL)		Shapoorji Pallonji Suryaprakas h Private Limited (SPSPL)	Shapoorji Pallonji Solar PV Private Limited	TN Solar Power Energy Private Limited	Universal Mine Developers and Service Providers Private Limited
DC / AC Capacity	104.0MW <sub>P</sub> / 80.0MW <sub>AC</sub>	65.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	54.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	36.0MW <sub>P</sub> / 30.0MW <sub>AC</sub>	5MW <sub>AC</sub> – 6.0MW <sub>P</sub> / 5.0MW <sub>AC</sub> 8MW <sub>AC</sub> – 9.6MW <sub>P</sub> / 8.0MW <sub>AC</sub> 10MW <sub>AC</sub> – 12.0MW <sub>P</sub> / 10.0MW <sub>AC</sub>	12MW <sub>AC</sub> - 14.4MW <sub>P</sub> / 12MW <sub>AC</sub> 13MW <sub>AC</sub> - 15.6MW <sub>P</sub> / 13MW <sub>AC</sub>
Commissioning date	50MW <sub>AC</sub> – 08.04.2018 30MW <sub>AC</sub> – 22.04.2018	26.04.2018	26.09.2018	26.03.2016	5MW <sub>AC</sub> – 28.12.2015 8MW <sub>AC</sub> – 28.09.2015 10MW <sub>AC</sub> – 31.10.2015	12MW <sub>AC</sub> – 16.11.2015 13MW <sub>AC</sub> – 21.03.2016

This report presents the evaluation of the 5MW<sub>AC</sub> + 8MW<sub>AC</sub> + 10MW<sub>AC</sub> TNSPEPL Solar PV plants (The Project) developed by TN Solar Power Energy Private Limited (TNSPEPL). The Solar PV plants under evaluation are located in *Muthuramalingapuram* village, *Tiruchuli* tehsil, *Virudhunagar* district of Tamil Nadu state. The purpose of this report is to provide a technical appraisal of PV plant under evaluation.

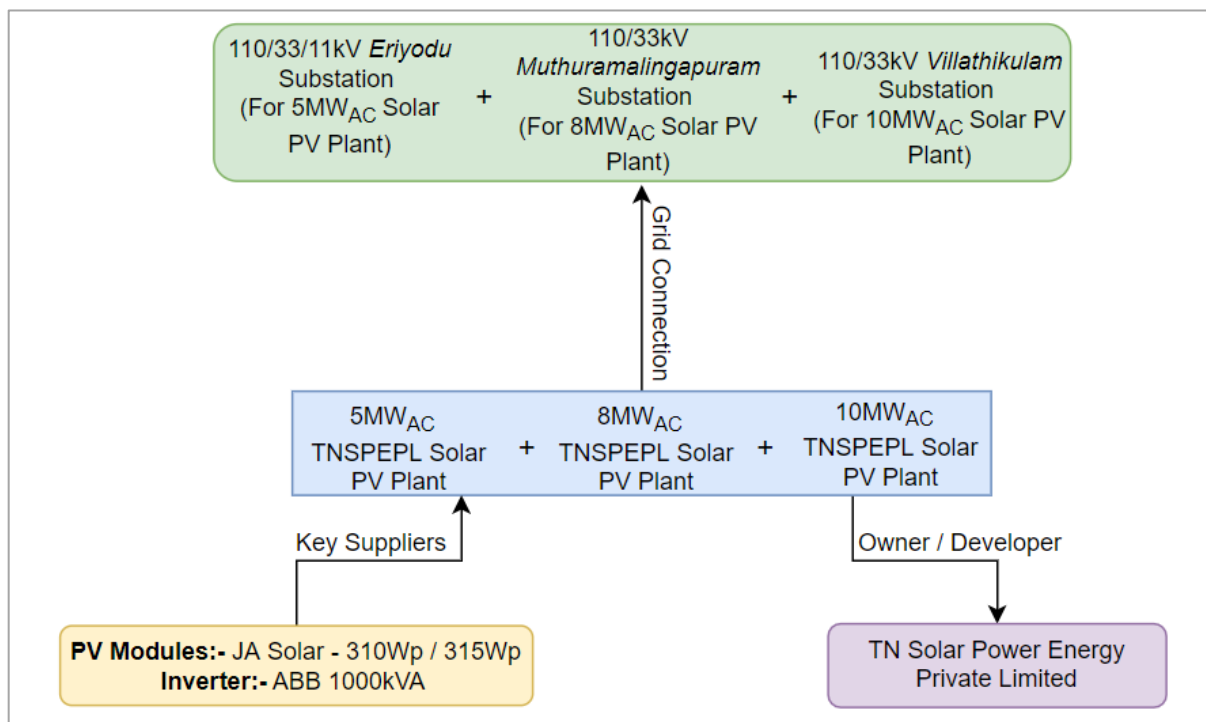
The report focuses on the following key parameters:



- System Design.
- Major Components.
- Engineering Design.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Plant Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project and is based on information made available by the Client through online dataroom.

Figure 1-1 illustrates the project structure indicating key project participants for the 8MW<sub>AC</sub> Solar PV plants.



**Figure 1-1: Project Structure for 8MW<sub>AC</sub> Solar PV Plant**

**Table 1-2: Project Key Summary**

Project Information	
<b>Project Name</b>	8MW <sub>AC</sub> TNSPEPL Solar PV plants
<b>Location</b>	8MW <sub>AC</sub> – Aruppukotai, Tamil Nadu
<b>Developer</b>	TN Solar Power Energy Private Limited
<b>DC/ AC capacity</b>	8MW <sub>AC</sub> PV Plant – 9.6MW <sub>P</sub> / 8.0MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: JA Solar Inverters: ABB
<b>MMS Configuration</b>	Fixed Tilt: 8°, Azimuth: 0°
<b>Commissioning Status</b>	Commissioning for 8MW <sub>AC</sub> PV Plant was achieved on 28 September 2015.



## 2 8MW<sub>AC</sub> Solar PV Plant Overview

The project site lies around the coordinates 9°26'48.93"N and 78°8'58.40"E. Satellite imageries of 8MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1. The Owner has utilised approximately 38 acres of land project. The Project site is located near the *Aruppukkotai* village, in *Virudhunagar* district of Tamil Nadu.

Project is contracted for generating 8MW<sub>AC</sub> power; SgurrEnergy therefore interprets 8MW<sub>AC</sub> as the maximum AC installed capacity for the solar PV plant.



**Figure 2-1: Satellite image of 8MW<sub>AC</sub> plant**

### 2.1 8MW<sub>AC</sub> Project Summary

Solar PV plant is modular in nature; therefore, TNSPEPL 8MW<sub>AC</sub> solar PV plants is implemented by adopting modularity in designs. 2MW<sub>AC</sub> is the typical inverter station considered for implementing TNSPEPL 8MW<sub>AC</sub> solar PV plant.

Table 2-1 presents the summary of 8MW<sub>AC</sub> PV plant

**Table 2-1: Summary of 8MW<sub>AC</sub> Plant Configurations**

General	
PV Module Technology	Poly-crystalline
Inverter Technology	Central Inverters
Installed DC Peak Capacity (MW <sub>P</sub> )	9.6



General	
Installed AC Capacity (MW)	8.0
Mounting Type	Fixed Tilt
Tilt Angle (°)	8°
Pitch (m)	6
PV Modules	
PV Module Manufacturer	JA Solar
Model	JAP6-72-310/3BB JAP6-72-315/3BB
Wattage (W <sub>P</sub> )	310W <sub>P</sub> / 315W <sub>P</sub>
Number of Modules per String	21
Inverter	
Inverter Manufacturer / Model	ABB / PVS-800
Inverter Nominal AC Output	1,000kW
Number of Inverters	8
Mounting Structure	
Mounting Structure Details (rows x columns)	2 x 21
Orientation of Modules	Portrait

The 8MW<sub>AC</sub> plant is implemented with a total of four (4) inverter station of capacity 2MW<sub>AC</sub>. Each inverter station is comprising of three winding transformers to accommodate two (2) 1,000kVA inverters, taking the individual inverter station size to 2MW<sub>AC</sub>. Inverter station is comprising of a physical block connecting to 2.4MW<sub>p</sub> of installed photovoltaic array. The output of 2MW<sub>AC</sub> inverter station is connected to 0.400/0.400/33kV three winding transformer of 2.2MVA for stepping up the voltage to 33kV.

The medium voltage 33kV output of the inverter station is placed in main control room (MCR), these are combined to form a solar PV plant of 8MW<sub>AC</sub>. The 33kV output is evacuated using a 33kV DP structure located in the plant premises.

The power generated by the TNSPEPL 8MW<sub>AC</sub> PV plant is fed to *Muthuramalingapuram* substation located approximately 7km from the Project site, through a single circuit Dog ACSR conductor. The point of interconnection is at the *Muthuramalingapuram* substation.

ABT / revenue metering is at *Muthuramalingapuram* substation; therefore, transmission line losses are accounted in the Owner's scope.



### 3 Review of Major plant components

SgurrEnergy has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions.

#### 3.1 PV modules

The PV modules selected for the Project are supplied by JA Solar Holding Co., Ltd., Canadian Solar and Astronergy. SgurrEnergy has conducted a technical review of the suppliers and proposed module specifications with regard to their suitability for use on the Project.

##### 3.1.1 Company Profile – JA Solar Holding Co., Ltd

JA Solar Holding Company Ltd. listed on NASDAQ (NASDAQ: JASO), was found in the year 2005 and started operation in 2006. The Company has 12 manufacturing bases and has production capacity of more than 11.5GW, 11GW, and 11GW for silicon wafer, solar cells, and solar modules, respectively.

JA solar has 20 branches around the world and employs more than 22,000 employees worldwide. As of December 2019, JA solar provides services in more than 135 countries and to more than 33,000 clients worldwide. As of second quarter 2020, JA solar had a cumulative shipment of more than 50GW. As of December 2019, JA solar had more than 779 authorized patents of independent R&D and 107 invention patents under its name. The Company's net revenue was RMB 21.16 billion in 2019.

Few of the commissioned solar power plants using JA modules are listed in Table 3-1.

**Table 3-1: Project References of JA Solar**

Sr. No.	Project and Location	Capacity (MW)
1	Bahia, Brazil	255.0
2	Northern Cooks, Australia	172.8
3	Cadiz, Philippines	132.5
4	Maharashtra, India	130.0
5	Three Gorges, Datong	100.0
6	Bahawalpur, Pakistan	100.0
7	Lincheng Country, Xingtai City, Hebei Province	100.0
8	Dunhuang, Gansu Province	100.0
9	Utah, USA	80.0
10	New South Wales, Australia	70.0
11	Maharashtra, India	70.0
12	Telangana, India	69.0
13	Bole, Xinjiang	60.0
14	San Carlos, Philippines	59.0
15	MP, India	57.0
16	Charanka Gujrat, India	53.0
17	Datong, Shanxi Province	50.0
18	Southwark, UK	49.0
19	Karnataka, India	43.0



Sr. No.	Project and Location	Capacity (MW)
20	Xiayu, Hebei Province	42.0
21	Yinchuan, Ningxia Province	40.0
22	Georgia, USA	38.7
23	Arawa Desert and Negev Desert, Israel	35.0
24	Hefeng, Tacheng, Xinjiang	30.0
25	Karnataka, India	23.0
26	Bulgaria	21.0
27	Haryana, India	21.0
28	Campania, Italy	20.0
29	Corp 184, Xinjiang	20.0
30	Telengana, India	18.0
31	Toshka, Egypt	10.1
32	Volkswagen Chattanooga Plant, USA	9.6
33	Antalya, Turkey	6.7
34	Kenitra, Morocco	2.0
35	ABC Bank, Jordan	1.5

JA is considered a Tier 1 supplier by Bloomberg (Q4, 2020). A Tier 1 supplier is defined as a module manufacturer who has *provided products to five different projects, which have been financed non-recourse by five different (non-development) banks, in the past two years.*

Whilst the Bloomberg tiering system does not reflect on a product's technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers JA solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

### 3.1.1.1 Main Technical Characteristics of JAP6-72/3BB

JA Solar, JAP6-72/3BB modules of 310W<sub>P</sub> and 315W<sub>P</sub> capacity have been utilized for the Project. These modules have an efficiency of 15.99% and 16.25% for 310W<sub>P</sub> and 315W<sub>P</sub> capacity modules, respectively, and a peak power tolerance of 0~+5W. The modules have a temperature coefficient (P<sub>max</sub>) of -0.41%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy's expectation for c-Si technology. The technical characteristics of JAP6-72/3BB are presented in Table 3-2.

**Table 3-2: Technical specifications of JAP6-72/3BB**

Specifications	JAP6-72-310/3BB	JAP6-72-315/3BB
Technology	Polycrystalline	
Nominal power (P <sub>MPP</sub> )	310W <sub>P</sub>	315W <sub>P</sub>
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	37.00V	37.28V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	8.38A	8.45A
Open circuit voltage (V <sub>OC</sub> )	45.45V	45.60V
Short circuit current (I <sub>SC</sub> )	8.85A	8.91A
Efficiency (%)	15.99%	16.25%





Specifications	JAP6-72-310/3BB	JAP6-72-315/3BB
Maximum System Voltage	1,000V (DC)	
Power tolerance (%)	0~+5W	
Dimensions (length × breadth × width) (mm)	1956 × 991 × 45	
Module area (m²)	1.94m²	
Weight (kg)	~26kg	
Temperature coefficient at P <sub>MAX</sub>	-0.41%/°C	
Operating temperature	-40°C to +85°C	
Maximum reverse current	15A	
Maximum mechanical load	5400Pa	
Maximum snow load	2400Pa	
Product warranty	10 years	
Power output guarantee	25 years	
Module technical characteristics are given at STC (1,000W/m² irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet)		

The maximum system voltage is 1,000V. The maximum reverse current is 15A. Overall, the module characteristics can be considered to be in line with market standard and JA Solar is listed as Tier 1 suppliers by Bloomberg since 2014.

### NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>1</sup> characteristics of selected JAP6-72/3BB modules of 310W<sub>P</sub> and 315W<sub>P</sub> is given in Table 3-3 corresponding to realistic operating conditions as compared to STC. It is affected by module materials used as well as the packing density of module materials. The NOCT for the module is 45±2°C. This is comparable with other manufacturers and demonstrates the module is effective at heat dissipation.

**Table 3-3: PV Module NOCT Characteristics of JAP6-72/3BB**

Model	JAP6-72-310/3BB	JAP6-72-315/3BB
Maximum Power (P <sub>MAX</sub> )	225.06W <sub>P</sub>	228.69W <sub>P</sub>
Max Power Voltage (V <sub>MPP</sub> )	34.05V	34.08V
Max Power Current (I <sub>MPP</sub> )	6.61A	6.71A
Open Circuit Voltage (V <sub>OC</sub> )	42.58V	42.63V
Short Circuit Current (I <sub>SC</sub> )	6.99A	7.06A

#### 3.1.1.2 Certification of Modules

General review of datasheet indicates JA Solar PV modules manufactured in facilities with the following certifications:

- ISO 14001 certification for environmental management systems

<sup>1</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C.



- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certifications available in public domain for the modules under evaluation within Table 3-4.

**Table 3-4: Certification for PV Module- JA Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
UL 1703	Standard for safety for flat-plate photovoltaic modules

### 3.1.1.3 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of six months from the dispatch from the JA solar factory or the delivery date to site.

### 3.1.1.4 Product Warranty

JA Solar provides a limited product warranty of 10 years, beginning on the earlier of module purchase date or one-year anniversary from the production date. If module fail to conform to this warranty, during the period ending of 10 years from the date of sale to the customer of the JA solar product, JA solar will at its opinion, either repair or replace the product, or refund the purchase price as paid by the customer. The repair or replacement or refund the customer at the current comparable market price of such module.

SgurrEnergy considers twelve-year product warranty provided by JA solar to be in line with the industry standard.

### 3.1.1.5 Linear Power-Output Warranty

According to the datasheet JA solar warrants that the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.7% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 80.7% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, JA solar will either repair, replace or provide additional modules to make up for the loss in power output.

## 3.2 Inverters – ASEA Brown Boveri (ABB)

The project has utilized ABB PVS800-57-1000kW central inverter for the project under evaluation.

### 3.2.1 Company background

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, ABB is one of the largest engineering companies as well as one of the largest conglomerates in the world. ABB has operations in around 100 countries, with





approximately 147,000 employees<sup>2</sup>. Company reported global revenue of around \$34,312 million for 2017.<sup>3</sup>

The firm's shares are traded on the stock exchanges of Zurich, Stockholm, and New York. ABB is a multinational corporation headquartered in Zurich, Switzerland, operating mainly in robotics and power and automation technology.

On July 9, 2019 the Italian company FIMER acquired ABB's solar inverter business. The takeover of ABB's solar inverter business included 800 employees in 26 countries as well as two manufacturing plants, in Italy and in India, and a R&D facility in Finland.

FIMER was founded in 1942, headquartered in Vimercate, Italy, has been actively working in inverter technology since 1983. As of 2020, the company employs more than 1,100 employees across its three manufacturing facilities and three R&D centres across the globe. As a result of acquisition of ABB's PV inverter line, FIMER ranked the fifth-largest PV inverter globally in 2019.

### 3.2.2 Track Record

ABB India commenced local manufacturing of solar inverters in 2012 and partnered with several customers. ABB is the solar inverter market leader in India holding approximately 24% market share in 2018. ABB has approximately 3,590MW in operation across more than 350 sites in India. ABB India manages close to 40% of the installed bases in India. As on 30 August 2017, ABB India crossed the 5GW threshold for the supply of inverters in the country.

Table 3-5 lists the state-wise installed capacity of ABB inverters in India. However, it is to be noted that the table below doesn't not comprise of the installed capacities till date.

**Table 3-5: ABB Inverter Track Record**

Location	Capacity (MW)
Tamil Nadu	747
Andhra Pradesh	647
Rajasthan	371
Karnataka	305
Madhya Pradesh	271
Maharashtra	261
Punjab	227
Bihar	225
Uttar Pradesh	106
Haryana	62
Kerala	50
Chhattisgarh	28
Odisha	20

ABB India has strategically located its headquarter in Bangalore and offices in other cities Pune, Ahmedabad, Jaipur, Faridabad, Hyderabad, Tamil Nadu, and Bhopal in order to

<sup>2</sup> <https://new.abb.com/news/detail/26838/abb-to-exit-solar-inverter-business>

<sup>3</sup> <https://new.abb.com/investorrelations/company-profile/facts-figures>



facilitate quick spare part availability and minimal response time. ABB aims to provide first response to its customers within 4 hours on weekdays and within 24 hours on weekends and holidays. ABB also provides a Turn-Around-Time of 48 and 72 hours on weekdays and weekends respectively, hence maintaining an average uptime of over 99%.

### 3.2.3 Technical Characteristics

ABB PVS800-57-1000kW inverter has been selected for technical feasibility of the Project. The technical specification of 1000kW ABB inverter is listed in Table 3-6.

The PVS800-57-1000kW Series of central inverters designed ideal for large PV Power Plants. PVS800 inverters are designed for fast and easy installation. These inverters are designed to operate with DC inputs up to 1,100 V. They incorporate maximum power point tracking (MPPT) and grid management features to meet utility requirements.

PVS800-57-1000kW inverter is designed for outdoor use with an IP42 ingress protection class. They are protected against solid objects over 1mm and against direct sprays of water up to 15° from the vertical. They perform optimally at ambient air temperatures between -15°C to 50°C and relative humidity in the range of 15% to 95% with maximum noise level of 75dBA.

The PVS800-57-1000kVA inverter has peak efficiency of 98.8% and a European efficiency of 98.6%.

The main technical characteristics of these inverters are illustrated in Table 3-6.

**Table 3-6: ABB inverter specifications**

<b>ABB Central Inverter Specifications</b>	
Inverter	ABB PVS800-57-1000kW
Type	Central Inverter
<b>Input Data</b>	
Maximum Input Power (kW <sub>p</sub> )	1200kW <sub>p</sub>
PV voltage range, MPP (V)	600 to 850V
Maximum DC voltage (V)	1100V
Maximum input current (A)	1710A
<b>Output Data</b>	
Nominal AC power (kW)	1000kW
Maximum AC current (A)	1445A
Nominal AC voltage(V)	400V
AC grid frequency (Hz)	50Hz -5%+3%
Maximum THD	< 3%
<b>Operating Performance</b>	
Maximum efficiency (%)	98.80%
Euro efficiency (%)	98.60%
<b>Power consumption</b>	
Own consumption in operation(W)	730W
Standby operation consumption (W)	70W
<b>Other</b>	



<b>ABB Central Inverter Specifications</b>	
Dimensions (W × H × D) (mm)	3630mm x 2130mm x 610mm
Weight (kg)	2600kg
Environmental Protection Rating	IP42
Operating temperature range (°C)	-15 to +50°C
Relative humidity (%)	15% to 95%

The following protection devices are included within the inverter design:

- Ground fault monitoring
- Grid Monitoring
- Anti-islanding protection
- DC reverse-polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection
- Remote monitoring solutions

ABB inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components.

### 3.2.4 Certification

ABB is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. ABB inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information available in public domain, SgurrEnergy has summarized the certification of the ABB inverter within Table 3-7.

**Table 3-7: Description of Certification of ABB inverters**

<b>Certification</b>	<b>Description</b>
IEC 60068-2-6/29	Environmental testing of inverters to assess their ability to perform and survive under conditions such as transportation, storage, operational environments, extreme cold and heat
IEC61683:1999	Measurement of the efficiency of power conditioners
IEC 62109-2:2011	Safety of Power Converters
IEC 62116:2014	Test procedure of islanding prevention measures

### 3.2.5 Warranties

SgurrEnergy referred the warranty documents available in public domain. Given the industry standard warranty of 60 months, SgurrEnergy does not raise any concern over the use of inverter for the project.



### 3.3 Inverter Transformer – Voltamp Transformers Limited

The power at low voltage from inverters is stepped up to 33kV using 2200kVA transformers of Voltamp Transformers Limited make.

#### 3.3.1 Company Profile

The inverter transformer used is manufactured by Voltamp Transformers limited (Voltamp).

Voltamp was founded in 1963 in Vadodara, Gujarat and now has a PAN India presence. The company initially started off by manufacturing small transformers by 1975 the largest transformer manufactured was for 132kV networks. This limit rose to 220kV class of transformers in 2008. The company employs more than 300 personnel (including 60 engineers) and has branch offices in Mumbai, New Delhi, Chennai, Bangalore, Secundrabad, Pune, Bhubaneshwar, etc.

The company has four manufacturing plants and the current manufacturing capacity totals to 13000 MVA per year. These facilities boast of manufacturing Oil filled Power and Distribution Transformers up to 160MVA, 220kV. The company got its ISO 9001 certification in 1998 and was listed on the NSE and BSE stock exchange in 2006.

Notable designs include:

- 75MVA 11/138kv GT
- 20MVA 33-22/11kV (DZ10)
- 50MVA 132-110/33kV transformer
- 6 MVA 1-ph transformer
- 15MVA 11/1.3-1.3kV (24 pulse)
- 100MVA 22kV

The company also manufacturers two types of dry transformers, i.e. resin impregnated (25KVA-5000KVA up to 11kV) and cast resin transformers (50kVA-12500kVA up to 33kV). Prominent clients include ABB, Exide, Adani, BHEL, BPCL, Suzlon etc.

#### 3.3.2 Technical Specifications

The 2200kVA Power transformers used in the project are outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 3-8.

**Table 3-8: Technical Specification of Voltamp Transformers**

Technical Parameters	Description
Rated Power	2200kVA
Rated HV	33kV
Rated LV	400-400V
Tapping on HV	-5% to +5% (steps of 2.5%)
Phases	3
Frequency	50Hz



Technical Parameters	Description
Vector group	Dy11y11
Impedance	5.93%
Cooling Strategy	ONAN
Oil temperature rise	50°C
Winding temperature rise	55°C
Winding material	Copper

SgurrEnergy considers the overall the technical specification to be adequate for the PV projects and in line with the industry accepted standards.

### 3.3.3 Temperature Rise Detection and Protection

Inverter transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.4 Warranties and Guaranties

Based on the information available in public domain, SgurrEnergy understands the Shilchar transformers have been provided with a warranty of 60 months from date of dispatch. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards.

## 3.4 Conclusion on Major Plant Components

### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of JA Solar, Canadian Solar and Astronergy assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.

Further, according to the warranty documents available in public domain for all three module manufacturers, SgurrEnergy considers the warranty terms and conditions offered by all three manufacturers to be in-line with the industry standard and raises no major concern regarding the warranties offered. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.

### Inverters

SgurrEnergy has conducted review of the ABB PVS800-57-1000kW central inverter ABB PVS800-57-1000kW central inverter has the required certification for use in solar PV plants. In-house testing of the inverter and individual components is relatively extensive during the R&D phase with functional and temperature cycling testing of each manufactured inverter. ABB offers a product warrant of 5 years which is in line with the current industry standards.

In conclusion, ABB can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters.



ABB inverters have more than 3GW of installation worldwide. These inverters are quite known to the Indian market and have installed capacity of more than 1.3GW which demonstrates a good track record in the Indian solar PV market.

# Transformers

Voltamp has a track record of more than 53,000 transformer installation across India, Nepal, Sri Lanka, Bhutan, Indonesia, Middle East Asia, South East, and African Countries<sup>4</sup>. The accreditations for manufacturing facility gained by the company are considered fair and satisfactory.

The inverter transformers (2200kVA) used within the project are manufactured by Voltamp Transformer Limited. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.

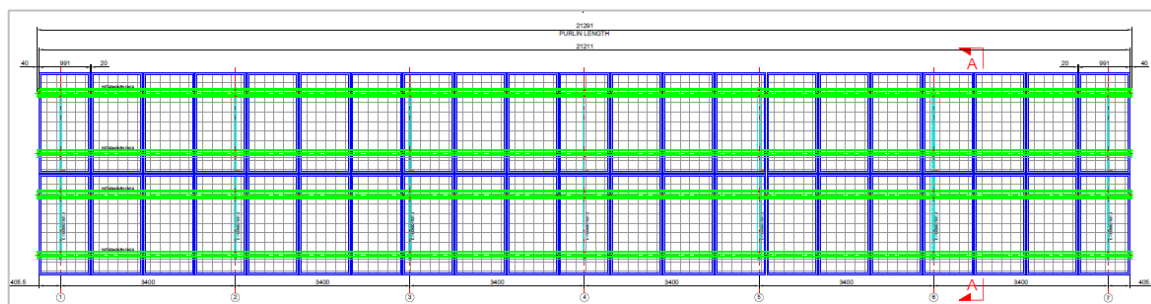
### 3.5 Module support structures

The Array Layout provided by the Client for the JA solar modules indicates the fixed tilt module mounting structure is inclined at 8° tilt angle.

Although the as-built MMS GA drawing for the 8MW<sub>AC</sub> Aruppukottai site has not been provided for review, SgurrEnergy observed that the EPC contractor, PV module, module orientation, MMS configuration and tilt angle provided for 5MW<sub>AC</sub> Perumpalli site is similar to that of 8MW<sub>AC</sub> Aruppukottai site. Hence, SgurrEnergy has reviewed the as-built MMS GA drawing provided for 5MW<sub>AC</sub> Perumpalli site, dated 12.06.2015.

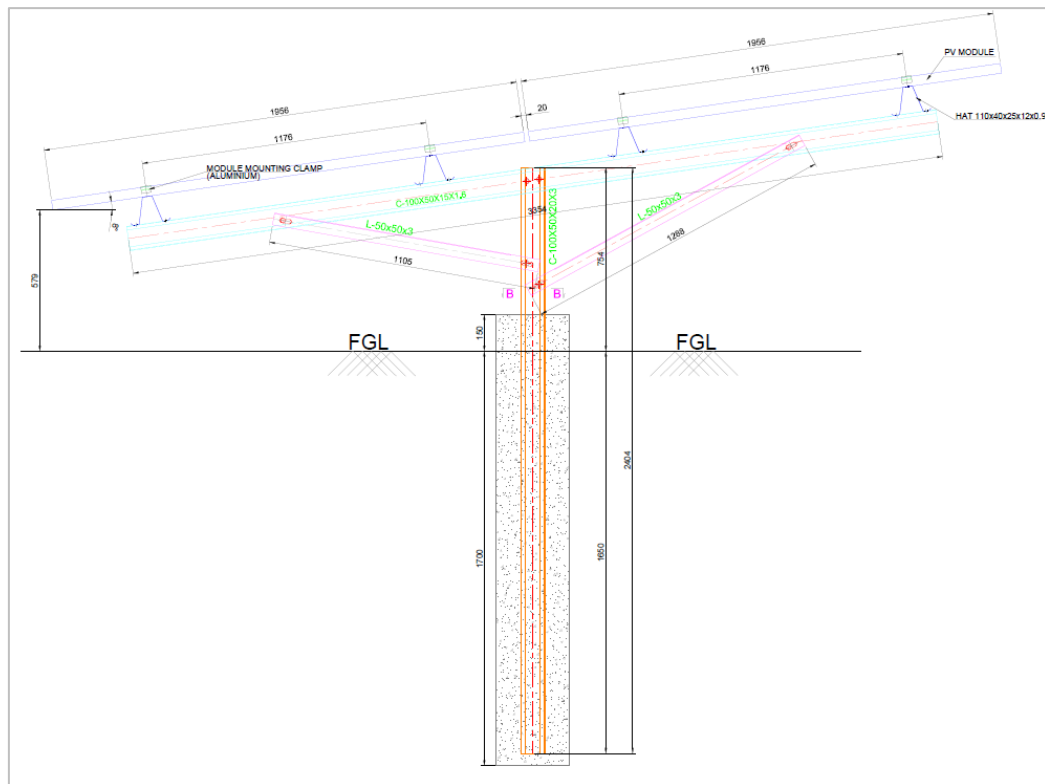
SgurrEnergy observed that the structure has been designed with two rows of modules placed in portrait orientation with 21 modules in each row. In total there are 42 modules in one mounting structure. The layout is designed with a pitch of 6m.

Figure 3-1 and Figure 3-2 illustrate the module mounting structure configuration provided by the Client for the JA solar PV modules.



**Figure 3-1: Two in portrait module mounting structure with 21 modules in a row**

<sup>4</sup> <http://www.voltamptransformers.com/index.php/dashboard/infrastructure>



**Figure 3-2: Side view of the module mounting structure configuration**

Based on the information provided in the GA drawing of the MMS, the technical specification has been summarized below.

Table 3-9 summarizes the technical specification of the module mounting structure.

**Table 3-9: Specification of MMS**

MMS Part	Material	Grades - Standard	Thickness (mm)	Minimum Yield Stress (MPa)
Rafter	Cold Formed	ASTM A 653-340-1	1.6	350
Purlin	Cold Formed	ASTM A 792/_2010/ G_80_550_CLASS_1	0.9	550
Leg	Cold Formed	E350- IS 5986-2011	3.0	350
Bracing	Cold Formed	E350- IS: 10262, IS 2911, IS 456, IS 800	3.0	350

Material used is a combination of hot-dipped galvanised mild steel and pre-galvanised cold rolled sheets sheared to form structural members for module mounting. The pre-galvanised sheets post process is appropriately coated with anti-corrosion compounds for the project life cycle. SgurrEnergy was not provided with the information regarding type of pile used in the project.





## 4 Allied Components and Systems

### 4.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

### 4.2 PV Power Transfer

SgurrEnergy has reviewed the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear, and plant substation as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

- “SWLB-SP-TN-8MW-E-DWG-SLD-100”, revision 1, dated 20.10.2015.
- “SWLB-SP-TN-8MW-E-DWG-SLD-100B”, revision 1, dated 27.10.2015.
- SWLB-SP-TN-8MW-E-DWG-AL-101”, dated 20.10.2015.

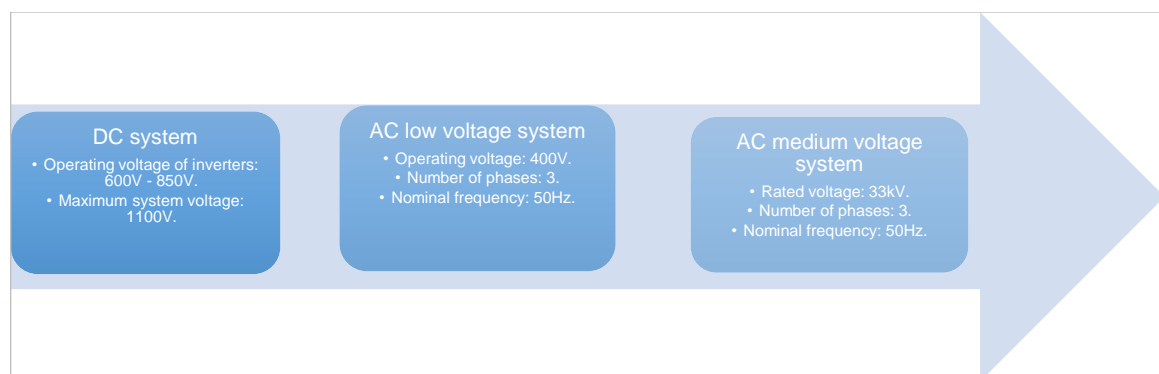
The 8MW<sub>AC</sub> solar PV Plant is designed with 310W<sub>P</sub> and 315W<sub>P</sub> JA solar PV modules and 1000kW ABB inverters. Modules are interconnected to form a string of 21 modules. Each string forms a single output that feeds as a single input to the 12 input combiner boxes. Eight string combiner boxes are further connected to the inverter.

The 8MW<sub>AC</sub> solar PV plant has been configured with 8 ABB 1000kW central inverters and four inverter stations. Each inverter station is of 2MW<sub>AC</sub> capacity contain two inverters of 1000kW capacity, which is further connected to 0.400/0.400/33kV three-winding, 2.2MVA transformer, that steps up the voltage up to 33kV for all inverter stations. The power from the HV side of the 33kV inverter transformer is transferred to 33kV HT panel.

The output power of each 33kV HT panel is connected to 33kV main HT panel located in the main control room. Further power from main control room is fed to 33kV metering yard through 33kV Double pole (DP) structure.

Power from 33kV metering yard is evacuated to the substation situated at a distance of 6.5km from the project site at 33kV voltage level through ACSR dog conductor overhead transmission line.

Figure below illustrates a power flow summary for the 8MW<sub>AC</sub> Solar PV plant.



**Figure 4-1: Power flow of 8MW<sub>AC</sub> PV plant**

### 4.3 Cabling

#### 4.3.1 DC Cabling

DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. Modules are interconnected in series with solar grade cables that





are tied along with the module mounting structures. Modules are interconnected in leap-frog scheme to form a string of 21 PV modules connected in series.

The Y harness equipped with 30A fuse has been used to pre-combine the string of PV module. Single core 6mm<sup>2</sup> multi-stranded copper PV cables connect Y- harness output to String Combiner Box (SCB).

These combiner boxes are equipped with 30A fuse for each of the string connection and a 315A disconnect switch on output side. Power from string combiner box is further transferred to the inverter using 2 runs, 1C, 185/240mm<sup>2</sup>, 1.1kV aluminium XLPE ((2R X 1C X 185/240Sqmm, 1.1kV AL. XLPE Armoured) cables.

#### 4.3.2 AC Cabling

Three phase AC output from inverter is connected to the LV winding of a three-winding 2.2MVA transformers, using 12 Runs single core 630mm<sup>2</sup> Aluminium Armoured XLPE (12R (4R/Ph) X1C x 630mm<sup>2</sup> Al. Ar. XLPE) cable. The inverter transformers step up the voltage to 33kV.

Power is fed from the high voltage side of each transformers using 1R,3C, 185mm<sup>2</sup>, 33kV Al XLPE armoured cable to the 33kV HT panel in the 2MW<sub>AC</sub> inverter stations using a radial feeder arrangement.

The 33kV output of each inverter station is transmitted to 33kV main HT panel located within Main control room using 1R,3C, 185mm<sup>2</sup>, 33kV(E) Al XLPE armoured HT cables.

The power from the Main HT panel is transferred to 33kV DP structure using triple core, 300mm<sup>2</sup>, 33kV Aluminium XLPE Armoured (1R x 3C x 300sqmm/Phase 33kV[E], Al, XLPE, Ar.) cable further the output power of 33kV DP structure is transferred to 33kV metering yard through overhead line.

Further the power from the solar PV plant is feed to the 33kV substation through ACSR dog conductor overhead transmission line.

#### 4.4 Inverter Station

The 8MW<sub>AC</sub> solar PV plant has been configured with 8 inverters and four inverter stations. Each inverter station is of 2MW<sub>AC</sub> capacity consist of two inverters of 1000kW capacity.

The 2MW<sub>AC</sub> inverter station consists of two inverters connected to a 2,200kVA three-winding transformers. Each transformer, along with allied switchgears, steps up the voltage to 33kV for all inverter stations. Further the power from the HV side of the transformer is fed to the 33kV outdoor type HT panel through radial feeder arrangement.

33kV outdoor type HT panel comprises of 50/5-5A current transformer, 33kV/110V fixed type line potential transformer, 33kV EDO TP, 630A Vacuum Circuit Breaker and other electrical protection system. The power from inverter duty transformer is transferred to aforesaid MV panel.

#### 4.5 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed 2.2MVA, 33kV/2x0.400kV, Dy11y11 three-winding transformers have been used in the project. These inverter duty transformers step up the voltage to 33kV.

The 2.2MVA inverter duty transformers output is connected to 33kV HT panels located within inverter station. The energy from all the inverter stations 33kV HT panels is radially combined at 33kV main HT panel located within main control room.

#### 4.6 33kV Main HT Panel

A 33kV main HT panel comprises of inverter station incoming feeders and one outgoing feeder. Each feeder comprises of dedicated VCB, instrument transformer with metering



and protection class. All feeders have been provided with relay and metering unit. The 33kV main HT panel outgoing and incoming feeders are provided with instantaneous and IDMT (50/51) O/C relay instantaneous and IDMT (50N/51N) E/F relay protections. The 33kV outgoing feeders are provided with 0.2S class instrument transformers.

Power is fed from 33kV main HT panel to and metering yard using 33kV DP structure further power from 33kV DP structure is transferred to metering yard through overhead line.

#### 4.7 33kV Metering Yard

The 33kV main HT panel outgoing feeders are connected to 33kV DP structure and 33kV Metering yard.

The 33kV metering yard is observed to be equipped with instrument transformers, isolator, and lightning arrestor with metering & protection cores. The 30kV, 10kA lightning arrestor is provided at 33kV incoming feeders to discharge surge currents caused by lightning strokes.

Subsequently energy from 33kV plant end metering yard is evacuated to the substation located at the distance of 6.5km from the project site at 33kV level through dog ACSR single circuit overhead transmission line.

#### 4.8 Auxiliary Power Supply

SgurrEnergy had reviewed the electrical schematics shared for the projects to evaluate auxiliary system. Three blocks of 2MW<sub>AC</sub> capacities are equipped with 15kVA and one block is equipped with 40kVA auxiliary transformers.

#### 4.9 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are normally mounted on individual structures.

Following the review of 33kV SLD, SgurrEnergy observed 33kV, 630A, 25kA/1sec load break switch has been used in the project.

#### 4.10 Isolators

Isolators are used to transfer load from one bus to another and also to isolate equipment for maintenance.

Based on the review of 33kV SLD, SgurrEnergy observed 33kV, 630A isolator with earth switch has been used in the project.

#### 4.11 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.

The current transformers with accuracy class of 0.2s for metering and class 5P and PS for protection has been used in 8MW<sub>AC</sub> solar PV plant. The potential transformers with accuracy class of 0.2 for metering and class 3P for protection has been used in the project.



#### 4.12 Surge Arresters and Lightning Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes on the lines entering the substation. The apparatus most commonly used for this purpose is the surge arrester. Transformer is the costliest equipment in substation, and it is normal practice to install surge arrester near to the transformer. Additional surge arresters shall be provided either on bus or on various lines for protection of the equipment.

Following the review, SgurrEnergy observed 30kV, 10kA, surge arrester and 30kV, 10kA lightning arrester has been used in 33kV main HT panel and 33kV metering yard, respectively.

#### 4.13 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy will be provided at the medium voltage switchboards for each of the feeder sections. These meters will be digital with an RS 485 port for remote monitoring. These usually have an accuracy class of 0.5.

Similarly, HV side shall also be equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point shall be 0.2S.



## 5 System Design Appraisal

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

### 5.1 Plant Layout Design

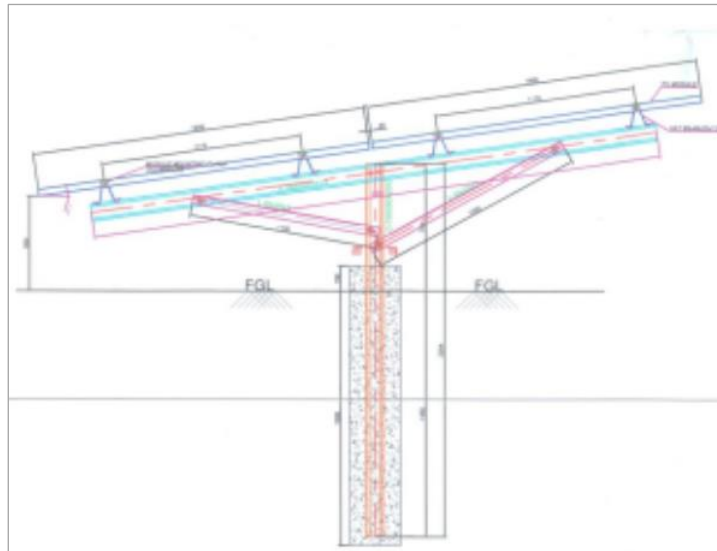
SgurrEnergy was provided with as built plant layout and electrical schematics. SgurrEnergy has verified the plant configuration with electrical schematics provided by the Client. The PV plant is JA Solar (310W<sub>P</sub> and 315W<sub>P</sub>) PV modules. The total DC installed capacity stands at 9.6MW<sub>P</sub>. The AC installed capacity stands at 8MW<sub>AC</sub> with 8 inverters of capacity 1,000kW each. Overall 8MW<sub>AC</sub> PV plant is illustrated below in the Figure 5-1.



**Figure 5-1: Plant layout of 8MW<sub>AC</sub>**

All the PV modules are orientated towards South. The mounting structure provides support for two rows of panels in portrait orientation.





**Figure 5-2: Side view of typical module mounting structure configuration**

The selected tilt for the 8MW<sub>AC</sub> plant is 8°. The 8MW<sub>AC</sub> plant is designed with a pitch of 6m.

Based on regional experience of detail designing, SgurrEnergy considers the selected tilt angle and pitch is optimized for maximum irradiation on the collector plane, minimum loss due to inter row shading, minimum ohmic losses and ease of maintenance.

21 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.2. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.

## 5.2 String Sizing

The plant layout provided by the Developer indicate thirty 310W<sub>p</sub> and 315W<sub>p</sub> JA Solar polycrystalline modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage ( $V_{OC}$ ) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum  $V_{OC}$  of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy in validating string configuration. Subsequent to calculating open circuit voltage ( $V_{OC}$  max), maximum power voltage ( $V_{mp}$  min) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 40°C and 15°C respectively for system design validation to be fair and representative for the PV plants' site.

The results of string sizing validation are presented in Table 5-1. Results indicate that  $V_{OC}$  max at the minimum ambient temperature is within the maximum system voltage of 1,000V for the selected ABB inverters.

**Table 5-1: String Sizing for JA Solar PV Modules**

Parameters	JA 310W <sub>p</sub>	JA 315W <sub>p</sub>
PV module power (W <sub>p</sub> )	310	315



Modules per string	21	
Inverters	ABB (PVS-800-57-1000kW)	
Maximum Open-circuit voltage ( $V_{oc}$ max) at minimum ambient temperature of 15°C	987V	991V
Minimum power voltage ( $V_{mp}$ min) at maximum ambient temperature of 40°C	905.1V	907V

### 5.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with JA Solar and ABB inverter is presented in Table 5-2. SgurrEnergy has selected the highest rated JA Solar module (315W<sub>p</sub>) their compatibility with ABB inverters, as SgurrEnergy considers this to be representative for all the JA Solar PV modules installed on site.

**Table 5-2: Inverter Compatibility with JA Solar 315W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>JA Solar 315W<sub>p</sub></b>	
Modules per string	21	Acceptable
Strings per inverter	182	Acceptable
Maximum power, $P_{mpp}$ at STC (kWp)	1,203.9	Nominal power ratio is 1.20, this is within the inverter bus current carrying capacity.
Maximum power voltage, $V_{mpp}$ at STC (V)	782.8	Acceptable.
Maximum power current, $I_{mpp}$ at STC (A)	1,537.9	Acceptable
Open-circuit voltage, $V_{oc}$ at STC (V)	957.6	Acceptable.
Minimum MPP voltage at 40°C ambient temperature (V)	730.8	Acceptable: Inverter MPPT ranges 600 - 850V.
Maximum MPP voltage at 15°C ambient temperature (V)	814.8	Acceptable: Inverter MPPT ranges 600 - 850V.
Maximum open circuit voltage, $V_{oc}$ at 15°C (V)	991	Acceptable: Maximum inverter voltage 1000V.

Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.





## 6 Resource assessment

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SEI has sourced monthly horizontal plane irradiation data for the Project site from:

- **NASA's Surface Meteorology and Solar Energy data set**; holds satellite derived monthly data for a grid of 0.5° × 0.5° covering the globe for a thirty-four-year period (1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.

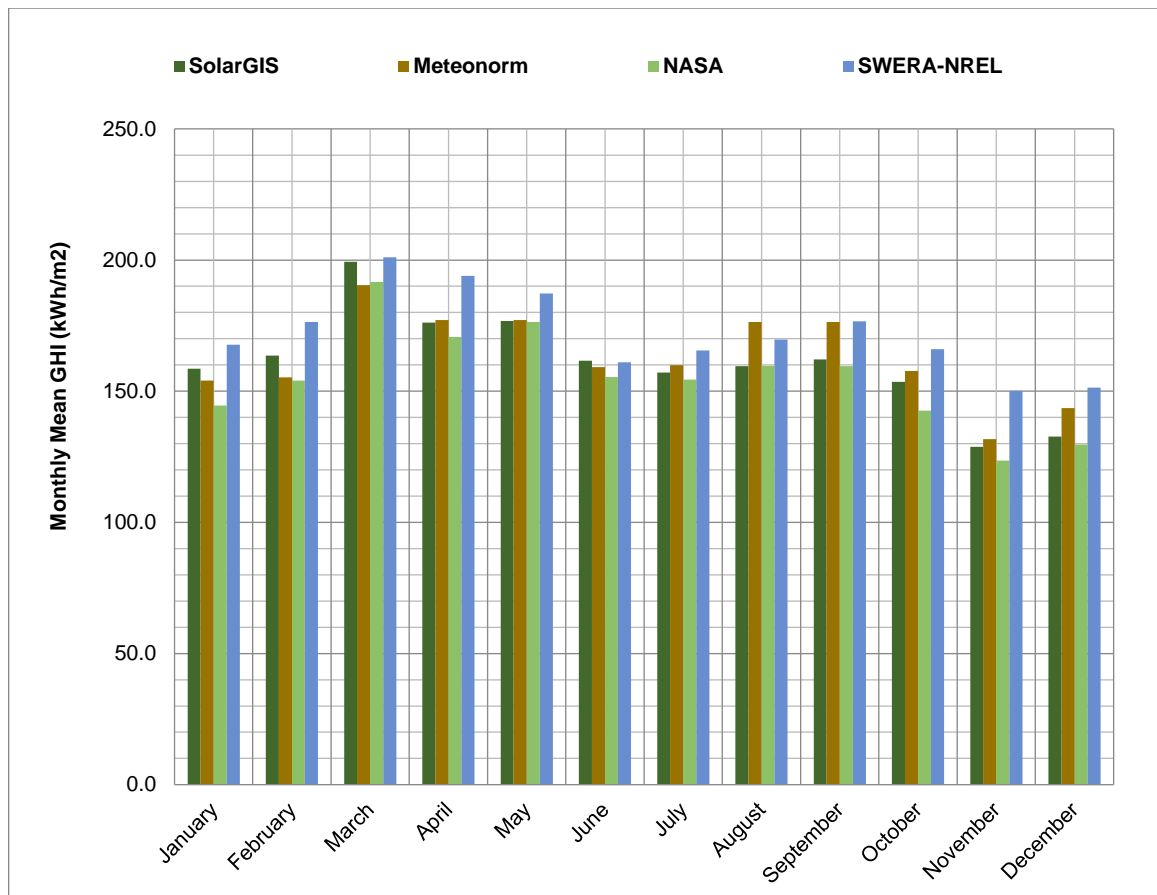


- The **METEONORM (version 7.3)** *global climatological database and synthetic weather generator*; contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.
- **SolarGIS:** SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km × 4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by *IEA (International Energy Agency) SHC Collaboration Agreement, and EU FP6 project MESoR* in terms of bias and RMSE.

SEI has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS data for the site. The comparison is graphically illustrated Table6-1







**Figure 6-1: Monthly Global Horizontal Irradiation**

**Table6-1: Comparison of Solar Irradiation Datasets for the site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	1,929.8
Meteonorm 7.3	14km × 14km	4.0%	1,958.8
NASA	55km × 55km	Unknown	1,862.1
NREL (SWERA)	40km × 40km	Unknown	2,066.6

The comparison of solar data for Project site location illustrated in Table6-1 indicates NREL (SWERA) dataset to give the highest irradiation levels. The next highest irradiation is given by Meteonorm 7.3 followed by SolarGIS and NASA.

The irradiation values given by Meteonorm 7.3 typically provide a combination of ground and satellite measured data. Meteonorm 7.3 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as 7% for the proposed site.

The NASA-SSE data source provides purely satellite measured data for a grid covering 0.5° × 0.5° on the earth's surface and generally more suited for initial site selection.

The NREL (SWERA) data illustrated has been obtained for a location approximately 5.87 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data

The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also



been compared with other data sources globally. The IEA (International Energy Agency) validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>5</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)
- Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 6%.

SEI is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 6.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 6-2 and shown graphically in Figure 6-2. Diffuse irradiation accounts for 49.59% of the total irradiation. Table 6-2 illustrates direct and diffuse daily irradiation on a horizontal plane for the proposed site. SolarGIS irradiation data is presented in Table 6-2.

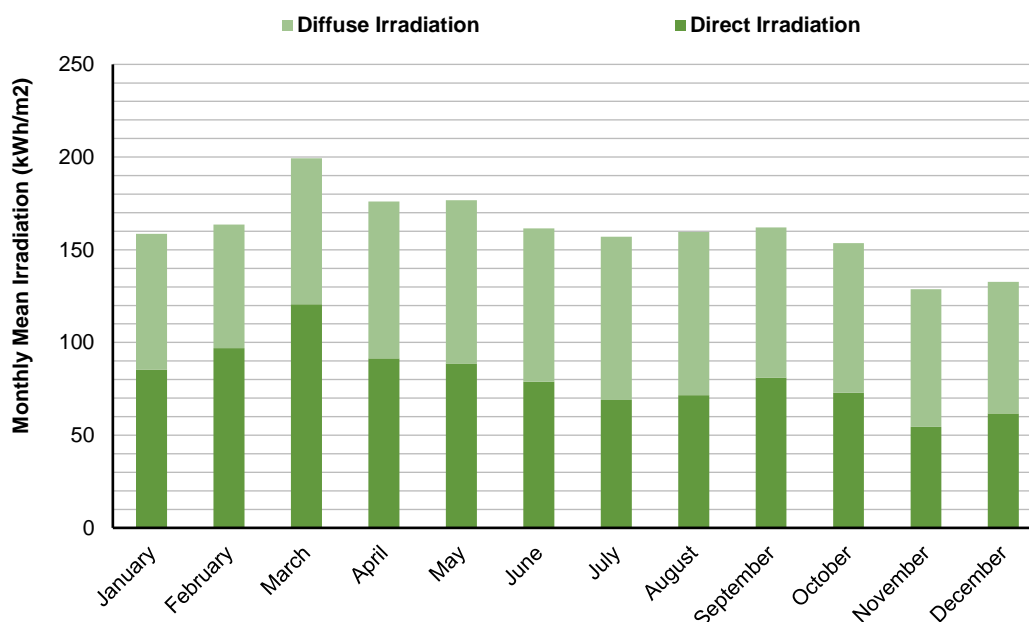
**Table 6-2: SolarGIS Irradiation Data for the Project sites**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	158.6	73.2	8.2%
February	163.6	66.6	8.5%
March	199.3	78.7	10.3%
April	176.1	84.6	9.1%
May	176.7	88.0	9.2%
June	161.6	82.8	8.4%
July	157.1	88.0	8.1%
August	159.6	88.0	8.3%
September	162.1	81.0	8.4%
October	153.6	80.6	8.0%

<sup>5</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>



Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
November	128.8	74.4	6.7%
December	132.7	71.0	6.9%
<b>Annual Sum</b>	<b>1,929.8</b>	<b>957.1</b>	<b>-</b>



**Figure 6-2: Monthly Direct and Diffuse Irradiation on a horizontal plane for the project site**

## 6.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.1.4), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -6-3 represents the monthly GTI profile.

**Table -6-3: Monthly Global Tilted Irradiation Data**

Month	GTI (kWh/m <sup>2</sup> )
January	169.80
February	171.80
March	203.40
April	174.20
May	170.90
June	155.00
July	151.50
August	156.90
September	162.90



Month	GTI (kWh/m <sup>2</sup> )
October	158.40
November	135.10
December	141.50
<b>Annual Sum</b>	<b>1,951.40</b>

### 6.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 6-4 below. The average wind speed of 2.3 m/s was measured at 10m height from ground level for the proposed project site location.

**Table 6-4: Simulated Wind Speed for site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	1.9
February	1.9
March	1.8
April	1.7
May	2.6
June	3.2
July	3.7
August	3.3
September	2.6
October	1.8
November	1.7
December	1.9
<b>Yearly Average</b>	<b>2.3</b>

### 6.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.

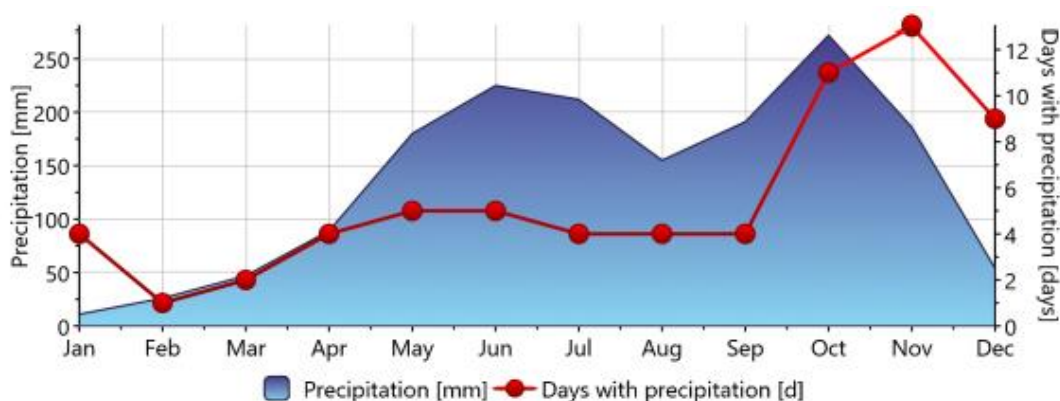


**Table 6-5: SolarGIS Temperature Data for Site (1999 – 2018)**

Months	Average Monthly Temperature (°C)
January	25.6
February	27.1
March	29.3
April	31.4
May	32.0
June	30.2
July	29.7
August	29.9
September	29.9
October	28.4
November	26.4
December	25.3
<b>Annual Average</b>	<b>28.8</b>

### 6.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.3 as illustrated in Figure 6-3. These figures show that the identified site is situated in a region that has marginal rainfall.

**Figure 6-3 Meteonorm Predicted Precipitation for the site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

Frequency of module cleaning depends on the rainfall frequency and the prevalence of dust and pollution in the local vicinity. Typical cleaning techniques include water cleaning, dry brushes or vehicle-based mechanical cleaning.

The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 1.5% has been considered by considering cleaning frequency of twice a month.



## 7 Energy Yield Analysis

SgurrEnergy has computed the annual energy yields for the 8 MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

Parameter	Description
Modules	JA Solar (JAP6-72-310/3BB, JAP6-72-315/3BB)
Inverters	ABB Central Inverters – 1.0MW <sub>AC</sub> (PVS800-57-1000kW-C)
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	9.6

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 7.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in Table 7-1 below.

**Table 7-1: Description of Energy Yield Losses**

Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.



Loss	Description
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 8 MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 7.2 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 8 MW<sub>p</sub> solar PV Plant with JA solar modules and ABB inverters. Table 7-2 summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.



**Table 7-2: Energy Yield for the 8 MW<sub>AC</sub> Solar PV Plant**

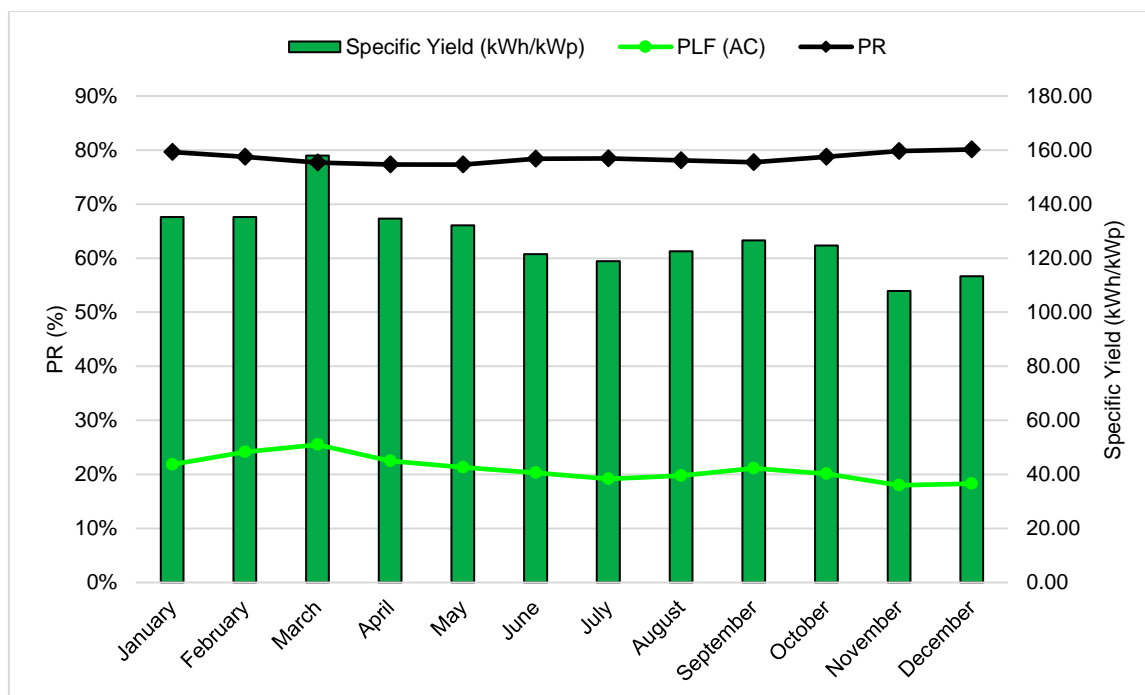
Parameters	Description
PV Module Technology	Polycrystalline
DC Capacity (MW <sub>p</sub> )	9.6
AC Capacity (MVA)	8
Contracted Capacity (MW)	8
P <sub>NOM</sub> Ratio	1.20
Tilt (°)	8
Pitch (m)	6
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1,929.80
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	1,951.40
Transposition Factor	1.01
<b>Losses</b>	
Horizon Shading	0.00%
Incident Irradiation Below Threshold	0.00%
Near Shading	0.54%
Incident Angle	2.55%
Soiling	1.50%
Low Irradiance	0.00%
Module Temperature	9.63%
Electrical Shadings	0.00%
Module Quality	0.00%
First year Degradation	1.50%
Module Mismatch	1.10%
DC Ohmic	1.03%
Inverter Performance	1.74%
Availability	1.00%
AC Ohmic	0.53%
Transformer (LV/MV)	1.07%
Transformer (MV/HV)	-
Transmission Line	0.90%
Auxiliary Consumption	0.60%
Curtailement	
<b>Total Annual Loss Factor</b>	<b>0.784</b>
<b>Sixth Year P50 Energy Yield (MWh/annum)</b>	<b>14,341.03</b>
<b>Sixth Year Specific Yield (kWh/kW<sub>p</sub>)</b>	<b>1492.75</b>
<b>Sixth Year CUF on AC Installed Capacity</b>	<b>20.46%</b>





Parameters	Description
Sixth Year CUF on Contracted Capacity	20.46%
Sixth Year CUF on DC Installed Capacity	17.04%
Sixth Year Performance Ratio	76.49%

Graphical representation of the monthly generation, performance ratio and CUF for 8 MW<sub>AC</sub> evaluated is illustrated graphically in the Figure 7-1.



**Figure 7-1: Monthly Energy Yield for 8 MW<sub>AC</sub>**

### 7.3 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 7.3.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

#### 7.3.2 Inter – Annual Variation in the Solar Resource

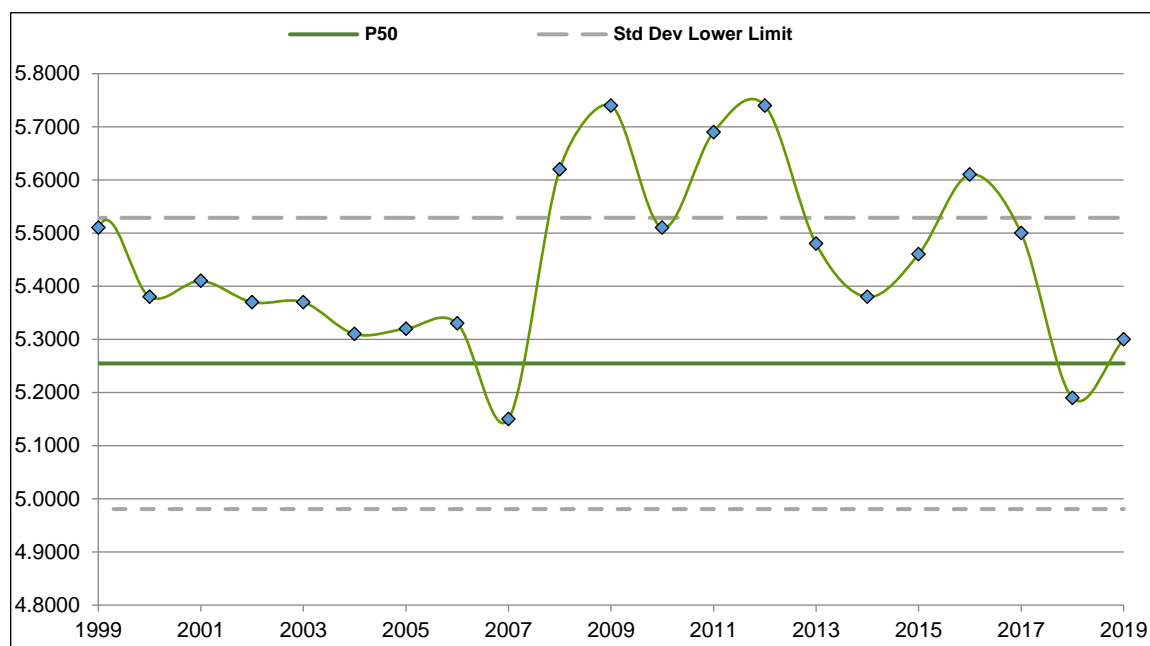
Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.



The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database for the proposed site location which is used to estimate the standard deviation of variation in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 7-3.

**Table 7-3: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	5.21



**Figure 7-2: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in Figure 7-2..

SgurrEnergy uses a coefficient of variation of 5.21% to quantify the inter-annual variation in the solar resource.

### 7.3.3 Modelling Uncertainty

The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

### 7.3.4 Total Uncertainty (P75, P90 and P99 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.



**Table 7-4: Life Cycle P50, P75 and P90 Generation Prediction for 8 MW<sub>AC</sub>**

Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>6</sup> (MWh/annum)	P90 Generation Prediction <sup>7</sup> (MWh/annum)
6	14,341.03	13,722.15	13,165.13
7	14,269.33	13,653.54	13,099.31
8	14,197.98	13,585.27	13,033.81
9	14,126.99	13,517.34	12,968.64
<b>10</b>	<b>14,056.36</b>	<b>13,449.76</b>	<b>12,903.80</b>
11	13,986.07	13,382.51	12,839.28
12	13,916.14	13,315.59	12,775.08
13	13,846.56	13,249.02	12,711.21
14	13,777.33	13,182.77	12,647.65
15	13,708.44	13,116.86	12,584.41
16	13,639.90	13,051.27	12,521.49
17	13,571.70	12,986.02	12,458.88
18	13,503.84	12,921.09	12,396.59
19	13,436.32	12,856.48	12,334.61
<b>20</b>	<b>13,369.14</b>	<b>12,792.20</b>	<b>12,272.93</b>
21	13,302.30	12,728.24	12,211.57
22	13,235.79	12,664.60	12,150.51
23	13,169.61	12,601.27	12,089.76
24	13,103.76	12,538.27	12,029.31
<b>25</b>	<b>13,038.24</b>	<b>12,475.58</b>	<b>11,969.16</b>

<sup>6</sup> The P75 values have been calculated over 10-year averages<sup>7</sup> The P90 values have been calculated over 10-year averages

## 8 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 0.6% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) and henceforth. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Developer, SgurrEnergy understands that the 8MW TNS solar PV plant was commissioned on 28<sup>th</sup> September 2015. SgurrEnergy was provided with plant and grid availability records from February 2016 to March 2021<sup>8</sup> for the solar PV plant. However, the irradiation measurement records were provided from April 2016 to March 2021.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from April 2016 to March 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

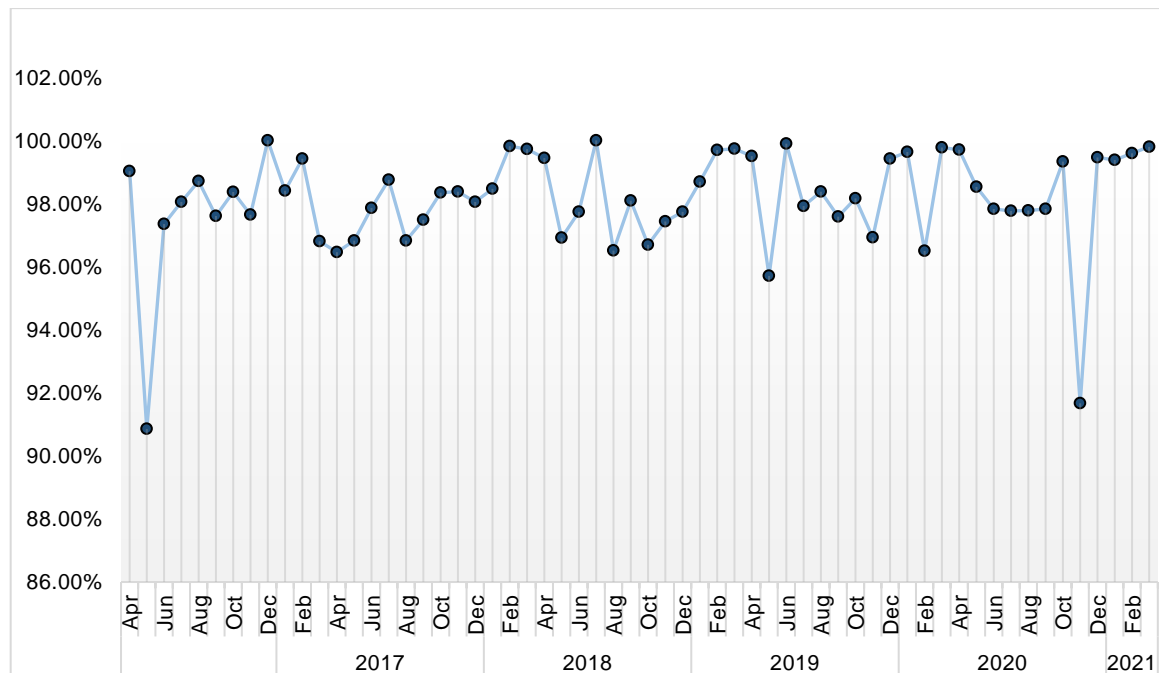
The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Developers control.

The monthly records of the grid availability from April 2016 to March 2021 have been graphically illustrated in Figure 8-1 below.

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<sup>8</sup> SgurrEnergy was provided with both the plant and grid availability records until March 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.





**Figure 8-1: Grid Availability**

Based on the above illustration, SgurrEnergy notes the grid availability for the TNS 8MW solar PV plant is notably inconsistent for all the months ranging between 90.85% to 100%.

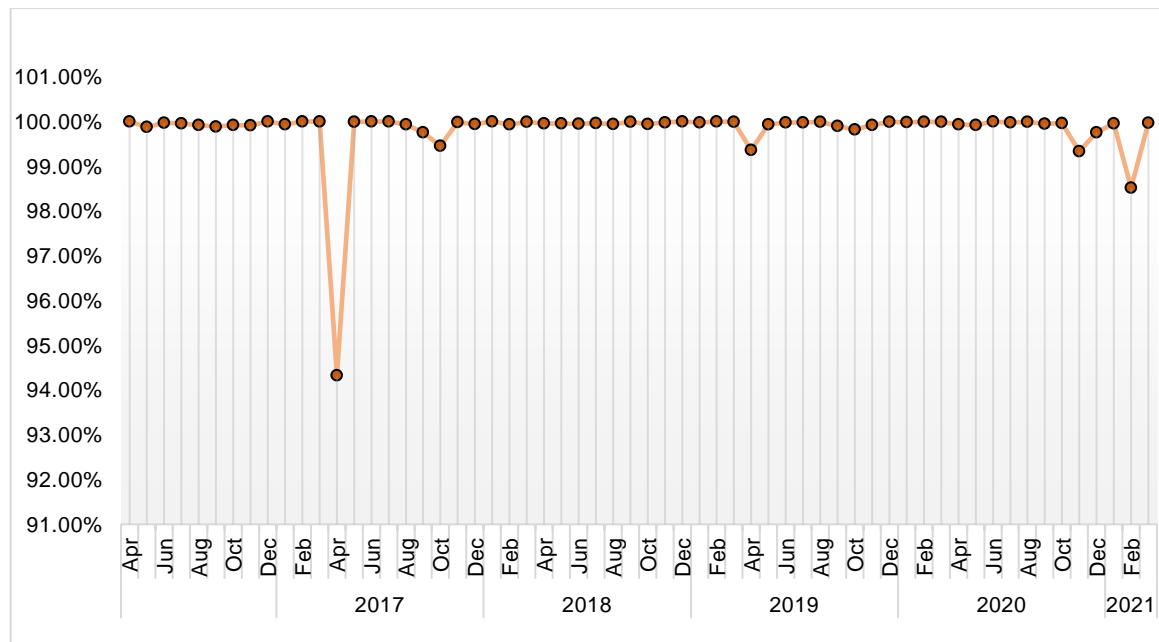
The resultant overall grid availability of the PV plant for the period evaluated was 98.10%. SgurrEnergy considers that the unavailability loss experienced due to grid anomalies for the operational period is higher than the expected range.

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the TNS 8MW solar PV plant is graphically illustrated below in Figure 8-2.





**Figure 8-2: Plant Availability**

Based on the above illustrations, SgurrEnergy notes the plant availability for the SPSP solar PV plant was above 99.3% for substantial amount of time over the operational period of the plant. However, for the months of April 2017 and February 2021 the plant unavailability was slightly higher when compared to other months.

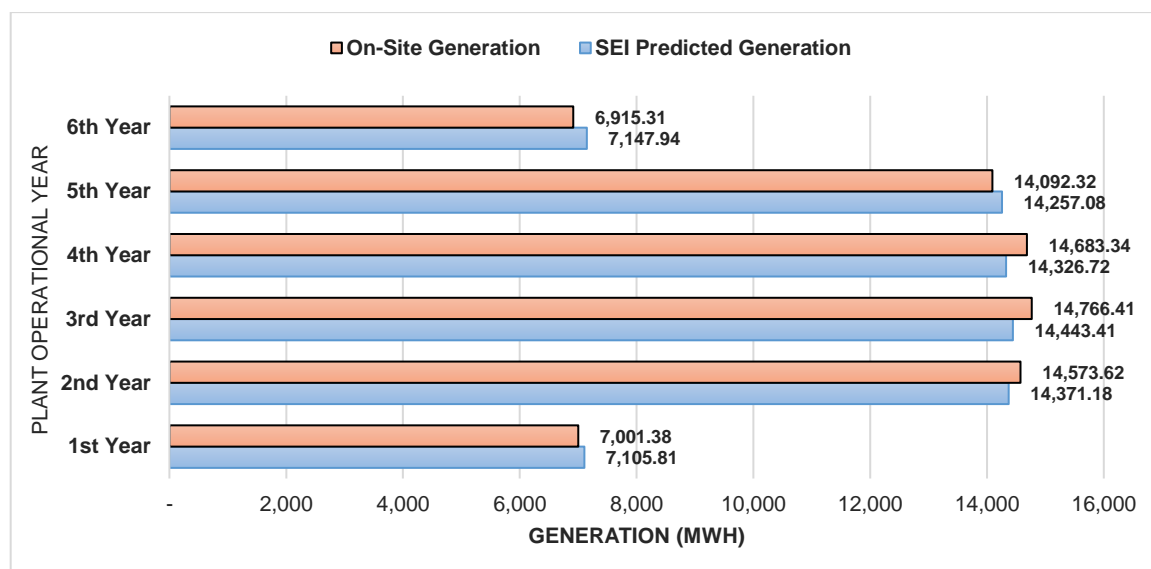
The resultant average plant availability of the PV plant for the period evaluated was 99.8% which is considered to be within expected range.

## 1.2 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer. To make the operational energy yield predictions more representative, SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Developer. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Developer.

The yearly comparison of the generation data is illustrated below in Figure 8-3.





**Figure 8-3: Generation Comparison**

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 8-1

**Table 8-1: PV Plant Performance – TNS 8MW**

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>9</sup> (%)
April 2016 -Sep 2016	7,105.81	7,001.38	-1.47%
Oct 2016 -Sep 2017	14,371.18	14,573.62	1.41%
Oct 2017 -Sep 2018	14,443.41	14,766.41	2.24%
Oct 2018 -Sep 2019	14,326.72	14,683.34	2.49%
Oct 2019 -Sep 2020	14,257.08	14,092.32	-1.16%
Oct 2020 -Mar 2021	7,147.94	6,915.31	-3.25%
<b>Cumulative Period</b>	<b>71,652.14</b>	<b>72,032.38</b>	<b>0.53%</b>

Based on the above presented comparisons, SgurrEnergy notes the plant to be performing higher than SEI's predictions. Generation of the plant was 0.53% higher than SgurrEnergy's prediction for the period under evaluation. In order to validate the higher generation, SgurrEnergy has compared the monthly incident irradiation data provided by the Developer with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation. The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 8-4.

**Table 8-2: Irradiation Comparison– TNS 8MW**

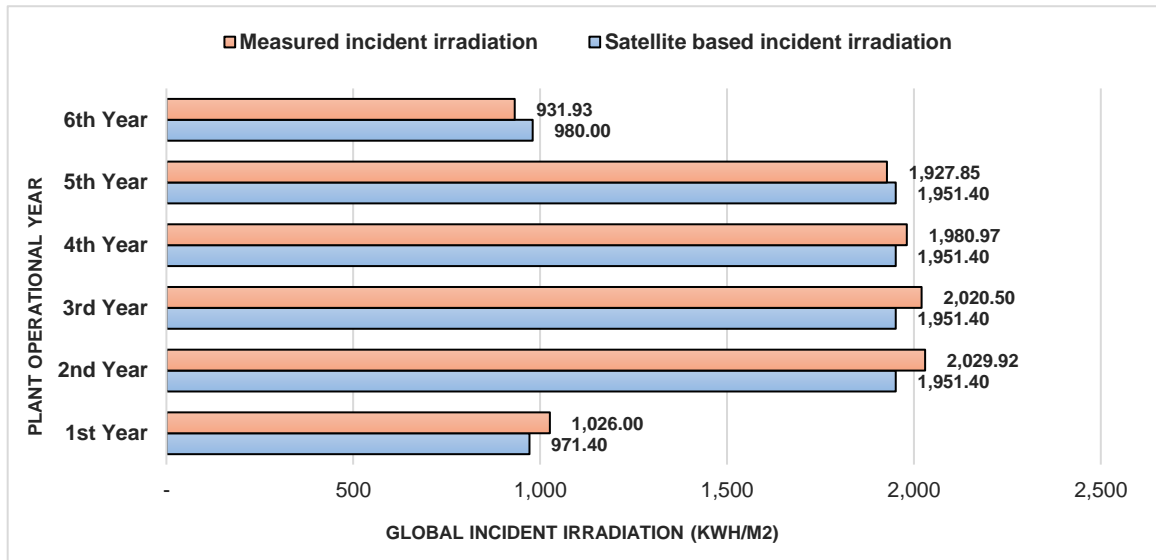
PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>10</sup> (%)
April 2016 -Sep 2016	971.40	1,026.00	5.62%
Oct 2016 -Sep 2017	1,951.40	2,029.92	4.02%
Oct 2017 -Sep 2018	1,951.40	2,020.50	3.54%

<sup>9</sup> Positive values indicate higher generation, while negative values indicate lower generation

<sup>10</sup> Positive values indicate higher generation, while negative values indicate lower generation



PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>10</sup> (%)
Oct 2018 -Sep 2019	1,951.40	1,980.97	1.52%
Oct 2019 -Sep 2020	1,951.40	1,927.85	-1.21%
Oct 2020 -Mar 2021	980.00	931.93	-4.90%
<b>Cumulative Period</b>	<b>9,757.00</b>	<b>9,917.18</b>	<b>1.64%</b>



**Figure 8-4: Irradiation Comparison**

Based on the above illustration, it is observed that the overall recorded generation is approximately 0.53% higher than the generation predicted on site. Correspondingly, it has also been observed that the recorded irradiation is approximately 1.64% higher than the predicted irradiation.

Overall, the comparative analysis indicates the PV plant to be performing in line with SgurrEnergy's prediction.





## 9 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar PV plants as having a lifetime of 25-40 years<sup>11</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>12</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the PV plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement.

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<sup>11</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>12</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>



Virescent Infrastructure

10MW(AC) Vilathikulam Solar PV Plant

TN Solar Power Energy Pvt Ltd

Technical Assessment Report

May 2021



## Report Details

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### Amendment Records

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B1	09.02.2021	For Client Issue	-
B2	19.02.2021	For Client Issue	Minor Changes
B3	22.02.2021	For Client Issue	Finalisation of Report
B4	28.05.2021	For Client Issue	Generation Analysis updated

SF/04/023

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## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 13MW<sub>AC</sub> Universal Mine Developers and Service Providers Pvt Ltd (the Project). The Project is located near Kovilpatti village, in Thoothukudi district of Tamil Nadu.

The summary of the technical assessment is captured in the below table.

**Table 1-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	<p>The project site lies around the coordinates 9° 7'7.12"N and 78° 6'11.08"E and is located near the Vilathikulam village, in Thoothukudi district of Tamil Nadu.</p> <p>Project is contracted for generating 10MW<sub>AC</sub> power. The Owner has utilised approximately 57 acres of land for the project.</p> <p>Project is implemented with poly-crystalline modules (JA Solar) and central inverters (ABB). The module mounting structure is implemented with a tilt of 8° for a pitch of 6m.</p> <p>The power generated from the TNSPEPL 10MW<sub>AC</sub> PV plant is fed to Villathikulam substation substation, through a single circuit transmission line.</p> <p>The total DC installed capacity stands at 12MW<sub>p</sub>. The AC installed capacity stands at 10MW<sub>AC</sub> with 10 inverters of capacity 1,000kW each.</p>
2	PV Module	<p>SgurrEnergy has conducted a desktop review of JA Solar assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard. SgurrEnergy considers the warranty period to be in line with the industry standards. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.</p>
3	Inverter	<p>ABB is considered to have good track record for supplying central inverters. Certificates mentioned in the technical specification datasheet indicate ABB to hold adequate certifications. Technical characteristics are acceptable, with a good efficiency level for central inverters. Standard warranty of five years is provided for the inverters, which is in line with the industry requirement. Overall, SgurrEnergy does not raise any concern on the utilization of ABB inverters for the Project.</p>
4	Inverter Transformer	<p>The inverter transformers (2200kVA) used within the project are manufactured by Voltamp Transformers Limited. The manufacturers have a good track record of supplying transformers to distinguished customers in Indian as well as in the global market. SgurrEnergy has reviewed the transformers based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with</p>





Sr. No.	Parameter	Comment						
		industry standards and raises no concerns over its use in the project						
5	String Sizing	The VOC does not exceed the inverter input voltage for the site, and therefore, SgurrEnergy considers the number of modules in series to be acceptable for the PV Project.						
6	Permits and Approvals	PPA signed between TN Solar Power Energy Ltd and Tamil Nadu Generation and Distribution Corporation Limited PPA term is 25 years from the Commercial Operation Date. Documents such as CEIG certificate, commissioning certificate, consent to operate etc. have not been provided.						
7	Resource Assessment	For resource analysis, SEI has compared various satellite datasets. For the satellite databases, SEI has compared Meteornorm 7, NASA, SWERA and SolarGIS data to find the most suitable solar resource for long-term energy yield prediction. Owing to low uncertainty and high resolution, SEI considers SolarGIS dataset to be the most representative satellite database among all the satellite databases for long-term energy yield assessment.						
8	Operational Analysis and Generation Comparison	Review presented in Section 8						
9	Allied Components and Systems	<p>The 10MW<sub>AC</sub> solar PV plant is designed with JA Solar (310/315Wp) and ABB 1000kVA central inverter.</p> <p>The Project has been implemented with three inverter station out of which two inverter station is of capacity 4W<sub>MAC</sub>, further one inverter station is of capacity 2W<sub>MAC</sub>).</p> <p>Each 4MW<sub>AC</sub> capacity inverter station consists of 2-sets of two 1000kW inverters connected to 0.400/0.400/33kV three-winding, 2.2MVA transformer, while the inverter station of 2MW<sub>AC</sub> capacity consists of one-set of 1000kW inverters connected to 0.400/0.400/33kV three-winding, 2.2MVA transformer, that step up the voltage upto 33kV. The power from the HV side of the 33kV inverter transformer is transferred to 33kV HT panel.</p> <p>The 33kV output of each inverter station combined at 33kV main HT panel located within Main control room (MCR). Further the power is fed from main HT panel to 33kV plant end metering yard.</p> <p>Further the power from the metering yard is then evacuated to the substation located approximately 7.2kms from the Project site through ACSR dog conductor overhead transmission line</p>						
10	Energy Yield Assessment	<p>Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for third year of plant operation for the 10 MW<sub>AC</sub> PV plant.</p> <table><tr><td>Global Horizontal Irradiation (kWh/m<sup>2</sup>)</td><td>1,953.50</td></tr><tr><td>Global Inclined Irradiation (kWh/m<sup>2</sup>)</td><td>1,970.60</td></tr><tr><td>Sixth Year P50 Energy Yield (MWh/annum)</td><td>18,169.81</td></tr></table>	Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1,953.50	Global Inclined Irradiation (kWh/m <sup>2</sup> )	1,970.60	Sixth Year P50 Energy Yield (MWh/annum)	18,169.81
Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1,953.50							
Global Inclined Irradiation (kWh/m <sup>2</sup> )	1,970.60							
Sixth Year P50 Energy Yield (MWh/annum)	18,169.81							



Sr. No.	Parameter	Comment	
		Specific Yield (kWh/kW <sub>p</sub> )	1513.80
		Performance Ratio (PR)	76.81%
		PLF on Contracted Capacity (10 MW <sub>AC</sub> )	20.74%



## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
m	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon



MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation



## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 258MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of six projects, as presented within Table 1-1.

**Table 1-1: Project Key Summary**

Project Name	SEPEPL – 80MW <sub>AC</sub>	SEPEPL – 50MW <sub>AC</sub>	SPSPL – 50MW <sub>AC</sub>	SPSPPL – 30MW <sub>AC</sub>	TNSPEPL – 5MW <sub>AC</sub> + 8MW <sub>AC</sub> + 10MW <sub>AC</sub>	UMD- 12MW <sub>AC</sub> + 13MW <sub>AC</sub> +
Site Location	18.926°N, 76.395°E, <i>Parli</i> , Maharash- tra, India	21.028°N, 75.985°E, <i>Muktainagar</i> Maharashtra ,India	9.324°N, 77.594°E. <i>Rajapalyam</i> , Tamil Nadu,India	12.344°N, 78.945°E <i>Tiruvannam- alai</i> , Tamil Nadu, India.	<b>5MW<sub>AC</sub> –</b> 10.480°N, 78.061°E <i>Dindigul</i> , Tamil Nadu, India <b>8MW<sub>AC</sub> –</b> 9.437°N, 78.172°E <i>Aruppukkotai</i> Tamil Nadu, India <b>10MW<sub>AC</sub> –</b> 9.118°N, 78.107°E <i>Vilathikulam</i> , Tamil Nadu, India	<b>12MW<sub>AC</sub> –</b> 9.554°N, 77.884°E <i>Amathur</i> , Tamil Nadu, India <b>13MW<sub>AC</sub> –</b> 9.093°N, 77.780°E <i>Kovilpatti</i> , Tamil Nadu, India
Owner	Solar Edge Power and Energy Private Limited (SEPEPL)		Shapoorji Pallonji Suryaprakas h Private Limited (SPSPL)	Shapoorji Pallonji Solar PV Private Limited	TN Solar Power Energy Private Limited	Universal Mine Developers and Service Providers Private Limited
DC / AC Capacity	104.0MW <sub>P</sub> / 80.0MW <sub>AC</sub>	65.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	54.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	36.0MW <sub>P</sub> / 30.0MW <sub>AC</sub>	<b>5MW<sub>AC</sub> –</b> 6.0MW <sub>P</sub> / 5.0MW <sub>AC</sub> <b>8MW<sub>AC</sub> –</b> 9.6MW <sub>P</sub> / 8.0MW <sub>AC</sub> <b>10MW<sub>AC</sub> –</b> 12.0MW <sub>P</sub> / 10.0MW <sub>AC</sub>	<b>12MW<sub>AC</sub> –</b> 14.4MW <sub>P</sub> / 12MW <sub>AC</sub> <b>13MW<sub>AC</sub> –</b> 15.6MW <sub>P</sub> / 13MW <sub>AC</sub>
Commissioning date	<b>50MW<sub>AC</sub> –</b> 08.04.2018 <b>30MW<sub>AC</sub> –</b> 22.04.2018	26.04.2018	26.09.2018	26.03.2016	<b>5MW<sub>AC</sub> –</b> 28.12.2015 <b>8MW<sub>AC</sub> –</b> 28.09.2015 <b>10MW<sub>AC</sub> –</b> 31.10.2015	<b>12MW<sub>AC</sub> –</b> 16.11.2015 <b>13MW<sub>AC</sub> –</b> 21.03.2016

This report presents the evaluation of the 10MW<sub>AC</sub> TNSPEPL Solar PV plant developed by TN Solar Power Energy Private Limited (TNSPEPL). The Solar PV plants under evaluation are located in S.Kumaragiri village, *Vilathikulam* taluk, *Tuticorin* district in Tamil Nadu state. The purpose of this report is to provide a technical appraisal of PV plant under evaluation.

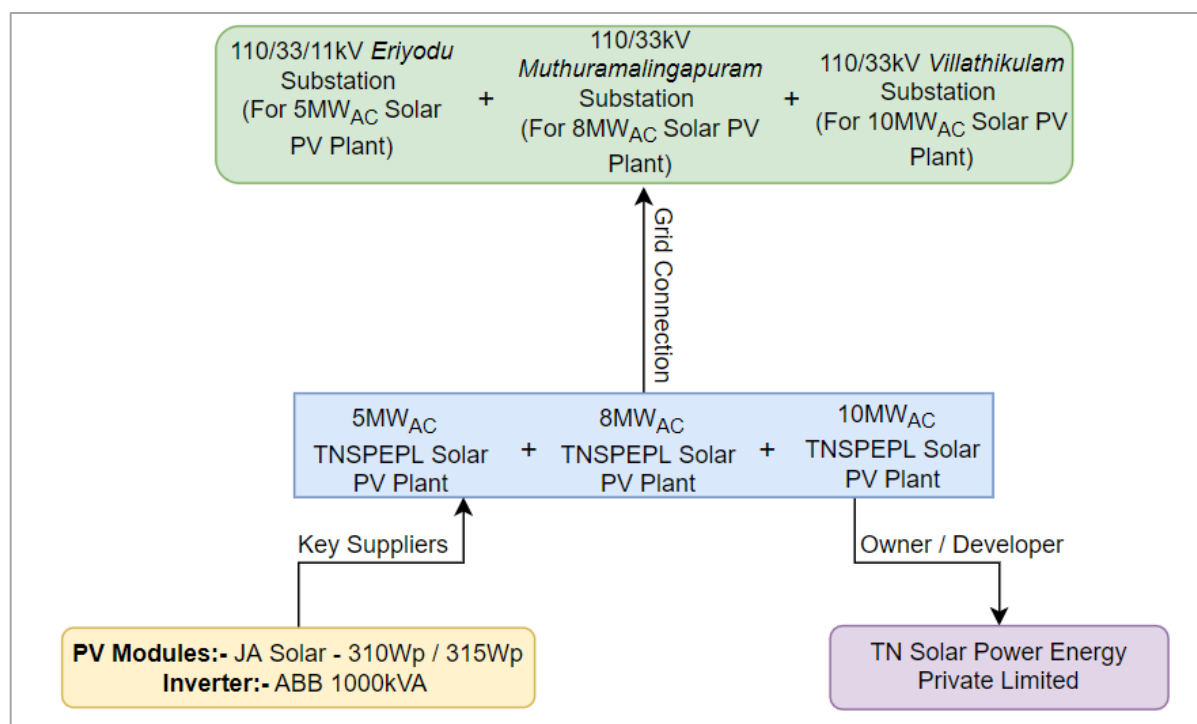


The report focuses on the following key parameters:

- System Design.
- Major Components.
- Engineering Design.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Plant Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project and is based on information made available by the Client through online dataroom. The main Project characteristic is summarised in Table 1-2.

Figure 1-1 illustrates the project structure indicating key project participants for the 10MW<sub>AC</sub> Solar PV plant.



**Figure 1-1: Project Structure for 5MW<sub>AC</sub>+8MW<sub>AC</sub>+10MW<sub>AC</sub> Solar PV Plant**

**Table 1-2: Project Key Summary**

Project Information	
<b>Project Name</b>	10MW <sub>AC</sub> TNSPEPL Solar PV plants
<b>Location</b>	10MW <sub>AC</sub> - Vilathikulam, Tamil Nadu
<b>Developer</b>	TN Solar Power Energy Private Limited
<b>DC/ AC capacity</b>	10MW <sub>AC</sub> PV Plant – 12.0MW <sub>P</sub> / 10.0MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: JA Solar Inverters: ABB
<b>MMS Configuration</b>	Fixed Tilt: 8°, Azimuth: 0°
<b>Commissioning Status</b>	Commissioning for 10MW <sub>AC</sub> PV Plant was achieved on 31 October 2015.



## 2 10MW<sub>AC</sub> Solar PV Plant Overview

The project site lies around the coordinates 9° 7'7.12"N and 78° 6'11.08"E. Satellite imageries of 10MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1. The Owner has acquired approximately 57 acres of land project. The Project site is located near the *Vilathikulam* village, in *Thoothukudi* district of Tamil Nadu.

Project is contracted for generating 10MW<sub>AC</sub> power; SEI therefore interprets 10MW<sub>AC</sub> as the maximum AC installed capacity for the solar PV plant.



**Figure 2-1: Satellite image of 10MW<sub>AC</sub> plant**

### 2.1 10MW<sub>AC</sub> Project Summary

Solar PV plant is modular in nature; therefore, TNSPEPL 10MW<sub>AC</sub> solar PV plants is implemented by adopting modularity in designs. 4MW<sub>AC</sub> and 2MW<sub>AC</sub> are the typical inverter stations considered for implementing TNSPEPL 10MW<sub>AC</sub> solar PV plant.

Table 2-1 presents the summary of 10MW<sub>AC</sub> PV plant

**Table 2-1: Summary of 10MW<sub>AC</sub> Plant Configurations**

General	
PV Module Technology	Poly-crystalline
Inverter Technology	Central Inverters
Installed DC Peak Capacity (MW <sub>p</sub> )	12.0
Installed AC Capacity (MW)	10.0





General	
Mounting Type	Fixed Tilt
Tilt Angle (°)	8°
Pitch (m)	6
PV Modules	
PV Module Manufacturer	JA Solar
Model	JAP6-72-310/3BB JAP6-72-315/3BB
Wattage (W <sub>p</sub> )	310W <sub>p</sub> / 315W <sub>p</sub>
Number of Modules per String	21
Inverter	
Inverter Manufacturer / Model	ABB / PVS-800
Inverter Nominal AC Output	1,000kW
Number of Inverters	10
Mounting Structure	
Mounting Structure Details (rows x columns)	2 x 21
Orientation of Modules	Portrait

The 10MW<sub>AC</sub> plant is implemented with a total of three (3) inverter station, inverter station of capacity 2MW<sub>AC</sub> which comprising of three winding transformers to accommodate 2 x 1,000kVA inverters, taking the individual inverter station size to 2MW<sub>AC</sub>. Inverter station is comprising of a physical block connecting 2.4MW<sub>p</sub> of installed photovoltaic array. While, inverter stations of capacity 4MW<sub>AC</sub> which comprising of three winding transformers to accommodate 4 x 1,000kVA inverters, taking the individual inverter station size to 4MW<sub>AC</sub>. Inverter station is comprising of a physical block connecting 4.8MW<sub>p</sub> of installed photovoltaic array.

The output of 4MW<sub>AC</sub> and 2MW<sub>AC</sub> inverter stations are connected to 0.400/0.400/33kV three winding transformer of 2.2MVA for stepping up the voltage to 33kV.

The medium voltage 33kV output of the inverter stations are placed in main control room (MCR), these are combined to form a solar PV plant of 10MW<sub>AC</sub>. The 33kV output is evacuated using a 33kV DP structure located in the plant premises.

The power generated by the TNSPEPL 10MW<sub>AC</sub> PV plant is fed to *Villathikulam* substation located approximately 7km from the Project site, through a single circuit Dog ACSR conductor. The point of interconnection is at the *Villathikulam* substation.

ABT / revenue metering is at *Villathikulam* substation; therefore, transmission line losses are accounted in the Owner's scope.





### 3 Review of Major plant components

SgurrEnergy has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions.

#### 3.1 PV modules

The PV modules selected for the Project are supplied by JA Solar Holding Co., Ltd., Canadian Solar and Astronergy. SgurrEnergy has conducted a technical review of the suppliers and proposed module specifications with regard to their suitability for use on the Project.

##### 3.1.1 Company Profile – JA Solar Holding Co., Ltd

JA Solar Holding Company Ltd. listed on NASDAQ (NASDAQ: JASO), was found in the year 2005 and started operation in 2006. The Company has 12 manufacturing bases and has production capacity of more than 11.5GW, 11GW, and 11GW for silicon wafer, solar cells, and solar modules, respectively.

JA solar has 20 branches around the world and employs more than 22,000 employees worldwide. As of December 2019, JA solar provides services in more than 135 countries and to more than 33,000 clients worldwide. As of second quarter 2020, JA solar had a cumulative shipment of more than 50GW. As of December 2019, JA solar had more than 779 authorized patents of independent R&D and 107 invention patents under its name. The Company's net revenue was RMB 21.16 billion in 2019.

Few of the commissioned solar power plants using JA modules are listed in Table 3-1.

**Table 3-1: Project References of JA Solar**

Sr. No.	Project and Location	Capacity (MW)
1	Bahia, Brazil	255.0
2	Northern Cooks, Australia	172.8
3	Cadiz, Philippines	132.5
4	Maharashtra, India	130.0
5	Three Gorges, Datong	100.0
6	Bahawalpur, Pakistan	100.0
7	Lincheng Country, Xingtai City, Hebei Province	100.0
8	Dunhuang, Gansu Province	100.0
9	Utah, USA	80.0
10	New South Wales, Australia	70.0
11	Maharashtra, India	70.0
12	Telangana, India	69.0
13	Bole, Xinjiang	60.0
14	San Carlos, Philippines	59.0
15	MP, India	57.0
16	Charankha Gujrat, India	53.0
17	Datong, Shanxi Province	50.0
18	Southwark, UK	49.0
19	Karnataka, India	43.0



Sr. No.	Project and Location	Capacity (MW)
20	Xiayu, Hebei Province	42.0
21	Yinchuan, Ningxia Province	40.0
22	Georgia, USA	38.7
23	Arawa Desert and Negev Desert, Israel	35.0
24	Hefeng, Tacheng, Xinjiang	30.0
25	Karnataka, India	23.0
26	Bulgaria	21.0
27	Haryana, India	21.0
28	Campania, Italy	20.0
29	Corp 184, Xinjiang	20.0
30	Telengana, India	18.0
31	Toshka, Egypt	10.1
32	Volkswagen Chattanooga Plant, USA	9.6
33	Antalya, Turkey	6.7
34	Kenitra, Morocco	2.0
35	ABC Bank, Jordan	1.5

JA is considered a Tier 1 supplier by Bloomberg (Q4, 2020). A Tier 1 supplier is defined as a module manufacturer who has *provided products to five different projects, which have been financed non-recourse by five different (non-development) banks, in the past two years.*

Whilst the Bloomberg tiering system does not reflect on a product's technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers JA solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

### 3.1.1.1 Main Technical Characteristics of JAP6-72/3BB

JA Solar, JAP6-72/3BB modules of 310W<sub>P</sub> and 315W<sub>P</sub> capacity have been utilized for the Project. These modules have an efficiency of 15.99% and 16.25% for 310W<sub>P</sub> and 315W<sub>P</sub> capacity modules, respectively, and a peak power tolerance of 0~+5W. The modules have a temperature coefficient (P<sub>max</sub>) of -0.41%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy's expectation for c-Si technology. The technical characteristics of JAP6-72/3BB are presented in Table 3-2.

**Table 3-2: Technical specifications of JAP6-72/3BB**

Specifications	JAP6-72-310/3BB	JAP6-72-315/3BB
Technology	Polycrystalline	
Nominal power (P <sub>MPP</sub> )	310W <sub>P</sub>	315W <sub>P</sub>
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	37.00V	37.28V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	8.38A	8.45A
Open circuit voltage (V <sub>OC</sub> )	45.45V	45.60V
Short circuit current (I <sub>SC</sub> )	8.85A	8.91A
Efficiency (%)	15.99%	16.25%



Specifications	JAP6-72-310/3BB	JAP6-72-315/3BB
Maximum System Voltage	1,000V (DC)	
Power tolerance (%)	0~+5W	
Dimensions (length × breadth × width) (mm)	1956 × 991 × 45	
Module area (m²)	1.94m²	
Weight (kg)	~26kg	
Temperature coefficient at P <sub>MAX</sub>	-0.41%/°C	
Operating temperature	-40°C to +85°C	
Maximum reverse current	15A	
Maximum mechanical load	5400Pa	
Maximum snow load	2400Pa	
Product warranty	10 years	
Power output guarantee	25 years	
Module technical characteristics are given at STC (1,000W/m² irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet)		

The maximum system voltage is 1,000V. The maximum reverse current is 15A. Overall, the module characteristics can be considered to be in line with market standard and JA Solar is listed as Tier 1 suppliers by Bloomberg since 2014.

### NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>1</sup> characteristics of selected JAP6-72/3BB modules of 310W<sub>P</sub> and 315W<sub>P</sub> is given in Table 3-3 corresponding to realistic operating conditions as compared to STC. It is affected by module materials used as well as the packing density of module materials. The NOCT for the module is 45±2°C. This is comparable with other manufacturers and demonstrates the module is effective at heat dissipation.

**Table 3-3: PV Module NOCT Characteristics of JAP6-72/3BB**

Model	JAP6-72-310/3BB	JAP6-72-315/3BB
Maximum Power (P <sub>MAX</sub> )	225.06W <sub>P</sub>	228.69W <sub>P</sub>
Max Power Voltage (V <sub>MPP</sub> )	34.05V	34.08V
Max Power Current (I <sub>MPP</sub> )	6.61A	6.71A
Open Circuit Voltage (V <sub>OC</sub> )	42.58V	42.63V
Short Circuit Current (I <sub>SC</sub> )	6.99A	7.06A

#### 3.1.1.2 Certification of Modules

General review of datasheet indicates JA Solar PV modules manufactured in facilities with the following certifications:

- ISO 14001 certification for environmental management systems

<sup>1</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C.



- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certifications available in public domain for the modules under evaluation within Table 3-4.

**Table 3-4: Certification for PV Module- JA Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
UL 1703	Standard for safety for flat-plate photovoltaic modules

### 3.1.1.3 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of six months from the dispatch from the JA solar factory or the delivery date to site.

### 3.1.1.4 Product Warranty

JA Solar provides a limited product warranty of 10 years, beginning on the earlier of module purchase date or one-year anniversary from the production date. If module fail to conform to this warranty, during the period ending of 10 years from the date of sale to the customer of the JA solar product, JA solar will at its opinion, either repair or replace the product, or refund the purchase price as paid by the customer. The repair or replacement or refund the customer at the current comparable market price of such module.

SgurrEnergy considers twelve-year product warranty provided by JA solar to be in line with the industry standard.

### 3.1.1.5 Linear Power-Output Warranty

According to the datasheet JA solar warrants that the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.7% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 80.7% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, JA solar will either repair, replace or provide additional modules to make up for the loss in power output.

## 3.2 Inverters – ASEA Brown Boveri (ABB)

The project has utilized ABB PVS800-57-1000kW central inverter for the project under evaluation.

### 3.2.1 Company background

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, ABB is one of the largest engineering companies as well as one of the largest conglomerates in the world. ABB has operations in around 100 countries, with



approximately 147,000 employees<sup>2</sup>. Company reported global revenue of around \$34,312 million for 2017.<sup>3</sup>

The firm's shares are traded on the stock exchanges of Zurich, Stockholm, and New York. ABB is a multinational corporation headquartered in Zurich, Switzerland, operating mainly in robotics and power and automation technology.

On July 9, 2019 the Italian company FIMER acquired ABB's solar inverter business. The takeover of ABB's solar inverter business included 800 employees in 26 countries as well as two manufacturing plants, in Italy and in India, and a R&D facility in Finland.

FIMER was founded in 1942, headquartered in Vimercate, Italy, has been actively working in inverter technology since 1983. As of 2020, the company employs more than 1,100 employees across its three manufacturing facilities and three R&D centres across the globe. As a result of acquisition of ABB's PV inverter line, FIMER ranked the fifth-largest PV inverter globally in 2019.

### 3.2.2 Track Record

ABB India commenced local manufacturing of solar inverters in 2012 and partnered with several customers. ABB is the solar inverter market leader in India holding approximately 24% market share in 2018. ABB has approximately 3,590MW in operation across more than 350 sites in India. ABB India manages close to 40% of the installed bases in India. As on 30 August 2017, ABB India crossed the 5GW threshold for the supply of inverters in the country.

Table 3-5 lists the state-wise installed capacity of ABB inverters in India. However, it is to be noted that the table below doesn't not comprise of the installed capacities till date.

**Table 3-5: ABB Inverter Track Record**

Location	Capacity (MW)
Tamil Nadu	747
Andhra Pradesh	647
Rajasthan	371
Karnataka	305
Madhya Pradesh	271
Maharashtra	261
Punjab	227
Bihar	225
Uttar Pradesh	106
Haryana	62
Kerala	50
Chhattisgarh	28
Odisha	20

ABB India has strategically located its headquarter in Bangalore and offices in other cities Pune, Ahmedabad, Jaipur, Faridabad, Hyderabad, Tamil Nadu, and Bhopal in order to

<sup>2</sup> <https://new.abb.com/news/detail/26838/abb-to-exit-solar-inverter-business>

<sup>3</sup> <https://new.abb.com/investorrelations/company-profile/facts-figures>



facilitate quick spare part availability and minimal response time. ABB aims to provide first response to its customers within 4 hours on weekdays and within 24 hours on weekends and holidays. ABB also provides a Turn-Around-Time of 48 and 72 hours on weekdays and weekends respectively, hence maintaining an average uptime of over 99%.

### 3.2.3 Technical Characteristics

ABB PVS800-57-1000kW inverter has been selected for technical feasibility of the Project. The technical specification of 1000kW ABB inverter is listed in Table 3-6.

The PVS800-57-1000kW Series of central inverters designed ideal for large PV Power Plants. PVS800 inverters are designed for fast and easy installation. These inverters are designed to operate with DC inputs up to 1,100 V. They incorporate maximum power point tracking (MPPT) and grid management features to meet utility requirements.

PVS800-57-1000kW inverter is designed for outdoor use with an IP42 ingress protection class. They are protected against solid objects over 1mm and against direct sprays of water up to 15° from the vertical. They perform optimally at ambient air temperatures between -15°C to 50°C and relative humidity in the range of 15% to 95% with maximum noise level of 75dBA.

The PVS800-57-1000kVA inverter has peak efficiency of 98.8% and a European efficiency of 98.6%.

The main technical characteristics of these inverters are illustrated in Table 3-6.

**Table 3-6: ABB inverter specifications**

<b>ABB Central Inverter Specifications</b>	
Inverter	ABB PVS800-57-1000kW
Type	Central Inverter
<b>Input Data</b>	
Maximum Input Power (kW <sub>p</sub> )	1200kW <sub>p</sub>
PV voltage range, MPP (V)	600 to 850V
Maximum DC voltage (V)	1100V
Maximum input current (A)	1710A
<b>Output Data</b>	
Nominal AC power (kW)	1000kW
Maximum AC current (A)	1445A
Nominal AC voltage(V)	400V
AC grid frequency (Hz)	50Hz -5%+3%
Maximum THD	< 3%
<b>Operating Performance</b>	
Maximum efficiency (%)	98.80%
Euro efficiency (%)	98.60%
<b>Power consumption</b>	
Own consumption in operation(W)	730W
Standby operation consumption (W)	70W
<b>Other</b>	



<b>ABB Central Inverter Specifications</b>	
Dimensions (W × H × D) (mm)	3630mm x 2130mm x 610mm
Weight (kg)	2600kg
Environmental Protection Rating	IP42
Operating temperature range (°C)	-15 to +50°C
Relative humidity (%)	15% to 95%

The following protection devices are included within the inverter design:

- Ground fault monitoring
- Grid Monitoring
- Anti-islanding protection
- DC reverse-polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection
- Remote monitoring solutions

ABB inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components.

### 3.2.4 Certification

ABB is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. ABB inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information available in public domain, SgurrEnergy has summarized the certification of the ABB inverter within Table 3-7.

**Table 3-7: Description of Certification of ABB inverters**

<b>Certification</b>	<b>Description</b>
IEC 60068-2-6/29	Environmental testing of inverters to assess their ability to perform and survive under conditions such as transportation, storage, operational environments, extreme cold and heat
IEC61683:1999	Measurement of the efficiency of power conditioners
IEC 62109-2:2011	Safety of Power Converters
IEC 62116:2014	Test procedure of islanding prevention measures

### 3.2.5 Warranties

SgurrEnergy referred the warranty documents available in public domain. Given the industry standard warranty of 60 months, SgurrEnergy does not raise any concern over the use of inverter for the project.





### 3.3 Inverter Transformer – Voltamp Transformers Limited

The power at low voltage from inverters is stepped up to 33kV using 2200kVA transformers of Voltamp Transformers Limited make.

#### 3.3.1 Company Profile

The inverter transformer used is manufactured by Voltamp Transformers limited (Voltamp).

Voltamp was founded in 1963 in Vadodara, Gujarat and now has a PAN India presence. The company initially started off by manufacturing small transformers by 1975 the largest transformer manufactured was for 132kV networks. This limit rose to 220kV class of transformers in 2008. The company employs more than 300 personnel (including 60 engineers) and has branch offices in Mumbai, New Delhi, Chennai, Bangalore, Secundrabad, Pune, Bhubaneshwar, etc.

The company has four manufacturing plants and the current manufacturing capacity totals to 13000 MVA per year. These facilities boast of manufacturing Oil filled Power and Distribution Transformers up to 160MVA, 220kV. The company got its ISO 9001 certification in 1998 and was listed on the NSE and BSE stock exchange in 2006.

Notable designs include:

- 75MVA 11/138kv GT
- 20MVA 33-22/11kV (DZ10)
- 50MVA 132-110/33kV transformer
- 6 MVA 1-ph transformer
- 15MVA 11/1.3-1.3kV (24 pulse)
- 100MVA 22kV

The company also manufacturers two types of dry transformers, i.e. resin impregnated (25KVA-5000KVA up to 11kV) and cast resin transformers (50kVA-12500kVA up to 33kV). Prominent clients include ABB, Exide, Adani, BHEL, BPCL, Suzlon etc.

#### 3.3.2 Technical Specifications

The 2200kVA Power transformers used in the project are outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 3-8.

**Table 3-8: Technical Specification of Voltamp Transformers**

Technical Parameters	Description
Rated Power	2200kVA
Rated HV	33kV
Rated LV	400-400V
Tapping on HV	-5% to +5% (steps of 2.5%)
Phases	3
Frequency	50Hz





Technical Parameters	Description
Vector group	Dy11y11
Impedance	5.93%
Cooling Strategy	ONAN
Oil temperature rise	50°C
Winding temperature rise	55°C
Winding material	Copper

SgurrEnergy considers the overall the technical specification to be adequate for the PV projects and in line with the industry accepted standards.

### 3.3.3 Temperature Rise Detection and Protection

Inverter transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.4 Warranties and Guaranties

Based on the information available in public domain, SgurrEnergy understands the Shilchar transformers have been provided with a warranty of 60 months from date of dispatch. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards.

## 3.4 Conclusion on Major Plant Components

### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of JA Solar, Canadian Solar and Astronergy assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.

Further, according to the warranty documents available in public domain for all three module manufacturers, SgurrEnergy considers the warranty terms and conditions offered by all three manufacturers to be in-line with the industry standard and raises no major concern regarding the warranties offered. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.

### Inverters

SgurrEnergy has conducted review of the ABB PVS800-57-1000kW central inverter ABB PVS800-57-1000kW central inverter has the required certification for use in solar PV plants. In-house testing of the inverter and individual components is relatively extensive during the R&D phase with functional and temperature cycling testing of each manufactured inverter. ABB offers a product warrant of 5 years which is in line with the current industry standards.

In conclusion, ABB can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters.



ABB inverters have more than 3GW of installation worldwide. These inverters are quite known to the Indian market and have installed capacity of more than 1.3GW which demonstrates a good track record in the Indian solar PV market.

### Transformers

Voltamp has a track record of more than 53,000 transformer installation across India, Nepal, Sri Lanka, Bhutan, Indonesia, Middle East Asia, South East, and African Countries<sup>4</sup>. The accreditations for manufacturing facility gained by the company are considered fair and satisfactory.

The inverter transformers (2200kVA) used within the project are manufactured by Voltamp Transformer Limited. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.

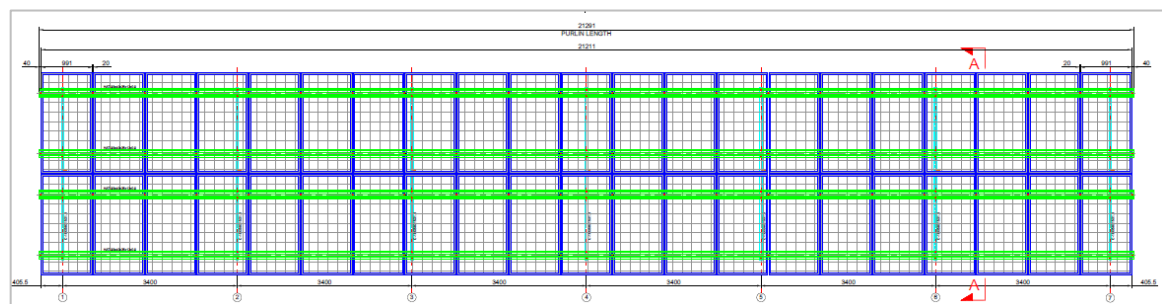
### 3.5 Module support structures

The Array Layout provided by the Client for the JA solar modules indicates the fixed tilt module mounting structure is inclined at 8° tilt angle.

Although the as-built MMS GA drawing for the 10MW<sub>AC</sub> Vilatikulam site has not been provided for review, SgurrEnergy observed that the EPC contractor, PV module, module orientation, MMS configuration and tilt angle provided for 5MW<sub>AC</sub> Perumpalli site is similar to that of 10MW<sub>AC</sub> Vilatikulam site. Hence, SgurrEnergy has reviewed the as-built MMS GA drawing provided for 5MW<sub>AC</sub> Perumpalli site, dated 12.06.2015.

SgurrEnergy observed that the structure has been designed with two rows of modules placed in portrait orientation with 21 modules in each row. In total there are 42 modules in one mounting structure. The layout is designed with a pitch of 6m.

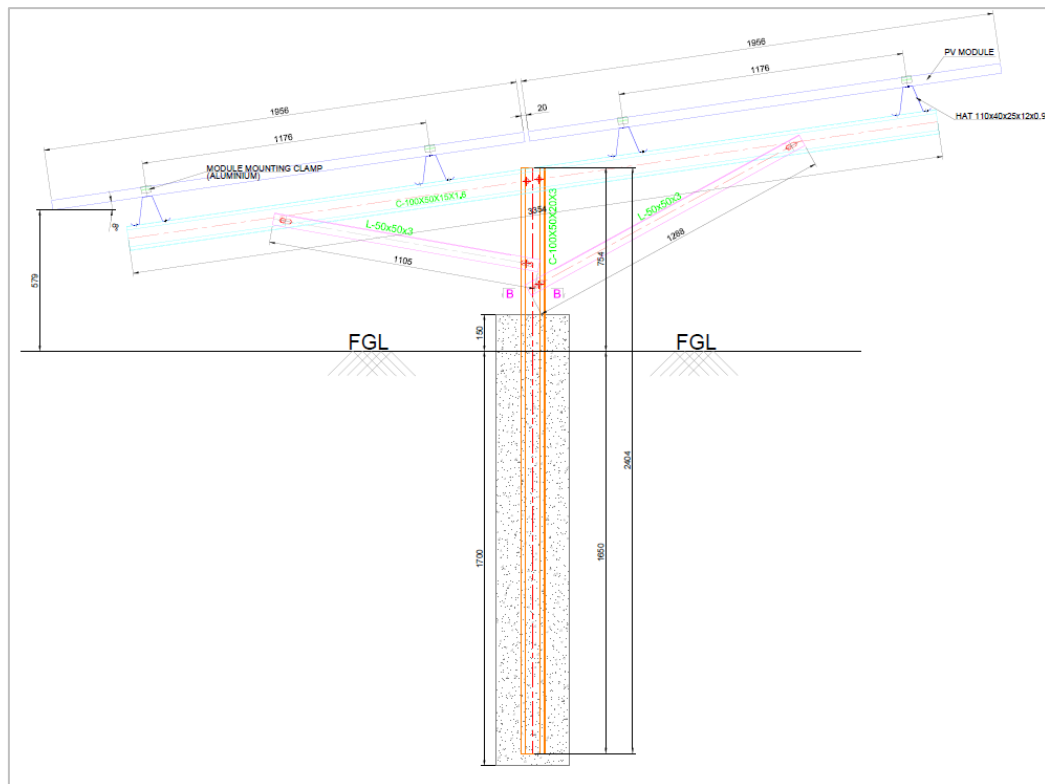
Figure 3-1 and Figure 3-2 illustrate the module mounting structure configuration provided by the Client for the JA PV modules.



**Figure 3-1: Two in portrait module mounting structure with 21 modules in a row**

<sup>4</sup> <http://www.voltamptransformers.com/index.php/dashboard/infrastructure>





**Figure 3-2: Side view of the module mounting structure configuration**

Based on the information provided in the GA drawing of the MMS, the technical specification has been summarized below.

Table 3-9 summarizes the technical specification of the module mounting structure.

**Table 3-9: Specification of MMS**

MMS Part	Material	Grades - Standard	Thickness (mm)	Minimum Yield Stress (MPa)
Rafter	Cold Formed	ASTM A 653-340-1	1.6	350
Purlin	Cold Formed	ASTM A 792/_2010/ G_80_550_CLASS_1	0.9	550
Leg	Cold Formed	E350- IS 5986-2011	3.0	350
Bracing	Cold Formed	E350- IS: 10262, IS 2911, IS 456, IS 800	3.0	350

Material used is a combination of hot-dipped galvanised mild steel and pre-galvanised cold rolled sheets sheared to form structural members for module mounting. The pre-galvanised sheets post process is appropriately coated with anti-corrosion compounds for the project life cycle. SgurrEnergy was not provided with the information regarding type of pile used in the project.



## 4 Allied Components and Systems

### 4.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

### 4.2 PV Power Transfer

SgurrEnergy has reviewed the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear, and plant substation as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

- “SWLB-SP-TN-10MW-E-DWG-SLD-100”, revision 2, dated 08.04.2015.
- “SWLB-SP-TN-10MW-E-DWG-SLD-100B”, revision 1, dated 03.11.15.

The 10MW<sub>AC</sub> solar PV Plant is designed with 310W<sub>P</sub> and 315W<sub>P</sub> JA solar PV modules and 1000kW ABB inverters. Modules are interconnected to form a string of 21 modules. Each string forms a single output that feeds as a single input to the 12 input combiner boxes. Eight string combiner boxes are further connected to the inverter.

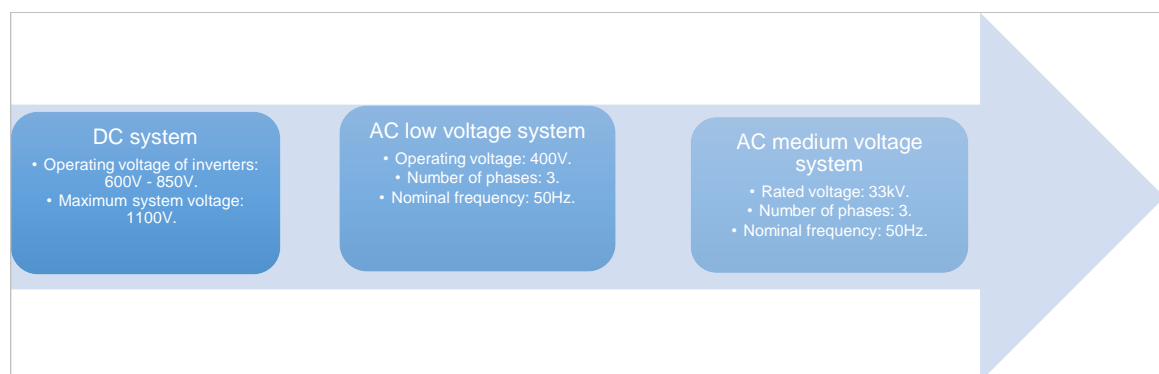
The plant is configured with 10 ABB 1000kW central inverter thereby taking the total AC installed capacity to 10MW<sub>AC</sub>. The Project has been implemented with three inverter station out of which one inverter block is of 2MW<sub>AC</sub> and rest is of 4MW<sub>AC</sub> capacity.

Each 4MW<sub>AC</sub> capacity inverter station consists of 2-sets of two 1000kW inverters connected to 0.400/0.400/33kV three-winding, 2.2MVA transformer, while the inverter station of 2MW<sub>AC</sub> capacity consists of one-set of 1000kW inverters connected to 0.400/0.400/33kV three-winding, 2.2MVA transformer, that step up the voltage upto 33kV. The power from the HV side of the 33kV inverter transformer is transferred to 33kV HT panel.

The output power of each 33kV HT panel is connected to 33kV main HT panel located in the main control room. Further power from main control room is fed to 33kV metering yard through 33kV Double pole (DP) structure.

Power from 33kV metering yard is evacuated to the substation situated at a distance of 7.2km from the project site at 33kV voltage level through ACSR dog conductor overhead transmission line.

Figure below illustrates a power flow summary for the 10MW<sub>AC</sub> Solar PV plant.



**Figure 4-1: Power flow of 10MW<sub>AC</sub> PV plant**

### 4.3 Cabling

#### 4.3.1 DC Cabling



DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. Modules are interconnected in series with solar grade cables that are tied along with the module mounting structures. Modules are interconnected in leap-frog scheme to form a string of 21 PV modules connected in series.

The Y harness equipped with 30A fuse has been used to pre-combine the string of PV module. Single core 6mm<sup>2</sup> multi-stranded copper PV cables connect Y- harness output to String Combiner Box (SCB).

These combiner boxes are equipped with 30A fuse for each of the string connection and a 315A disconnect switch on output side. Power from string combiner box is further transferred to the inverter using 2 runs, 1C, 185/240/300mm<sup>2</sup>, 1.1kV aluminium XLPE ((2R X 1C X 185/240Sqmm, 1.1kV AL. XLPE Armoured) cables.

#### 4.3.2 AC Cabling

Three phase AC output from inverter is connected to the LV winding of a three-winding 2.2MVA transformers, using 12 Runs single core 630mm<sup>2</sup> Aluminium Armoured XLPE (12R (4R/Ph) X1C x 630mm<sup>2</sup> Al. Ar. XLPE) cable. The inverter transformers step up the voltage to 33kV.

Power is fed from the high voltage side of each transformers using 1R,3C, 185mm<sup>2</sup>, 33kV Al XLPE armoured cable to the 33kV HT panel in the 4MW<sub>AC</sub> and 2MW<sub>AC</sub> inverter stations using a radial feeder arrangement.

The 33kV output of each inverter station is transmitted to 33kV main HT panel located within Main control room using 1R,3C, 185mm<sup>2</sup>, 33kV(E) Al XLPE armoured HT cables.

The power from the Main HT panel is transferred to 33kV DP structure and 33kV metering yard through triple core, 300mm<sup>2</sup>, 33kV Aluminium XLPE Armoured (1R x 3C x 300sqmm/Phase 33kV[E], Al, XLPE, Ar.) cable.

Further the power from the solar PV plant is feed to the 33kV substation through ACSR dog conductor overhead transmission line.

#### 4.4 Inverter Station

The 10MW<sub>AC</sub> solar PV plant has been configured with 10 inverters and three inverter stations. Out of the total three inverter stations, two inverter stations of 4MW<sub>AC</sub> capacity consist of four inverters and one inverter stations of 2MW<sub>AC</sub> capacity consists of two inverters.

Each 4MW<sub>AC</sub> inverter station consists of two-sets of two inverters connected to a 2,200kVA three-winding transformers, while 2MW<sub>AC</sub> inverter station consists of two inverters connected to a 2,200kVA three-winding transformer. Each transformer, along with allied switchgears, steps up the voltage to 33kV for all inverter stations. Further the power from the HV side of the transformer is fed to the 33kV outdoor type HT panel through radial feeder arrangement.

33kV outdoor type HT panel comprises of 50/5-5A current transformer, 33kV/110V fixed type line potential transformer, 33kV EDO TP, 630A Vacuum Circuit Breaker and other electrical protection system. The power from inverter duty transformer is transferred to aforesaid MV panel.

#### 4.5 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed 2.2MVA, 33kV/2x0.400kV, Dy11y11 three-winding transformers have been used in the project. These inverter duty transformers step up the voltage to 33kV.



The 2.2MVA inverter duty transformers output is connected to 33kV HT panels located within inverter station. The energy from all the inverter stations 33kV HT panels are radially combined at 33kV main HT panel located within main control room.

#### 4.6 33kV Main HT Panel

A 33kV main HT panel comprises of inverter station incoming feeders and one outgoing feeder. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class. All feeders have been provided with relay and metering unit. The 33kV main HT panel outgoing and incoming feeders are provided with instantaneous and IDMT (50/51) O/C relay instantaneous and IDMT (50N/51N) E/F relay protections. The 33kV outgoing feeders are provided with 0.2S class instrument transformers.

Power is fed from 33kV main HT panel to and metering yard using 33kV DP structure further power from 33kV DP structure is transferred to metering yard through overhead line.

#### 4.7 33kV Metering Yard

The 33kV main HT panel outgoing feeders are connected to 33kV DP structure and 33kV Metering yard.

The 33kV metering yard is observed to be equipped with instrument transformers, isolator, and lightning arrestor with metering & protection cores. The 30kV, 10kA lightning arrestor is provided at 33kV incoming feeders to discharge surge currents caused by lightning strokes.

Subsequently energy from 33kV plant end metering yard is evacuated to the substation located at the distance of 7.2km from the project site at 33kV level through dog ACSR single circuit overhead transmission line.

#### 4.8 Auxiliary Power Supply

SgurrEnergy had reviewed the electrical schematics shared for the projects to evaluate auxiliary system. The inverter stations of 4MW<sub>AC</sub> and 2MW<sub>AC</sub> capacities are equipped with 15kVA and 35kVA auxiliary transformers, respectively.

#### 4.9 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are normally mounted on individual structures.

Following the review of 33kV SLD, SgurrEnergy observed 33kV, 630A, 25kA/1sec load break switch has been used in the project.

#### 4.10 Isolators

Isolators are used to transfer load from one bus to another and also to isolate equipment for maintenance.

Based on the review of 33kV SLD, SgurrEnergy observed 33kV, 630A isolator with earth switch has been used in the project.

#### 4.11 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.



The current transformers with accuracy class of 0.2s for metering and class 5P and PS for protection has been used in 10MW<sub>AC</sub> solar PV plant. The potential transformers with accuracy class of 0.2 for metering and class 3P for protection has been used in the project.

#### 4.12 Surge Arresters and Lightning Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes on the lines entering the substation. The apparatus most commonly used for this purpose is the surge arrester. Transformer is the costliest equipment in substation, and it is normal practice to install surge arrester near to the transformer. Additional surge arresters shall be provided either on bus or on various lines for protection of the equipment.

Following the review, SgurrEnergy observed 30kV, 10kA, surge arrester and 30kV, 10kA lightning arrester has been used in 33kV main HT panel and 33kV metering yard, respectively.

#### 4.13 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy will be provided at the medium voltage switchboards for each of the feeder sections. These meters will be digital with an RS 485 port for remote monitoring. These usually have an accuracy class of 0.5.

Similarly, HV side shall also be equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point shall be 0.2S.





## 5 System Design Appraisal

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

### 5.1 Plant Layout Design

SEI was provided with as built plant layout and electrical schematics. SEI has verified the plant configuration with electrical schematics provided by the Client. The PV plant is JA Solar (310W<sub>p</sub> and 315W<sub>p</sub>) PV modules. The total DC installed capacity stands at 12MW<sub>p</sub>. The AC installed capacity stands at 10MW<sub>AC</sub> with 10 inverters of capacity 1,000kW each. Overall 10MW<sub>AC</sub> PV plant is illustrated below in the Figure 5-1.

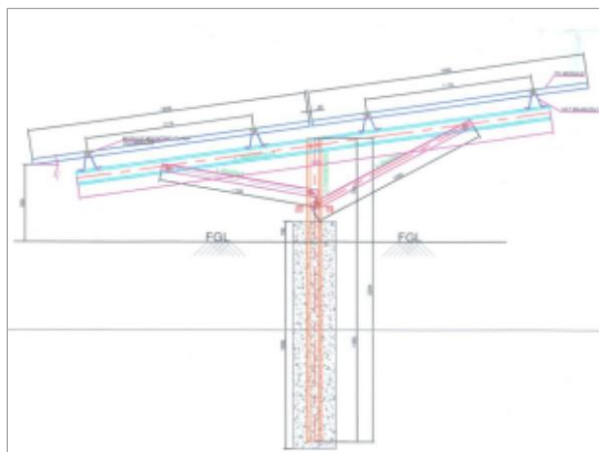


**Figure 5-1: Plant layout of 10MW<sub>AC</sub>**

All the PV modules are orientated towards South. The mounting structure provides support for two rows of panels in portrait orientation.







**Figure 5-2: Side view of typical module mounting structure configuration**

The selected tilt for the 10MW<sub>AC</sub> plant is 8°. The 10MW<sub>AC</sub> plant is designed with a pitch of 6m.

Based on regional experience of detail designing, SEI considers the selected tilt angle and pitch is optimized for maximum irradiation on the collector plane, minimum loss due to inter row shading, minimum ohmic losses and ease of maintenance.

21 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.2. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.

## 5.2 String Sizing

The plant layout provided by the Developer indicate thirty 310W<sub>p</sub> and 315W<sub>p</sub> JA Solar polycrystalline modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage ( $V_{OC}$ ) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum  $V_{OC}$  of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy in validating string configuration. Subsequent to calculating open circuit voltage ( $V_{OC}$  max), maximum power voltage ( $V_{mp}$  min) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 40°C and 15°C respectively for system design validation to be fair and representative for the PV plants' site.

The results of string sizing validation are presented in Table 5-1. Results indicate that  $V_{OC}$  max at the minimum ambient temperature is within the maximum system voltage of 1,000V for the selected ABB inverters.

**Table 5-1: String Sizing for JA Solar PV Modules**

Parameters	JA 310W <sub>p</sub>	JA 315W <sub>p</sub>
PV module power (W <sub>p</sub> )	310	315
Modules per string	21	
Inverters	ABB (PVS-800-57-1000kW)	



Maximum Open-circuit voltage ( $V_{oc}$ max) at minimum ambient temperature of 15°C	987V	991V
Minimum power voltage ( $V_{mp}$ min) at maximum ambient temperature of 40°C	905.1V	907V

### 5.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with JA Solar and ABB inverter is presented in Table 5-2. SgurrEnergy has selected the highest rated JA Solar module (315W<sub>p</sub>) their compatibility with ABB inverters, as SgurrEnergy considers this to be representative for all the JA Solar PV modules installed on site.

**Table 5-2: Inverter Compatibility with JA Solar 315W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>JA Solar 315W<sub>p</sub></b>	
Modules per string	21	Acceptable
Strings per inverter	182	Acceptable
Maximum power, $P_{mpp}$ at STC (kW <sub>p</sub> )	1,203.9	Nominal power ratio is 1.20, this is within the inverter bus current carrying capacity.
Maximum power voltage, $V_{mpp}$ at STC (V)	782.8	Acceptable.
Maximum power current, $I_{mpp}$ at STC (A)	1,537.9	Acceptable
Open-circuit voltage, $V_{oc}$ at STC (V)	957.6	Acceptable.
Minimum MPP voltage at 40°C ambient temperature (V)	730.8	Acceptable: Inverter MPPT ranges 600 - 850V.
Maximum MPP voltage at 15°C ambient temperature (V)	814.8	Acceptable: Inverter MPPT ranges 600 - 850V.
Maximum open circuit voltage, $V_{oc}$ at 15°C (V)	991	Acceptable: Maximum inverter voltage 1000V.

Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.



## 6 Resource assessment

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SEI has sourced monthly horizontal plane irradiation data for the Project site from:

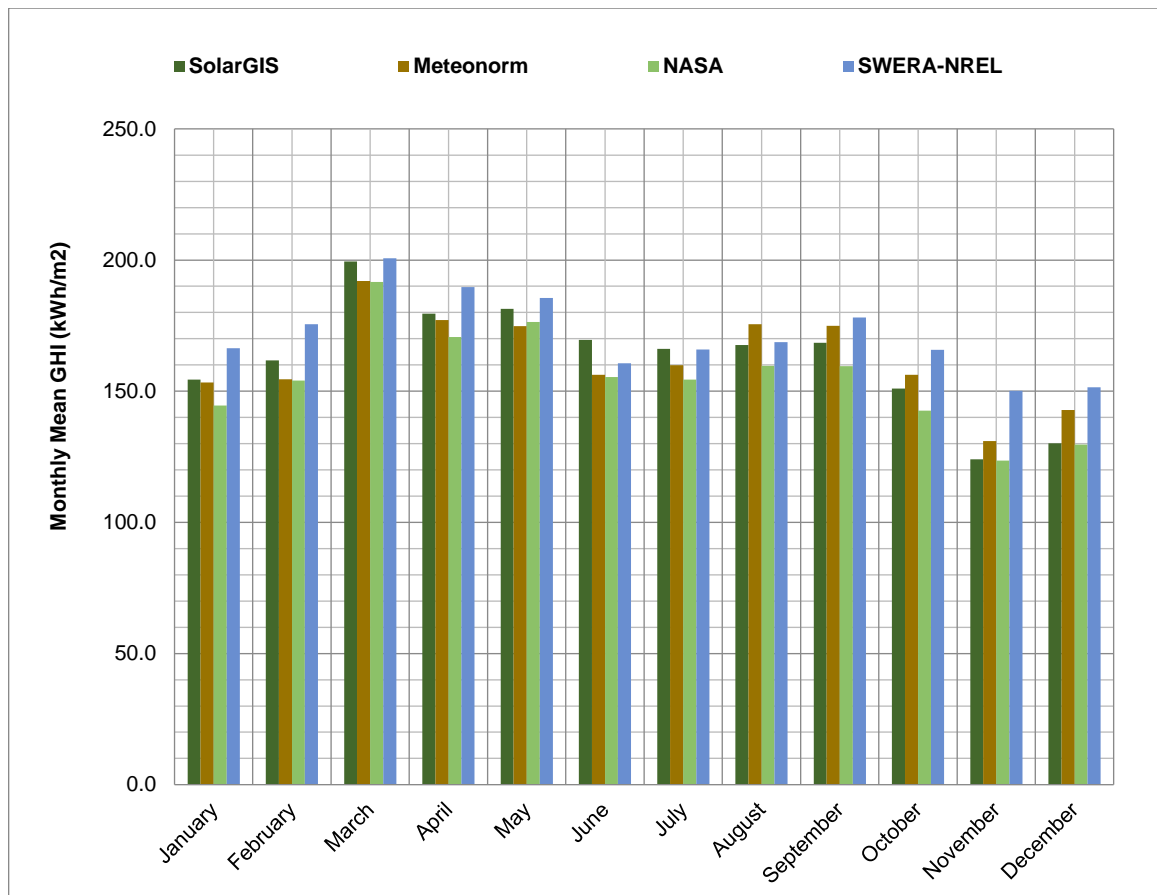
- **NASA's Surface Meteorology and Solar Energy data set**; holds satellite derived monthly data for a grid of 0.5° × 0.5° covering the globe for a thirty-four-year period (1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.



- The **METEONORM (version 7.3)** *global climatological database and synthetic weather generator*; contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.
- **SolarGIS:** SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km × 4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by *IEA (International Energy Agency) SHC Collaboration Agreement, and EU FP6 project MESoR* in terms of bias and RMSE.

SEI has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS data for the site. The comparison is graphically illustrated Table6-1





**Figure 6-1: Monthly Global Horizontal Irradiation**

**Table6-1: Comparison of Solar Irradiation Datasets for the site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	1,953.5
Meteonorm 7.3	14km × 14km	4.0%	1,948.6
NASA	55km × 55km	Unknown	1,862.1
NREL (SWERA)	40km × 40km	Unknown	2,058.5

The comparison of solar data for Project site location illustrated in Table6-1 indicates NREL (SWERA) dataset to give the highest irradiation levels. The next highest irradiation is given by SolarGIS followed by Meteonorm 7.3 and NASA.

The irradiation values given by Meteonorm 7.3 typically provide a combination of ground and satellite measured data. Meteonorm 7.3 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as 7% for the proposed site.

The NASA-SSE data source provides purely satellite measured data for a grid covering 0.5° × 0.5° on the earth's surface and generally more suited for initial site selection.

The NREL (SWERA) data illustrated has been obtained for a location approximately 5.49 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data

The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also



been compared with other data sources globally. The IEA (International Energy Agency) validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>5</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)
- Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 6%.

SEI is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 6.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 6-2 and shown graphically in Figure 6-2. Diffuse irradiation accounts for 49.21% of the total irradiation. Table 6-2 illustrates direct and diffuse daily irradiation on a horizontal plane for the proposed site. SolarGIS irradiation data is presented in Table 6-2.

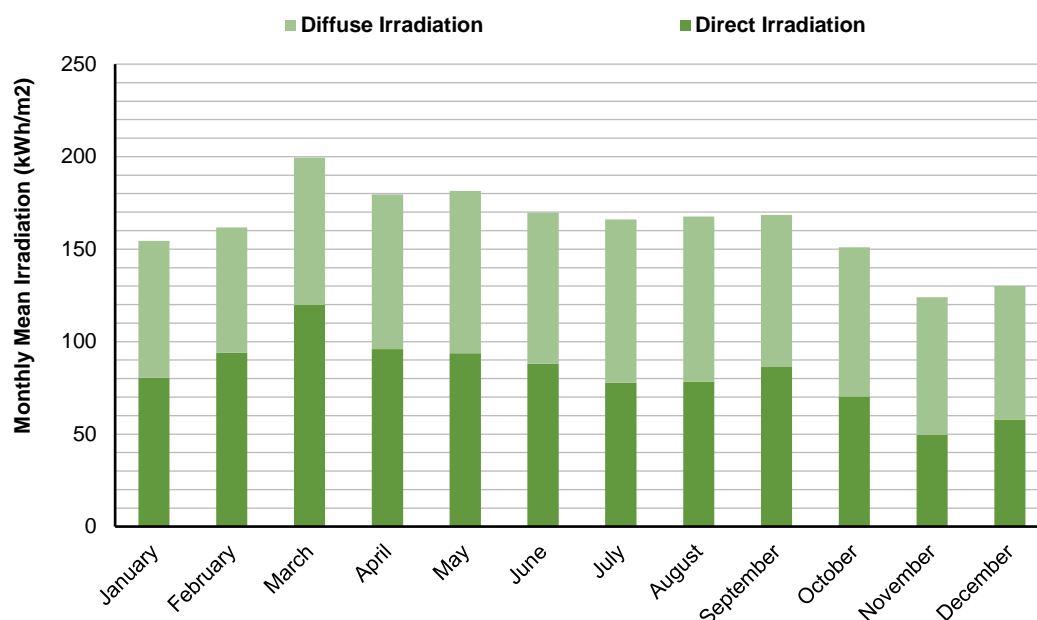
**Table 6-2: SolarGIS Irradiation Data for the Project sites**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	154.4	73.8	7.9%
February	161.8	67.8	8.3%
March	199.5	79.7	10.2%
April	179.6	83.7	9.2%
May	181.4	87.7	9.3%
June	169.6	81.6	8.7%
July	166.1	88.4	8.5%
August	167.6	89.3	8.6%
September	168.4	82.2	8.6%
October	151.0	80.6	7.7%

<sup>5</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>



Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
November	124.0	74.4	6.3%
December	130.1	72.2	6.7%
<b>Annual Sum</b>	<b>1,953.5</b>	<b>961.3</b>	<b>-</b>



**Figure 6-2: Monthly Direct and Diffuse Irradiation on a horizontal plane for the project site**

## 6.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.1.4), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -6-3 represents the monthly GTI profile.

**Table -6-3: Monthly Global Tilted Irradiation Data**

Month	GTI (kWh/m <sup>2</sup> )
January	164.70
February	169.50
March	203.20
April	177.70
May	175.60
June	162.40
July	160.20
August	164.30
September	169.30



Month	GTI (kWh/m <sup>2</sup> )
October	155.70
November	129.60
December	138.40
<b>Annual Sum</b>	<b>1,970.60</b>

### 6.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 6-4 below. The average wind speed of 1.6 m/s was measured at 10m height from ground level for the proposed project site location.

**Table 6-4: Simulated Wind Speed for site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	1.1
February	1.2
March	1.3
April	1.3
May	1.8
June	2
July	2.5
August	2.4
September	1.9
October	1.2
November	0.9
December	1
<b>Yearly Average</b>	<b>1.6</b>

### 6.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.



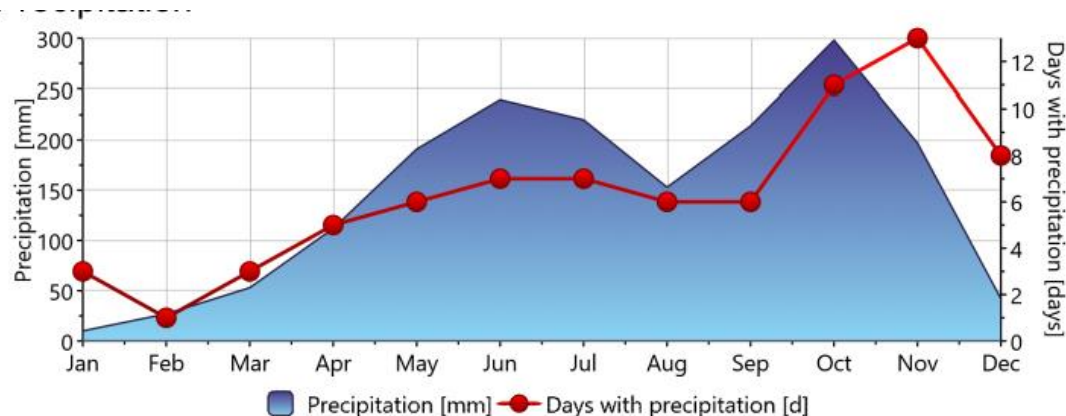


**Table 6-5: SolarGIS Temperature Data for Site (1999 – 2018)**

Months	Average Monthly Temperature (°C)
January	26.0
February	27.2
March	29.3
April	31.2
May	31.7
June	30.1
July	29.6
August	29.8
September	29.8
October	28.5
November	26.7
December	25.7
<b>Annual Average</b>	<b>28.8</b>

## 6.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.3 as illustrated in Figure 6-3. These figures show that the identified site is situated in a region that has marginal rainfall.

**Figure 6-3 Meteonorm Predicted Precipitation for the site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

Frequency of module cleaning depends on the rainfall frequency and the prevalence of dust and pollution in the local vicinity. Typical cleaning techniques include water cleaning, dry brushes or vehicle-based mechanical cleaning.

The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 1.5% has been considered by considering cleaning frequency of twice a month.



## 7 Energy Yield Assessment

SgurrEnergy has computed the annual energy yields for the 10 MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

Parameter	Description
Modules	JA Solar (JAP6-72-310/3BB, JAP6-72-315/3BB)
Inverters	ABB Central Inverters – 1.0MW <sub>AC</sub> (PVS800-57-1000kW-C)
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	12

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 7.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in Table 7-1 below.

**Table 7-1: Description of Energy Yield Losses**

Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.



Loss	Description
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 10 MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 7.2 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 10 MW<sub>p</sub> solar PV Plant with JA solar modules and ABB inverters. Table 7-2 summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.



**Table 7-2: Energy Yield for the 10MW<sub>AC</sub> Solar PV Plant**

Parameters	Description
PV Module Technology	Polycrystalline
DC Capacity (MW <sub>p</sub> )	12
AC Capacity (MVA)	10
Contracted Capacity (MW)	10
P <sub>NOM</sub> Ratio	1.20
Tilt (°)	8
Pitch (m)	6
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1,953.50
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	1,970.60
Transposition Factor	1.01
<b>Losses</b>	
Horizon Shading	0.00%
Incident Irradiation Below Threshold	0.00%
Near Shading	0.54%
Incident Angle	2.53%
Soiling	1.50%
Low Irradiance	0.43%
Module Temperature	9.43%
Electrical Shadings	0.00%
Module Quality	0.00%
First year Degradation	1.50%
Module Mismatch	1.00%
DC Ohmic	1.03%
Inverter Performance	1.74%
Availability	1.00%
AC Ohmic	0.54%
Transformer (LV/MV)	1.07%
Transformer (MV/HV)	-
Transmission Line	1.24%
Auxiliary Consumption	0.60%
Curtailment	
<b>Total Annual Loss Factor</b>	<b>0.788</b>
<b>Sixth Year P50 Energy Yield (MWh/annum)</b>	<b>18,169.81</b>
<b>Sixth Year Specific Yield (kWh/kW<sub>p</sub>)</b>	<b>1513.80</b>
<b>Sixth Year CUF on AC Installed Capacity</b>	<b>20.74%</b>



Parameters	Description
Sixth Year CUF on Contracted Capacity	20.74%
Sixth Year CUF on DC Installed Capacity	17.28%
Sixth Year Performance Ratio	76.81%

Graphical representation of the monthly generation, performance ratio and CUF for 10 MW<sub>AC</sub> evaluated is illustrated graphically in the Figure 7-1.

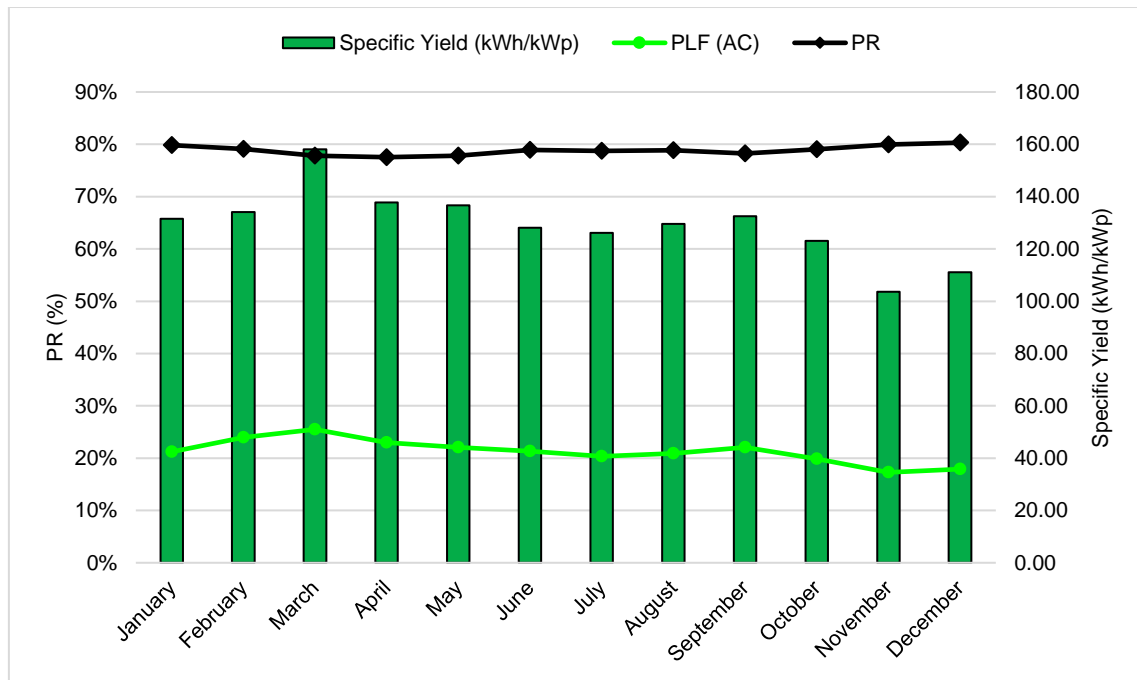


Figure 7-1: Monthly Energy Yield for 10MW<sub>AC</sub>

### 7.3 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 7.3.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

#### 7.3.2 Inter – Annual Variation in the Solar Resource

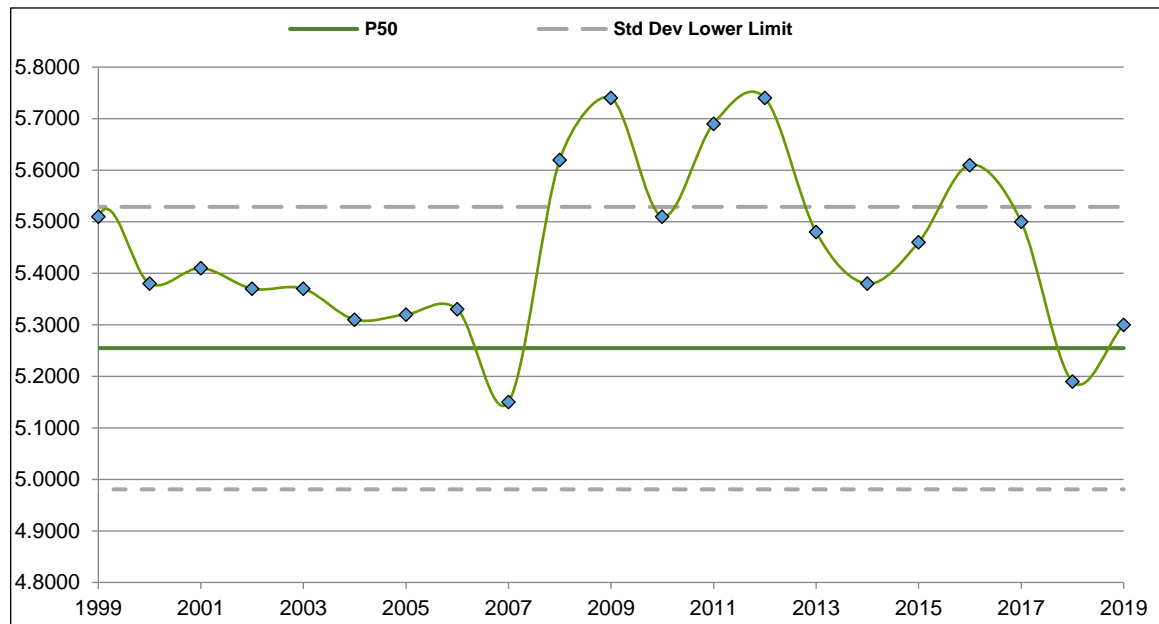
Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.



The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database for the proposed site location which is used to estimate the standard deviation of variation in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 7-3.

**Table 7-3: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	5.21



**Figure 7-2: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in Figure 7-2.

SgurrEnergy uses a coefficient of variation of 5.21% to quantify the inter-annual variation in the solar resource.

### 7.3.3 Modelling Uncertainty

The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

### 7.3.4 Total Uncertainty (P75, P90 and P99 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.



**Table 7-4: Life Cycle P50, P75 and P90 Generation Prediction for 10 MW<sub>AC</sub>**

Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>6</sup> (MWh/annum)	P90 Generation Prediction <sup>7</sup> (MWh/annum)
6	18,169.81	17,385.69	16,679.97
7	18,078.96	17,298.77	16,596.57
8	17,988.57	17,212.27	16,513.58
9	17,898.62	17,126.21	16,431.02
<b>10</b>	<b>17,809.13</b>	<b>17,040.58</b>	<b>16,348.86</b>
11	17,720.08	16,955.38	16,267.12
12	17,631.48	16,870.60	16,185.78
13	17,543.33	16,786.25	16,104.85
14	17,455.61	16,702.32	16,024.33
15	17,368.33	16,618.80	15,944.21
16	17,281.49	16,535.71	15,864.48
17	17,195.08	16,453.03	15,785.16
18	17,109.11	16,370.77	15,706.24
19	17,023.56	16,288.91	15,627.71
<b>20</b>	<b>16,938.44</b>	<b>16,207.47</b>	<b>15,549.57</b>
21	16,853.75	16,126.43	15,471.82
22	16,769.48	16,045.80	15,394.46
23	16,685.64	15,965.57	15,317.49
24	16,602.21	15,885.74	15,240.90
<b>25</b>	<b>16,519.20</b>	<b>15,806.31</b>	<b>15,164.70</b>

<sup>6</sup> The P75 values have been calculated over 10-year averages<sup>7</sup> The P90 values have been calculated over 10-year averages

## 8 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 0.6% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) and henceforth. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Developer, SgurrEnergy understands that the 10MW TNS solar PV plant was commissioned on 31<sup>th</sup> October 2015. SgurrEnergy was provided with plant and grid availability records from Feb 2016 to March 2021<sup>8</sup> for the solar PV plant. However, the irradiation measurement records were provided from April 2016 to March 2021.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from April 2016 to March 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Developers control.

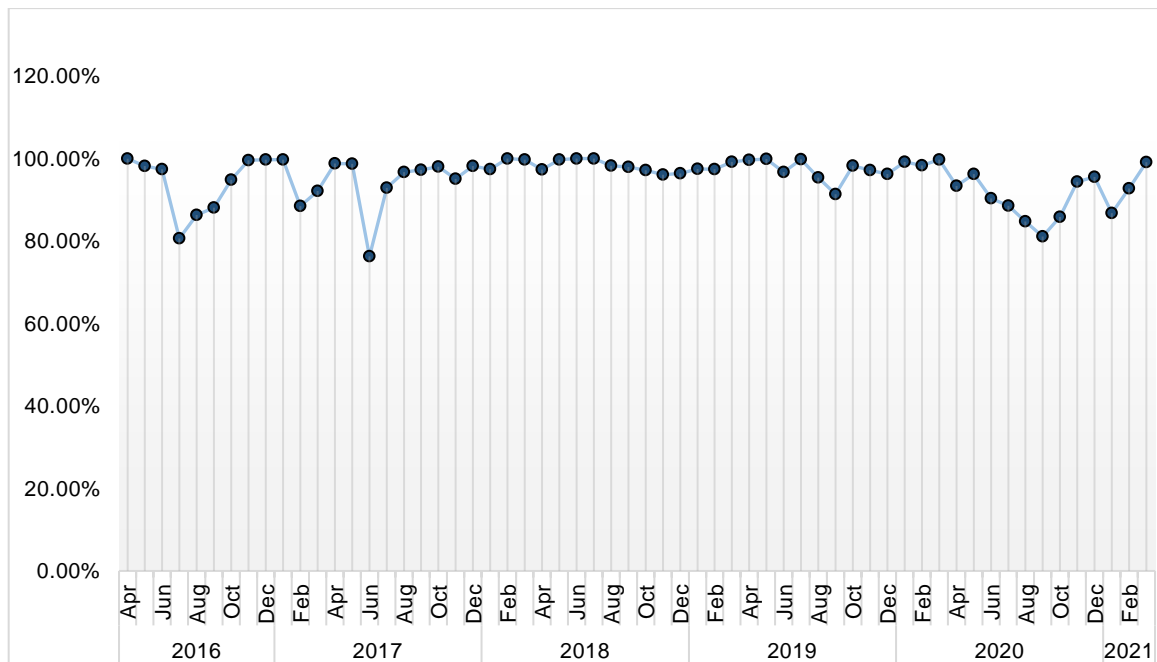
The monthly records of the grid availability from April 2016 to March 2021 have been graphically illustrated in Figure 8-1 below.

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<sup>8</sup> SgurrEnergy was provided with both the plant and grid availability records until March 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.







**Figure 8-1: Grid Availability**

Based on the above illustration, SgurrEnergy notes the grid availability for the TNS 10MW solar PV plant is notably inconsistent for all the months ranging between 76.26% to 100%.

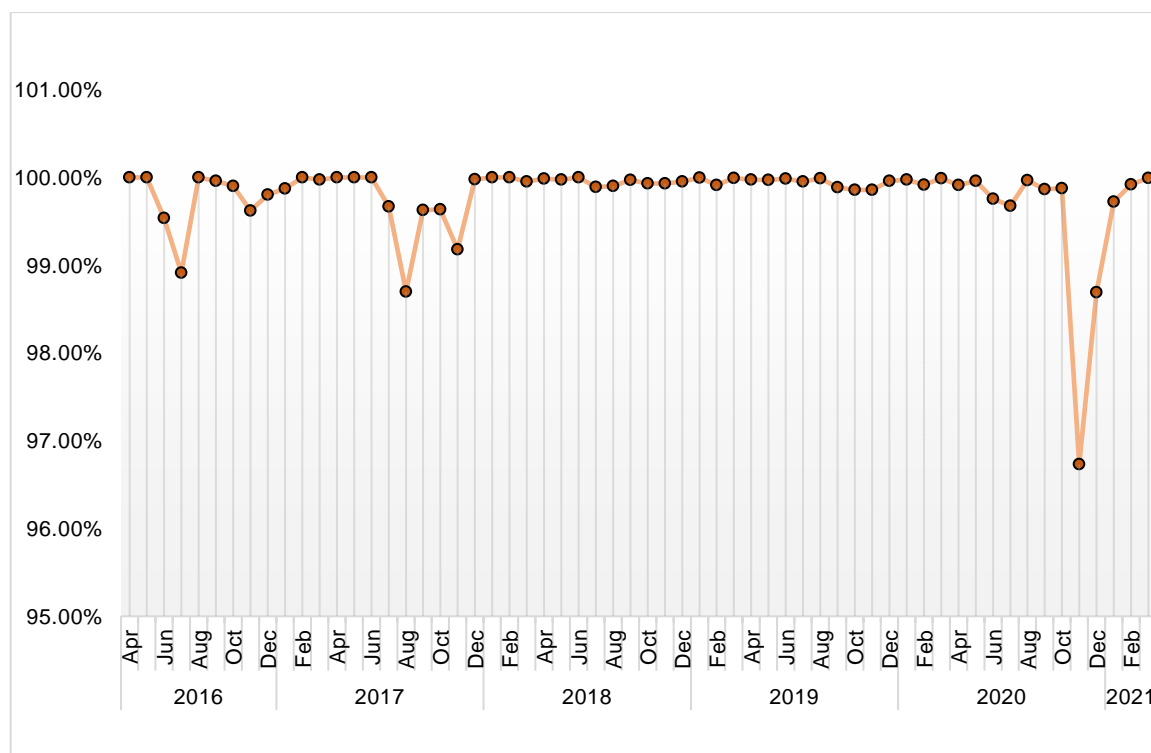
The resultant overall grid availability of the PV plant for the period evaluated was 95.19%. SgurrEnergy considers that the unavailability loss experienced due to grid anomalies for the operational period is higher than the expected range.

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the SPSPL solar PV plant is graphically illustrated below in Figure 8-2.





**Figure 8-2: Plant Availability**

Based on the above illustrations, SgurrEnergy notes the plant availability for the TNS 10MW solar PV plant was above 99% for substantial amount of time over the operational period of the plant. However, for the month of November 2020 the plant unavailability was significantly higher when compared to other months.

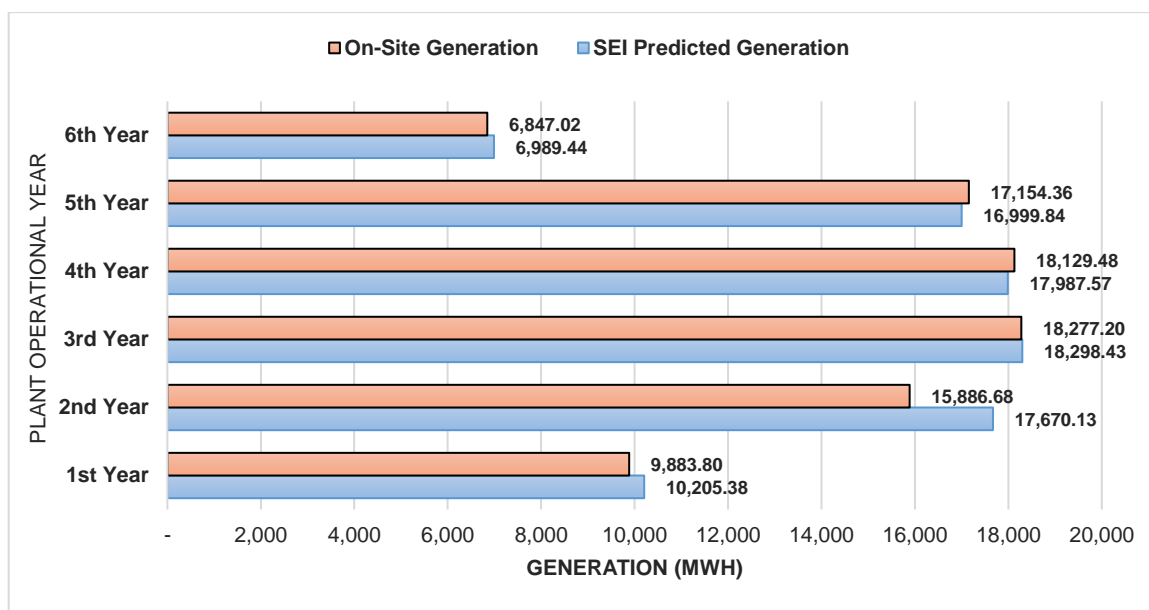
The resultant average plant availability of the PV plant for the period evaluated was 99.8% which is considered to be within expected range.

## 1.2 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer. To make the operational energy yield predictions more representative, SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Developer. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Developer.

The yearly comparison of the generation data is illustrated below in Figure 8-3.





**Figure 8-3: Generation Comparison**

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 8-1

**Table 8-1: PV Plant Performance – TNS 10MW**

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>9</sup> (%)
Apr 2016 -Oct 2016	10,205.38	9,883.80	-3.15%
Nov 2016 -Oct 2017	17,670.13	15,886.68	-10.09%
Nov 2017 -Oct 2018	18,298.43	18,277.20	-0.12%
Nov 2018 -Oct 2019	17,987.57	18,129.48	0.79%
Nov 2019 -Oct 2020	16,999.84	17,154.36	0.91%
Nov 2020 -March 2021	6,989.44	6,847.02	-2.04%
<b>Cumulative Period</b>	<b>88,150.79</b>	<b>86,178.54</b>	<b>-2.24%</b>

Based on the above comparison, SgurrEnergy notes that the PV plant is generating lower than the expected yield. However, SgurrEnergy considers that the variations in the energy yield can be attributed to lower irradiation level experienced on the Project site. The irradiation levels significantly impact the actual generation from the PV plant as the system losses may vary significantly due to slight change in the irradiation.

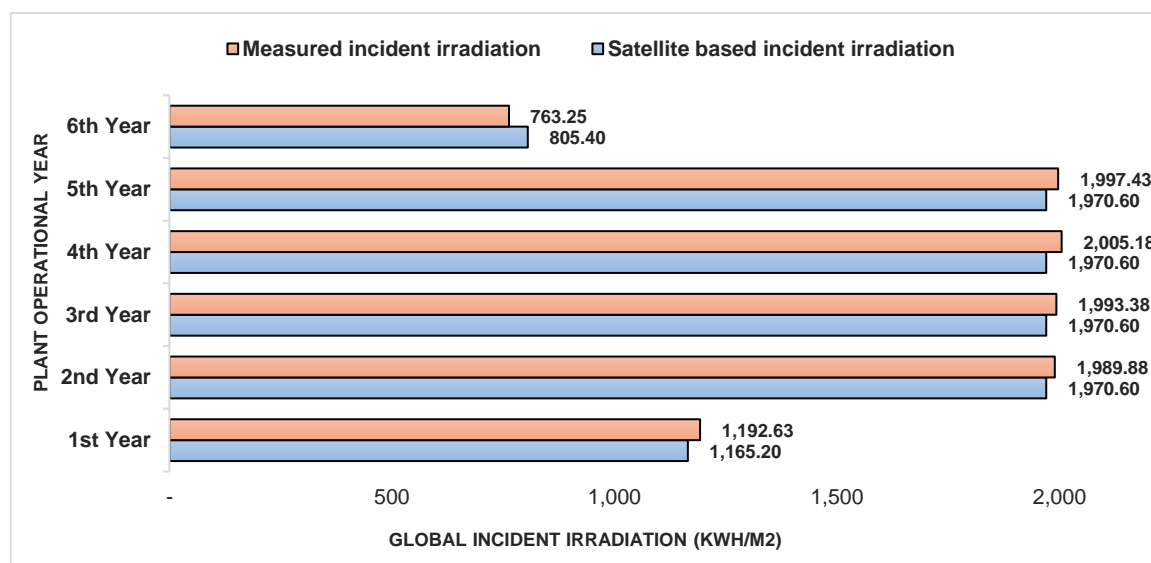
In order to understand the deviation in the irradiation pattern, SgurrEnergy has compared the monthly incident irradiation data provided by the Developer with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation. The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 8-4.

<sup>9</sup> Positive values indicate higher generation, while negative values indicate lower generation



**Table 8-2: Irradiation Comparison– TNS 10MW**

PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>10</sup> (%)
Apr 2016 -Oct 2016	1,165.20	1,192.63	2.35%
Nov 2016 -Oct 2017	1,970.60	1,989.88	0.98%
Nov 2017 -Oct 2018	1,970.60	1,993.38	1.16%
Nov 2018 -Oct 2019	1,970.60	2,005.18	1.76%
Nov 2019 -Oct 2020	1,970.60	1,997.43	1.36%
Nov 2020 -March 2021	805.40	763.25	-5.23%
<b>Cumulative Period</b>	<b>9,853.00</b>	<b>9,941.75</b>	<b>0.90%</b>

**Figure 8-4: Irradiation Comparison**

Based on the above illustrations, it is observed that the overall recorded generation is approximately 2.24% lower than the generation predicted. The irradiation recorded is 0.90% higher than the predicted irradiation.

SgurrEnergy thus infers that the PV plant is underperforming based on the conditions experienced on site.

<sup>10</sup> Positive values indicate higher irradiation, while negative values indicate lower irradiation



## 9 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar PV plants as having a lifetime of 25-40 years<sup>11</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>12</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the PV plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement.

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<sup>11</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>12</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>



Virescent Infrastructure

12MW(AC) Amathur Solar PV Plant  
Universal Mine Developers and Service Providers  
Technical Assessment Report

May 2021



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A1	09 February 2021	Draft Issue	-
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B4	28.05.2021	For Client Issue	Generation Analysis Updated

SF/04/023

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## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 13MW<sub>AC</sub> Universal Mine Developers and Service Providers Pvt Ltd (the Project). The Project is located near Kovilpatti village, in Thoothukudi district of Tamil Nadu.

The summary of the technical assessment is captured in the below table.

**Table 1-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	<p>The project site lies around the coordinates 9°33'14.82"N and 77°53'4.43"E and is located near the Amathur village, in Virudhunagar district of Tamil Nadu.</p> <p>Project is contracted for generating 12MW<sub>AC</sub> power. The Owner has utilised approximately 62 acres of land for the project.</p> <p>Project is implemented with poly-crystalline modules (JA Solar) and central inverters (ABB). The module mounting structure is implemented with a tilt of 8° for a pitch of 6m.</p> <p>The power generated from the UMDSPPL 12MW<sub>AC</sub> PV plant is fed to GN Patti substation, through a single circuit transmission line.</p> <p>The total DC installed capacity stands at 14.41MW<sub>p</sub>. The AC installed capacity stands at 12MW<sub>AC</sub> with 12 inverters of capacity 1,000kW each.</p>
2	PV Module	<p>SgurrEnergy has conducted a desktop review of JA Solar assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard. SgurrEnergy considers the warranty period to be in line with the industry standards. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.</p>
3	Inverter	<p>ABB is considered to have good track record for supplying central inverters. Certificates mentioned in the technical specification datasheet indicate ABB to hold adequate certifications. Technical characteristics are acceptable, with a good efficiency level for central inverters. Standard warranty of five years is provided for the inverters, which is in line with the industry requirement. Overall, SgurrEnergy does not raise any concern on the utilization of ABB inverters for the Project.</p>
4	Inverter Transformer	<p>The inverter transformers (2200kVA) used within the project are manufactured by Voltamp Transformers Limited. The manufacturers have a good track record of supplying transformers to distinguished customers in Indian as well as in the global market. SgurrEnergy has reviewed the transformers based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with</p>



Sr. No.	Parameter	Comment
		industry standards and raises no concerns over its use in the project
5	String Sizing	The V <sub>OC</sub> does not exceed the inverter input voltage for the site, and therefore, SgurrEnergy considers the number of modules in series to be acceptable for the PV Project.
6	Permits and Approvals	PPA signed between Universal Mine Developers and Service Providers Pvt Ltd and Tamil Nadu Generation and Distribution Corporation Limited. PPA term is 25 years from the Commercial Operation Date. Documents such as CEIG certificate, commissioning certificate, consent to operate etc. have not been provided.
7	Resource Assessment	For resource analysis, SEI has compared various satellite datasets. For the satellite databases, SEI has compared Meteonorm 7, NASA, SWERA and SolarGIS data to find the most suitable solar resource for long-term energy yield prediction. Owing to low uncertainty and high resolution, SEI considers SolarGIS dataset to be the most representative satellite database among all the satellite databases for long-term energy yield assessment.
8	Operational Analysis and Generation Comparison	<p>SgurrEnergy was provided with plant and grid availability records from February 2016 to December 2020 for the solar PV plant. In addition, the irradiation measurement records were provided from April 2016 to December 2020.</p> <p>SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer for the period from April 2016 to December 2020.</p> <p>Overall, the average grid availability experienced on site for the operational period was calculated to be 95.16% which is considered to be significantly lower than the expected range. Correspondingly the average plant availability is noted to be 99.8% which is considered to be within expected range.</p> <p>Furthermore, SgurrEnergy observed that the overall recorded generation is approximately 1.68% lower than the generation predicted on site. Correspondingly, it has also been observed that the irradiation measured on site is approximately 3.03% higher than the predicted irradiation.</p> <p>SgurrEnergy thus infers that the PV plant is underperforming based on the conditions experienced on site.</p>
9	Allied Components and Systems	<p>The 12MW<sub>AC</sub> solar PV plant is designed with JA solar (310/315Wp) solar PV modules and Sineng 1250kW central inverter.</p> <p>The 12MW<sub>AC</sub> solar PV plant has been configured with 12 ABB 1000kW central inverters and four inverter stations. Out of the total four inverter stations, two inverter stations of 4MW<sub>AC</sub> capacity contain four inverters of 1000MW capacities and two 3-winding transformers of 2.2MVA capacities. While two inverter station of 2MW<sub>AC</sub> capacity consists of two inverter of 1000kW capacity and one 3-winding, 2.2MVA transformer.</p> <p>The 33kV output of each inverter station combined at 33kV main HT panel located within Main control room (MCR). Further the</p>



Sr. No.	Parameter	Comment												
		<p>power is fed from main HT panel to 33/11kV plant end metering yard.</p> <p>Further the power from the metering yard is then evacuated to the 33/11 KV GN-patti substation located approximately 5.5kms from the Project site through dog ACSR single circuit overhead cable.</p>												
10	Energy Yield Assessment	<p>Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for third year of plant operation for the 12 MWAC PV plant.</p> <table><tr><td>Global Horizontal Irradiation (kWh/m2)</td><td>1,962.50</td></tr><tr><td>Global Inclined Irradiation (kWh/m2)</td><td>1,987.30</td></tr><tr><td>Sixth Year P50 Energy Yield (MWh/annum)</td><td>22,156.97</td></tr><tr><td>Specific Yield (kWh/kWp)</td><td>1538.67</td></tr><tr><td>Performance Ratio (PR)</td><td>77.42%</td></tr><tr><td>PLF on Contracted Capacity (12 MWAC)</td><td>21.07%</td></tr></table>	Global Horizontal Irradiation (kWh/m2)	1,962.50	Global Inclined Irradiation (kWh/m2)	1,987.30	Sixth Year P50 Energy Yield (MWh/annum)	22,156.97	Specific Yield (kWh/kWp)	1538.67	Performance Ratio (PR)	77.42%	PLF on Contracted Capacity (12 MWAC)	21.07%
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PLF on Contracted Capacity (12 MWAC)	21.07%													



## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
m	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon



MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation





## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 258MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of six projects, as presented within Table 1-1.

**Table 1-1: Project Key Summary**

Project Name	SEPEPL – 80MW <sub>AC</sub>	SEPEPL – 50MW <sub>AC</sub>	SPSPL – 50MW <sub>AC</sub>	SPSPPL – 30MW <sub>AC</sub>	TNSPEPL – 5MW <sub>AC</sub> + 8MW <sub>AC</sub> + 10MW <sub>AC</sub>	UMD- 12MW <sub>AC</sub> + 13MW <sub>AC</sub> +
Site Location	18.926°N, 76.395°E, <i>Parli</i> , Maharash- tra, India	21.028°N, 75.985°E, <i>Muktainagar</i> Maharashtra ,India	9.324°N, 77.594°E. <i>Rajapalyam</i> , Tamil Nadu,India	12.344°N, 78.945°E <i>Tiruvannam- alai</i> , Tamil Nadu, India.	<b>5MW<sub>AC</sub> –</b> 10.480°N, 78.061°E <i>Dindigul</i> , Tamil Nadu, India <b>8MW<sub>AC</sub> –</b> 9.437°N, 78.172°E <i>Aruppukkotai</i> Tamil Nadu, India <b>10MW<sub>AC</sub> –</b> 9.118°N, 78.107°E <i>Vilathikulam</i> , Tamil Nadu, India	<b>12MW<sub>AC</sub> –</b> 9.554°N, 77.884°E <i>Amathur</i> , Tamil Nadu, India <b>13MW<sub>AC</sub> –</b> 9.093°N, 77.780°E <i>Kovilpatti</i> , Tamil Nadu, India
Owner	Solar Edge Power and Energy Private Limited (SEPEPL)		Shapoorji Pallonji Suryaprakas h Private Limited (SPSPL)	Shapoorji Pallonji Solar PV Private Limited	TN Solar Power Energy Private Limited	Universal Mine Developers and Service Providers Private Limited
DC / AC Capacity	104.0MW <sub>P</sub> / 80.0MW <sub>AC</sub>	65.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	54.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	36.0MW <sub>P</sub> / 30.0MW <sub>AC</sub>	<b>5MW<sub>AC</sub> –</b> 6.0MW <sub>P</sub> / 5.0MW <sub>AC</sub> <b>8MW<sub>AC</sub> –</b> 9.6MW <sub>P</sub> / 8.0MW <sub>AC</sub> <b>10MW<sub>AC</sub> –</b> 12.0MW <sub>P</sub> / 10.0MW <sub>AC</sub>	<b>12MW<sub>AC</sub> –</b> 14.4MW <sub>P</sub> / 12MW <sub>AC</sub> <b>13MW<sub>AC</sub> –</b> 15.6MW <sub>P</sub> / 13MW <sub>AC</sub>
Commissioning date	<b>50MW<sub>AC</sub> –</b> 08.04.2018 <b>30MW<sub>AC</sub> –</b> 22.04.2018	26.04.2018	26.09.2018	26.03.2016	<b>5MW<sub>AC</sub> –</b> 28.12.2015 <b>8MW<sub>AC</sub> –</b> 28.09.2015 <b>10MW<sub>AC</sub> –</b> 31.10.2015	<b>12MW<sub>AC</sub> –</b> 16.11.2015 <b>13MW<sub>AC</sub> –</b> 21.03.2016

This report presents the evaluation of the 12MW<sub>AC</sub> UMD Solar PV plant developed by Universal Mine Developers and Service Providers Private Limited (UMD).

The 12MW<sub>AC</sub> Solar PV plant is located near *Amathur* village, *Virudhunagar* tehsil, *Virudhunagar* district of the Tamil Nadu state.

The purpose of this report is to provide a technical appraisal of PV plant under evaluation.

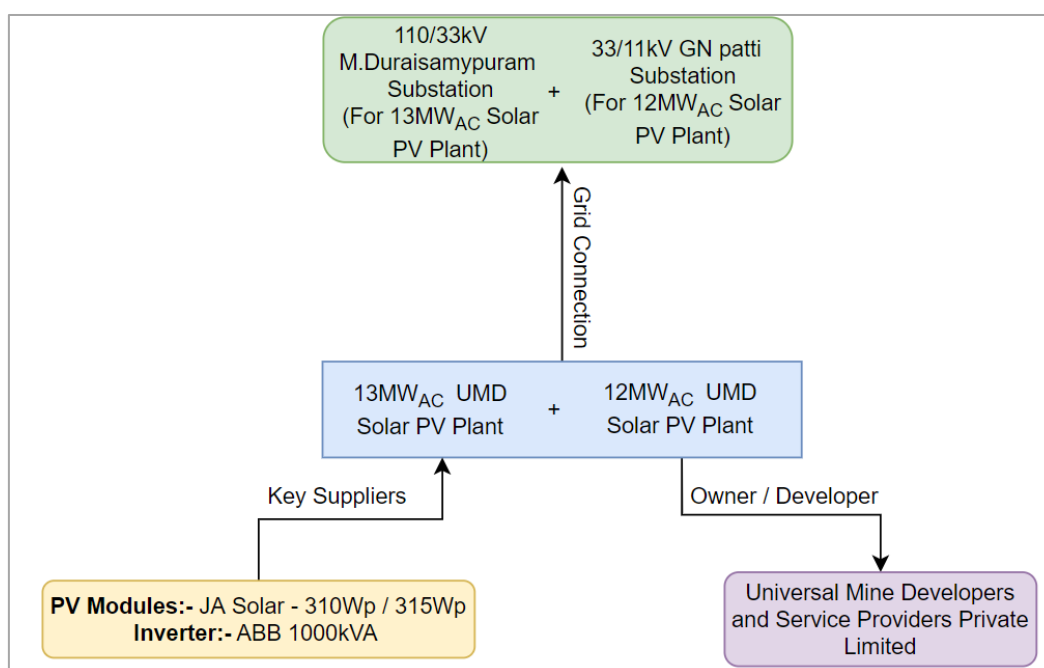


The report focuses on the following key parameters:

- System Design.
- Major Components.
- Engineering Design.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Plant Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project and is based on information made available by the Client through online dataroom. The main Project characteristic is summarised in Table 1-2.

Figure 1-1 illustrates the project structure indicating key project participants for the 12MW<sub>AC</sub> Solar PV plant.



**Figure 1-1: Project Structure for 12 MW<sub>AC</sub> Solar PV Plant**

**Table 1-2: Project Key Summary**

Project Information	
<b>Project Name</b>	12MW <sub>AC</sub> UMD Solar PV plant
<b>Location</b>	12MW <sub>AC</sub> - Amathur, Tamil Nadu
<b>Developer</b>	Universal Mine Developers and Service Providers Private Limited
<b>DC/ AC capacity</b>	14.4MW <sub>P</sub> / 12MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: JA Solar Inverters: ABB
<b>MMS Configuration</b>	Fixed Tilt: 8°, Azimuth: 0°
<b>Commissioning Status</b>	– Commissioning for 12MW <sub>AC</sub> PV Plant was achieved on 16 November 2015.



## 2 12MW<sub>AC</sub> Solar PV Plant Overview

The project site lies around the coordinates 9°33'14.82"N and 77°53'4.43"E. Satellite imageries of 12MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1. The Owner has utilised approximately 62 acres of land project. The Project site is located near the *Amathur* village, in *Virudhunagar* district of Tamil Nadu.

Project is contracted for generating 12MW<sub>AC</sub> power; SgurrEnergy therefore interprets 12MW<sub>AC</sub> as the maximum AC installed capacity for the solar PV plant.



**Figure 2-1: Satellite image of 12MW<sub>AC</sub>**

### 2.1 12MW<sub>AC</sub> Project Summary

Solar PV plant is modular in nature; therefore, UMDSPPL 12MW<sub>AC</sub> solar PV plants is implemented by adopting modularity in designs. 4MW<sub>AC</sub> is the typical inverter station considered for implementing UMDSPPL 12MW<sub>AC</sub> solar PV plant.

Table 2-1 presents the summary of 12MW<sub>AC</sub> PV plant

**Table 2-1: Summary of 12MW<sub>AC</sub> Plant Configurations**

General	
PV Module Technology	Poly-crystalline



<b>General</b>	
Inverter Technology	Central Inverters
Installed DC Peak Capacity (MW <sub>p</sub> )	14.41
Installed AC Capacity (MW)	12.0
Mounting Type	Fixed Tilt
Tilt Angle (°)	8°
Pitch (m)	6
<b>PV Modules</b>	
PV Module Manufacturer	JA Solar
Model	JAP6-72-310/3BB JAP6-72-315/3BB
Wattage (W <sub>p</sub> )	310W <sub>p</sub> / 315W <sub>p</sub>
Number of Modules per String	21
<b>Inverter</b>	
Inverter Manufacturer / Model	ABB / PVS-800
Inverter Nominal AC Output	1,000kW
Number of Inverters	12
<b>Mounting Structure</b>	
Mounting Structure Details (rows × columns)	2 × 21
Orientation of Modules	Portrait

The 12MW<sub>AC</sub> plant is implemented with a total of 4 inverter stations, two (2) of capacity 2MW<sub>AC</sub> while two (2) of capacity 4MW<sub>AC</sub>. Each inverter station is comprising of three winding transformers to accommodate 4 × 1,000kVA and 2 × 1,000 kVA inverters respectively, taking the individual inverter station size to 4MW<sub>AC</sub> and 2MW<sub>AC</sub>. Each inverter station is comprising of a physical block connecting to 4.8MW<sub>p</sub> and 2.8MW<sub>p</sub> of installed photovoltaic array. The output of 4MW<sub>AC</sub> and 2MW<sub>AC</sub> inverter station is connected to 0.400/0.400/33kV three winding transformer of 2.2MVA for stepping up the voltage to 33kV.

The medium voltage 33kV output of all the inverter stations are placed in main control room (MCR), these are combined to form a solar PV plant of 12MW<sub>AC</sub>. The 33kV output is evacuated using a DP structure located in the plant premises.

The power generated by the UMDSPPL 12MW<sub>AC</sub> PV plant is fed to *GN Patti* substation located approximately 5.5km from the Project site, through a single circuit 33KV, Dog ACSR Conductor. The point of interconnection is at the *GN Patti* substation.

ABT / revenue metering is at *GN Patti* substation; therefore, transmission line losses are accounted in the Owner's scope.



### 3 Review of Major plant components

SEI has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions.

#### 3.1 PV modules

The PV modules selected for the Project are supplied by JA Solar Holding Co., Ltd., Canadian Solar and Astronergy. SgurrEnergy has conducted a technical review of the suppliers and proposed module specifications with regard to their suitability for use on the Project.

##### 3.1.1 Company Profile – JA Solar Holding Co., Ltd

JA Solar Holding Company Ltd. listed on NASDAQ (NASDAQ: JASO), was found in the year 2005 and started operation in 2006. The Company has 12 manufacturing bases and has production capacity of more than 11.5GW, 11GW, and 11GW for silicon wafer, solar cells, and solar modules, respectively.

JA solar has 20 branches around the world and employs more than 22,000 employees worldwide. As of December 2019, JA solar provides services in more than 135 countries and to more than 33,000 clients worldwide. As of second quarter 2020, JA solar had a cumulative shipment of more than 50GW. As of December 2019, JA solar had more than 779 authorized patents of independent R&D and 107 invention patents under its name. The Company's net revenue was RMB 21.16 billion in 2019.

Few of the commissioned solar power plants using JA modules are listed in Table 3-1.

**Table 3-1: Project References of JA Solar**

Sr. No.	Project and Location	Capacity (MW)
1	Bahia, Brazil	255.0
2	Northern Cooks, Australia	172.8
3	Cadiz, Philippines	132.5
4	Maharashtra, India	130.0
5	Three Gorges, Datong	100.0
6	Bahawalpur, Pakistan	100.0
7	Lincheng Country, Xingtai City, Hebei Province	100.0
8	Dunhuang, Gansu Province	100.0
9	Utah, USA	80.0
10	New South Wales, Australia	70.0
11	Maharashtra, India	70.0
12	Telangana, India	69.0
13	Bole, Xinjiang	60.0
14	San Carlos, Philippines	59.0
15	MP, India	57.0
16	Charanka Gujrat, India	53.0
17	Datong, Shanxi Province	50.0
18	Southwark, UK	49.0
19	Karnataka, India	43.0





Sr. No.	Project and Location	Capacity (MW)
20	Xiayu, Hebei Province	42.0
21	Yinchuan, Ningxia Province	40.0
22	Georgia, USA	38.7
23	Arawa Desert and Negev Desert, Israel	35.0
24	Hefeng, Tacheng, Xinjiang	30.0
25	Karnataka, India	23.0
26	Bulgaria	21.0
27	Haryana, India	21.0
28	Campania, Italy	20.0
29	Corp 184, Xinjiang	20.0
30	Telengana, India	18.0
31	Toshka, Egypt	10.1
32	Volkswagen Chattanooga Plant, USA	9.6
33	Antalya, Turkey	6.7
34	Kenitra, Morocco	2.0
35	ABC Bank, Jordan	1.5

JA is considered a Tier 1 supplier by Bloomberg (Q4, 2020). A Tier 1 supplier is defined as a module manufacturer who has *provided products to five different projects, which have been financed non-recourse by five different (non-development) banks, in the past two years.*

Whilst the Bloomberg tiering system does not reflect on a product's technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers JA solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

### 3.1.1.1 Main Technical Characteristics of JAP6-72/3BB

JA Solar, JAP6-72/3BB modules of 310W<sub>P</sub> and 315W<sub>P</sub> capacity have been utilized for the Project. These modules have an efficiency of 15.99% and 16.25% for 310W<sub>P</sub> and 315W<sub>P</sub> capacity modules, respectively, and a peak power tolerance of 0~+5W. The modules have a temperature coefficient (P<sub>max</sub>) of -0.41%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy's expectation for c-Si technology. The technical characteristics of JAP6-72/3BB are presented in Table 3-2.

**Table 3-2: Technical specifications of JAP6-72/3BB**

Specifications	JAP6-72-310/3BB	JAP6-72-315/3BB
Technology	Polycrystalline	
Nominal power (P <sub>MPP</sub> )	310W <sub>P</sub>	315W <sub>P</sub>
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	37.00V	37.28V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	8.38A	8.45A
Open circuit voltage (V <sub>OC</sub> )	45.45V	45.60V
Short circuit current (I <sub>SC</sub> )	8.85A	8.91A
Efficiency (%)	15.99%	16.25%



Specifications	JAP6-72-310/3BB	JAP6-72-315/3BB
Maximum System Voltage	1,000V (DC)	
Power tolerance (%)	0~+5W	
Dimensions (length × breadth × width) (mm)	1956 × 991 × 45	
Module area (m²)	1.94m²	
Weight (kg)	~26kg	
Temperature coefficient at P <sub>MAX</sub>	-0.41%/°C	
Operating temperature	-40°C to +85°C	
Maximum reverse current	15A	
Maximum mechanical load	5400Pa	
Maximum snow load	2400Pa	
Product warranty	10 years	
Power output guarantee	25 years	
Module technical characteristics are given at STC (1,000W/m² irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet)		

The maximum system voltage is 1,000V. The maximum reverse current is 15A. Overall, the module characteristics can be considered to be in line with market standard and JA Solar is listed as Tier 1 suppliers by Bloomberg since 2014.

### NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>1</sup> characteristics of selected JAP6-72/3BB modules of 310W<sub>P</sub> and 315W<sub>P</sub> is given in Table 3-3 corresponding to realistic operating conditions as compared to STC. It is affected by module materials used as well as the packing density of module materials. The NOCT for the module is 45±2°C. This is comparable with other manufacturers and demonstrates the module is effective at heat dissipation.

**Table 3-3: PV Module NOCT Characteristics of JAP6-72/3BB**

Model	JAP6-72-310/3BB	JAP6-72-315/3BB
Maximum Power (P <sub>MAX</sub> )	225.06W <sub>P</sub>	228.69W <sub>P</sub>
Max Power Voltage (V <sub>MPP</sub> )	34.05V	34.08V
Max Power Current (I <sub>MPP</sub> )	6.61A	6.71A
Open Circuit Voltage (V <sub>OC</sub> )	42.58V	42.63V
Short Circuit Current (I <sub>SC</sub> )	6.99A	7.06A

#### 3.1.1.2 Certification of Modules

General review of datasheet indicates JA Solar PV modules manufactured in facilities with the following certifications:

- ISO 14001 certification for environmental management systems

<sup>1</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C.



- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certifications available in public domain for the modules under evaluation within Table 3-4.

**Table 3-4: Certification for PV Module- JA Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
UL 1703	Standard for safety for flat-plate photovoltaic modules

### 3.1.1.3 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of six months from the dispatch from the JA solar factory or the delivery date to site.

### 3.1.1.4 Product Warranty

JA Solar provides a limited product warranty of 10 years, beginning on the earlier of module purchase date or one-year anniversary from the production date. If module fail to conform to this warranty, during the period ending of 10 years from the date of sale to the customer of the JA solar product, JA solar will at its opinion, either repair or replace the product, or refund the purchase price as paid by the customer. The repair or replacement or refund the customer at the current comparable market price of such module.

SgurrEnergy considers twelve-year product warranty provided by JA solar to be in line with the industry standard.

### 3.1.1.5 Linear Power-Output Warranty

According to the datasheet JA solar warrants that the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.7% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 80.7% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, JA solar will either repair, replace or provide additional modules to make up for the loss in power output.

## 3.2 Inverters – ASEA Brown Boveri (ABB)

The project has utilized ABB PVS800-57-1000kW central inverter for the project under evaluation.

### 3.2.1 Company background

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, ABB is one of the largest engineering companies as well as one of the largest conglomerates in the world. ABB has operations in around 100 countries, with





approximately 147,000 employees<sup>2</sup>. Company reported global revenue of around \$34,312 million for 2017.<sup>3</sup>

The firm's shares are traded on the stock exchanges of Zurich, Stockholm, and New York. ABB is a multinational corporation headquartered in Zurich, Switzerland, operating mainly in robotics and power and automation technology.

On July 9, 2019 the Italian company FIMER acquired ABB's solar inverter business. The takeover of ABB's solar inverter business included 800 employees in 26 countries as well as two manufacturing plants, in Italy and in India, and a R&D facility in Finland.

FIMER was founded in 1942, headquartered in Vimercate, Italy, has been actively working in inverter technology since 1983. As of 2020, the company employs more than 1,100 employees across its three manufacturing facilities and three R&D centres across the globe. As a result of acquisition of ABB's PV inverter line, FIMER ranked the fifth-largest PV inverter globally in 2019.

### 3.2.2 Track Record

ABB India commenced local manufacturing of solar inverters in 2012 and partnered with several customers. ABB is the solar inverter market leader in India holding approximately 24% market share in 2018. ABB has approximately 3,590MW in operation across more than 350 sites in India. ABB India manages close to 40% of the installed bases in India. As on 30 August 2017, ABB India crossed the 5GW threshold for the supply of inverters in the country.

Table 3-5 lists the state-wise installed capacity of ABB inverters in India. However, it is to be noted that the table below doesn't not comprise of the installed capacities till date.

**Table 3-5: ABB Inverter Track Record**

Location	Capacity (MW)
Tamil Nadu	747
Andhra Pradesh	647
Rajasthan	371
Karnataka	305
Madhya Pradesh	271
Maharashtra	261
Punjab	227
Bihar	225
Uttar Pradesh	106
Haryana	62
Kerala	50
Chhattisgarh	28
Odisha	20

ABB India has strategically located its headquarter in Bangalore and offices in other cities Pune, Ahmedabad, Jaipur, Faridabad, Hyderabad, Tamil Nadu, and Bhopal in order to

<sup>2</sup> <https://new.abb.com/news/detail/26838/abb-to-exit-solar-inverter-business>

<sup>3</sup> <https://new.abb.com/investorrelations/company-profile/facts-figures>



facilitate quick spare part availability and minimal response time. ABB aims to provide first response to its customers within 4 hours on weekdays and within 24 hours on weekends and holidays. ABB also provides a Turn-Around-Time of 48 and 72 hours on weekdays and weekends respectively, hence maintaining an average uptime of over 99%.

### 3.2.3 Technical Characteristics

ABB PVS800-57-1000kW inverter has been selected for technical feasibility of the Project. The technical specification of 1000kW ABB inverter is listed in Table 3-6.

The PVS800-57-1000kW Series of central inverters designed ideal for large PV Power Plants. PVS800 inverters are designed for fast and easy installation. These inverters are designed to operate with DC inputs up to 1,100 V. They incorporate maximum power point tracking (MPPT) and grid management features to meet utility requirements.

PVS800-57-1000kW inverter is designed for outdoor use with an IP42 ingress protection class. They are protected against solid objects over 1mm and against direct sprays of water up to 15° from the vertical. They perform optimally at ambient air temperatures between -15°C to 50°C and relative humidity in the range of 15% to 95% with maximum noise level of 75dBA.

The PVS800-57-1000kVA inverter has peak efficiency of 98.8% and a European efficiency of 98.6%.

The main technical characteristics of these inverters are illustrated in Table 3-6.

**Table 3-6: ABB inverter specifications**

<b>ABB Central Inverter Specifications</b>	
Inverter	ABB PVS800-57-1000kW
Type	Central Inverter
<b>Input Data</b>	
Maximum Input Power (kW <sub>p</sub> )	1200kW <sub>p</sub>
PV voltage range, MPP (V)	600 to 850V
Maximum DC voltage (V)	1100V
Maximum input current (A)	1710A
<b>Output Data</b>	
Nominal AC power (kW)	1000kW
Maximum AC current (A)	1445A
Nominal AC voltage(V)	400V
AC grid frequency (Hz)	50Hz -5%+3%
Maximum THD	< 3%
<b>Operating Performance</b>	
Maximum efficiency (%)	98.80%
Euro efficiency (%)	98.60%
<b>Power consumption</b>	
Own consumption in operation(W)	730W
Standby operation consumption (W)	70W
<b>Other</b>	



<b>ABB Central Inverter Specifications</b>	
Dimensions (W × H × D) (mm)	3630mm x 2130mm x 610mm
Weight (kg)	2600kg
Environmental Protection Rating	IP42
Operating temperature range (°C)	-15 to +50°C
Relative humidity (%)	15% to 95%

The following protection devices are included within the inverter design:

- Ground fault monitoring
- Grid Monitoring
- Anti-islanding protection
- DC reverse-polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection
- Remote monitoring solutions

ABB inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components.

### 3.2.4 Certification

ABB is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. ABB inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information available in public domain, SgurrEnergy has summarized the certification of the ABB inverter within Table 3-7.

**Table 3-7: Description of Certification of ABB inverters**

<b>Certification</b>	<b>Description</b>
IEC 60068-2-6/29	Environmental testing of inverters to assess their ability to perform and survive under conditions such as transportation, storage, operational environments, extreme cold and heat
IEC61683:1999	Measurement of the efficiency of power conditioners
IEC 62109-2:2011	Safety of Power Converters
IEC 62116:2014	Test procedure of islanding prevention measures

### 3.2.5 Warranties

SgurrEnergy referred the warranty documents available in public domain. Given the industry standard warranty of 60 months, SgurrEnergy does not raise any concern over the use of inverter for the project.



### 3.3 Inverter Transformer – Voltamp Transformers Limited

The power at low voltage from inverters is stepped up to 33kV using 2200kVA transformers of Voltamp Transformers Limited make.

#### 3.3.1 Company Profile

The inverter transformer used is manufactured by Voltamp Transformers limited (Voltamp).

Voltamp was founded in 1963 in Vadodara, Gujarat and now has a PAN India presence. The company initially started off by manufacturing small transformers by 1975 the largest transformer manufactured was for 132kV networks. This limit rose to 220kV class of transformers in 2008. The company employs more than 300 personnel (including 60 engineers) and has branch offices in Mumbai, New Delhi, Chennai, Bangalore, Secundrabad, Pune, Bhubaneshwar, etc.

The company has four manufacturing plants and the current manufacturing capacity totals to 13000 MVA per year. These facilities boast of manufacturing Oil filled Power and Distribution Transformers up to 160MVA, 220kV. The company got its ISO 9001 certification in 1998 and was listed on the NSE and BSE stock exchange in 2006.

Notable designs include:

- 75MVA 11/138kv GT
- 20MVA 33-22/11kV (DZ10)
- 50MVA 132-110/33kV transformer
- 6 MVA 1-ph transformer
- 15MVA 11/1.3-1.3kV (24 pulse)
- 100MVA 22kV

The company also manufacturers two types of dry transformers, i.e. resin impregnated (25KVA-5000KVA up to 11kV) and cast resin transformers (50kVA-12500kVA up to 33kV). Prominent clients include ABB, Exide, Adani, BHEL, BPCL, Suzlon etc.

#### 3.3.2 Technical Specifications

The 2200kVA Power transformers used in the project are outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 3-8.

**Table 3-8: Technical Specification of Voltamp Transformers**

Technical Parameters	Description
Rated Power	2200kVA
Rated HV	33kV
Rated LV	400-400V
Tapping on HV	-5% to +5% (steps of 2.5%)
Phases	3
Frequency	50Hz



Technical Parameters	Description
Vector group	Dy11y11
Impedance	5.93%
Cooling Strategy	ONAN
Oil temperature rise	50°C
Winding temperature rise	55°C
Winding material	Copper

SgurrEnergy considers the overall the technical specification to be adequate for the PV projects and in line with the industry accepted standards.

### 3.3.3 Temperature Rise Detection and Protection

Inverter transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.4 Warranties and Guaranties

Based on the information available in public domain, SgurrEnergy understands the Shilchar transformers have been provided with a warranty of 60 months from date of dispatch. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards.

## 3.4 Conclusion on Major Plant Components

### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of JA Solar, Canadian Solar and Astronergy assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.

Further, according to the warranty documents available in public domain for all three module manufacturers, SgurrEnergy considers the warranty terms and conditions offered by all three manufacturers to be in-line with the industry standard and raises no major concern regarding the warranties offered. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.

### Inverters

SgurrEnergy has conducted review of the ABB PVS800-57-1000kW central inverter ABB PVS800-57-1000kW central inverter has the required certification for use in solar PV plants. In-house testing of the inverter and individual components is relatively extensive during the R&D phase with functional and temperature cycling testing of each manufactured inverter. ABB offers a product warrant of 5 years which is in line with the current industry standards.

In conclusion, ABB can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters.



ABB inverters have more than 3GW of installation worldwide. These inverters are quite known to the Indian market and have installed capacity of more than 1.3GW which demonstrates a good track record in the Indian solar PV market.

### Transformers

Voltamp has a track record of more than 53,000 transformer installation across India, Nepal, Sri Lanka, Bhutan, Indonesia, Middle East Asia, South East, and African Countries<sup>4</sup>. The accreditations for manufacturing facility gained by the company are considered fair and satisfactory.

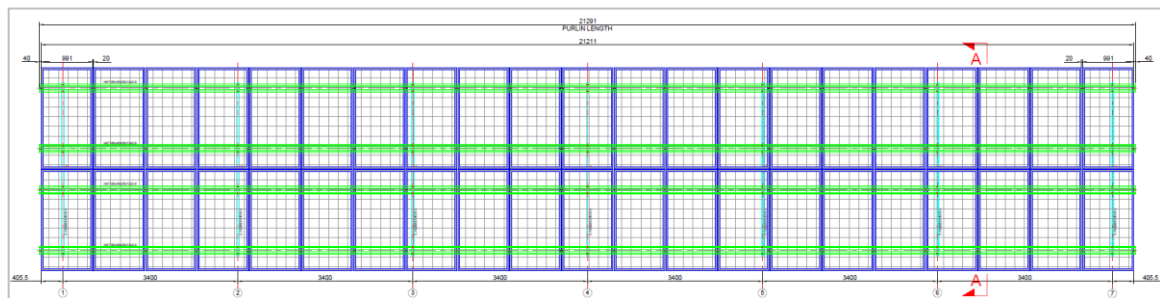
The inverter transformers (2200kVA) used within the project are manufactured by Voltamp Transformer Limited. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.

### 3.5 Module support structures

The Array Layout provided by the Client for the JA Solar(310/315Wp) PV modules indicates the fixed tilt module mounting structure is inclined at 8° tilt angle.

Following the review of MMS GA drawing dated 01.06.2015, SgurrEnergy observed that the structure has been designed with two rows of modules placed in portrait orientation with 21 modules in each row. In total there are 42 modules in one mounting structure. The layout is designed with a pitch of 6m.

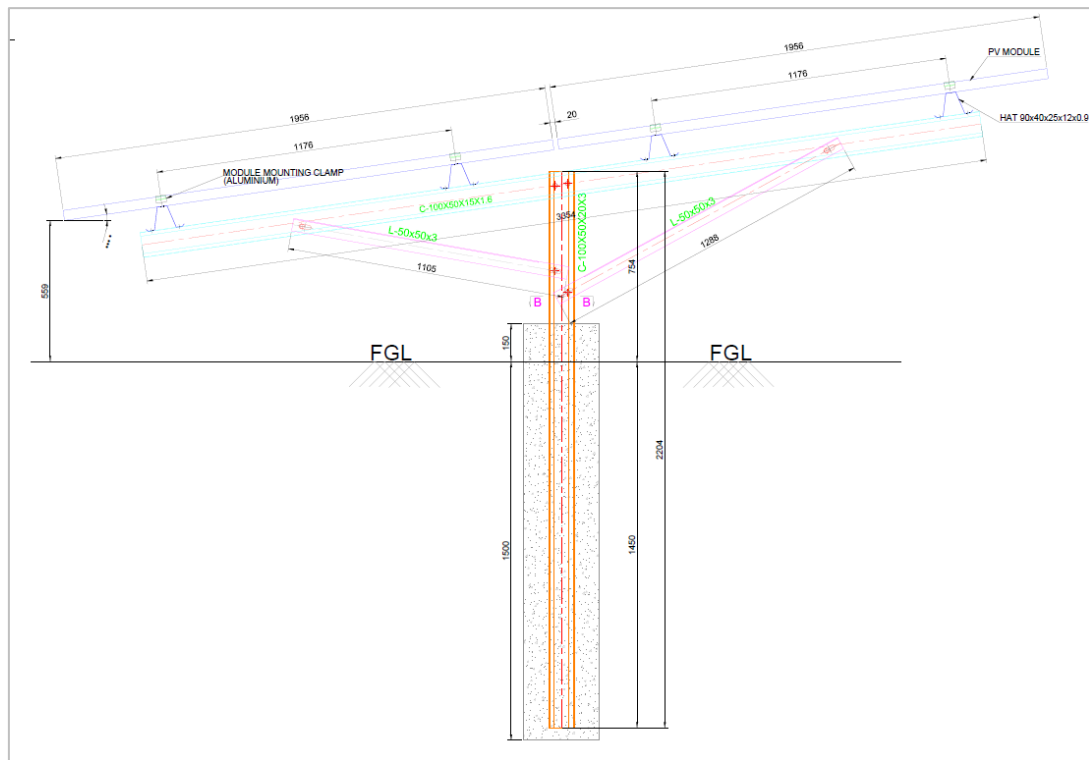
Figure 3-1 and Figure 3-2 illustrates the module mounting structure configuration provided by the Client for JA Solar PV modules.



**Figure 3-1: Two in portrait module mounting structure with 21 modules in a row**

<sup>4</sup> <http://www.voltamptransformers.com/index.php/dashboard/infrastructure>





**Figure 3-2: Side view of the module mounting structure configuration**

Based on the information provided in the GA drawing of the MMS, the technical specification has been summarized below.

Table 3-9 summarizes the technical specification of the module mounting structure.

**Table 3-9: Specification of MMS**

MMS Part	Material	Grades - Standard	Thickness (mm)	Minimum Yield Stress (MPA)
Rafter	Cold Formed	ASTM A653-340-1	1.6	350
Purlin	Cold Formed	ASTM A_792_2010/G_80_550_/CLASS_1	0.9	550
Leg	Cold Formed	E350- IS: 5986:2011	3.0	350

Material used is a combination of hot-dipped galvanised mild steel and pre-galvanised cold rolled sheets sheared to form structural members for module mounting. The pre-galvanised sheets post process is appropriately coated with anti-corrosion compounds for the project life cycle.

SgurrEnergy was not provided with the information regarding type of pile used in the project. Further based on the information provided under GA drawing of the MMS, SgurrEnergy understands that the Owner has considered the wind speed of 39m/s according to IS 875 (part 3) – 1987.





## 4 Allied Components and Systems

### 4.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

### 4.2 PV Power Transfer

SgurrEnergy has reviewed the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear and plant substation as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

- “SWLB-SP-TN-12MW-E-DWG-SLD-100”, revision 0, dated 01.12.15.
- “SWLB-SP-TN-12MW-E-DWG-SLD-100B”, revision 0, dated 01.12.15.
- “SWLB-SP-TN-12MW-E-DWG-AF-102B”, revision 0, dated 12.12.15

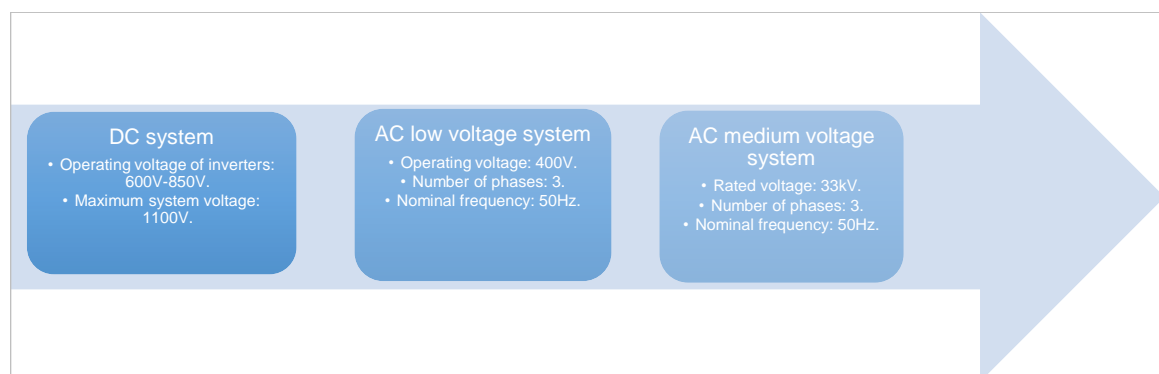
The 12MW<sub>AC</sub> solar PV Plant is designed with 310W<sub>P</sub>/ 315W<sub>P</sub> JA solar PV modules and 1000kW ABB inverters. Modules are interconnected to form a string of 21 modules. Each string forms a single output that feeds as a single input to the 12 input combiner boxes. Eight string combiner boxes are further connected to the inverter.

The 12MW<sub>AC</sub> solar PV plant has been configured with 12 ABB 1000kW central inverters and four inverter stations. Out of the total four inverter stations, two inverter stations of 4MW<sub>AC</sub> capacity contain four inverters of 1000MW capacities and two 3-winding transformers of 2.2MVA capacities. While two inverter station of 2MW<sub>AC</sub> capacity consists of two inverter of 1000kW capacity and one 3-winding, 2.2MVA transformer.

Each 4MW<sub>AC</sub> capacity inverter station consists of 2-sets of two 1000kW inverters connected to 0.400/0.400/33kV three-winding, 2.2MVA transformer, while the inverter station of 2MW<sub>AC</sub> capacity consists of one-set of 1000kW inverters connected to 0.400/0.400/33kV three-winding, 2.2MVA transformer, that step up the voltage to 33kV for all inverter stations. The power from the HV side of the 33kV inverter transformer is transferred to 33kV HT panel located within main control room pooling station.

The output power is transferred from main control room is transferred to 33kV metering yard 33kV DP structure. Further the power from the metering yard is then evacuated to the 33/11 KV GN-patti substation located approximately 5.5kms from the Project site.

Figure 4-1 below illustrates a power flow summary for the 12MW<sub>AC</sub> Solar PV plant.



**Figure 4-1: Power flow of 12MW<sub>AC</sub> PV plant**

### 4.3 Cabling

#### 4.3.1 DC Cabling





DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. Modules are interconnected in series with solar grade cables that are tied along with the module mounting structures. Modules are interconnected in leap-frog scheme to form a string of 21 PV modules connected in series.

The Y harness equipped with 30A fuse has been used to pre-combine the string of PV module. Single core 6mm<sup>2</sup> multi-stranded copper PV cables connect Y- harness output to String Combiner Box (SCB).

These combiner boxes are equipped with 30A fuse for each of the string connection and a 315A disconnect switch on output side. Power from string combiner box is further transferred to the inverter using 2 runs, 1C, 185/240/300mm<sup>2</sup>, 1.1kV aluminium XLPE ((2R X 1C X 185/240/300Sqmm, 1.1kV AL. XLPE Armoured) cables.

#### 4.3.2 AC Cabling

Three phase AC output from inverter is connected to the LV winding of a three-winding 2.2MVA transformers, using 12 Runs single core 630mm<sup>2</sup> Aluminium Armoured XLPE (12R (4R/Ph) X1C x 630mm<sup>2</sup> Al. Ar. XLPE) cable. The inverter transformers step up the voltage to 33kV.

Power is fed from the high voltage side of each transformer using 1R,3C, 185mm<sup>2</sup>, 33kV Al XLPE armoured cable to the 33kV HT panel in the 4MW<sub>AC</sub> inverter station using a radial feeder arrangement.

The 33kV output of each inverter station is transmitted to 33kV main HT panel located within Main control room using 1R,3C, 185mm<sup>2</sup>, 33kV(E) Al XLPE armoured HT cables.

The power from main control room is fed to 33kV DP structure and 33kV metering yard through single Runs three core, 300mm<sup>2</sup>, 33kV Aluminium XLPE Armoured (1R x 3C x 300sqmm 33kV[E], Al, XLPE, Ar.) cable.

Power at 33kV is then evacuated through overhead line to the 33/11 KV GN patti substation located approximately 5.5kms from the Project site.

#### 4.4 Inverter Station

The 12MW<sub>AC</sub> solar PV plant has been configured with 12 inverters and four inverter stations. Two inverter stations consist of four inverters and two inverter stations consists of two inverters.

Each 4MW<sub>AC</sub> inverter station consists of two-sets of two inverters connected to a 2,200kVA three-winding transformers, while each 2MW<sub>AC</sub> inverter station consists of two inverters connected to a 2,200kVA three-winding transformer. Each transformer, along with allied switchgears, steps up the voltage to 33kV for all inverter stations. Further the power from the HV side of the transformer is fed to the 33kV outdoor type HT panel through radial feeder arrangement.

33kV outdoor type HT panel comprises of 50/5-5A current transformer, 33kV/110V fixed type potential transformer, 33kV EDO TP, 630A Vacuum Circuit Breaker and other electrical protection system.

#### 4.5 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed 2.2MVA, 33kV/2x0.400kV, Dy11y11 three-winding transformers have been used in the project. These inverter duty transformers step up the voltage to 33kV.

The 2.2MVA inverter duty transformers output is connected to 33kV HT panels located within inverter station. The energy from all the inverter stations 33kV HT panels are radially combined at 33kV main HT panel located within main control room.



#### 4.6 33kV Main HT Panel

A 33kV main HT panel comprises of inverter station incoming feeders, one outgoing feeders. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class. All feeders have been provided with relay and metering unit. The 33kV main HT panel outgoing and incoming feeders are provided with instantaneous and IDMT (50/51) O/C relay instantaneous and IDMT (50N/51N) E/F relay protections. The 33kV outgoing feeders are provided with 0.2S class instrument transformers.

Power is fed from 33kV main HT panel to and metering yard using 33kV DP structure further power from 33kV DP structure is transferred to metering yard through overhead line.

#### 4.7 33kV Metering Yard

The 33kV main HT panel outgoing feeders are connected to 33kV DP structure and 33kV Metering yard.

The 33kV metering yard is observed to be equipped with instrument transformers, isolator, and lightning arrestor with metering & protection cores. The 30kV, 10kA lightning arrestor is provided at 33kV incoming feeders to discharge surge currents caused by lightning strokes.

Subsequently energy from 33kV plant end metering yard is evacuated to 33/11 KV GN-patti substation at 33kV level through dog ACSR single circuit overhead transmission line.

#### 4.8 Auxiliary Power Supply

SgurrEnergy had reviewed the electrical schematics shared for the projects to evaluate auxiliary system. The 4MW<sub>AC</sub> and 2MW<sub>AC</sub> inverter stations are equipped with 20kVA and 15kVA respectively. Further inverter station 1 consist of 40kVA auxiliary transformer.

#### 4.9 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying, and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are normally mounted on individual structures.

Following the review of 33kV SLD, SgurrEnergy observed manually operated 33kV, 630A, 25kA/1sec load break switch has been used in the project.

#### 4.10 Isolators

Isolators are used to transfer load from one bus to another and also to isolate equipment for maintenance.

Based on the review of 33kV SLD, SgurrEnergy observed 33kV, 630A isolator with earth switch has been used in the project.

#### 4.11 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.

The current transformers with accuracy class of 0.2s for metering and class 5P and PS for protection has been used in 12MW<sub>AC</sub> solar PV plant. The potential transformers with accuracy class of 0.2 for metering and class 3P for protection has been used in the project.



#### 4.12 Surge Arrestors and Lightning Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes on the lines entering the substation. The apparatus most commonly used for this purpose are the surge arrestors and the lightning arrester. Transformer is the costliest equipment in substation, and it is normal practice to install lightning arrester near to the transformer. Additional lightning arresters is provided on various lines for protection of the equipment.

Following the review, SgurrEnergy observed 30kV, 10kA, surge arrestor and 30,10kA CL-III lightning arrester has been used in 33kV main HT panel and 33kV metering yard, respectively.

#### 4.13 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy is provided at the inverter station for each of the feeder sections. These meters are digital with an RS485 port for remote monitoring. These usually have an accuracy class of 0.5.

Similarly, HV side is equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point is 0.2S.



## 5 System Design Appraisal

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

### 5.1 Plant Layout Design

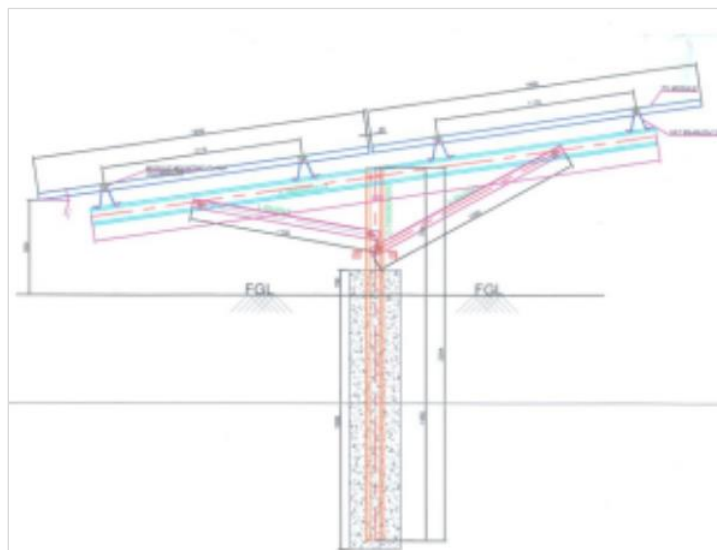
SgurrEnergy was provided with as built plant layout and electrical schematics. SgurrEnergy has verified the plant configuration with electrical schematics provided by the Client. The PV plant is JA Solar (310W<sub>p</sub> and 315W<sub>p</sub>) PV modules. The total DC installed capacity stands at 14.41MW<sub>p</sub>. The AC installed capacity stands at 12MW<sub>AC</sub> with 12 inverters of capacity 1,000kW each. Overall 12MW<sub>AC</sub> PV plant is illustrated below in the Figure 5-1.



**Figure 5-1: Plant layout of 12MW<sub>AC</sub>**

All the PV modules are orientated towards South. The mounting structure provides support for two rows of panels in portrait orientation.





**Figure 5-2: Side view of typical module mounting structure configuration**

The selected tilt for the 12MW<sub>AC</sub> plant is 8°. The 12MW<sub>AC</sub> plant is designed with a pitch of 6m.

Based on regional experience of detail designing, SgurrEnergy considers the selected tilt angle and pitch is optimized for maximum irradiation on the collector plane, minimum loss due to inter row shading, minimum ohmic losses and ease of maintenance.

21 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.2. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.

## 5.2 String Sizing

The plant layout provided by the Developer indicate thirty 310W<sub>p</sub> and 315W<sub>p</sub> JA Solar polycrystalline modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage ( $V_{OC}$ ) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum  $V_{OC}$  of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy in validating string configuration. Subsequent to calculating open circuit voltage ( $V_{OC}$  max), maximum power voltage ( $V_{mp}$  min) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 40°C and 15°C respectively for system design validation to be fair and representative for the PV plants' site.

The results of string sizing validation are presented in Table 5-1. Results indicate that  $V_{OC}$  max at the minimum ambient temperature is within the maximum system voltage of 1,000V for the selected ABB inverters.

**Table 5-1: String Sizing for JA Solar PV Modules**

Parameters	JA 310W <sub>p</sub>	JA 315W <sub>p</sub>
PV module power (W <sub>p</sub> )	310	315



Modules per string	21	
Inverters	ABB (PVS-800-57-1000kW)	
Maximum Open-circuit voltage ( $V_{oc}$ max) at minimum ambient temperature of 15°C	987V	991V
Minimum power voltage ( $V_{mp}$ min) at maximum ambient temperature of 40°C	905.1V	907V

### 5.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with JA Solar and ABB inverter is presented in Table 5-2. SgurrEnergy has selected the highest rated JA Solar module (315W<sub>p</sub>) their compatibility with ABB inverters, as SgurrEnergy considers this to be representative for all the JA Solar PV modules installed on site.

**Table 5-2: Inverter Compatibility with JA Solar 315W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>JA Solar 315W<sub>p</sub></b>	
Modules per string	21	Acceptable
Strings per inverter	182	Acceptable
Maximum power, $P_{mpp}$ at STC (kWp)	1,203.9	Nominal power ratio is 1.20, this is within the inverter bus current carrying capacity.
Maximum power voltage, $V_{mpp}$ at STC (V)	782.8	Acceptable.
Maximum power current, $I_{mpp}$ at STC (A)	1,537.9	Acceptable
Open-circuit voltage, $V_{oc}$ at STC (V)	957.6	Acceptable.
Minimum MPP voltage at 40°C ambient temperature (V)	730.8	Acceptable: Inverter MPPT ranges 600 - 850V.
Maximum MPP voltage at 15°C ambient temperature (V)	814.8	Acceptable: Inverter MPPT ranges 600 - 850V.
Maximum open circuit voltage, $V_{oc}$ at 15°C (V)	991	Acceptable: Maximum inverter voltage 1000V.

Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.





## 6 Resource assessment

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SEI has sourced monthly horizontal plane irradiation data for the Project site from:

- **NASA's Surface Meteorology and Solar Energy data set**; holds satellite derived monthly data for a grid of 0.5° × 0.5° covering the globe for a thirty-four-year period (1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.

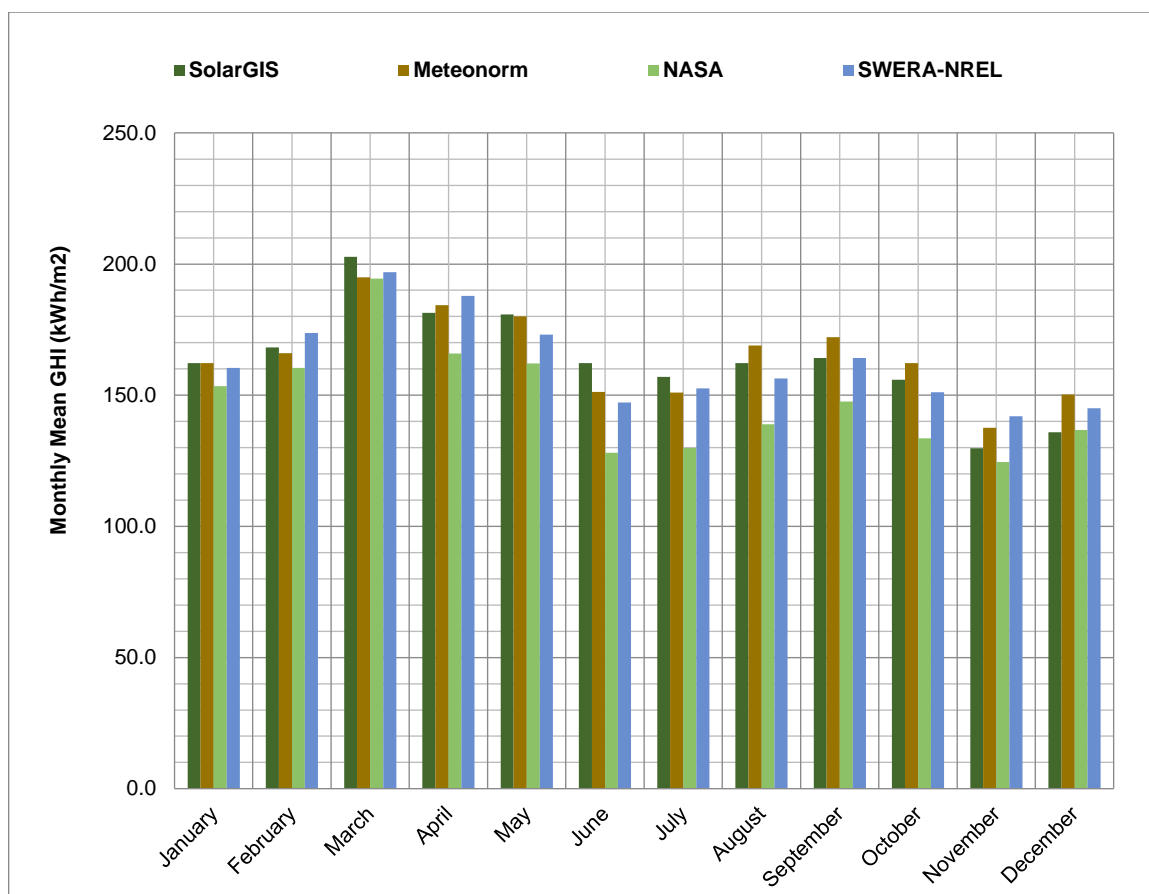


- The **METEONORM (version 7.3)** *global climatological database and synthetic weather generator*; contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.
- **SolarGIS:** SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km × 4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by *IEA (International Energy Agency) SHC Collaboration Agreement, and EU FP6 project MESoR* in terms of bias and RMSE.

SEI has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS data for the site. The comparison is graphically illustrated Table6-1







**Figure 6-1: Monthly Global Horizontal Irradiation**

**Table6-1: Comparison of Solar Irradiation Datasets for the site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	1,962.5
Meteonorm 7.3	14km × 14km	4.0%	1,980.7
NASA	55km × 55km	Unknown	1,775.6
NREL (SWERA)	40km × 40km	Unknown	1,950.2

The comparison of solar data for Project site location illustrated in Table6-1 indicates Meteonorm 7.3 dataset to give the highest irradiation levels. The next highest irradiation is given by SolarGIS followed by NREL (SWERA) and NASA.

The irradiation values given by Meteonorm 7.3 typically provide a combination of ground and satellite measured data. Meteonorm 7.3 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as 7% for the proposed site.

The NASA-SSE data source provides purely satellite measured data for a grid covering 0.5° × 0.5° on the earth's surface and generally more suited for initial site selection.

The NREL (SWERA) data illustrated has been obtained for a location approximately 2.85 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data

The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also been compared with other data sources globally. The IEA (International Energy Agency)



validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>5</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)
- Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 6%.

SEI is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 6.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 6-2 and shown graphically in Figure 6-2. Diffuse irradiation accounts for 48.30% of the total irradiation. Table 6-2 illustrates direct and diffuse daily irradiation on a horizontal plane for the proposed site. SolarGIS irradiation data is presented in Table 6-2.

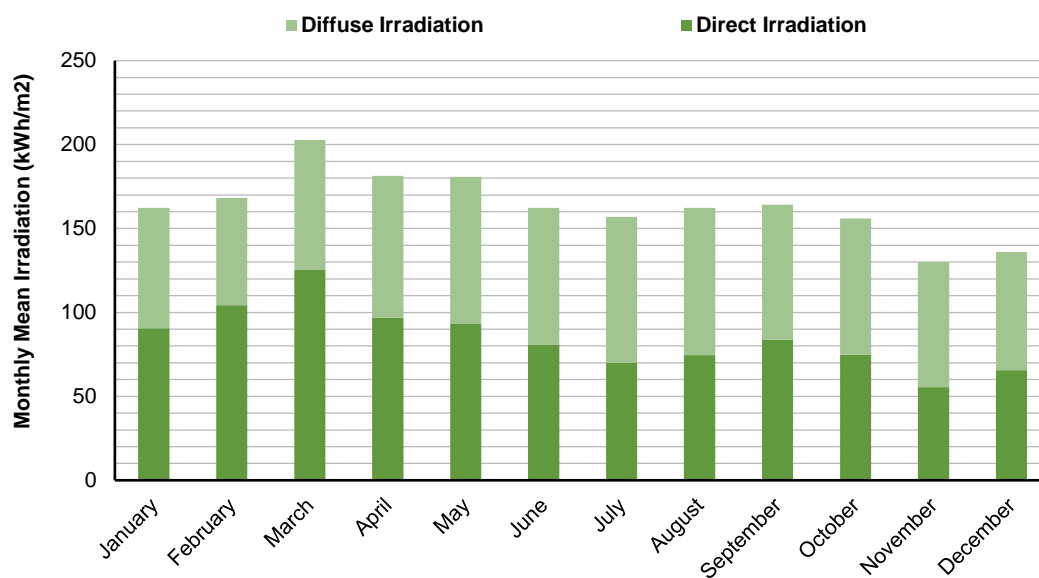
**Table 6-2: SolarGIS Irradiation Data for the Project sites**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	162.2	71.6	8.3%
February	168.2	63.8	8.6%
March	202.7	77.5	10.3%
April	181.4	84.6	9.2%
May	180.8	87.4	9.2%
June	162.2	81.6	8.3%
July	157.0	87.1	8.0%
August	162.2	87.7	8.3%
September	164.2	80.4	8.4%
October	155.9	81.2	7.9%
November	129.8	74.4	6.6%

<sup>5</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>



Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
December	135.9	70.4	6.9%
<b>Annual Sum</b>	<b>1,962.5</b>	<b>947.8</b>	<b>-</b>



**Figure 6-2: Monthly Direct and Diffuse Irradiation on a horizontal plane for the project site**

## 6.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.1.1), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -6-3 represents the monthly GTI profile.

**Table -6-3: Monthly Global Tilted Irradiation Data**

Month	GTI (kWh/m <sup>2</sup> )
January	174.10
February	177.00
March	207.00
April	179.80
May	175.30
June	155.70
July	151.60
August	159.20
September	165.30
October	161.10
November	135.80
December	145.40



Month	GTI (kWh/m <sup>2</sup> )
Annual Sum	1,987.30

### 6.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 6-4 below. The average wind speed of 1.4 m/s was measured at 10m height from ground level for the proposed project site location.

**Table 6-4: Simulated Wind Speed for site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	1.7
February	1.7
March	1.7
April	1.7
May	2.4
June	2.8
July	3.2
August	3
September	2.4
October	1.7
November	1.4
December	1.6
<b>Yearly Average</b>	2.1

### 6.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.

**Table 6-5: SolarGIS Temperature Data for Site (1999 – 2018)**

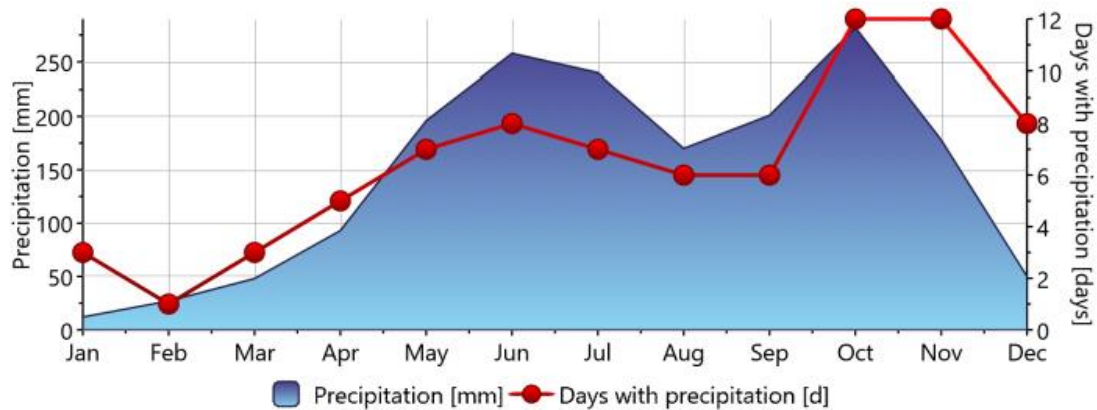
Months	Average Monthly Temperature (°C)
January	25.2
February	26.9
March	29.3
April	31.1



Months	Average Monthly Temperature (°C)
May	31.4
June	29.5
July	28.9
August	29.1
September	29.3
October	27.8
November	25.8
December	24.9
<b>Annual Average</b>	<b>28.3</b>

### 6.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.3 as illustrated in Figure 6-3. These figures show that the identified site is situated in a region that has marginal rainfall.



**Figure 6-3 Meteonorm Predicted Precipitation for the site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

Frequency of module cleaning depends on the rainfall frequency and the prevalence of dust and pollution in the local vicinity. Typical cleaning techniques include water cleaning, dry brushes or vehicle-based mechanical cleaning.

The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 1.5% has been considered by considering cleaning frequency of twice a month.



## 7 Energy Yield Analysis

SgurrEnergy has computed the annual energy yields for the 12 MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

Parameter	Description
Modules	JA Solar (JAP6-72-310/3BB, JAP6-72-315/3BB)
Inverters	ABB Central Inverters – 1.0MW <sub>AC</sub> (PVS800-57-1000kW-C)
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	14.4

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 7.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in Table 7-1 below.

**Table 7-1: Description of Energy Yield Losses**

Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.



Loss	Description
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 12 MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 7.2 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 12 MW<sub>p</sub> solar PV Plant with JA solar modules and ABB inverters. Table 7-2 summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.



**Table 7-2: Energy Yield for the 12 MW<sub>AC</sub> Solar PV Plant**

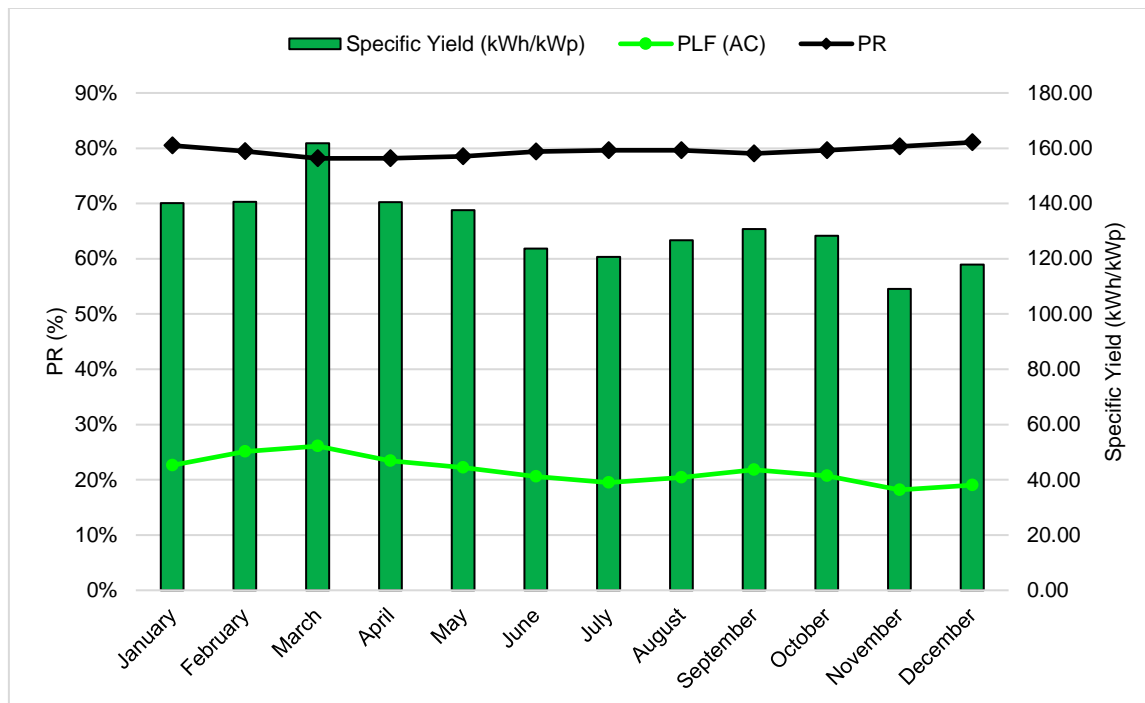
Parameters	Description
PV Module Technology	Polycrystalline
DC Capacity (MW <sub>p</sub> )	14.4
AC Capacity (MVA)	12
Contracted Capacity (MW)	12
P <sub>NOM</sub> Ratio	1.20
Tilt (°)	8
Pitch (m)	6
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1,962.50
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	1,987.30
Transposition Factor	1.01
<b>Losses</b>	
Horizon Shading	0.00%
Incident Irradiation Below Threshold	0.00%
Near Shading	0.33%
Incident Angle	2.06%
Soiling	1.50%
Low Irradiance	0.40%
Module Temperature	9.37%
Electrical Shadings	0.00%
Module Quality	0.00%
First year Degradation	1.50%
Module Mismatch	1.00%
DC Ohmic	1.05%
Inverter Performance	1.77%
Availability	1.00%
AC Ohmic	0.54%
Transformer (LV/MV)	1.07%
Transformer (MV/HV)	-
Transmission Line	1.16%
Auxiliary Consumption	0.60%
Curtailment	
<b>Total Annual Loss Factor</b>	<b>0.794</b>
<b>Sixth Year P50 Energy Yield (MWh/annum)</b>	<b>22,156.97</b>
<b>Sixth Year Specific Yield (kWh/kW<sub>p</sub>)</b>	<b>1538.67</b>
<b>Sixth Year CUF on AC Installed Capacity</b>	<b>21.07%</b>
<b>Sixth Year CUF on Contracted Capacity</b>	<b>21.07%</b>





Parameters	Description
Sixth Year CUF on DC Installed Capacity	17.56%
Sixth Year Performance Ratio	77.42%

Graphical representation of the monthly generation, performance ratio and CUF for 12 MW<sub>AC</sub> evaluated is illustrated graphically in the Figure 7-1.



**Figure 7-1: Monthly Energy Yield for 12 MW<sub>AC</sub>**

### 7.3 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 7.3.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

#### 7.3.2 Inter – Annual Variation in the Solar Resource

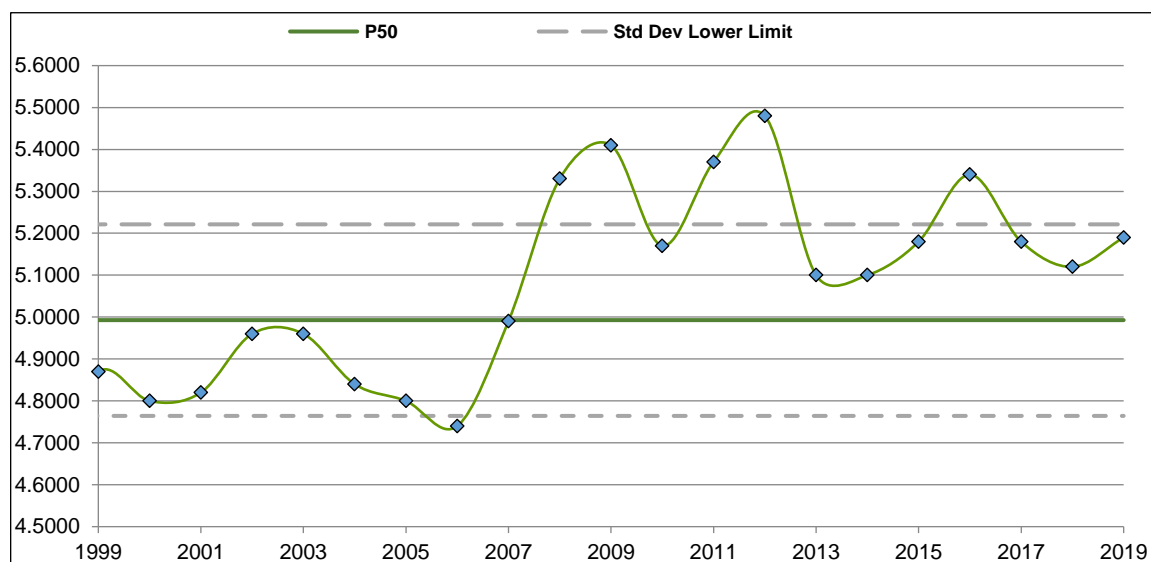
Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.



The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database for the proposed site location which is used to estimate the standard deviation of variation in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 7-3.

**Table 7-3: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	4.58



**Figure 7-2: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in

Figure 7-2.

SgurrEnergy uses a coefficient of variation of 4.58 % to quantify the inter-annual variation in the solar resource.

### 7.3.3 Modelling Uncertainty

The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

### 7.3.4 Total Uncertainty (P75, P90 and P99 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.



**Table 7-4: Life Cycle P50, P75 and P90 Generation Prediction for 12 MW<sub>AC</sub>**

Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>6</sup> (MWh/annum)	P90 Generation Prediction <sup>7</sup> (MWh/annum)
6	22,156.97	21,208.02	20,353.93
7	22,046.18	21,101.98	20,252.16
8	21,935.95	20,996.47	20,150.90
9	21,826.27	20,891.49	20,050.15
<b>10</b>	<b>21,717.14</b>	<b>20,787.03</b>	<b>19,949.90</b>
11	21,608.56	20,683.09	19,850.15
12	21,500.51	20,579.68	19,750.90
13	21,393.01	20,476.78	19,652.14
14	21,286.05	20,374.40	19,553.88
15	21,179.62	20,272.52	19,456.11
16	21,073.72	20,171.16	19,358.83
17	20,968.35	20,070.31	19,262.04
18	20,863.51	19,969.95	19,165.73
19	20,759.19	19,870.10	19,069.90
<b>20</b>	<b>20,655.39</b>	<b>19,770.75</b>	<b>18,974.55</b>
21	20,552.12	19,671.90	18,879.68
22	20,449.36	19,573.54	18,785.28
23	20,347.11	19,475.67	18,691.35
24	20,245.37	19,378.29	18,597.90
<b>25</b>	<b>20,144.15</b>	<b>19,281.40</b>	<b>18,504.91</b>

<sup>6</sup> The P75 values have been calculated over 10-year averages<sup>7</sup> The P90 values have been calculated over 10-year averages

## 8 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 0.6% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) and henceforth. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Developer, SgurrEnergy understands that the 12MW UMD solar PV plant was commissioned on 16<sup>th</sup> November 2015. SgurrEnergy was provided with plant and grid availability records from Feb 2016 to March 2021<sup>8</sup> for the solar PV plant. However, the irradiation measurement records were provided from April 2016 to March 2021.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from April 2016 to March 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

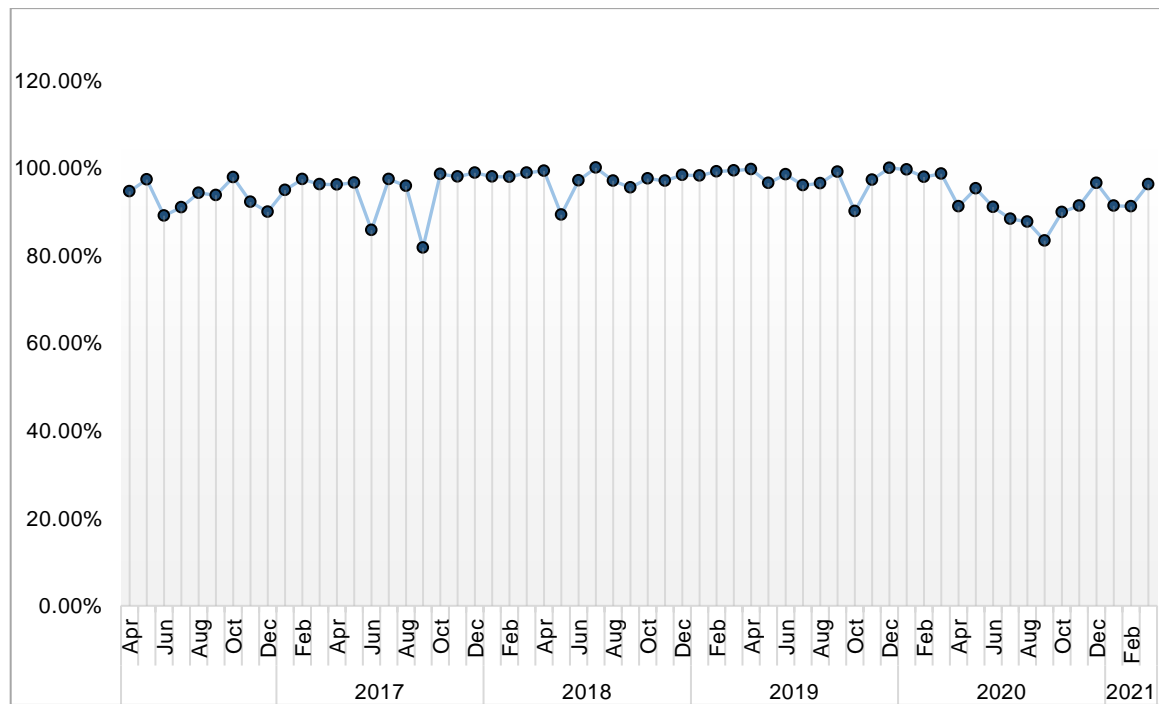
The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Developers control.

The monthly records of the grid availability from April 2016 to March 2021 have been graphically illustrated in Figure 8-1 below.

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<sup>8</sup> SgurrEnergy was provided with both the plant and grid availability records until March 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.





**Figure 8-1: Grid Availability**

Based on the above illustration, SgurrEnergy notes the grid availability for the UMD 12MW solar PV plant is notably inconsistent for all the months ranging between 81.79% to 100%.

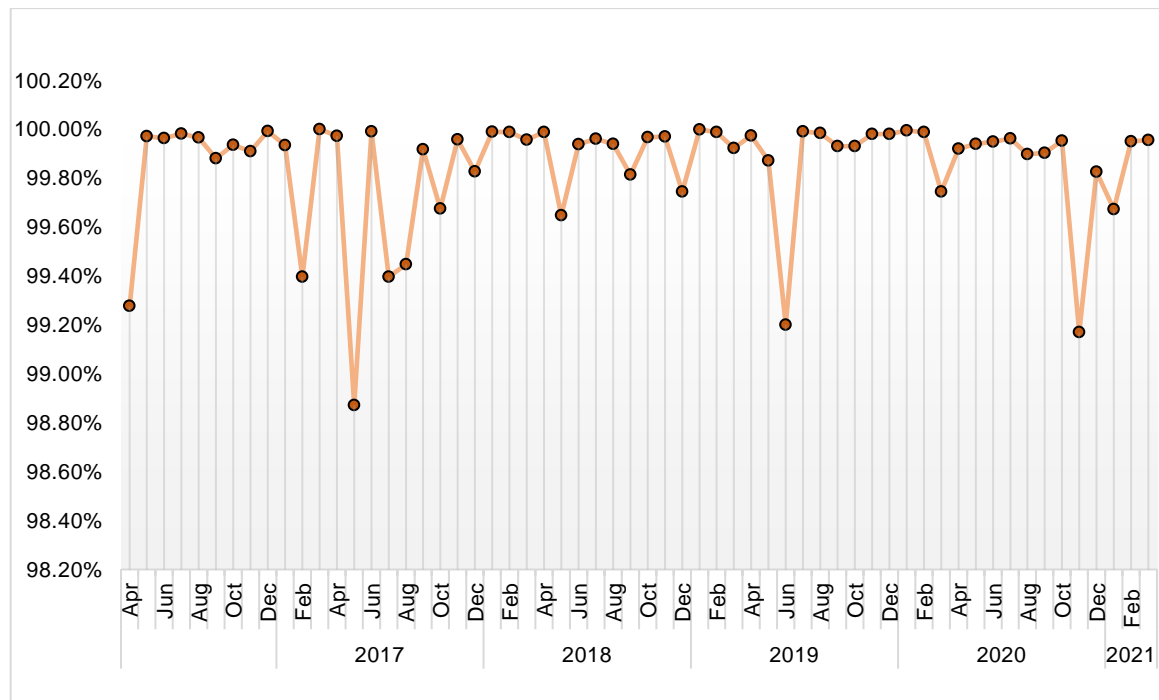
The resultant overall grid availability of the PV plant for the period evaluated was 95.05%. SgurrEnergy considers that the unavailability loss experienced due to grid anomalies for the operational period is higher than the expected range.

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the UMD 12MW solar PV plant is graphically illustrated below in Figure 8-2.





**Figure 8-2: Plant Availability**

Based on the above illustrations, SgurrEnergy notes the plant availability for the UMD 12MW solar PV plant was above 99% for substantial amount of time over the operational period of the plant.

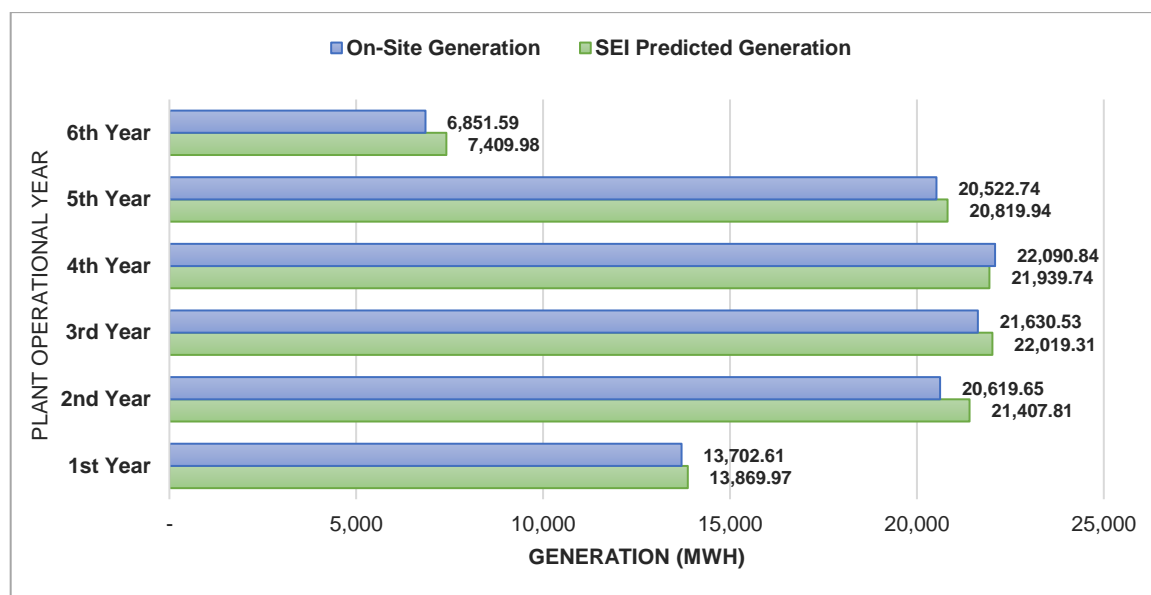
The resultant average plant availability of the PV plant for the period evaluated was 99.85% which is considered to be within expected range.

## 1.2 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer. To make the operational energy yield predictions more representative, SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Developer. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Developer.

The yearly comparison of the generation data is illustrated below in Figure 8-3.





**Figure 8-3: Generation Comparison**

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 8-1.

**Table 8-1: PV Plant Performance – UMD 12MW**

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>9</sup> (%)
Apr 2016 -Nov 2016	13,869.97	13,702.61	-1.21%
Dec 2016 -Nov 2017	21,407.81	20,619.65	-3.68%
Dec 2017 -Nov 2018	22,019.31	21,630.53	-1.77%
Dec 2018 -Nov 2019	21,939.74	22,090.84	0.69%
Dec 2019 -Nov 2020	20,819.94	20,522.74	-1.43%
Dec 2020 – Mar 2021	7,409.98	6,851.59	-7.54%
<b>Cumulative Period</b>	<b>107,466.76</b>	<b>105,417.95</b>	<b>-1.91%</b>

Based on the above comparison, SgurrEnergy notes that the PV plant is generating lower than the expected yield. However, SgurrEnergy considers that the variations in the energy yield can be attributed to lower irradiation level experienced on the Project site. The irradiation levels significantly impact the actual generation from the PV plant as the system losses may vary significantly due to slight change in the irradiation.

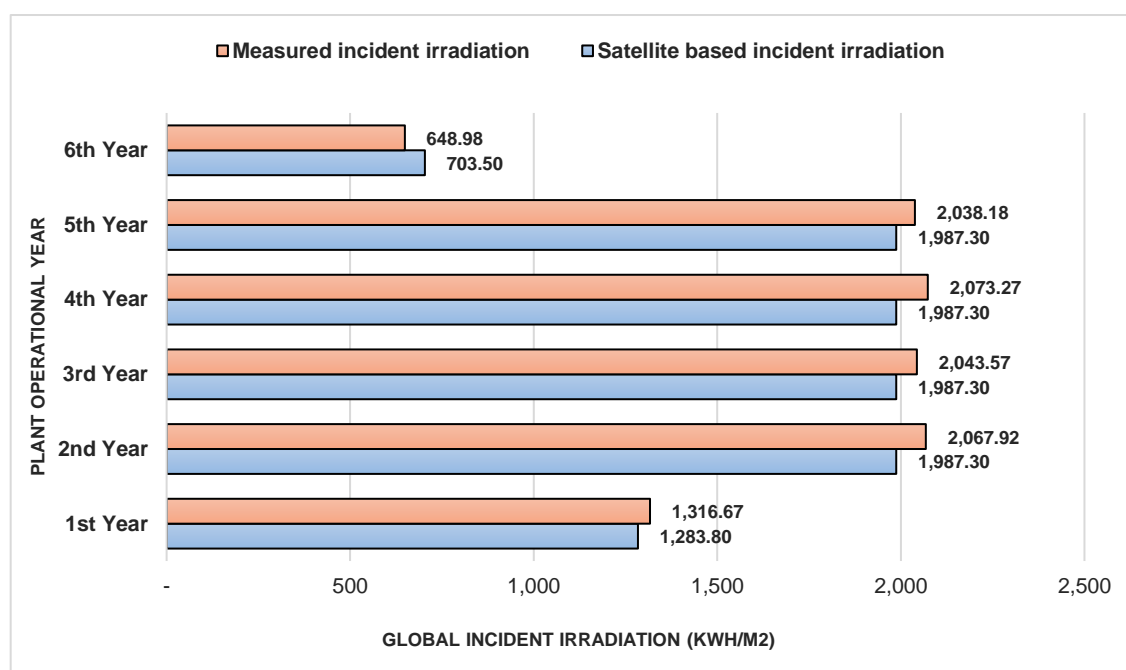
In order to understand the deviation in the irradiation pattern, SgurrEnergy has compared the monthly incident irradiation data provided by the Developer with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation. The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 8-4.

<sup>9</sup> Positive values indicate higher generation, while negative values indicate lower generation



**Table 8-2: Irradiation Comparison– UMD 12MW**

PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>10</sup> (%)
Apr 2016 -Nov 2016	1,283.80	1,316.67	2.56%
Dec 2016 -Nov 2017	1,987.30	2,067.92	4.06%
Dec 2017 -Nov 2018	1,987.30	2,043.57	2.83%
Dec 2018 -Nov 2019	1,987.30	2,073.27	4.33%
Dec 2019 -Nov 2020	1,987.30	2,038.18	2.56%
Dec 2020 – Mar 2021	703.50	648.98	-7.75%
<b>Cumulative Period</b>	<b>9,936.50</b>	<b>10,188.60</b>	<b>2.54%</b>

**Figure 8-4: Irradiation Comparison**

Based on the above illustrations, it is observed that the overall recorded generation is approximately 1.91% lower than the generation predicted on site. Correspondingly, it has also been observed that the irradiation measured on site is approximately 2.54% higher than the predicted irradiation.

SgurrEnergy thus infers that the PV plant is underperforming based on the conditions experienced on site.

<sup>10</sup> Positive values indicate higher irradiation, while negative values indicate lower irradiation





## 9 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar PV plants as having a lifetime of 25-40 years<sup>11</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>12</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the PV plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement.

---

<sup>11</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>12</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>



Virescent Infrastructure

13MW(AC) Kovilpatti Solar PV Plant  
Universal Mine Developers and Service Providers  
Technical Assessment Report

May 2021



## Report Details

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<b>Date of Issue</b>	28 May 2021		



### Amendment Records

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B2	19.02.2021	For Client Issue	Minor Changes
B3	22.02.2021	For Client Issue	Finalisation of Report
B4	28.05.2021	For Client Issue	Generation Analysis Updated

SF/04/023

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## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 13MW<sub>AC</sub> Universal Mine Developers and Service Providers Pvt Ltd (the Project). The Project is located near Kovilpatti village, in Thoothukudi district of Tamil Nadu.

The summary of the technical assessment is captured in the below table.

**Table 1-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	<p>The project site lies around the coordinates 9°5'30.60"N and 77°46'40.96"E and is located near the Kovilpatti village, in Thoothukudi district of Tamil Nadu.</p> <p>Project is contracted for generating 13MW<sub>AC</sub> power. The Owner has utilised approximately 86 acres of land for the project.</p> <p>Project is implemented with poly-crystalline modules (JA Solar) and central inverters (ABB). The module mounting structure is implemented with a tilt of 8° for a pitch of 6m.</p> <p>The power generated from the UMDSPPL 13MW<sub>AC</sub> PV plant is fed to M.Duraisampuram substation substation, through a single circuit transmission line.</p> <p>The total DC installed capacity stands at 15.6MW<sub>p</sub>. The AC installed capacity stands at 13MW<sub>AC</sub> with 13 inverters of capacity 1,000kW each.</p>
2	PV Module	<p>SgurrEnergy has conducted a desktop review of JA Solar assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard. SgurrEnergy considers the warranty period to be in line with the industry standards. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.</p>
3	Inverter	<p>ABB is considered to have good track record for supplying central inverters. Certificates mentioned in the technical specification datasheet indicate ABB to hold adequate certifications. Technical characteristics are acceptable, with a good efficiency level for central inverters. Standard warranty of five years is provided for the inverters, which is in line with the industry requirement. Overall, SgurrEnergy does not raise any concern on the utilization of ABB inverters for the Project.</p>
4	Inverter Transformer	<p>The inverter transformers (2200kVA) used within the project are manufactured by Voltamp Transformers Limited. The manufacturers have a good track record of supplying transformers to distinguished customers in Indian as well as in the global market. SgurrEnergy has reviewed the transformers based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with</p>





Sr. No.	Parameter	Comment
		industry standards and raises no concerns over its use in the project
5	String Sizing	The $V_{OC}$ does not exceed the inverter input voltage for the site, and therefore, SgurrEnergy considers the number of modules in series to be acceptable for the PV Project.
6	Permits and Approvals	PPA signed between Universal Mine Developers and Service Providers Pvt Ltd and Tamil Nadu Generation and Distribution Corporation Limited. PPA term is 25 years from the Commercial Operation Date. Documents such as CEIG certificate, commissioning certificate, consent to operate etc. have not been provided.
7	Resource Assessment	For resource analysis, SgurrEnergy has compared various satellite datasets. For the satellite databases, SgurrEnergy has compared Meteonorm 7, NASA, SWERA and SolarGIS data to find the most suitable solar resource for long-term energy yield prediction. Owing to low uncertainty and high resolution, SgurrEnergy considers SolarGIS dataset to be the most representative satellite database among all the satellite databases for long-term energy yield assessment.
8	Operational Analysis and Generation Comparison	<p>SgurrEnergy was provided with plant and grid availability records from March 2016 to December 2020 for the solar PV plant. In addition, the irradiation measurement records were provided from April 2016 to December 2020.</p> <p>SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer for the period from April 2016 to December 2020.</p> <p>Overall the average grid availability experienced on site for the operational period was calculated to be 95.06% which is considered to be significantly lower than the expected range. Correspondingly the average plant availability is noted to be 99.8% which is considered to be within expected range.</p> <p>Furthermore, SgurrEnergy observed that the overall recorded generation is approximately 4.48% lower than the generation predicted on site. Correspondingly, it has also been observed that the irradiation measured on site is approximately 2.17% higher than the predicted irradiation.</p> <p>SgurrEnergy thus infers that the PV plant is underperforming based on the conditions experienced on site.</p>
9	Allied Components and Systems	<p>The 13MW<sub>AC</sub> solar PV plant is designed with JA solar (315/310Wp) solar PV modules and 1000kW ABB central inverter.</p> <p>The 13MW<sub>AC</sub> solar PV plant has been configured with 13 ABB 1000kW central inverters and four inverter stations. Out of the total four inverter stations, three inverter stations of 4MW<sub>AC</sub> capacity contain four inverters of 1000MW capacities and two 3-winding transformers of 2.2MVA capacities. While one inverter station of 1MW<sub>AC</sub> capacity consists of one inverter of 1000kW capacity and one 2-winding, 1.1MVA transformer.</p>



Sr. No.	Parameter	Comment												
		The output power of each 33kV HT panel is connected to 33kV main HT panel located in the main control room. Further from the control room power is fed to 33kV DP structure and 33kV metering yard. Power from the metering yard is then evacuated to the 110/33KV M.Duraisampuram substation located approximately 8.75kms from the Project site through dog ACSR single conductor overhead transmission line.												
10	Energy Assessment Yield	<div>Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for third year of plant operation for the 13 MWAC PV plant.</div> <table><tr><td>Global Horizontal Irradiation (kWh/m2)</td><td>1,983.50</td></tr><tr><td>Global Inclined Irradiation (kWh/m2)</td><td>2,002.90</td></tr><tr><td>Fifth Year P50 Energy Yield (MWh/annum)</td><td>24,204.76</td></tr><tr><td>Specific Yield (kWh/kWp)</td><td>1551.58</td></tr><tr><td>Performance Ratio (PR)</td><td>77.46%</td></tr><tr><td>PLF on Contracted Capacity (10 MWAC)</td><td>21.25%</td></tr></table>	Global Horizontal Irradiation (kWh/m2)	1,983.50	Global Inclined Irradiation (kWh/m2)	2,002.90	Fifth Year P50 Energy Yield (MWh/annum)	24,204.76	Specific Yield (kWh/kWp)	1551.58	Performance Ratio (PR)	77.46%	PLF on Contracted Capacity (10 MWAC)	21.25%
Global Horizontal Irradiation (kWh/m2)	1,983.50													
Global Inclined Irradiation (kWh/m2)	2,002.90													
Fifth Year P50 Energy Yield (MWh/annum)	24,204.76													
Specific Yield (kWh/kWp)	1551.58													
Performance Ratio (PR)	77.46%													
PLF on Contracted Capacity (10 MWAC)	21.25%													



## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
m	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon



MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation



## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

KKR global was founded in 1976 and the company had expanded its presence in India in 2009. The company is a global investment firm that manages multiple alternative asset classes, including private equity, credit and real assets with strategic partners that manage hedge funds. As of 30 September 2020, KKR has a team of over 1,600 employees, consultants, investment professionals and senior advisors working across 16 industries in offices around the world.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 258MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of six Solar PV plants, as presented within Table 1-1.

**Table 1-1: Portfolio Key Summary**

Project Name	SEPEPL – 80MW <sub>AC</sub>	SEPEPL – 50MW <sub>AC</sub>	SPSPL – 50MW <sub>AC</sub>	SPSPPL – 30MW <sub>AC</sub>	TNSPEPL – 5MW <sub>AC</sub> + 8MW <sub>AC</sub> + 10MW <sub>AC</sub>	UMD- 12MW <sub>AC</sub> + 13MW <sub>AC</sub> +
Site Location	18.926°N, 76.395°E, Parli, Maharash- tra, India	21.028°N, 75.985°E, Muktainagar Maharashtra ,India	9.324°N, 77.594°E. Rajapalyam, Tamil Nadu,India	12.344°N, 78.945°E Tiruvanna m-alai, Tamil Nadu, India.	5MW <sub>AC</sub> – 10.491°N, 78.063°E Dindigul, Tamil Nadu, India 8MW <sub>AC</sub> – 9.437°N, 78.172°E Aruppukkotai Tamil Nadu, India 10MW <sub>AC</sub> – 9.118°N, 78.107°E Vilathikulam, Tamil Nadu, India	12MW <sub>AC</sub> - 9.554°N, 77.884°E Amathur, Tamil Nadu, India 13MW <sub>AC</sub> - 9.093°N, 77.780°E Kovilpatti, Tamil Nadu, India
Owner / Special Purpose Vehicle (SPV)	Solar Edge Power and Energy Private Limited (SEPEPL)		Shapoorji Pallonji Suryaprakas h Private Limited (SPSPL)	Shapoorji Pallonji Solar PV Private Limited	TN Solar Power Energy Private Limited	Universal Mine Developers and Service Providers Private Limited
DC / AC Capacity	104.0MW <sub>P</sub> / 80.0MW <sub>AC</sub>	65.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	54.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	36.0MW <sub>P</sub> / 30.0MW <sub>AC</sub>	5MW <sub>AC</sub> – 6.0MW <sub>P</sub> / 5.0MW <sub>AC</sub> 8MW <sub>AC</sub> – 9.6MW <sub>P</sub> / 8.0MW <sub>AC</sub> 10MW <sub>AC</sub> – 12.0MW <sub>P</sub> / 10.0MW <sub>AC</sub>	12MW <sub>AC</sub> - 14.4MW <sub>P</sub> / 12MW <sub>AC</sub> 13MW <sub>AC</sub> - 15.6MW <sub>P</sub> / 13MW <sub>AC</sub>
Commissioning date	50MW <sub>AC</sub> – 08 April 2018 30MW <sub>AC</sub> – 22 April 2018	26 April 2018	26 September 2018	26 March 2016	5MW <sub>AC</sub> – 28 December 2015 8MW <sub>AC</sub> – 28 September 2015 10MW <sub>AC</sub> – 31 October 2015	12MW <sub>AC</sub> – 16 November 2015 13MW <sub>AC</sub> – 21 March 2016

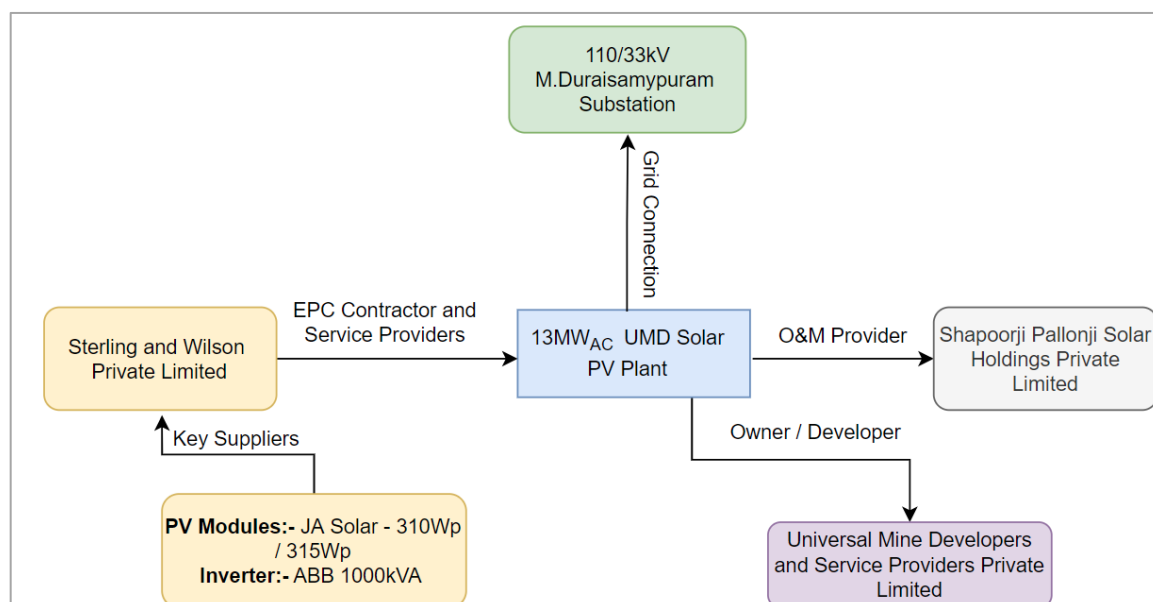


This report presents the technical appraisal of the 13MW<sub>AC</sub> UMD Solar PV plants (The Project) developed by Universal Mine Developers and Service Providers Private Limited (UMD), near *Kattarankulam* village, *Kovilpatti* tehsil, *Thoothukkudi* district of the Tamil Nadu state.

The purpose of this report is to provide a technical appraisal of PV plant under evaluation. The report focuses on the following key aspects:

- System Overview.
- Major Components.
- System Design Appraisal.
- Allied Components and Systems.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project, based on information made available by the Client through online data room and site assessment. Figure 1-1 illustrates the project structure indicating key project participants.



**Figure 1-1: Project Structure**

The main Project characteristics are summarised in Table 1-2.

**Table 1-2: Project Key Summary**

Project Information	
<b>Project Name</b>	13MW <sub>AC</sub> UMD Solar PV plant
<b>Location</b>	<i>Kovilpatti</i> , Tamil Nadu
<b>Owner</b>	Universal Mine Developers and Service Providers Private Limited
<b>DC/ AC capacity</b>	15.6MW <sub>P</sub> / 13.0MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: JA Solar Inverters: ABB



Project Information	
MMS Configuration	Fixed Tilt: 8°, Azimuth: 0°
Commissioning Status	Commissioning for was achieved on 21 March 2016.





## 2 13MW<sub>AC</sub> Solar PV Plant Overview

The project site lies around the coordinates 9°5'30.60"N and 77°46'40.96"E. Satellite imageries of 13MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1. The Owner has utilised approximately 86 acres of land project. The Project site is located near the *Kovilpatti* village, in Thoothukudi district of Tamil Nadu.

Project is contracted for generating 13MW<sub>AC</sub> power; SgurrEnergy therefore interprets 13MW<sub>AC</sub> as the maximum AC installed capacity for the solar PV plant.



**Figure 2-1: Satellite image of 13MW<sub>AC</sub>**

### 2.1 13MW<sub>AC</sub> Project Summary

Solar PV plant is modular in nature; therefore, UMDSPPL 13MW<sub>AC</sub> solar PV plants is implemented by adopting modularity in designs. 4MW<sub>AC</sub> is the typical inverter station considered for implementing UMDSPPL 13MW<sub>AC</sub> solar PV plant.

Table 2-1 presents the summary of 13MW<sub>AC</sub> PV plant

**Table 2-1: Summary of 13MW<sub>AC</sub> Plant Configurations**

General	
PV Module Technology	Poly-crystalline
Inverter Technology	Central Inverters
Installed DC Peak Capacity (MW <sub>p</sub> )	15.6
Installed AC Capacity (MW)	13.0





General	
Mounting Type	Fixed Tilt
Tilt Angle (°)	8°
Pitch (m)	6
PV Modules	
PV Module Manufacturer	JA Solar
Model	JAP6-72-310/3BB JAP6-72-315/3BB
Wattage (W <sub>p</sub> )	310W <sub>p</sub> / 315W <sub>p</sub>
Number of Modules per String	21
Inverter	
Inverter Manufacturer / Model	ABB / PVS-800
Inverter Nominal AC Output	1,000kW
Number of Inverters	13
Mounting Structure	
Mounting Structure Details (rows x columns)	2 x 21
Orientation of Modules	Portrait

The plant is implemented with a total of 3 inverter stations, each of capacity 4MW<sub>AC</sub> while there is one inverter of capacity 1MW<sub>AC</sub> which is placed in the main control room. Each inverter station is comprising of three winding transformers to accommodate 4 x 1,000kVA inverters taking the individual inverter station size to 4MW<sub>AC</sub>. Each inverter station is comprising of a physical block connecting to 4.8MW<sub>p</sub> of installed photovoltaic array. The output of 4MW<sub>AC</sub> inverter station is connected to 0.400/0.400/33kV three winding transformer of 2.2MVA for stepping up the voltage to 33kV.

The medium voltage 33kV output of all the inverter stations are placed in main control room (MCR), these are combined to form a solar PV plant of 13MW<sub>AC</sub>. The 33kV output is evacuated using a DP structure located in the plant premises.

The power generated by the UMDSPPL 13MW<sub>AC</sub> PV plant is fed to *M.Duraisampuram* substation located approximately 9km from the Project site, through a single circuit transmission line. The point of interconnection is at the *M.Duraisampuram* substation.

ABT / revenue metering is at *M.Duraisampuram* substation; therefore, transmission line losses are accounted in the Owner's scope.



### 3 Review of Major plant components

SgurrEnergy has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions.

#### 3.1 PV modules

The PV modules selected for the Project are supplied by JA Solar Holding Co., Ltd., Canadian Solar and Astronergy. SgurrEnergy has conducted a technical review of the suppliers and proposed module specifications with regard to their suitability for use on the Project.

##### 3.1.1 Company Profile – JA Solar Holding Co., Ltd

JA Solar Holding Company Ltd. listed on NASDAQ (NASDAQ: JASO), was found in the year 2005 and started operation in 2006. The Company has 12 manufacturing bases and has production capacity of more than 11.5GW, 11GW, and 11GW for silicon wafer, solar cells, and solar modules, respectively.

JA solar has 20 branches around the world and employs more than 22,000 employees worldwide. As of December 2019, JA solar provides services in more than 135 countries and to more than 33,000 clients worldwide. As of second quarter 2020, JA solar had a cumulative shipment of more than 50GW. As of December 2019, JA solar had more than 779 authorized patents of independent R&D and 107 invention patents under its name. The Company's net revenue was RMB 21.16 billion in 2019.

Few of the commissioned solar power plants using JA modules are listed in Table 3-1.

**Table 3-1: Project References of JA Solar**

Sr. No.	Project and Location	Capacity (MW)
1	Bahia, Brazil	255.0
2	Northern Cooks, Australia	172.8
3	Cadiz, Philippines	132.5
4	Maharashtra, India	130.0
5	Three Gorges, Datong	100.0
6	Bahawalpur, Pakistan	100.0
7	Lincheng Country, Xingtai City, Hebei Province	100.0
8	Dunhuang, Gansu Province	100.0
9	Utah, USA	80.0
10	New South Wales, Australia	70.0
11	Maharashtra, India	70.0
12	Telangana, India	69.0
13	Bole, Xinjiang	60.0
14	San Carlos, Philippines	59.0
15	MP, India	57.0
16	Charanka Gujrat, India	53.0
17	Datong, Shanxi Province	50.0
18	Southwark, UK	49.0
19	Karnataka, India	43.0



Sr. No.	Project and Location	Capacity (MW)
20	Xiayu, Hebei Province	42.0
21	Yinchuan, Ningxia Province	40.0
22	Georgia, USA	38.7
23	Arawa Desert and Negev Desert, Israel	35.0
24	Hefeng, Tacheng, Xinjiang	30.0
25	Karnataka, India	23.0
26	Bulgaria	21.0
27	Haryana, India	21.0
28	Campania, Italy	20.0
29	Corp 184, Xinjiang	20.0
30	Telangana, India	18.0
31	Toshka, Egypt	10.1
32	Volkswagen Chattanooga Plant, USA	9.6
33	Antalya, Turkey	6.7
34	Kenitra, Morocco	2.0
35	ABC Bank, Jordan	1.5

JA is considered a Tier 1 supplier by Bloomberg (Q4, 2020). A Tier 1 supplier is defined as a module manufacturer who has *provided products to five different projects, which have been financed non-recourse by five different (non-development) banks, in the past two years.*

Whilst the Bloomberg tiering system does not reflect on a product's technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers JA solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

### 3.1.1.1 Main Technical Characteristics of JAP6-72/3BB

JA Solar, JAP6-72/3BB modules of 310W<sub>P</sub> and 315W<sub>P</sub> capacity have been utilized for the Project. These modules have an efficiency of 15.99% and 16.25% for 310W<sub>P</sub> and 315W<sub>P</sub> capacity modules, respectively, and a peak power tolerance of 0~+5W. The modules have a temperature coefficient (P<sub>max</sub>) of -0.41%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy's expectation for c-Si technology. The technical characteristics of JAP6-72/3BB are presented in Table 3-2.

**Table 3-2: Technical specifications of JAP6-72/3BB**

Specifications	JAP6-72-310/3BB	JAP6-72-315/3BB
Technology	Polycrystalline	
Nominal power (P <sub>MPP</sub> )	310W <sub>P</sub>	315W <sub>P</sub>
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	37.00V	37.28V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	8.38A	8.45A
Open circuit voltage (V <sub>OC</sub> )	45.45V	45.60V
Short circuit current (I <sub>SC</sub> )	8.85A	8.91A
Efficiency (%)	15.99%	16.25%



Specifications	JAP6-72-310/3BB	JAP6-72-315/3BB
Maximum System Voltage	1,000V (DC)	
Power tolerance (%)	0~+5W	
Dimensions (length × breadth × width) (mm)	1956 × 991 × 45	
Module area (m²)	1.94m²	
Weight (kg)	~26kg	
Temperature coefficient at P <sub>MAX</sub>	-0.41%/°C	
Operating temperature	-40°C to +85°C	
Maximum reverse current	15A	
Maximum mechanical load	5400Pa	
Maximum snow load	2400Pa	
Product warranty	10 years	
Power output guarantee	25 years	
Module technical characteristics are given at STC (1,000W/m² irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet)		

The maximum system voltage is 1,000V. The maximum reverse current is 15A. Overall, the module characteristics can be considered to be in line with market standard and JA Solar is listed as Tier 1 suppliers by Bloomberg since 2014.

### NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>1</sup> characteristics of selected JAP6-72/3BB modules of 310W<sub>P</sub> and 315W<sub>P</sub> is given in Table 3-3 corresponding to realistic operating conditions as compared to STC. It is affected by module materials used as well as the packing density of module materials. The NOCT for the module is 45±2°C. This is comparable with other manufacturers and demonstrates the module is effective at heat dissipation.

**Table 3-3: PV Module NOCT Characteristics of JAP6-72/3BB**

Model	JAP6-72-310/3BB	JAP6-72-315/3BB
Maximum Power (P <sub>MAX</sub> )	225.06W <sub>P</sub>	228.69W <sub>P</sub>
Max Power Voltage (V <sub>MPP</sub> )	34.05V	34.08V
Max Power Current (I <sub>MPP</sub> )	6.61A	6.71A
Open Circuit Voltage (V <sub>OC</sub> )	42.58V	42.63V
Short Circuit Current (I <sub>SC</sub> )	6.99A	7.06A

#### 3.1.1.2 Certification of Modules

General review of datasheet indicates JA Solar PV modules manufactured in facilities with the following certifications:

- ISO 14001 certification for environmental management systems

<sup>1</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C.



- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certifications available in public domain for the modules under evaluation within Table 3-4.

**Table 3-4: Certification for PV Module- JA Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
UL 1703	Standard for safety for flat-plate photovoltaic modules

### 3.1.1.3 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of six months from the dispatch from the JA solar factory or the delivery date to site.

### 3.1.1.4 Product Warranty

JA Solar provides a limited product warranty of 10 years, beginning on the earlier of module purchase date or one-year anniversary from the production date. If module fail to conform to this warranty, during the period ending of 10 years from the date of sale to the customer of the JA solar product, JA solar will at its opinion, either repair or replace the product, or refund the purchase price as paid by the customer. The repair or replacement or refund the customer at the current comparable market price of such module.

SgurrEnergy considers twelve-year product warranty provided by JA solar to be in line with the industry standard.

### 3.1.1.5 Linear Power-Output Warranty

According to the datasheet JA solar warrants that the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.7% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 80.7% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, JA solar will either repair, replace or provide additional modules to make up for the loss in power output.

## 3.2 Inverters – ASEA Brown Boveri (ABB)

The project has utilized ABB PVS800-57-1000kW central inverter for the project under evaluation.

### 3.2.1 Company background

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, ABB is one of the largest engineering companies as well as one of the largest conglomerates in the world. ABB has operations in around 100 countries, with



approximately 147,000 employees<sup>2</sup>. Company reported global revenue of around \$34,312 million for 2017.<sup>3</sup>

The firm's shares are traded on the stock exchanges of Zurich, Stockholm, and New York. ABB is a multinational corporation headquartered in Zurich, Switzerland, operating mainly in robotics and power and automation technology.

On July 9, 2019 the Italian company FIMER acquired ABB's solar inverter business. The takeover of ABB's solar inverter business included 800 employees in 26 countries as well as two manufacturing plants, in Italy and in India, and a R&D facility in Finland.

FIMER was founded in 1942, headquartered in Vimercate, Italy, has been actively working in inverter technology since 1983. As of 2020, the company employs more than 1,100 employees across its three manufacturing facilities and three R&D centres across the globe. As a result of acquisition of ABB's PV inverter line, FIMER ranked the fifth-largest PV inverter globally in 2019.

### 3.2.2 Track Record

ABB India commenced local manufacturing of solar inverters in 2012 and partnered with several customers. ABB is the solar inverter market leader in India holding approximately 24% market share in 2018. ABB has approximately 3,590MW in operation across more than 350 sites in India. ABB India manages close to 40% of the installed bases in India. As on 30 August 2017, ABB India crossed the 5GW threshold for the supply of inverters in the country.

Table 3-5 lists the state-wise installed capacity of ABB inverters in India. However, it is to be noted that the table below doesn't not comprise of the installed capacities till date.

**Table 3-5: ABB Inverter Track Record**

Location	Capacity (MW)
Tamil Nadu	747
Andhra Pradesh	647
Rajasthan	371
Karnataka	305
Madhya Pradesh	271
Maharashtra	261
Punjab	227
Bihar	225
Uttar Pradesh	106
Haryana	62
Kerala	50
Chhattisgarh	28
Odisha	20

ABB India has strategically located its headquarter in Bangalore and offices in other cities Pune, Ahmedabad, Jaipur, Faridabad, Hyderabad, Tamil Nadu, and Bhopal in order to

<sup>2</sup> <https://new.abb.com/news/detail/26838/abb-to-exit-solar-inverter-business>

<sup>3</sup> <https://new.abb.com/investorrelations/company-profile/facts-figures>



facilitate quick spare part availability and minimal response time. ABB aims to provide first response to its customers within 4 hours on weekdays and within 24 hours on weekends and holidays. ABB also provides a Turn-Around-Time of 48 and 72 hours on weekdays and weekends respectively, hence maintaining an average uptime of over 99%.

### 3.2.3 Technical Characteristics

ABB PVS800-57-1000kW inverter has been selected for technical feasibility of the Project. The technical specification of 1000kW ABB inverter is listed in Table 3-6.

The PVS800-57-1000kW Series of central inverters designed ideal for large PV Power Plants. PVS800 inverters are designed for fast and easy installation. These inverters are designed to operate with DC inputs up to 1,100 V. They incorporate maximum power point tracking (MPPT) and grid management features to meet utility requirements.

PVS800-57-1000kW inverter is designed for outdoor use with an IP42 ingress protection class. They are protected against solid objects over 1mm and against direct sprays of water up to 15° from the vertical. They perform optimally at ambient air temperatures between -15°C to 50°C and relative humidity in the range of 15% to 95% with maximum noise level of 75dBA.

The PVS800-57-1000kVA inverter has peak efficiency of 98.8% and a European efficiency of 98.6%.

The main technical characteristics of these inverters are illustrated in Table 3-6.

**Table 3-6: ABB inverter specifications**

<b>ABB Central Inverter Specifications</b>	
Inverter	ABB PVS800-57-1000kW
Type	Central Inverter
<b>Input Data</b>	
Maximum Input Power (kW <sub>p</sub> )	1200kW <sub>p</sub>
PV voltage range, MPP (V)	600 to 850V
Maximum DC voltage (V)	1100V
Maximum input current (A)	1710A
<b>Output Data</b>	
Nominal AC power (kW)	1000kW
Maximum AC current (A)	1445A
Nominal AC voltage(V)	400V
AC grid frequency (Hz)	50Hz -5%+3%
Maximum THD	< 3%
<b>Operating Performance</b>	
Maximum efficiency (%)	98.80%
Euro efficiency (%)	98.60%
<b>Power consumption</b>	
Own consumption in operation(W)	730W
Standby operation consumption (W)	70W
<b>Other</b>	





ABB Central Inverter Specifications	
Dimensions (W × H × D) (mm)	3630mm x 2130mm x 610mm
Weight (kg)	2600kg
Environmental Protection Rating	IP42
Operating temperature range (°C)	-15 to +50°C
Relative humidity (%)	15% to 95%

The following protection devices are included within the inverter design:

- Ground fault monitoring
- Grid Monitoring
- Anti-islanding protection
- DC reverse-polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection
- Remote monitoring solutions

ABB inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components.

### 3.2.4 Certification

ABB is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. ABB inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information available in public domain, SgurrEnergy has summarized the certification of the ABB inverter within Table 3-7.

**Table 3-7: Description of Certification of ABB inverters**

Certification	Description
IEC 60068-2-6/29	Environmental testing of inverters to assess their ability to perform and survive under conditions such as transportation, storage, operational environments, extreme cold and heat
IEC61683:1999	Measurement of the efficiency of power conditioners
IEC 62109-2:2011	Safety of Power Converters
IEC 62116:2014	Test procedure of islanding prevention measures

### 3.2.5 Warranties

SgurrEnergy referred the warranty documents available in public domain. Given the industry standard warranty of 60 months, SgurrEnergy does not raise any concern over the use of inverter for the project.





### 3.3 Inverter Transformer – Voltamp Transformers Limited

The power at low voltage from inverters is stepped up to 33kV using 2200kVA transformers of Voltamp Transformers Limited make.

#### 3.3.1 Company Profile

The inverter transformer used is manufactured by Voltamp Transformers limited (Voltamp).

Voltamp was founded in 1963 in Vadodara, Gujarat and now has a PAN India presence. The company initially started off by manufacturing small transformers by 1975 the largest transformer manufactured was for 132kV networks. This limit rose to 220kV class of transformers in 2008. The company employs more than 300 personnel (including 60 engineers) and has branch offices in Mumbai, New Delhi, Chennai, Bangalore, Secundrabad, Pune, Bhubaneshwar, etc.

The company has four manufacturing plants and the current manufacturing capacity totals to 13000 MVA per year. These facilities boast of manufacturing Oil filled Power and Distribution Transformers up to 160MVA, 220kV. The company got its ISO 9001 certification in 1998 and was listed on the NSE and BSE stock exchange in 2006.

Notable designs include:

- 75MVA 11/138kv GT
- 20MVA 33-22/11kV (DZ10)
- 50MVA 132-110/33kV transformer
- 6 MVA 1-ph transformer
- 15MVA 11/1.3-1.3kV (24 pulse)
- 100MVA 22kV

The company also manufacturers two types of dry transformers, i.e. resin impregnated (25KVA-5000KVA up to 11kV) and cast resin transformers (50kVA-12500kVA up to 33kV). Prominent clients include ABB, Exide, Adani, BHEL, BPCL, Suzlon etc.

#### 3.3.2 Technical Specifications

The 2200kVA Power transformers used in the project are outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 3-8.

**Table 3-8: Technical Specification of Voltamp Transformers**

Technical Parameters	Description
Rated Power	2200kVA
Rated HV	33kV
Rated LV	400-400V
Tapping on HV	-5% to +5% (steps of 2.5%)
Phases	3
Frequency	50Hz



Technical Parameters	Description
Vector group	Dy11y11
Impedance	5.93%
Cooling Strategy	ONAN
Oil temperature rise	50°C
Winding temperature rise	55°C
Winding material	Copper

SgurrEnergy considers the overall the technical specification to be adequate for the PV projects and in line with the industry accepted standards.

### 3.3.3 Temperature Rise Detection and Protection

Inverter transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.4 Warranties and Guaranties

Based on the information available in public domain, SgurrEnergy understands the Shilchar transformers have been provided with a warranty of 60 months from date of dispatch. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards.

## 3.4 Conclusion on Major Plant Components

### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of JA Solar, Canadian Solar and Astronergy assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.

Further, according to the warranty documents available in public domain for all three module manufacturers, SgurrEnergy considers the warranty terms and conditions offered by all three manufacturers to be in-line with the industry standard and raises no major concern regarding the warranties offered. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.

### Inverters

SgurrEnergy has conducted review of the ABB PVS800-57-1000kW central inverter ABB PVS800-57-1000kW central inverter has the required certification for use in solar PV plants. In-house testing of the inverter and individual components is relatively extensive during the R&D phase with functional and temperature cycling testing of each manufactured inverter. ABB offers a product warrant of 5 years which is in line with the current industry standards.

In conclusion, ABB can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters.



ABB inverters have more than 3GW of installation worldwide. These inverters are quite known to the Indian market and have installed capacity of more than 1.3GW which demonstrates a good track record in the Indian solar PV market.

# Transformers

Voltamp has a track record of more than 53,000 transformer installation across India, Nepal, Sri Lanka, Bhutan, Indonesia, Middle East Asia, South East, and African Countries<sup>4</sup>. The accreditations for manufacturing facility gained by the company are considered fair and satisfactory.

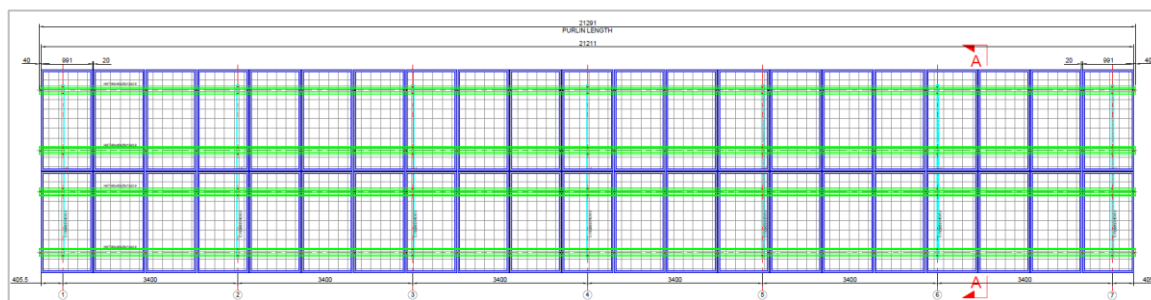
The inverter transformers (2200kVA) used within the project are manufactured by Voltamp Transformer Limited. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.

### 3.5 Module support structures

The Array Layout provided by the Client for the JA Solar(310/315Wp) PV modules indicates the fixed tilt module mounting structure is inclined at 8° tilt angle.

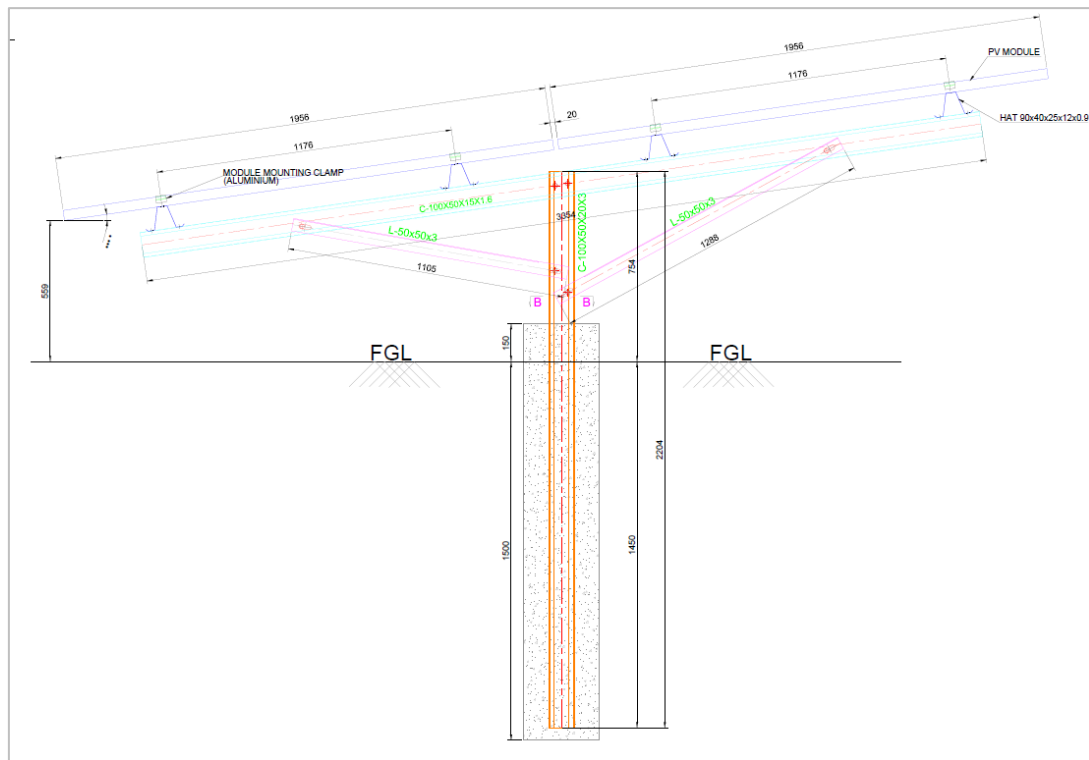
Following the review of as-built MMS GA drawing dated 03.07.2015, SgurrEnergy observed that the structure has been designed with two rows of modules placed in portrait orientation with 21 modules in each row. In total there are 42 modules in one mounting structure. The layout is designed with a pitch of 6m.

Figure 3-1 and Figure 3-2 illustrates the module mounting structure configuration provided by the Client for JA Solar PV modules.



**Figure 3-1: Two in portrait module mounting structure with 21 modules in a row**

<sup>4</sup> <http://www.voltamptransformers.com/index.php/dashboard/infrastructure>



**Figure 3-2: Side view of the module mounting structure configuration**

Based on the information provided in the GA drawing of the MMS, the technical specification has been summarized below.

Table 3-9 summarizes the technical specification of the module mounting structure.

**Table 3-9: Specification of MMS**

MMS Part	Material	Grades - Standard	Thickness (mm)	Minimum Yield Stress (MPa)
Rafter	Cold Formed	ASTM A653-340-1	1.6	350
Purlin	Cold Formed	ASTM A_792_2010/G_80_550_/CLASS_1	0.9	550
Leg	Cold Formed	E350- IS: 5986:2011	3.0	350
Bracing	-	-	3.0	350

Material used is a combination of hot-dipped galvanised mild steel and pre-galvanised cold rolled sheets sheared to form structural members for module mounting. The pre-galvanised sheets post process is appropriately coated with anti-corrosion compounds for the project life cycle.

SgurrEnergy was not provided with the information regarding type of pile used in the project. Further based on the information provided under GA drawing of the MMS, SgurrEnergy understands that the Owner has considered the wind speed of 39m/s according to IS 875 (part 3) – 1987.



## 4 Allied Components and Systems

### 4.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

### 4.2 PV Power Transfer

SgurrEnergy has reviewed the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear and metering yard as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

- “SWLB-SP-TN-13MW-E-DWG-DCSLD-100”, revision 0, dated 01.08.15.
- “SWLB-SP-TN-12MW-E-DWG-SLD-100B”, revision 0, dated 01.12.15.
- “SWLB-SP-TN-13MW-E-DWG-AL-101, dated 20.02.2016

SgurrEnergy is not provided with the 13MW<sub>AC</sub> DC SLD, however based on the review of AC SLD of 12MW<sub>AC</sub> solar PV plant, SgurrEnergy observed the AC schematic is same as of 13MW<sub>AC</sub> solar Pv plant, further the EPC contractor of both the PV plant under review is same entity, hence SEI envisages that the DC SLD is identical for 13MW<sub>AC</sub> solar PV plant.

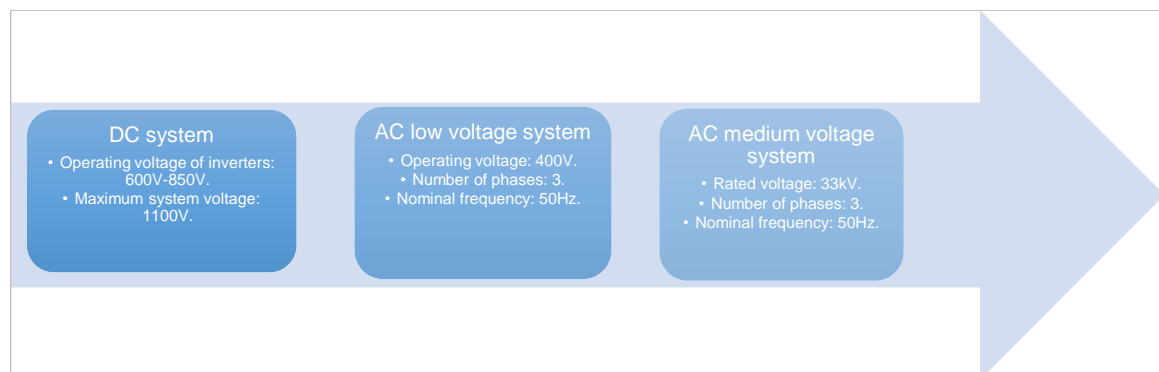
The 13MW<sub>AC</sub> solar PV Plant is designed with 310W<sub>P</sub>/ 315W<sub>P</sub> JA solar PV modules and 1000kW ABB inverters. Modules are interconnected to form a string of 21 modules. Each string forms a single output that feeds as a single input to the 12 input combiner boxes. Eight string combiner boxes are further connected to the inverter.

The 13MW<sub>AC</sub> solar PV plant has been configured with 13 ABB 1000kW central inverters and four inverter stations. Out of the total four inverter stations, three inverter stations of 4MW<sub>AC</sub> capacity contain four inverters of 1000MW capacities and two 3-winding transformers of 2.2MVA capacities. While one inverter station of 1MW<sub>AC</sub> capacity consists of one inverter of 1000kW capacity and one 2-winding, 1.1MVA transformer.

Each 4MW<sub>AC</sub> capacity inverter station consists of 2-sets of two 1000kW inverters connected to 0.400/0.400/33kV three-winding, 2.2MVA transformer, while the inverter station of 1MW<sub>AC</sub> capacity consists of one 1000kW inverter connected to 0.400/33kV two-winding, 1.1MVA transformer, that step up the voltage to 33kV for all inverter stations. The power from the HV side of the 33kV inverter transformer is transferred to 33kV HT panel.

The output power of each 33kV HT panel is connected to 33kV main HT panel located in the main control room. Further from the control room power is fed to 33kV DP structure and 33kV metering yard. Power from the metering yard is then evacuated to the 110/33KV M.Duraisampuram substation located approximately 8.75kms from the Project site.

Figure 4-1 below illustrates a power flow summary for the 13MW<sub>AC</sub> Solar PV plant.



**Figure 4-1: Power flow of 13MW<sub>AC</sub> PV plant**



### 4.3 Cabling

#### 4.3.1 DC Cabling

Although the DC SLD for 13MW<sub>AC</sub> Kovilpatti solar PV plant was not provided by the Client, however, SgurrEnergy observed that the contractor and the main SLD provided for 1313MW<sub>AC</sub> Kovilpatti solar PV plant and 12MW<sub>AC</sub> Amathur solar PV plant is similar. Hence, SgurrEnergy referred DC SLD provided for 12MW<sub>AC</sub> Amathur solar PV plant and the observations are as follows:

DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. Modules are interconnected in series with solar grade cables that are tied along with the module mounting structures. Modules are interconnected in leap-frog scheme to form a string of 21 PV modules connected in series.

The Y harness equipped with 30A fuse has been used to pre-combine the string of PV module. Single core 6mm<sup>2</sup> multi-stranded copper PV cables connect Y- harness output to String Combiner Box (SCB).

These combiner boxes are equipped with 30A fuse for each of the string connection and a 315A disconnect switch on output side. Power from string combiner box is further transferred to the inverter using 2 runs, 1C, 185/240/300mm<sup>2</sup>, 1.1kV aluminium XLPE ((2R X 1C X 185/240/300Sqmm, 1.1kV AL. XLPE Armoured) cables.

#### 4.3.2 AC Cabling

Three phase AC output from two inverters and single inverter are connected to the LV winding of a three-winding 2.2MVA and two-winding 1.1MVA transformers, respectively, using 12 Runs single core 630mm<sup>2</sup> Aluminium Armoured XLPE (12R (4R/Ph) X1C x 630mm<sup>2</sup> Al. Ar. XLPE) cable. The inverter transformers step up the voltage to 33kV.

Power is fed from the high voltage side of each transformer using 1R,3C, 185mm<sup>2</sup>, 33kV Al XLPE armoured cable to the 33kV HT panel in the 4MW<sub>AC</sub> inverter station using a radial feeder arrangement.

The 33kV output of each inverter station is transmitted to 33kV main HT panel located within Main control room using 1R,3C, 185mm<sup>2</sup>, 33kV(E) Al XLPE armoured HT cables.

The power from main control room is fed to 33kV DP structure and 33kV metering yard through single Runs three core, 300mm<sup>2</sup>, 33kV Aluminium XLPE Armoured (1R x 3C x 300sqmm 33kV[E], Al, XLPE, Ar.) cable.

Power at 33kV is then evacuated through overhead line to the 110/33KV M.Duraisampuram substation located approximately 8.75kms from the Project site.

### 4.4 Inverter Station

The 13MW<sub>AC</sub> solar PV plant has been configured with 13 inverters and four inverter stations. Three inverter stations consist of four inverters and one inverter station comprises of one inverter.

Each 4MW<sub>AC</sub> inverter station consists of two-sets of two inverters connected to a 2,200kVA three-winding transformers, while 1MW<sub>AC</sub> inverter station consists of one inverter connected to a 1,100kVA two-winding transformer. Each transformer, along with allied switchgears, steps up the voltage to 33kV for all inverter stations. Further the power from the HV side of the transformer is fed to the 33kV outdoor type HT panel through radial feeder arrangement.

33kV outdoor type HT panel comprises of 50/5-5A current transformer, 33kV/110V fixed type potential transformer, 33kV EDO TP, 630A Vacuum Circuit Breaker and other electrical protection system.





#### 4.5 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed 2.2MVA, 33kV/2x0.400kV, Dy11y11 three-winding transformers and 1.1MVA, 33kV/0.400kV two-winding transformer have been used in the project. These inverter duty transformers step up the voltage to 33kV.

The 2.2MVA inverter duty transformers output is connected to 33kV HT panels located within inverter station. The energy from all the inverter stations 33kV HT panels and 1KW<sub>AC</sub> inverter station are radially combined at 33kV main HT panel located within main control room.

#### 4.6 33kV Main HT Panel

A 33kV main HT panel comprises of inverter station incoming feeders, one outgoing feeders. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class. All feeders have been provided with relay and metering unit. The 33kV main HT panel outgoing and incoming feeders are provided with instantaneous and IDMT (50/51) O/C relay instantaneous and IDMT (50N/51N) E/F relay protections. The 33kV outgoing feeders are provided with 0.2S class instrument transformers.

Power is fed from 33kV main HT panel to 33kV DP structure and metering yard.

#### 4.7 33kV Metering Yard

The 33kV main HT panel outgoing feeders are connected to 33kV DP structure and 33kV Metering yard.

The 33kV metering yard is observed to be equipped with instrument transformers, isolator, and lightning arrestor with metering & protection cores. The 30kV, 10kA lightning arrestor is provided at 33kV incoming feeders to discharge surge currents caused by lightning strokes.

Subsequently energy from 33kV plant end metering yard is evacuated to 110/33KV M.Duraisampuram at 33kV level through dog ACSR single conductor overhead transmission line.

#### 4.8 Auxiliary Power Supply

SgurrEnergy had reviewed the electrical schematics shared for the projects to evaluate auxiliary system. The 4MW<sub>AC</sub> and 1MW<sub>AC</sub> inverter stations are equipped with 15kVA and 40kVA auxiliary transformers, respectively.

#### 4.9 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying, and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are normally mounted on individual structures.

Following the review of 33kV SLD, SgurrEnergy observed 33kV, 630A, 25kA/1sec load break switch has been used in the project.

#### 4.10 Isolators

Isolators are used to transfer load from one bus to another and also to isolate equipment for maintenance.

Based on the review of 33kV SLD, SgurrEnergy observed 33kV, 630A isolator with earth switch has been used in the project.



#### 4.11 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.

The current transformers with accuracy class of 0.2s for metering and class 5P and PS for protection has been used in 13MW<sub>AC</sub> solar PV plant. The potential transformers with accuracy class of 0.2 for metering and class 3P for protection has been used in the project.

#### 4.12 Surge Arrestors and Lightning Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes on the lines entering the substation. The apparatus most commonly used for this purpose are the surge arrestors and the lightning arrester. Transformer is the costliest equipment in substation, and it is normal practice to install lightning arrester near to the transformer. Additional lightning arresters is provided on various lines for protection of the equipment.

Following the review, SgurrEnergy observed 30kV, 10kA, surge arrestor and lightning arrester has been used in 33kV main HT panel and 33kV metering yard, respectively.

#### 4.13 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy is provided at the inverter station for each of the feeder sections. These meters are digital with an RS485 port for remote monitoring. These usually have an accuracy class of 0.5.

Similarly, HV side is equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point is 0.2S.





## 5 System Design Appraisal

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

### 5.1 Plant Layout Design

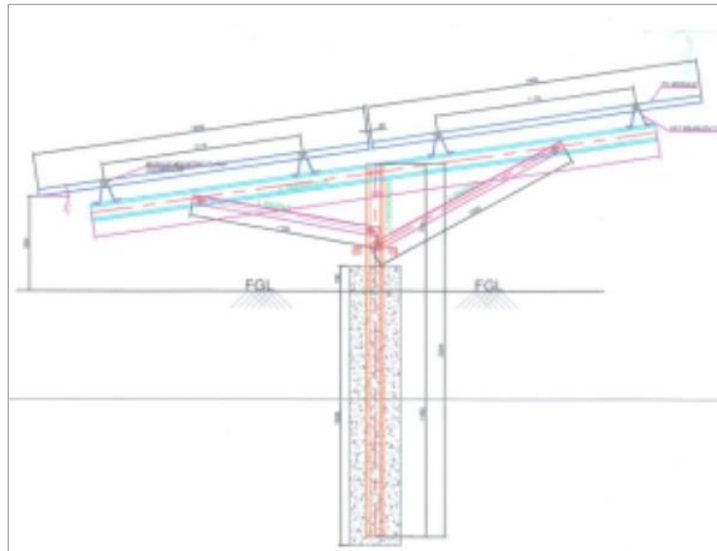
SgurrEnergy was provided with as built plant layout and electrical schematics. SgurrEnergy has verified the plant configuration with electrical schematics provided by the Client. The PV plant is JA Solar (310W<sub>p</sub> and 315W<sub>p</sub>) PV modules. The total DC installed capacity stands at 15.6MW<sub>p</sub>. The AC installed capacity stands at 13MW<sub>AC</sub> with 13 inverters of capacity 1,000kW each. Overall 13MW<sub>AC</sub> PV plant is illustrated below in the Figure 5-1.



**Figure 5-1: Plant layout of 13MW<sub>AC</sub>**

All the PV modules are orientated towards South. The mounting structure provides support for two rows of panels in portrait orientation.





**Figure 5-2: Side view of typical module mounting structure configuration**

The selected tilt for the 13MW<sub>AC</sub> plant is 8°. The 13MW<sub>AC</sub> plant is designed with a pitch of 6m.

Based on regional experience of detail designing, SgurrEnergy considers the selected tilt angle and pitch is optimized for maximum irradiation on the collector plane, minimum loss due to inter row shading, minimum ohmic losses and ease of maintenance.

21 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.2. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.

## 5.2 String Sizing

The plant layout provided by the Client indicate thirty 310W<sub>p</sub> and 315W<sub>p</sub> JA Solar polycrystalline modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage ( $V_{OC}$ ) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum  $V_{OC}$  of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy in validating string configuration. Subsequent to calculating open circuit voltage ( $V_{OC}$  max), maximum power voltage ( $V_{mp}$  min) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 40°C and 15°C respectively for system design validation to be fair and representative for the PV plants' site.

The results of string sizing validation are presented in Table 5-1. Results indicate that  $V_{OC}$  max at the minimum ambient temperature is within the maximum system voltage of 1,000V for the selected ABB inverters.

**Table 5-1: String Sizing for JA Solar PV Modules**

Parameters	JA 310W <sub>p</sub>	JA 315W <sub>p</sub>
PV module power (W <sub>p</sub> )	310	315



Modules per string	21	
Inverters	ABB (PVS-800-57-1000kW)	
Maximum Open-circuit voltage ( $V_{oc}$ max) at minimum ambient temperature of 15°C	987V	991V
Minimum power voltage ( $V_{mp}$ min) at maximum ambient temperature of 40°C	905.1V	907V

### 5.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with JA Solar and ABB inverter is presented in Table 5-2. SgurrEnergy has selected the highest rated JA Solar module (315W<sub>p</sub>) their compatibility with ABB inverters, as SgurrEnergy considers this to be representative for all the JA Solar PV modules installed on site.

**Table 5-2: Inverter Compatibility with JA Solar 315W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>JA Solar 315W<sub>p</sub></b>	
Modules per string	21	Acceptable
Strings per inverter	182	Acceptable
Maximum power, $P_{mpp}$ at STC (kWp)	1,203.9	Nominal power ratio is 1.20, this is within the inverter bus current carrying capacity.
Maximum power voltage, $V_{mpp}$ at STC (V)	782.8	Acceptable.
Maximum power current, $I_{mpp}$ at STC (A)	1,537.9	Acceptable
Open-circuit voltage, $V_{oc}$ at STC (V)	957.6	Acceptable.
Minimum MPP voltage at 40°C ambient temperature (V)	730.8	Acceptable: Inverter MPPT ranges 600 - 850V.
Maximum MPP voltage at 15°C ambient temperature (V)	814.8	Acceptable: Inverter MPPT ranges 600 - 850V.
Maximum open circuit voltage, $V_{oc}$ at 15°C (V)	991	Acceptable: Maximum inverter voltage 1000V.

Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.



## 6 Resource assessment

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SgurrEnergy has sourced monthly horizontal plane irradiation data for the Project site from:

- **NASA's Surface Meteorology and Solar Energy data set**; holds satellite derived monthly data for a grid of 0.5° × 0.5° covering the globe for a thirty-four-year period

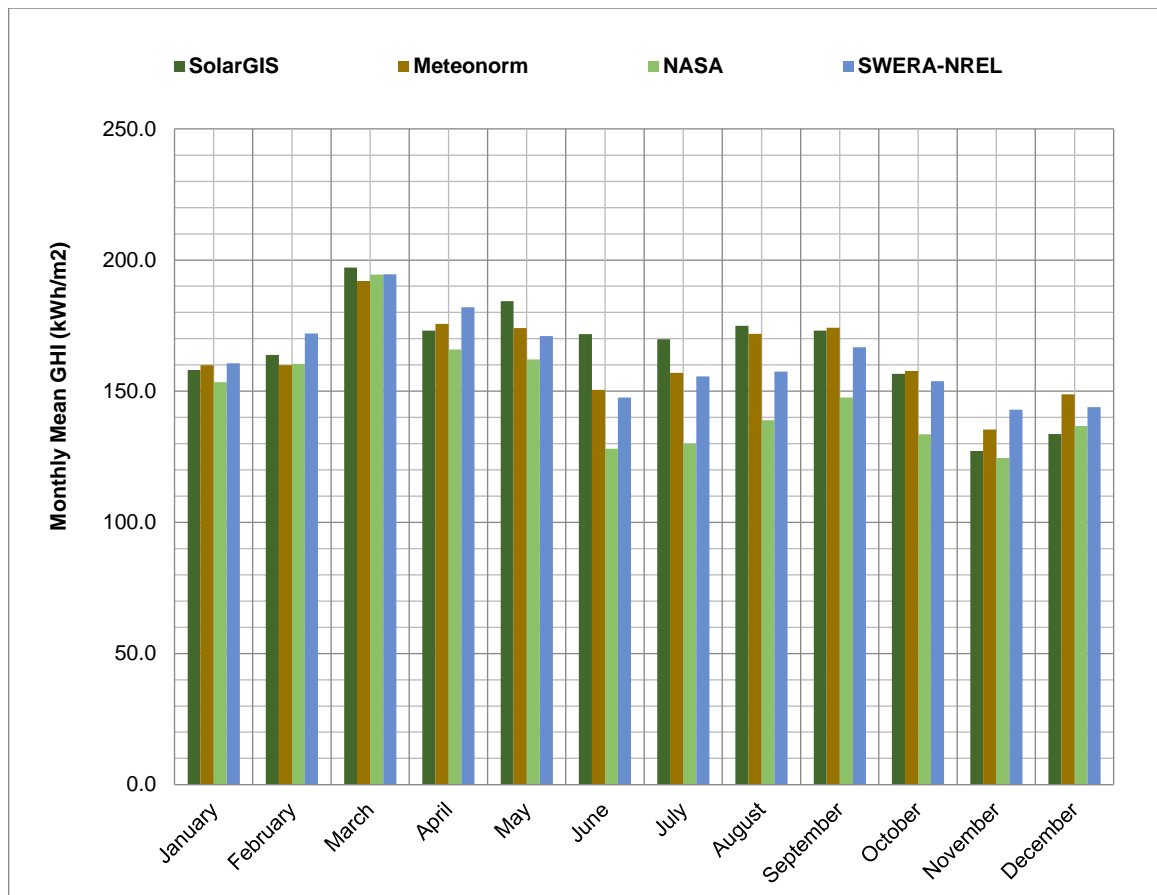


(1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.

- **The *METEONORM (version 7.3)* global climatological database and synthetic weather generator**; contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.
- **SolarGIS**: SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km x 4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by *IEA (International Energy Agency) SHC Collaboration Agreement, and EU FP6 project MESoR* in terms of bias and RMSE.

SgurrEnergy has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS data for the site. The comparison is graphically illustrated Table6-1





**Figure 6-1: Monthly Global Horizontal Irradiation**

**Table6-1: Comparison of Solar Irradiation Datasets for the site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	1,983.5
Meteonorm 7.3	14km × 14km	4.0%	1,957.1
NASA	55km × 55km	Unknown	1,775.6
NREL (SWERA)	40km × 40km	Unknown	1,948.2

The comparison of solar data for Project site location illustrated in Table6-1 indicates SolarGIS dataset to give the highest irradiation levels. The next highest irradiation is given by Meteonorm 7.3 followed by NREL (SWERA) and NASA.

The irradiation values given by Meteonorm 7.3 typically provide a combination of ground and satellite measured data. Meteonorm 7.3 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as 7% for the proposed site.

The NASA-SSE data source provides purely satellite measured data for a grid covering  $0.5^\circ \times 0.5^\circ$  on the earth's surface and generally more suited for initial site selection.

The NREL (SWERA) data illustrated has been obtained for a location approximately 13.07 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data

The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also





been compared with other data sources globally. The IEA (International Energy Agency) validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>5</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)
- Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 6%.

SgurrEnergy is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 6.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 6-2 and shown graphically in Figure 6-2. Diffuse irradiation accounts for 47.47% of the total irradiation. Table 6-2 illustrates direct and diffuse daily irradiation on a horizontal plane for the proposed site. SolarGIS irradiation data is presented in Table 6-2.

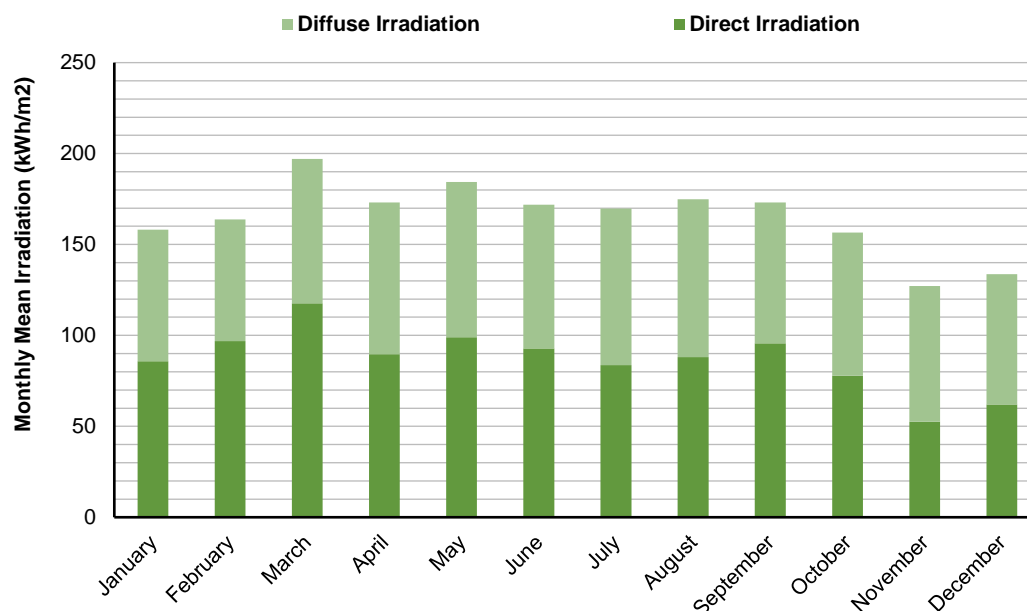
**Table 6-2: SolarGIS Irradiation Data for the Project sites**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	158.1	72.2	8.0%
February	163.8	66.9	8.3%
March	197.1	79.4	9.9%
April	173.1	83.4	8.7%
May	184.3	85.3	9.3%
June	171.8	78.9	8.7%
July	169.8	86.2	8.6%
August	174.9	86.8	8.8%
September	173.1	77.4	8.7%
October	156.6	78.7	7.9%

<sup>5</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>



Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
November	127.2	74.7	6.4%
December	133.7	71.6	6.7%
<b>Annual Sum</b>	<b>1,983.5</b>	<b>941.5</b>	<b>-</b>



**Figure 6-2: Monthly Direct and Diffuse Irradiation on a horizontal plane for the project site**

## 6.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.1.1), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -6-3 represents the monthly GTI profile.

**Table -6-3: Monthly Global Tilted Irradiation Data**

Month	GTI (kWh/m <sup>2</sup> )
January	169.30
February	171.90
March	200.90
April	171.10
May	178.30
June	164.30
July	163.70
August	171.60
September	174.40
October	161.90





Month	GTI (kWh/m <sup>2</sup> )
November	133.30
December	142.20
<b>Annual Sum</b>	<b>2,002.90</b>

### 6.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 6-4 below. The average wind speed of 1.4 m/s was measured at 10m height from ground level for the proposed project site location.

**Table 6-4: Simulated Wind Speed for site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	0.9
February	1
March	1.2
April	1.2
May	1.6
June	1.8
July	2.2
August	2.1
September	1.7
October	1.1
November	0.7
December	0.8
<b>Yearly Average</b>	<b>1.4</b>

### 6.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.

**Table 6-5: SolarGIS Temperature Data for Site (1999 – 2018)**

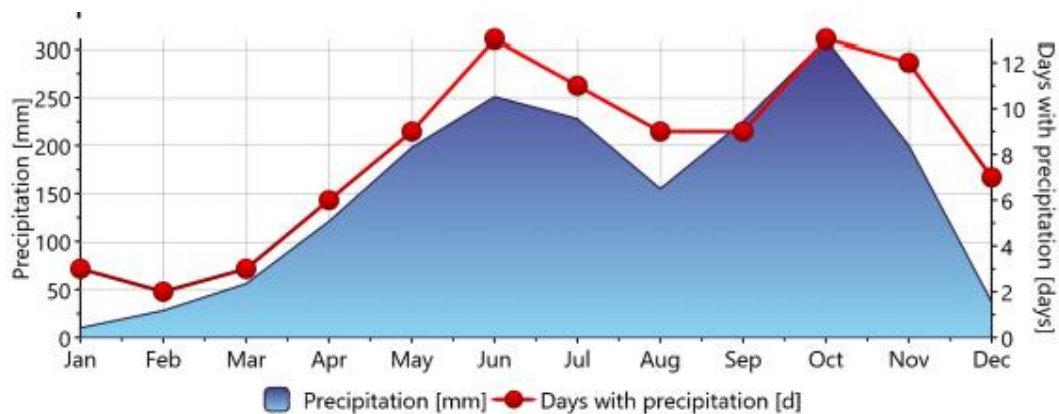
Months	Average Monthly Temperature (°C)
January	25.4
February	26.9



Months	Average Monthly Temperature (°C)
March	29.1
April	30.6
May	30.8
June	28.9
July	28.4
August	28.6
September	28.8
October	27.7
November	26.0
December	25.1
<b>Annual Average</b>	<b>28.0</b>

### 6.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.3 as illustrated in Figure 6-3. These figures show that the identified site is situated in a region that has marginal rainfall.



**Figure 6-3 Meteonorm Predicted Precipitation for the site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

Frequency of module cleaning depends on the rainfall frequency and the prevalence of dust and pollution in the local vicinity. Typical cleaning techniques include water cleaning, dry brushes or vehicle-based mechanical cleaning.

The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 1.5% has been considered by considering cleaning frequency of twice a month.



## 7 Energy yields

SgurrEnergy has computed the annual energy yields for the 13 MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

Parameter	Description
Modules	JA Solar (JAP6-72-310/3BB, JAP6-72-315/3BB)
Inverters	ABB Central Inverters – 1.0MW <sub>AC</sub> (PVS800-57-1000kW-C)
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	15.6

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 7.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in Table 7-1 below.

**Table 7-1: Description of Energy Yield Losses**

Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.



Loss	Description
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 13 MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 7.2 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 13 MW<sub>p</sub> solar PV Plant with JA solar modules and ABB inverters. Table 7-2 summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.



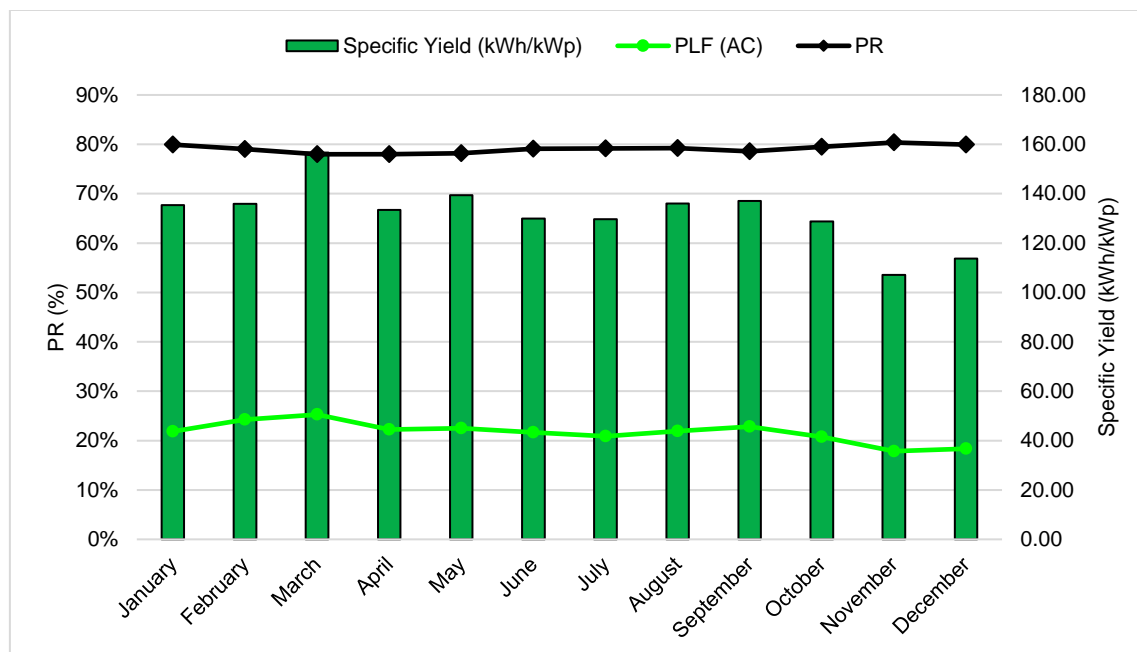
**Table 7-2: Energy Yield for the 13 MW<sub>AC</sub> Solar PV Plant**

Parameters	Description
PV Module Technology	Polycrystalline
DC Capacity (MW <sub>p</sub> )	15.6
AC Capacity (MVA)	13
Contracted Capacity (MW)	13
P <sub>NOM</sub> Ratio	1.20
Tilt (°)	8
Pitch (m)	6
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1,983.50
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	2,002.90
Transposition Factor	1.01
<b>Losses</b>	
Horizon Shading	0.00%
Incident Irradiation Below Threshold	0.00%
Near Shading	0.33%
Incident Angle	2.07%
Soiling	1.50%
Low Irradiance	0.53%
Module Temperature	9.10%
Electrical Shadings	0.00%
Module Quality	0.00%
First year Degradation	1.50%
Module Mismatch	1.00%
DC Ohmic	1.05%
Inverter Performance	1.77%
Availability	1.00%
AC Ohmic	0.55%
Transformer (LV/MV)	1.07%
Transformer (MV/HV)	-
Transmission Line	2.02%
Auxiliary Consumption	0.60%
Curtailment	
<b>Total Annual Loss Factor</b>	<b>0.790</b>
<b>Fifth Year P50 Energy Yield (MWh/annum)</b>	<b>24,204.76</b>
<b>Fifth Year Specific Yield (kWh/kW<sub>p</sub>)</b>	<b>1551.58</b>
<b>Fifth Year CUF on AC Installed Capacity</b>	<b>21.25%</b>
<b>Fifth Year CUF on Contracted Capacity</b>	<b>21.25%</b>



Parameters	Description
Fifth Year CUF on DC Installed Capacity	17.71%
Fifth Year Performance Ratio	77.46%

Graphical representation of the monthly generation, performance ratio and CUF for 13 MW<sub>AC</sub> evaluated is illustrated graphically in the Figure 7-1.



**Figure 7-1: Monthly Energy Yield for 13 MW<sub>AC</sub>**

### 7.3 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 7.3.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

#### 7.3.2 Inter – Annual Variation in the Solar Resource

Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.

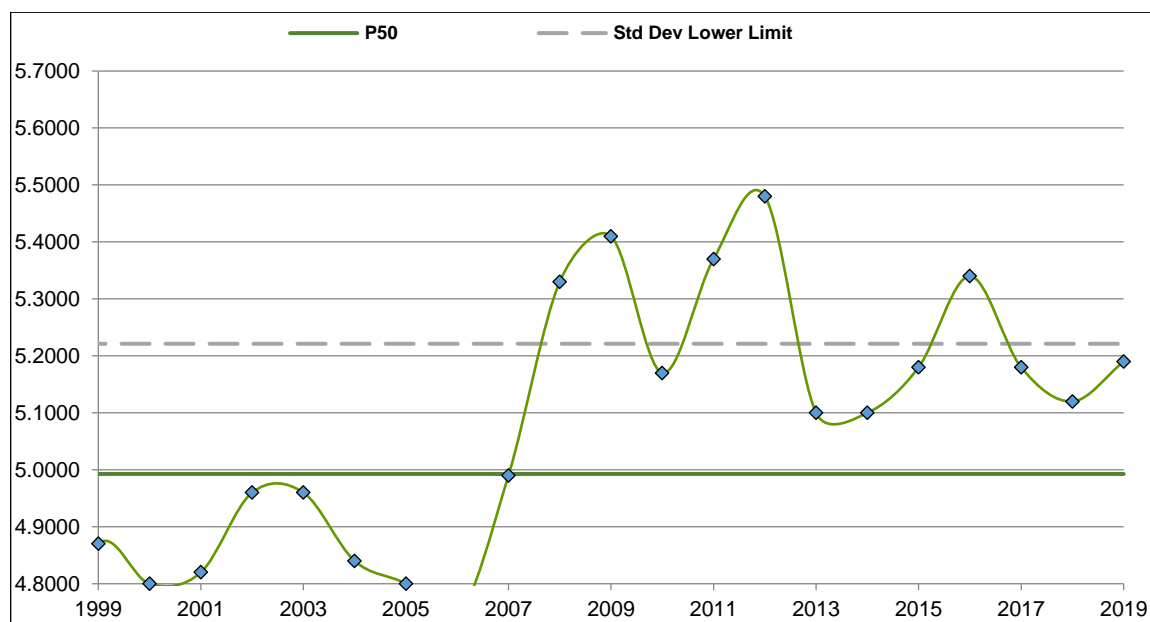
The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database



for the proposed site location which is used to estimate the standard deviation of variation in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 7-3.

**Table 7-3: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	4.58



**Figure 7-2: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in

Figure 7-2.

SgurrEnergy uses a coefficient of variation of 4.58% to quantify the inter-annual variation in the solar resource.

### 7.3.3 Modelling Uncertainty

The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

### 7.3.4 Total Uncertainty (P75, P90 and P99 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.



**Table 7-4: Life Cycle P50, P75 and P90 Generation Prediction for 13 MW<sub>AC</sub>**

Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>6</sup> (MWh/annum)	P90 Generation Prediction <sup>7</sup> (MWh/annum)
5	24,204.76	23,168.11	22,235.09
6	24,083.74	23,052.27	22,123.91
7	23,963.32	22,937.01	22,013.29
8	23,843.51	22,822.32	21,903.23
9	23,724.29	22,708.21	21,793.71
<b>10</b>	<b>23,605.67</b>	<b>22,594.67</b>	<b>21,684.74</b>
11	23,487.64	22,481.70	21,576.32
12	23,370.20	22,369.29	21,468.44
13	23,253.35	22,257.44	21,361.10
14	23,137.08	22,146.16	21,254.29
15	23,021.40	22,035.42	21,148.02
16	22,906.29	21,925.25	21,042.28
17	22,791.76	21,815.62	20,937.07
18	22,677.80	21,706.54	20,832.38
19	22,564.41	21,598.01	20,728.22
<b>20</b>	<b>22,451.59</b>	<b>21,490.02</b>	<b>20,624.58</b>
21	22,339.33	21,382.57	20,521.46
22	22,227.63	21,275.66	20,418.85
23	22,116.50	21,169.28	20,316.76
24	22,005.91	21,063.43	20,215.17
<b>25</b>	<b>21,895.88</b>	<b>20,958.12</b>	<b>20,114.10</b>

<sup>6</sup> The P75 values have been calculated over 10-year averages<sup>7</sup> The P90 values have been calculated over 10-year averages



## 8 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 0.6% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) and henceforth. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Client, SgurrEnergy understands that the 13MW UMD solar PV plant was commissioned on 21<sup>st</sup> March 2016. SgurrEnergy was provided with plant and grid availability records from March 2016 to March 2021<sup>8</sup> for the solar PV plant. Furthermore, the irradiation measurement records were provided from April 2016 to March 2021.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from April 2016 to March 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Client.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

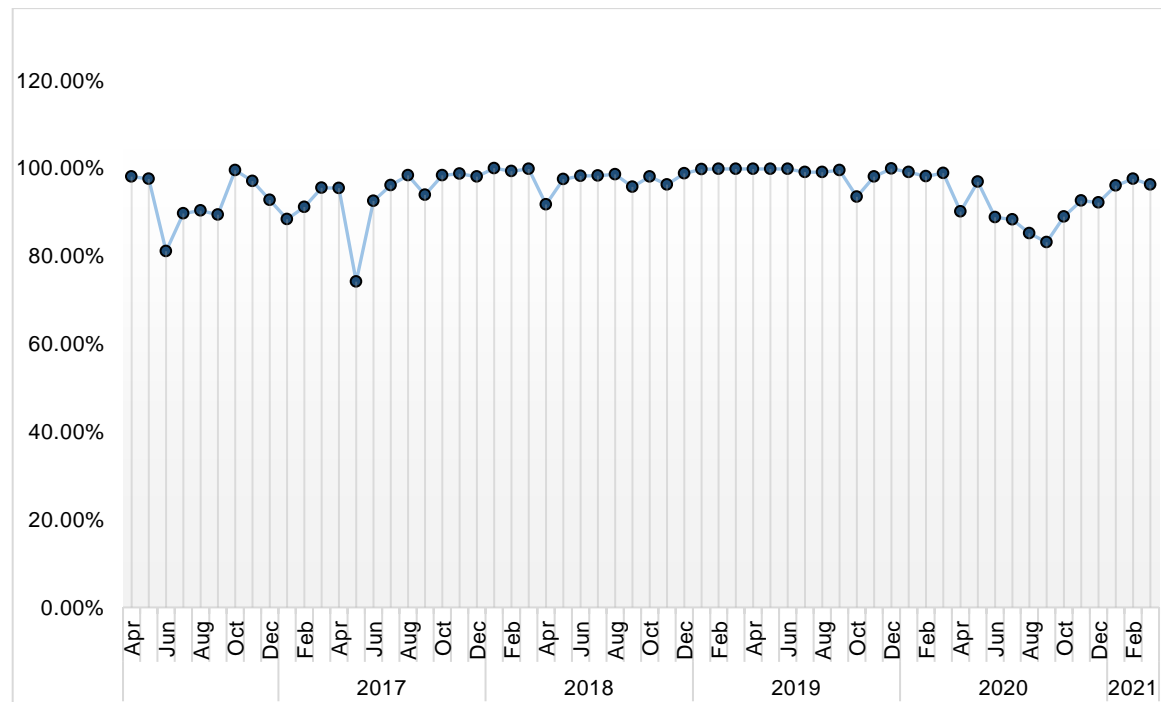
The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Owners control.

The monthly records of the grid availability from April 2016 to March 2021 have been graphically illustrated in Figure 8-1 below.

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<sup>8</sup> SgurrEnergy was provided with both the plant and grid availability records until March 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.





**Figure 8-1: Grid Availability**

Based on the above illustration, SgurrEnergy notes the grid availability for the UMD 13MW solar PV plant is notably inconsistent for all the months ranging between 74.16% to 99.98%.

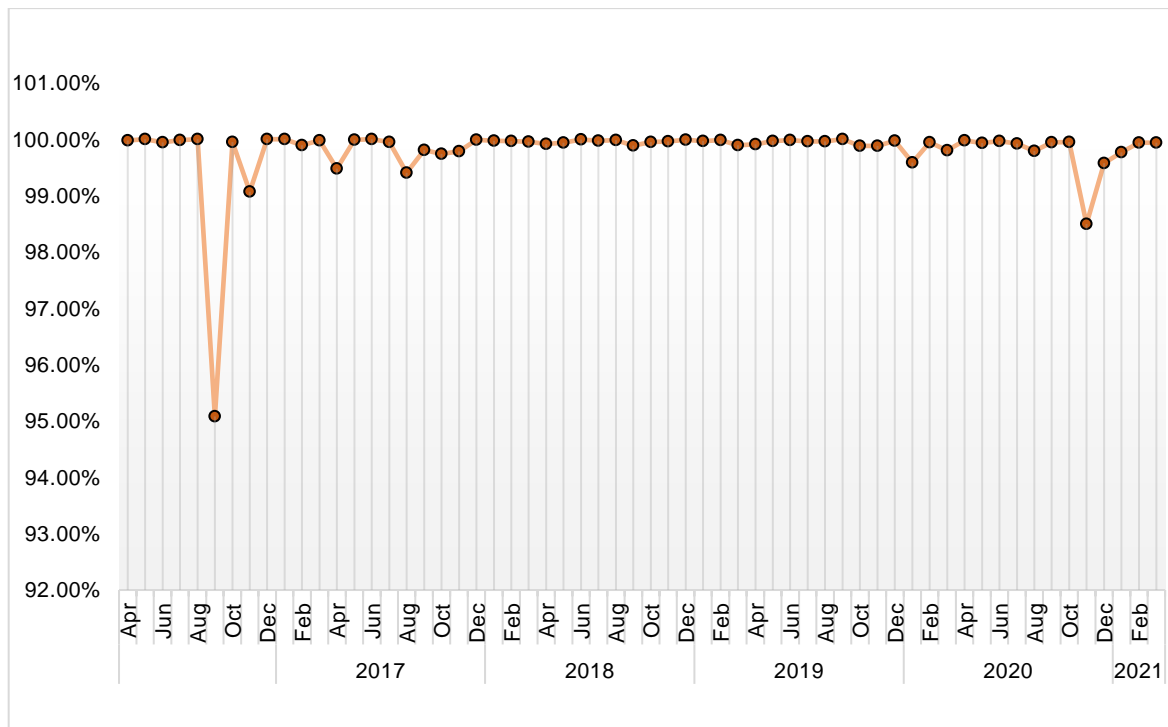
The resultant overall grid availability of the PV plant for the period evaluated was 95.13%. SgurrEnergy considers that the unavailability loss experienced due to grid anomalies for the operational period is higher than the expected range.

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the UMD 13MW solar PV plant is graphically illustrated below in Figure 8-2.





**Figure 8-2: Plant Availability**

Based on the above illustrations, SgurrEnergy notes the plant availability for the UMD 13MW solar PV plant was above 99% for substantial amount of time over the operational period of the plant.

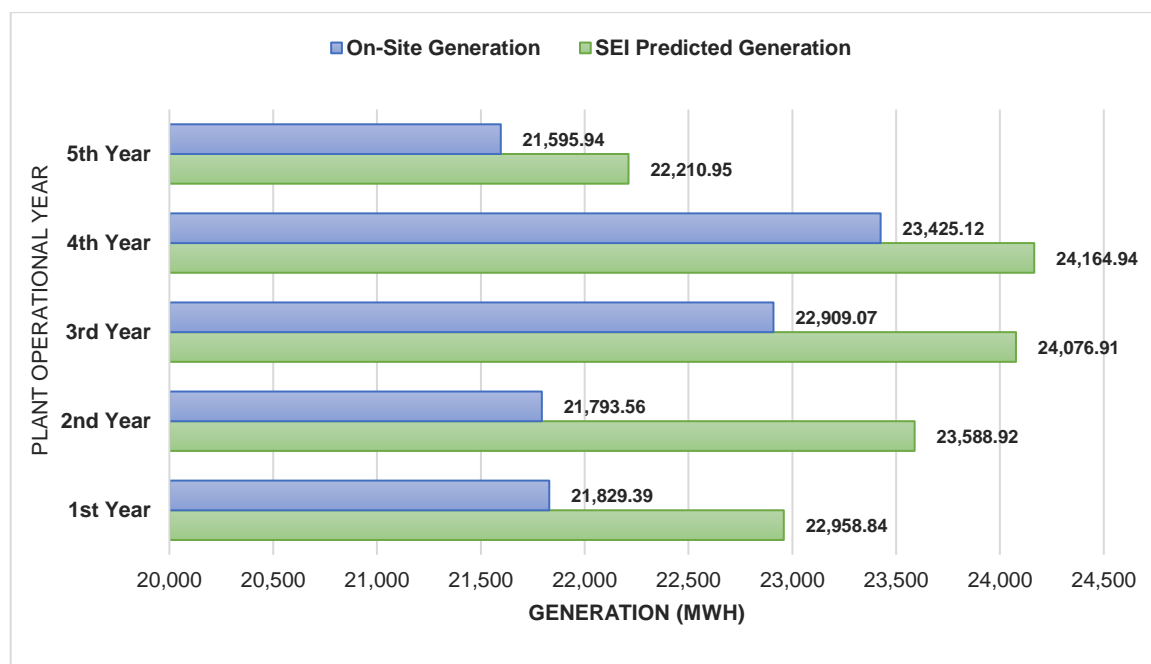
The resultant average plant availability of the PV plant for the period evaluated was 99.79% which is considered to be within expected range.

## 1.2 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Client. To make the operational energy yield predictions more representative, SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Client. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Client.

The yearly comparison of the generation data is illustrated below in Figure 8-3.





**Figure 8-3: Generation Comparison**

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 8-1.

**Table 8-1: PV Plant Performance – UMD 13MW**

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>9</sup> (%)
Apr 2016 -March 2017	22,958.84	21,829.39	-4.92%
Apr 2017 -March 2018	23,588.92	21,793.56	-7.61%
Apr 2018 -March 2019	24,076.91	22,909.07	-4.85%
Apr 2019 -March 2020	24,164.94	23,425.12	-3.06%
Apr 2020 -March 2021	22,210.95	21,595.94	-2.77%
<b>Cumulative Period</b>	<b>117,000.56</b>	<b>111,553.07</b>	<b>-4.66%</b>

Based on the above comparison, SgurrEnergy notes that the PV plant is generating lower than the expected yield. However, SgurrEnergy considers that the variations in the energy yield can be attributed to lower irradiation level experienced on the Project site. The irradiation levels significantly impact the actual generation from the PV plant as the system losses may vary significantly due to slight change in the irradiation.

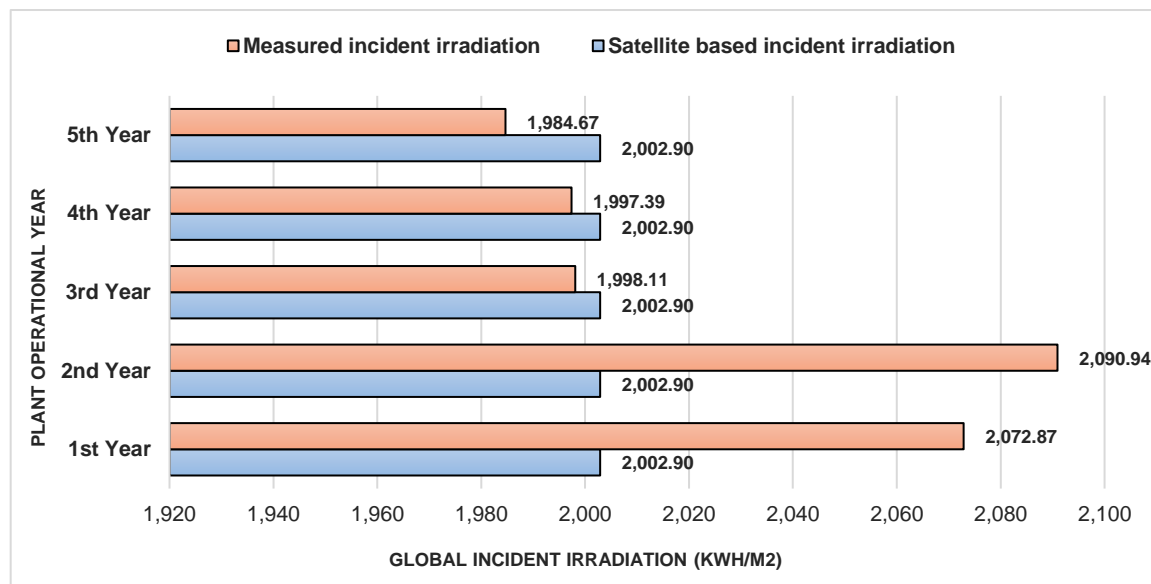
In order to understand the deviation in the irradiation pattern, SgurrEnergy has compared the monthly incident irradiation data provided by the Client with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation. The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 8-4.

<sup>9</sup> Positive values indicate higher generation, while negative values indicate lower generation



**Table 8-2: Irradiation Comparison– UMD 13MW**

PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>10</sup> (%)
Apr 2016 -March 2017	2,002.90	2,072.87	3.49%
Apr 2017 -March 2018	2,002.90	2,090.94	4.40%
Apr 2018 -March 2019	2,002.90	1,998.11	-0.24%
Apr 2019 -March 2020	2,002.90	1,997.39	-0.28%
Apr 2020 -March 2021	2,002.90	1,984.67	-0.91%
<b>Cumulative Period</b>	<b>10,014.50</b>	<b>10,143.98</b>	<b>1.29%</b>

**Figure 8-4: Irradiation Comparison**

Based on the above illustrations, it is observed that the overall recorded generation is approximately 4.66% lower than the generation predicted on site. Correspondingly, it has also been observed that the irradiation measured on site is approximately 1.29% higher than the predicted irradiation.

SgurrEnergy thus infers that the PV plant is underperforming based on the conditions experienced on site.

<sup>10</sup> Positive values indicate higher irradiation, while negative values indicate lower irradiation



## 9 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar PV plants as having a lifetime of 25-40 years<sup>11</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>12</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the PV plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement.

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<sup>11</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>12</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>



Virescent Infrastructure

30MW(AC) Tiruvannamalai Solar PV Plant  
Shapoorji Pallonji Solar PV Pvt Ltd  
Technical Assessment Report

May 2021



## Report Details

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### Amendment Records

Revision Number	Date	Purpose of Revision	Summary of Amendments
A1	09.02.2021	Draft Issue	-
B1	09.02.2021	For Client Issue	-
B2	19.02.2021	For Client Issue	Minor Changes
B3	22.02.2021	For Client Issue	Finalisation of Report
B4	28.05.2021	For Client Issue	Generation Analysis Updated

SF/04/023

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## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 50MW<sub>AC</sub> Shapoorji Pallonji Suryaprakash Pvt Ltd (SEPEPL) solar PV plant (the Project). The Project is located near the Rajapalyam village, in Virudhunagar district of Tamil Nadu.

The summary of the technical assessment is captured in the below table.

**Table 1-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	<p>The project site lies around the coordinates 12°20'38.76"N and 78°56'45.24"E and is located near the Aliandal village, in Thiruannamalai district of Tamil Nadu.</p> <p>Project is contracted for generating 30MW<sub>AC</sub> power. The Owner has utilised approximately 160 acres of land for the project.</p> <p>Project is implemented with poly-crystalline modules (Talesun Solar) and central inverters (ABB). The module mounting structure is implemented with a tilt of 10° for a pitch of 6m.</p> <p>The power generated from the TNSPEPL 30MW<sub>AC</sub> PV plant is fed to Kanji substation substation, through a single circuit transmission line.</p> <p>The total DC installed capacity stands at 36MW<sub>p</sub>. The AC installed capacity stands at 30MW<sub>AC</sub> with 30 inverters of capacity 1,000kW each.</p>
2	PV Module	<p>SgurrEnergy has conducted a desktop review of Talesun Solar assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard. SgurrEnergy considers the warranty period to be in line with the industry standards. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.</p>
3	Inverter	<p>ABB is considered to have good track record for supplying central inverters. Certificates mentioned in the technical specification datasheet indicate ABB to hold adequate certifications. Technical characteristics are acceptable, with a good efficiency level for central inverters. Standard warranty of five years is provided for the inverters, which is in line with the industry requirement. Overall, SgurrEnergy does not raise any concern on the utilization of ABB inverters for the Project.</p>
4	Inverter Transformer	<p>The inverter transformers (1100kVA and 2200kVA) and power transformer (15/18MVA) used within the project are manufactured by Shilchar Technologies Limited and Andrew Yule &amp; Co., Ltd., respectively. The manufacturers have a good track record of supplying transformers to distinguished customers in Indian as well as in the global market. SgurrEnergy has reviewed the</p>



Sr. No.	Parameter	Comment				
		transformers based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project				
5	String Sizing	The $V_{OC}$ does not exceed the inverter input voltage for the site, and therefore, SgurrEnergy considers the number of modules in series to be acceptable for the PV Project.				
6	Permits and Approvals	PPA signed between Shapoorji Pallonji Solar PV Pvt Ltd and Tamil Nadu Generation and Distribution Corporation Limited. PPA term is 25 years from the Commercial Operation Date. Documents such as CEIG certificate, commissioning certificate, consent to operate etc. have not been provided.				
7	Resource Assessment	For resource analysis, SEI has compared various satellite datasets. For the satellite databases, SEI has compared Meteonorm 7, NASA, SWERA and SolarGIS data to find the most suitable solar resource for long-term energy yield prediction. Owing to low uncertainty and high resolution, SEI considers SolarGIS dataset to be the most representative satellite database among all the satellite databases for long-term energy yield assessment.				
8	Operational Analysis and Generation Comparison	Review of Operational Analysis and Genration comparison has been presented in Section 8.				
9	Allied Components and Systems	<p>The 30MW<sub>AC</sub> PV plant is designed with 310Wp Talesun solar PV modules and 1000kW ABB inverters.</p> <p>The Project has been implemented with eight inverter station out of which four inverter station comprises of four inverters each while two inverter station comprises of three inverters each. The AC capacity of each inverter station is 4WM<sub>AC</sub> and 3WM<sub>AC</sub>.</p> <p>The 11kV output of each inverter station is combined at 11kV main HT panel located within main control room. The energy at 11kV is further stepped up to 110kV within the 110/11kV substation through two 15/18MVA ONAN/ONAF two winding power transformers.</p> <p>The power is transferred to Kanji substation located approximately 5.5kms from the Project site through Dog ACSR Panther single circuit overhead line.</p>				
10	Energy Yield Assessment	<p>Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for third year of plant operation for the 30 MWAC PV plant.</p> <table><tr><td>Global Horizontal Irradiation (kWh/m2)</td><td>1,973.90</td></tr><tr><td>Global Inclined Irradiation (kWh/m2)</td><td>2,014.70</td></tr></table>	Global Horizontal Irradiation (kWh/m2)	1,973.90	Global Inclined Irradiation (kWh/m2)	2,014.70
Global Horizontal Irradiation (kWh/m2)	1,973.90					
Global Inclined Irradiation (kWh/m2)	2,014.70					



Sr. No.	Parameter	Comment	
		Fifth Year P50 Energy Yield (MWh/annum)	56,232.22
		Specific Yield (kWh/kWp)	1561.42
		Performance Ratio (PR)	77.49%
		PLF on Contracted Capacity (30MWAC)	21.39%



## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
m	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon





MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation



## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 258MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of six projects, as presented within Table 1-1.

**Table 1-1: Project Key Summary**

Project Name	SEPEPL – 80MW <sub>AC</sub>	SEPEPL – 50MW <sub>AC</sub>	SPSPL – 50MW <sub>AC</sub>	SPSPPL – 30MW <sub>AC</sub>	TNSPEPL – 5MW <sub>AC</sub> + 8MW <sub>AC</sub> + 10MW <sub>AC</sub>	UMD- 12MW <sub>AC</sub> + 13MW <sub>AC</sub> +
Site Location	18.926°N, 76.395°E, Parli, Maharash- tra, India	21.028°N, 75.985°E, Muktainagar Maharashtra ,India	9.324°N, 77.594°E. Rajapalyam, Tamil Nadu,India	12.344°N, 78.945°E Tiruvannam- alai, Tamil Nadu, India.	5MW <sub>AC</sub> – 10.480°N, 78.061°E Dindigul, Tamil Nadu, India 8MW <sub>AC</sub> – 9.437°N, 78.172°E Aruppukkotai Tamil Nadu, India 10MW <sub>AC</sub> – 9.118°N, 78.107°E Vilathikulam, Tamil Nadu, India	12MW <sub>AC</sub> - 9.554°N, 77.884°E Amathur, Tamil Nadu, India 13MW <sub>AC</sub> - 9.093°N, 77.780°E Kovilpatti, Tamil Nadu, India
Owner	Solar Edge Power and Energy Private Limited (SEPEPL)		Shapoorji Pallonji Suryaprakas h Private Limited (SPSPL)	Shapoorji Pallonji Solar PV Private Limited	TN Solar Power Energy Private Limited	Universal Mine Developers and Service Providers Private Limited
DC / AC Capacity	104.0MW <sub>P</sub> / 80.0MW <sub>AC</sub>	65.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	54.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	36.0MW <sub>P</sub> / 30.0MW <sub>AC</sub>	5MW <sub>AC</sub> – 6.0MW <sub>P</sub> / 5.0MW <sub>AC</sub> 8MW <sub>AC</sub> – 9.6MW <sub>P</sub> / 8.0MW <sub>AC</sub> 10MW <sub>AC</sub> – 12.0MW <sub>P</sub> / 10.0MW <sub>AC</sub>	12MW <sub>AC</sub> - 14.4MW <sub>P</sub> / 12MW <sub>AC</sub> 13MW <sub>AC</sub> - 15.6MW <sub>P</sub> / 13MW <sub>AC</sub>
Commissioning date	50MW <sub>AC</sub> – 08.04.2018 30MW <sub>AC</sub> – 22.04.2018	26.04.2018	26.09.2018	26.03.2016	5MW <sub>AC</sub> – 28.12.2015 8MW <sub>AC</sub> – 28.09.2015 10MW <sub>AC</sub> – 31.10.2015	12MW <sub>AC</sub> – 16.11.2015 13MW <sub>AC</sub> – 21.03.2016

This report presents the evaluation of the 30MW<sub>AC</sub> SPSPPL Solar PV plant (The Project) developed by Shapoorji Pallonji Solar PV Private Limited (SPSPPL) near *Alliandal* village, *Tiruvannamalai* district of the Tamil Nadu state.

The purpose of this report is to provide a technical appraisal of PV plant under evaluation.

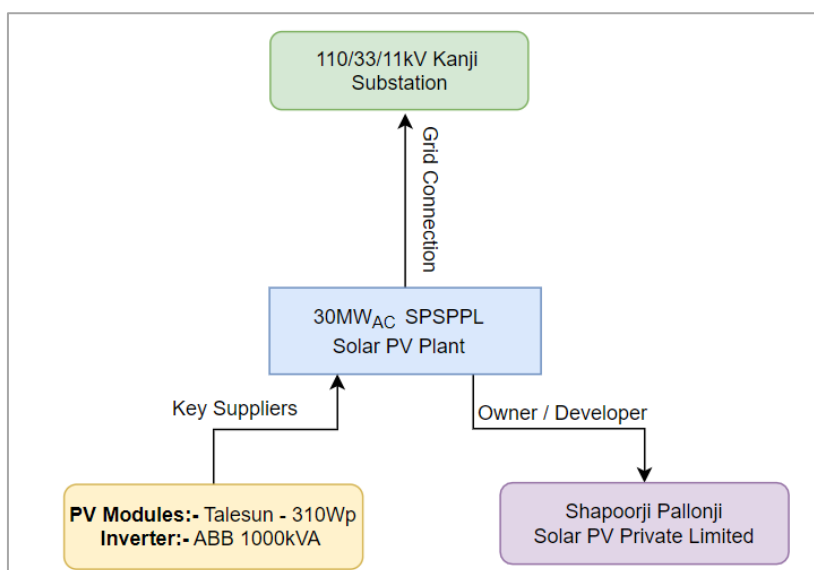


The report focuses on the following key parameters:

- System Design.
- Major Components.
- Engineering Design.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Plant Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project and is based on information made available by the Client through online dataroom. The main Project characteristic is summarised in Table 1-2.

Figure 1-1 illustrates the project structure indicating key project participants.



**Figure 1-1: Project Structure**

**Table 1-2: Project Key Summary**

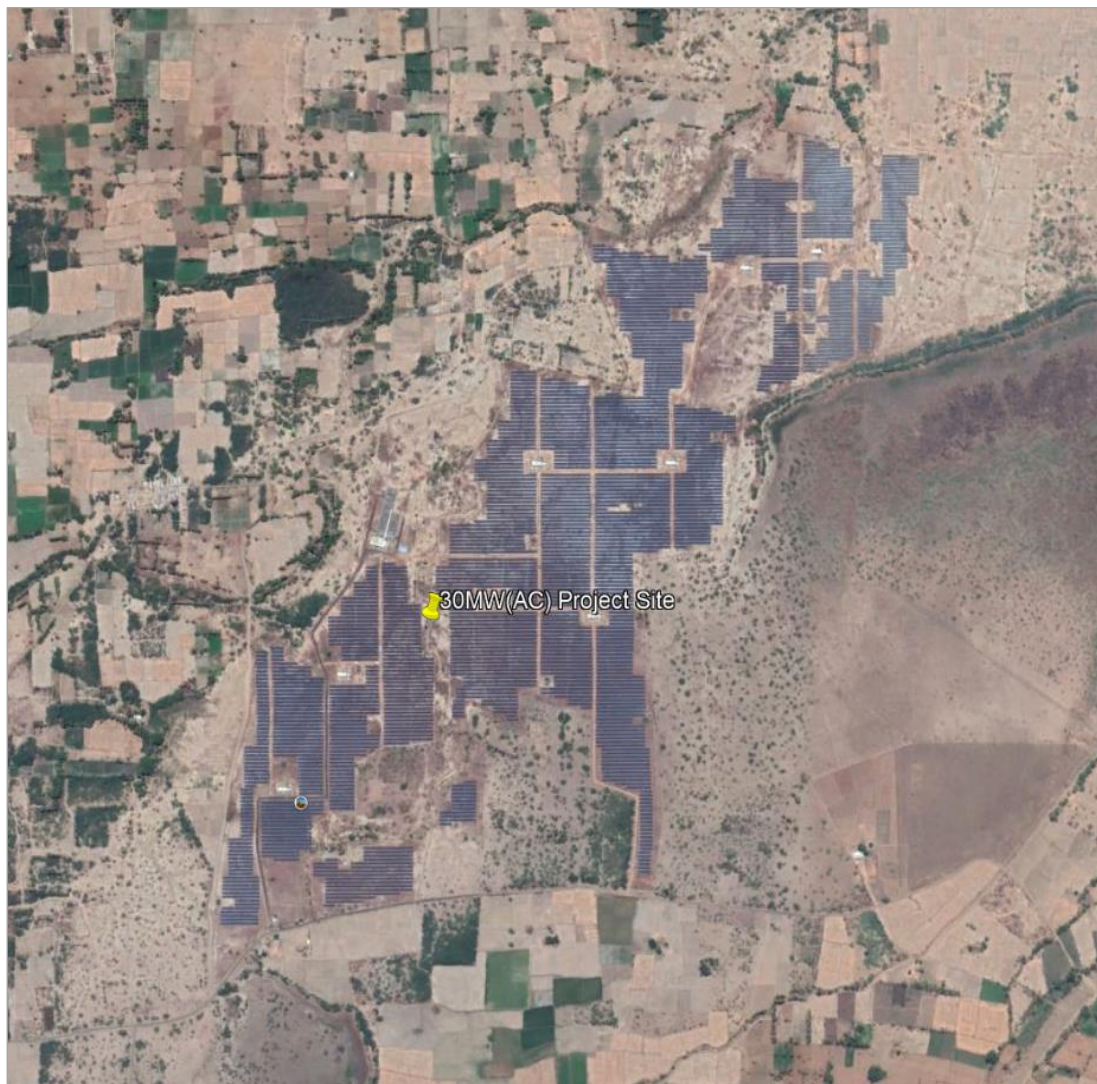
Project Information	
<b>Project Name</b>	30MW <sub>AC</sub> SPSPPL Solar PV plant
<b>Location</b>	Tiruvannamalai, Tamil Nadu
<b>Developer</b>	Shapoorji Pallonji Solar PV Private Limited
<b>DC/ AC capacity</b>	36MW <sub>P</sub> / 30MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: Talesun Inverters: ABB
<b>MMS Configuration</b>	Fixed Tilt: 10°, Azimuth: 0°
<b>Commissioning Status</b>	Commissioning was achieved on 26 March 2016



## 2 30MW<sub>AC</sub> Solar PV Plant Overview

The project site lies around the coordinates 12°20'38.76"N and 78°56'45.24"E. Satellite imageries of 30MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1. The Owner has utilised approximately 160 acres of land project. The Project site is located near the *Aliandal* village, in Thiruannamalai district of Tamil Nadu.

Project is contracted for generating 30MW<sub>AC</sub> power; SgurrEnergy therefore interprets 30MW<sub>AC</sub> as the maximum AC installed capacity for the solar PV plant.



**Figure 2-1: Satellite image of 30MW<sub>AC</sub> plant**

### 2.1 30MW<sub>AC</sub> Project Summary

Solar PV plant is modular in nature; therefore, SPSPL 30MW<sub>AC</sub> solar PV plants is implemented by adopting modularity in designs. 4MW<sub>AC</sub> and 3MW<sub>AC</sub> is the typical inverter station considered for implementing SPSPL 30MW<sub>AC</sub> solar PV plant.

Table 2-1 presents the summary of 30MW<sub>AC</sub> PV plant

**Table 2-1: Summary of 30MW<sub>AC</sub> Plant Configurations**

General	
PV Module Technology	Poly-crystalline
Inverter Technology	Central Inverters



General	
Installed DC Peak Capacity (MW <sub>p</sub> )	36
Installed AC Capacity (MW)	30
Mounting Type	Fixed Tilt
Tilt Angle (°)	10°
Pitch (m)	6
PV Modules	
PV Module Manufacturer	Talesun Solar
Model	TP672P-310
Wattage (W <sub>p</sub> )	310W <sub>p</sub>
Number of Modules per String	21
Inverter	
Inverter Manufacturer / Model	ABB / PVS-800
Inverter Nominal AC Output	1,000kW
Number of Inverters	30
Mounting Structure	
Mounting Structure Details (rows × columns)	2 × 21
Orientation of Modules	Portrait

The 30MW<sub>AC</sub> plant is implemented with a total of 8 inverter stations, six (6) of capacity 4MW<sub>AC</sub> and two (2) of 3MW<sub>AC</sub>. Six (6) inverter station are comprising of three winding transformers to accommodate 4 × 1,000kVA where each inverter station is comprising of a physical block connecting to 4.8MW<sub>p</sub> installed photovoltaic array. The output of two inverters in the 4MW<sub>AC</sub> blocks are connected to a 0.400/0.400/11kV three winding transformer of 2.2MVA for stepping up the voltage to 11kV. The output of two such transformers are clubbed to form the inverter station of 4MW<sub>AC</sub>.

Similarly, two (2) inverter station are comprising of three winding transformers to accommodate 3 × 1,000kVA inverters taking the individual inverter station size to 3MW<sub>AC</sub>. where each inverter station is comprising of a physical block connecting to 3.6MW<sub>p</sub> of installed photovoltaic array. The output of two inverters in the 3MW<sub>AC</sub> blocks are connected to a 0.400/0.400/11kV three winding transformer of 2.2MVA for stepping up the voltage to 11kV. Further one inverter in the block is connected to a 0.400/11kV two winding transformer of 1.1MVA. The output of two both the transformers are clubbed to form the inverter station of 3MW<sub>AC</sub>.

The medium voltage 11kV output of all the inverter stations are combined at the main control room (MCR), these are combined to form a solar PV plant of 30MW<sub>AC</sub>. The 11kV output is stepped up to 110kV by means of two 15/18MVA, ONAN/ONAF transformers at HV substation built within the plant premises. The output of both these transformers is clubbed at a Single Bus ACSR Zebra Conductor.

The power generated by the SPSPL 30MW<sub>AC</sub> PV plant is fed to *Kanji* substation located approximately 6km from the Project site, through a single circuit transmission line. The point of interconnection is at the *Kanji* substation.

ABT / revenue metering is at *Kanji* substation; therefore, transmission line losses are accounted in the Owner's scope.







### 3 Review of Major plant components

SgurrEnergy has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions.

#### 3.1 PV modules – Talesun Solar Technologies Co., Ltd.

The PV modules selected for the Project are supplied by Talesun Solar. SgurrEnergy has conducted a technical review of the supplier and proposed module specification with regards their suitability for use on the Project.

##### 3.1.1 Company Profile

Established in 2010, Talesun Solar is a subsidiary of the Zhongli group, created in 1988. Zhongli is a global Chinese group dealing in production of high-tech products. The group includes six distinct activities around two main sectors: solar (photovoltaic, energy storage, rack, and panel assembly system) and optics (optic fiber, its use for auto parts and for real estate).

Talesun solar has its headquarters and one of its production factories located in China. Talesun solar increased its production capacity to 5GW in 2017 and as of December 2020, the company had production capacity of 8GW of solar panels and 7.5GW of solar cells. The company provides services in more than 50 countries and employs more than 10,000 employees. As of December 2020, Talesun solar had nearly USD350 million allotted budget for research and development and has nearly 340 patents registered its name.

Few of the commissioned solar power plants using Talesun solar modules are listed in Table 3-1.

**Table 3-1: Project References of Talesun Solar**

Sr. No.	Project and Location	Capacity (MW)
11	Argentina Utility Projects, South America	314.0
2	Jiayuguan, Gansu	100.0
3	Jinchang, Gansu	100.0
4	Gonghe, Qinghai	100.0
5	California, USA	97.0
6	Sa Kaeo, Thailand	70.0
7	Turpan, Xinjiang	40.0
8	Ausburg, Germany	39.4
9	Yumen, Gansu	30.0
10	Gaultney, UK	21.6
11	Berlin, Germany	20.0
12	Aspartia, UK	18.3
13	Denmark	17.3
14	Cha-Am, Thailand	15.0
15	Calabria, Italy	14.5
16	Whitchurch, UK	14.0
17	Lincolnshire, UK	13.0
18	Essex, UK	12.0



Sr. No.	Project and Location	Capacity (MW)
19	Beziers, France	12.0
20	Tokmak, Ukraine	11.0
21	Punjab, India	10.0
22	Changshu, China	9.8
23	Kherson, Ukraine	9.2
24	Maharashtra, India	8.0
25	Kopaygorod, Ukraine	7.3
26	Bonvillars, Switzerland	7.2
27	Saparevo, Bulgaria	5.5
28	Jocksdorf, Germany	5.0
29	Yamaga, Japan	3.5
30	Sardinia, Italy	2.8
31	Nordhorn, Germany	2.2
32	Thuringia, Germany	1.8
33	Saarland, Germany	1.5
34	Murg, Germany	1.0
35	Hannahs Mill, USA	1.0

Talesun is considered a Tier 1 supplier by Bloomberg (Q4, 2020). A Tier 1 supplier is defined as a module manufacturer who has *‘provided products to five different projects, which have been financed non-recourse by five different (non-development) banks, in the past two years.*

Whilst the Bloomberg tiering system does not reflect on a product’s technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers Talesun solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

### 3.1.2 Main Technical Characteristics of TP672P

Talesun Solar, TP672P-310W<sub>P</sub> modules of 310W<sub>P</sub> capacity have been utilized for the Project. The modules have an efficiency of 16.0% and a peak power tolerance of 0~+3%. The modules have a temperature coefficient (P<sub>max</sub>) of -0.40%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy’s expectation for c-Si technology. The technical characteristics of TP672P-310W<sub>P</sub> are presented in Table 3-2.

**Table 3-2: Technical specifications of TP672P-310W<sub>P</sub>**

Specifications	TP672P-310W <sub>P</sub>
Technology	Polycrystalline
Nominal power (P <sub>MPP</sub> )	310W <sub>P</sub>
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	36.5V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	8.5A
Open circuit voltage (V <sub>OC</sub> )	45.0V
Short circuit current (I <sub>SC</sub> )	9.1A
Efficiency (%)	16.0%





Specifications	TP672P-310W <sub>P</sub>
Maximum System Voltage	1,000V (DC)
Power tolerance (%)	0~+3%
Dimensions (length × breadth × width) (mm)	1960 × 990 × 40
Module area (m <sup>2</sup> )	1.94m <sup>2</sup>
Weight (kg)	22kg
Temperature coefficient at P <sub>MAX</sub>	-0.40%/°C
Operating temperature	-40°C to +85°C
Maximum reverse current	15A
Maximum mechanical load	5400Pa
Maximum snow load	2400Pa
Product warranty	10 years
Power output guarantee	25 years
<i>Module technical characteristics are given at STC (1,000W/m<sup>2</sup> irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet)</i>	

The maximum system voltage is 1,000V. The maximum reverse current is 15A. Overall the module characteristics can be considered to be in line with market standard.

### 3.1.3 Certification of Modules

General review of datasheet indicates Talesun Solar PV modules manufactured in facilities with the following certifications:

- ISO 14001 certification for environmental management systems
- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certification mentioned in the datasheet of the modules under evaluation within Table 3-3.

**Table 3-3: Certification for PV Module- Talesun Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
IEC 61701	Resistance to salt mist and corrosion
IEC 62716	Ammonia Corrosion Testing
UL 1703	Standard for safety for flat-plate photovoltaic modules

### 3.1.4 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of six months from the dispatch from the Talesun solar factory or the delivery date to site.



#### 3.1.4.1 Product Warranty

Talesun Solar provides a limited product warranty of 10 years, beginning on the earlier of module purchase date or one-year anniversary from the production date. If module fail to conform to this warranty, during the period ending of 10 years from the date of sale to the customer of the Talesun solar product, Talesun solar will at its opinion, either repair or replace the product, or refund the purchase price as paid by the customer. The repair or replacement or refund the customer at the current comparable market price of such module.

SgurrEnergy considers 10year product warranty provided by Talesun solar to be in line with the industry standard.

#### 3.1.4.2 Linear Power-Output Warranty

According to the datasheet Talesun solar warrants that the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.7% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 80.7% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, Talesun solar will either repair, replace or provide additional modules to make up for the loss in power output.

### 3.2 Inverters – ASEA Brown Boveri (ABB)

The project has utilized ABB PVS800-57-1000kW central inverter for the project under evaluation.

#### 3.2.1 Company background

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, ABB is one of the largest engineering companies as well as one of the largest conglomerates in the world. ABB has operations in around 100 countries, with approximately 147,000 employees<sup>1</sup>. Company reported global revenue of around \$34,312 million for 2017.<sup>2</sup>

The firm's shares are traded on the stock exchanges of Zurich, Stockholm, and New York. ABB is a multinational corporation headquartered in Zurich, Switzerland, operating mainly in robotics and power and automation technology.

On July 9, 2019 the Italian company FIMER acquired ABB's solar inverter business. The takeover of ABB's solar inverter business included 800 employees in 26 countries as well as two manufacturing plants, in Italy and in India, and a R&D facility in Finland.

FIMER was founded in 1942, headquartered in Vimercate, Italy, has been actively working in inverter technology since 1983. As of 2020, the company employs more than 1,100 employees across its three manufacturing facilities and three R&D centres across the globe. As a result of acquisition of ABB's PV inverter line, FIMER ranked the fifth-largest PV inverter globally in 2019.

#### 3.2.2 Track Record

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<sup>1</sup> <https://new.abb.com/news/detail/26838/abb-to-exit-solar-inverter-business>

<sup>2</sup> <https://new.abb.com/investorrelations/company-profile/facts-figures>



ABB India commenced local manufacturing of solar inverters in 2012 and partnered with several customers. ABB is the solar inverter market leader in India holding approximately 24% market share in 2018. ABB has approximately 3,590MW in operation across more than 350 sites in India. ABB India manages close to 40% of the installed bases in India. As on 30 August 2017, ABB India crossed the 5GW threshold for the supply of inverters in the country.

Table 3-4 lists the state-wise installed capacity of ABB inverters in India. However, it is to be noted that the table below doesn't not comprise of the installed capacities till date.

**Table 3-4: ABB Inverter Track Record**

Location	Capacity (MW)
Punjab	227
Haryana	62
Uttar Pradesh	106
Bihar	225
Rajasthan	371
Madhya Pradesh	271
Chhattisgarh	28
Odisha	20
Andhra Pradesh	647
Maharashtra	261
Tamil Nadu	747
Karnataka	305
Kerala	50

ABB India has strategically located its headquarter in Bangalore and offices in other cities Pune, Ahmedabad, Jaipur, Faridabad, Hyderabad, Tamil Nadu, and Bhopal in order to facilitate quick spare part availability and minimal response time. ABB aims to provide first response to its customers within 4 hours on weekdays and within 24 hours on weekends and holidays. ABB also provides a Turn-Around-Time of 48 and 72 hours on weekdays and weekends respectively, hence maintaining an average uptime of over 99%.

### 3.2.3 Technical Characteristics

ABB PVS800-57-1000kVA inverter has been selected for technical feasibility of the Project. The technical specification of 1000kW ABB inverter is listed in Table 3-5.

The PVS800-57-1000kVA Series of central inverters designed ideal for large PV Power Plants. PVS980 inverters are designed for fast and easy installation. These inverters are designed to operate with DC inputs up to 1,500 V. They incorporate maximum power point tracking (MPPT) and grid management features to meet utility requirements.

PVS800-57-1000kVA inverter is designed for outdoor use with an IP42 ingress protection class. They have closed loop cooling system based on phase transition and thermosiphon technology with water and dustproof enclosure. They perform optimally at ambient air temperatures between -15°C to 50°C and relative humidity in the range of 15% to 95% with maximum noise level of less than 75dBA.

The PVS800-57-1000kVA inverter has peak efficiency of 98.8% and a European efficiency of 98.6%.

The main technical characteristics of these inverters are illustrated in Table 3-5.



**Table 3-5: ABB inverter specifications**

<b>ABB Central Inverter Specifications</b>	
Inverter	ABB PVS800-57-1000kVA
Type	Central Inverter
<b>Input Data</b>	
Maximum Input Power (kW <sub>p</sub> )	1200kW <sub>p</sub>
PV voltage range, MPP (V)	600 to 850V
Maximum DC voltage (V)	1100V
Maximum input current (A)	1710A
<b>Output Data</b>	
Nominal AC power (kW)	1000kW
Maximum AC current (A)	1445A
Nominal AC voltage(V)	400V
AC grid frequency (Hz)	50Hz-5%+3%
Maximum THD	< 3%
<b>Operating Performance</b>	
Maximum efficiency (%)	98.80%
Euro efficiency (%)	98.60%
<b>Power consumption</b>	
Own consumption in operation(W)	730W
Standby operation consumption (W)	70W
<b>Other</b>	
Dimensions (W × H × D) (mm)	3630mm x 2130mm x 610mm
Weight (kg)	2600kg
Environmental Protection Rating	IP42
Operating temperature range (°C)	-15 to+50°C
Relative humidity (%)	15% to 95%

The following protection devices are included within the inverter design:

- Earth fault monitoring
- Negative Monitoring
- Anti-islanding protection
- DC reverse-polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection
- Synchronous Loss protection
- Cooling fan failure, KW, KVA, KVARH, KWH, PF, Hz, V, A protection

ABB inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components.

### 3.2.4 Certification



ABB is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. ABB inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information available in public domain, SgurrEnergy has summarized the certification of the ABB inverter within Table 3-6.

**Table 3-6: Description of Certification of ABB inverters**

Certification	Description
IEC 60068-2-6/29	Environmental testing of inverters to assess their ability to perform and survive under conditions such as transportation, storage, operational environments, extreme cold and heat
IEC 61683:1999	Procedure for measuring efficiency
IEC 62109-2:2011	Safety of Power Converters
IEC 62116:2014	Islanding prevention measures

### 3.2.5 Warranties

SgurrEnergy referred the warranty documents available in public domain. Given the industry standard warranty of 60 months, SgurrEnergy does not raise any concern over the use of inverter for the project.

## 3.3 Transformers

The power at low voltage from inverters is stepped up to 33kV using 4000kVA and 2000kVA transformers of Shilchar Technologies Limited make.

### 3.3.1 Inverter Transformer– Shilchar Technologies Limited

The inverter transformer used for the project are manufactured by Shilchar Technologies Limited.

Established in 1990 and headquartered in Gujrat, India, Shilchar is one of the prominent manufacturers of Power & Distribution transformers. As of April 2020, the Company has commissioned the manufacturing facility capable of manufacturing up to 50MVA, 132KV class transformer and up to 4000MVA transformers annually.

Shilchar Technologies is an ISO 90001:2015, ISO 14001:2015 and ISO 45001:2018 certified company providing services to wide range of industries across the world including utility sector to renewable energy. The Company has a dedicated marketing team to cater services required in 20 different countries in the world. Since 2011, 40% of the revenue generated by Shilchar is through export.

The Company manufactures and has type tested various 3-winding, 4-winding, and 5-winding transformer with copper and aluminium conductor. The highest rating type tested by Shilchar is 12.5MVA, 5 winding Inverter Duty Transformer (IDT). The Company has supplied nearly 4GWs of transformers for solar application throughout the world including in Philippines, Egypt, Kenya and Chile.

#### 3.3.1.1 Technical Specifications



The 2200kVA and 1100kVA inverter transformers used in the project are outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 3-7.

**Table 3-7: Technical Specification of Shilchar Transformer**

Technical Parameters	Description	
Rated Power	1100kVA	2200kVA
Rated HV	11kV	
Rated LV	400V	400-400
Tapping on HV	-5% to +5% (steps of 2.5%)	-5% to +5% (steps of 2.5%)
Phases	3	
Frequency	50Hz	
Vector group	Dy11	Dy11y11
Impedance	6.25% (As per IS)	
Cooling Strategy	ONAN	
Oil temperature rise	50°C	
Winding temperature rise	55°C	
Winding material	Copper	

SgurrEnergy considers the overall the technical specification to be adequate for the PV projects and in line with the industry accepted standards.

### 3.3.1.2 Temperature Rise Detection and Protection

Inverter transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.1.3 Warranties and Guaranties

Based on the information available in public domain, SgurrEnergy understands the Shilchar transformers have been provided with a warranty of 60 months from date of dispatch. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards.

### 3.3.2 Power Transformer- Andrew Yule & Co. Ltd.

The power transformer used for the project are manufactured by Andrew Yule & Co. Ltd.

Established in 1863 and headquartered in Kolkata, West Bengal, India, Andrew Yule & Co. Ltd. is a public sector company under the Ministry of Heavy Industries & Public Enterprises. The company was converted into Public Limited Company in 1948 and became a Central Public Sector Enterprise in 1979.



As of December 2020, nearly 89.25% of the company's share are held by Govt. of India, 4.75% by Financial Institutions and the balance 6.00% is held by Public, Bodies Corporate etc. Andrew Yule Group has a turnover of Rs. 1,200 crore and employs nearly 16,500 people.

### 3.3.2.1 Technical Specifications

The 15/18MVA Power transformers used in the project are outdoor type, three-winding (copper wound), Class A insulation class, oil immersed with ONAN/ONAF type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 3-8.

**Table 3-8: Technical Specification of Andrew Yule Transformer**

Technical Parameters	Description
Rated Power	15/18MVA
Rated HV	110kV
Rated LV	11kV
Tapping on HV	+5% to -5% (steps of 1.25%)
Phases	3
Frequency	50Hz
Vector group	YNyn0
Impedance	10%
Cooling Strategy	ONAN/ ONAF
Oil temperature rise	50°C
Winding temperature rise	55°C

SgurrEnergy considers the overall the technical specification to be adequate for the PV projects and in line with the industry accepted standards.

### 3.3.2.2 Temperature Rise Detection and Protection

The 15/18MVA Power transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.3 Conclusion on Major Plant Components

#### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of Talesun Solar, assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.





Further, according to the warranty documents available in public domain for the module manufacturer, SgurrEnergy considers the warranty terms and conditions offered by Talesun to be in-line with the industry standard and raises no major concern regarding the warranties offered. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.

### **Inverters**

SgurrEnergy has conducted review of the ABB PVS980-58-2000kVA central inverter ABB PVS980-58-2000kVA central inverter has the required certification for use in solar PV plants. In-house testing of the inverter and individual components is relatively extensive during the R&D phase with functional and temperature cycling testing of each manufactured inverter. ABB offers a product warrant of 5 years which is in line with the current industry standards.

In conclusion, ABB can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters. ABB inverters have more than 3GW of installation worldwide. These inverters are quite known to the Indian market and have installed capacity of more than 1.3GW which demonstrates a good track record in the Indian solar PV market.

### **Transformers**

The inverter transformers (2200kVA and 1100kVA) and power transformer (15/18MVA) used within the project are manufactured by Shilchar Technologies Limited and Andrew Yule & Co. Ltd., respectively. The manufacturers have good track record of supplying transformers for solar application throughout the. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.

### **3.4 Module support structures**

SgurrEnergy was not provided with the MMS GA drawing hence SgurrEnergy is unable to comment on the same.





## 4 Allied Components and Systems

### 4.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

### 4.2 PV Power Transfer

SgurrEnergy has reviewed the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear, and plant substation as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

- “SWLB-SP-TN-30MW-E-DWG-SLD-100”, revision 0, dated 21.04.16.
- “SWLB-SP-TN-30MW-E-DWG-SLD-100B”, revision 5, dated 07.11.15.
- “SWLB-SP-TN-30MW-E-DWG-AL-101”, dated 24.04.2016.

The 30MW<sub>AC</sub> solar PV Plant is designed with 310Wp Talesun solar PV modules and 1000kW ABB inverters. There are total Modules are interconnected to form a string of 21 modules. Each string forms a single output that feeds as a single input to the 12 input combiner boxes. Eight string combiner boxes are further connected to the inverter.

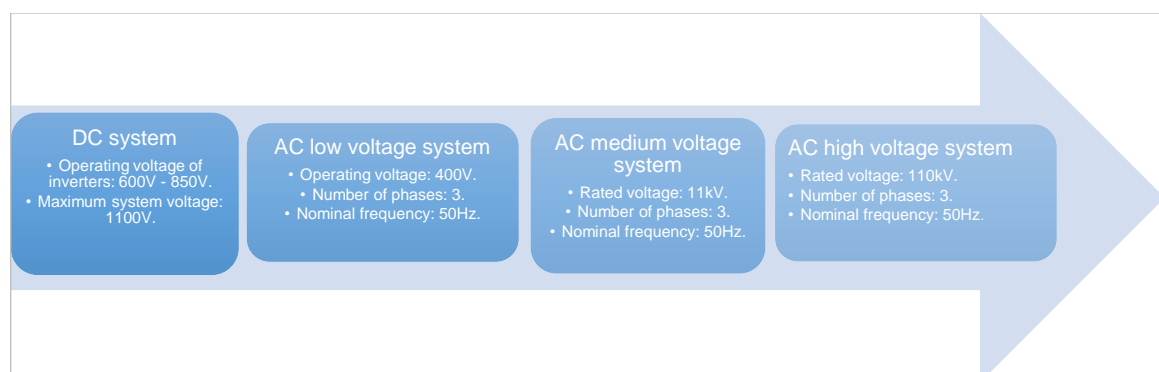
The 30MW<sub>AC</sub> solar PV plant has been configured with thirty ABB 1000kW central inverters and eight inverter stations. SgurrEnergy observed out of eight inverter station, six inverter station is of 4MW<sub>AC</sub> capacity and other two is of 3MW<sub>AC</sub> capacity.

Each 4MW<sub>AC</sub> capacity inverter station consists of 2-sets of two 1000kW inverters connected to 0.400/0.400/11kV three-winding, 2.2MVA transformer while the inverter station of 3MW<sub>AC</sub> capacity consists of three inverters, out of which two inverters are connected to 0.400/0.400/11kV three-winding, 2.2MVA transformer and one inverter is connected to 0.400/11kV two-winding 1.1MVA transformer. The voltage is stepped up to 11kV for all inverter stations by 2.2MVA and 1.1MVA transformers.

The output power of each 11kV HT panel is connected to 11kV main HT panel located in the main control room. The energy at 11kV is further stepped up to 110kV within the 110/11kV substation through two 15/18MVA ONAN/ONAF two winding power transformers.

The power is transferred to Kanji substation located approximately 5.5kms from the Project site through Dog ACSR Panther single circuit overhead line.

Figure below illustrates a power flow summary for the 30MW<sub>AC</sub> Solar PV plant.



**Figure 4-1: Power flow of 30MW<sub>AC</sub> PV plant**



### 4.3 Cabling

#### 4.3.1 DC Cabling

DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. Modules are interconnected in series with solar grade cables that are tied along with the module mounting structures. Modules are interconnected in leap-frog scheme to form a string of 21 PV modules connected in series.

The Y harness equipped with 30A fuse has been used to pre-combine the string of PV module. Single core 6mm<sup>2</sup> multi-stranded copper PV cables connect Y- harness output to String Combiner Box (SCB).

These combiner boxes are equipped with 30A fuse for each of the string connection and a 315A disconnect switch on output side. Power from string combiner box is further transferred to the inverter using 2 runs, 1C, 185/240/300mm<sup>2</sup>, 1.1kV aluminium XLPE ((2R X 1C X 185/240/300/400Sqmm, 1.1kV AL. XLPE Armoured) cables.

#### 4.3.2 AC Cabling

Three phase AC output from inverter is connected to the LV winding of a three-winding 2.2MVA and 1.1MVA transformers, using 12 Runs single core 630mm<sup>2</sup> Aluminium Armoured XLPE (12R (4R/Ph) X1C x 630mm<sup>2</sup> Al. Ar. XLPE) cable. The inverter transformers step up the voltage to 11kV.

Power is fed from the high voltage side of each transformers using 1R,3C, 300mm<sup>2</sup>, 11kV Al XLPE armoured cable to the 11kV outdoor HT panel using a radial feeder arrangement.

The 11kV output of each inverter station is transmitted to 11kV main HT panel located within Main control room using 1R,3C, 185mm<sup>2</sup>, 11kV(E) Al XLPE armoured HT cables.

The power from the Main HT panel is transferred to 11/110kV, 15/18MVA power transformer through single core, 630mm<sup>2</sup>, 11kV Aluminium XLPE Armoured (3R x 1C x 630sqmm/Phase 11kV[E], Al, XLPE, Ar.) cable.

Further the power from the solar PV plant is feed to the 110kV Kanji substation through 110kV Dog ACSR Panther single circuit overhead line.

### 4.4 Inverter Station

The 30MW<sub>AC</sub> solar PV plant has been configured with 30 inverters and eight inverter stations. Out of the total eight inverter stations, six inverter stations of 4MW<sub>AC</sub> capacity consist of four inverters and two inverter stations of 3MW<sub>AC</sub> capacity each consists of three inverters.

Each 4MW<sub>AC</sub> inverter station consists of two-sets of two inverters connected to a 2,200kVA three-winding transformers, while each 3MW<sub>AC</sub> inverter station consists of two inverters connected to a 2,200kVA three-winding transformer and one inverter connected to a 1,100kVA two-winding transformer. Each transformer, along with allied switchgears, steps up the voltage to 11kV for all inverter stations. Further the power from the HV side of the transformer is fed to the 11kV outdoor type HT panel through radial feeder arrangement.

11kV outdoor type HT panel comprises of 135/5-5A current transformer, 11kV/110V fixed type line potential transformer, 11kV EDO TP, 630A Vacuum Circuit Breaker and other electrical protection system. The power from inverter duty transformer is transferred to aforesaid HT panel.

### 4.5 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed two type of inverter duty transformer has been used in the project. The inverter station comprises of 2.2MVA, 11kV/2x0.400kV,



Dy11y11 three-winding transformer and 1.1MVA, 11kV/0.400kV, Dy11 two-winding transformer. These inverter duty transformers step up the voltage to 11kV.

The inverter transformers output is connected to 11kV HT panels located within inverter station. The energy from all the inverter stations is radially combined at 110/11kV main HT panel located in main control room.

#### 4.6 11kV Main HT Panel

A 11kV main HT panel comprises of inverter station incoming feeders, two outgoing feeders. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class. All feeders have been provided with relay and metering unit. The 11kV main HT panel outgoing and incoming feeders are provided with instantaneous and IDMT (50/51) O/C relay instantaneous and IDMT (50N/51N) E/F relay protections. The 11kV outgoing feeders are provided with 0.2S class instrument transformers.

Power is fed from 11kV main HT panel to 11/110kV, 15/18MVA two-winding, power transformers.

#### 4.7 110/11kV Switchyard

The 11kV Main HT panel outgoing feeders are connected to respective 15/18MVA, ONAN/ONAF, YNyn0, 110/11kV, power transformers located in 110/11kV plant end switchyard.

The 30MW<sub>ac</sub> solar PV plant comprise of 11kV main HT panel, which comprises of inverter station incoming feeders, auxiliary transformer feeders. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class. All feeders have been provided with relay and metering unit. The 11kV main switch board outgoing feeders are provided with instantaneous and IDMT (50/51) O/C relay instantaneous, IDMT (50N/51N) E/F relay protections, (63X) transformer fault Auxiliary relay, (64R HV/ LV) HV and LV side of restricted earth fault relay, standby earth fault relay (51S), directional over current relay (67), directional earth fault relay (67N), transformer differential relay(87T) and other supporting relays.

The 110/11kV switchyard is observed to be equipped with SF<sub>6</sub> circuit breaker, instrument transformers with metering & protection cores. The 110kV outgoing cable is protected with cable differential protection, which is considered to be standard engineering practice.

Further, each transformer line feeders are equipped with 0.2S instrument transformers with ABT main and check meters for measurement purpose, and isolators at incoming line for maintenance. The 96kV, 10kA surge arrestor is provided at 110kV outgoing feeders to discharge surge currents caused by lightning strokes and switching operation of equipment's.

Subsequently energy from 110/11kV plant end switchyard single feeder is evacuated to 110kV, Kanji substation at 110kV level through overhead cable.

#### 4.8 Auxiliary Power Supply

SgurrEnergy had reviewed the electrical schematics shared for the projects to evaluate auxiliary system. The inverter stations of all blocks are equipped with 20kVA auxiliary transformers.

#### 4.9 Bus-Bar Schemes

The bus bar scheme consisted of 110kV, 600A, TP 31.5kA per 1second twin ACSR Zebra conductor. The single bus bar scheme has been considered as cost effective for evacuation at 110kV.



#### 4.10 Power transformer

The 110/11kV switchyard comprises of two 15/18MVA, 110/11kV, YNyn0 two winding transformer. These power transformers step up the voltage to 110kV.

The power transformer output is connected to 110kV, 600A, TP.31.5kA/1sec, Single ACSR Zebra conductor busbar. Further the combined power of both the feeders will further evacuate to the 110kV Kanji substation.

#### 4.11 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are normally mounted on individual structures.

Following the review of 110kV SLD, SgurrEnergy observed 145kV, 2000A, 31.5A/3sec SF6 motorized circuit breaker has been used in the project.

#### 4.12 Isolators

Isolators are used to transfer load from one bus to another and also to isolate equipment for maintenance.

Based on the review of 110kV SLD, SgurrEnergy observed manual type 145kV, 1250A, 31.5kA/sec isolator with and without earth switch has been used in the project.

#### 4.13 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.

The current transformers with accuracy class of 0.2s for metering and class 5P and PS for protection has been used in 30MW<sub>AC</sub> solar PV plant. The potential transformers with accuracy class of 0.2 for metering and class 5P20 for protection has been used in the project.

#### 4.14 Surge Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes on the lines entering the substation. The apparatus most commonly used for this purpose is the surge arrester. Transformer is the costliest equipment in substation, and it is normal practice to install surge arrester near to the transformer. Additional surge arresters shall be provided either on bus or on various lines for protection of the equipment.

Following the review, SgurrEnergy observed 96kV, 10kA, CL-03 gapless Metal Oxide Surge arrester has been used in the switchyard.

#### 4.15 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy will be provided at the medium voltage switchboards for each of the feeder sections. These meters will be digital with an RS 485 port for remote monitoring. These usually have an accuracy class of 0.5.

Similarly, HV side shall also be equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point shall be 0.2S.

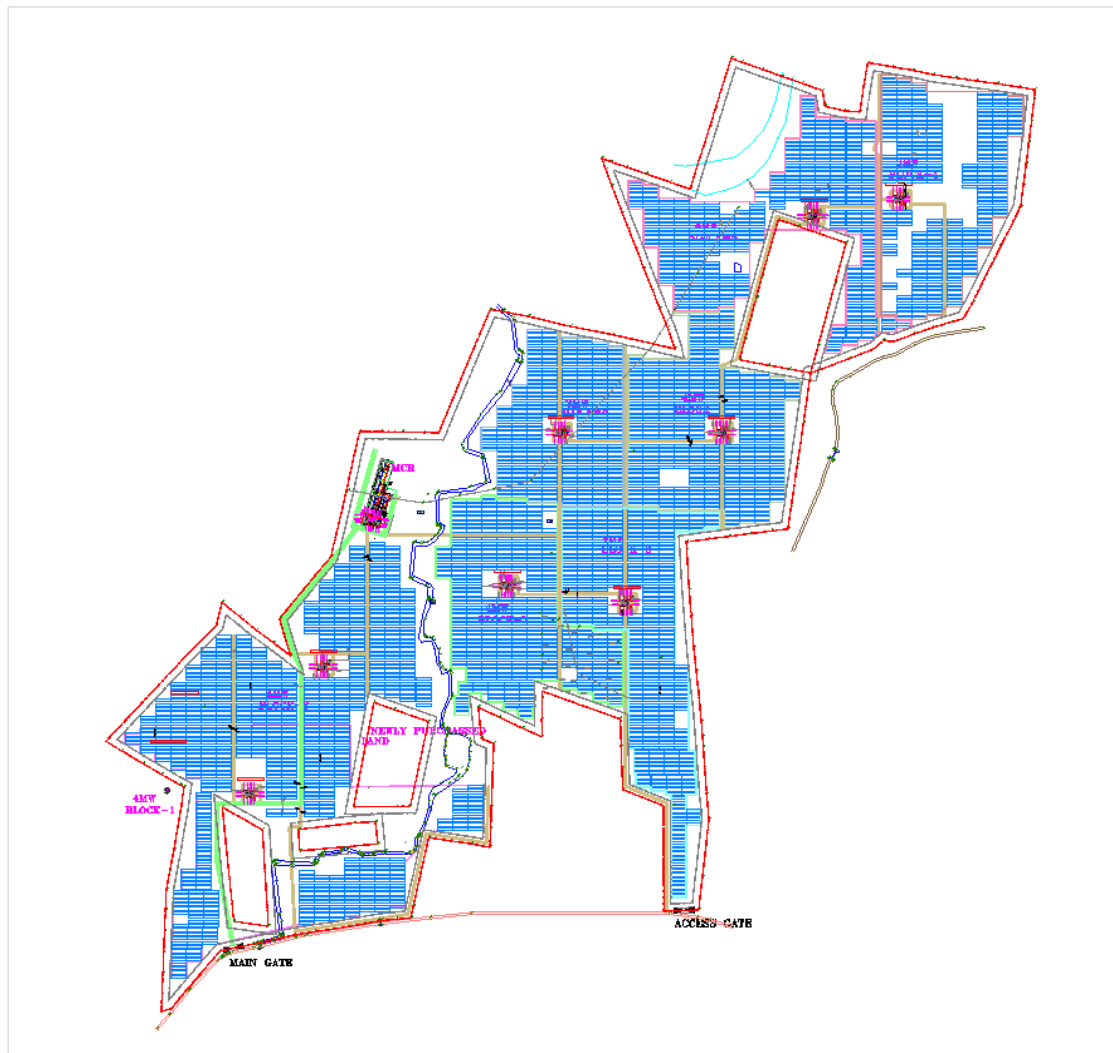


## 5 System Design Appraisal

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

### 5.1 Plant Layout Design

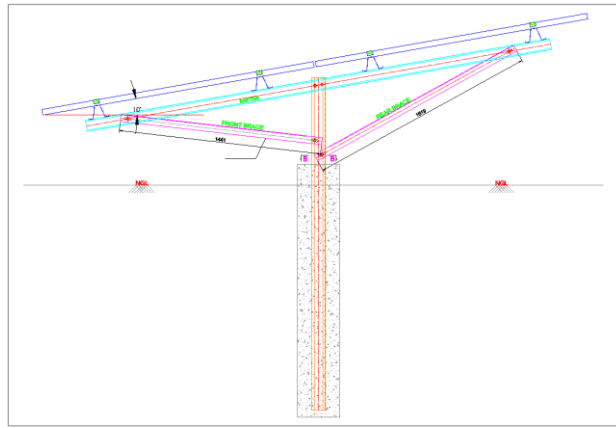
SgurrEnergy was provided with as built plant layout and electrical schematics. SgurrEnergy has verified the plant configuration with electrical schematics provided by the Client. The PV plant is Talesun Solar (310W<sub>p</sub>) PV modules. The total DC installed capacity stands at 36MW<sub>p</sub>. The AC installed capacity stands at 30MW<sub>AC</sub> with 30 inverters of capacity 1,000kW each. Overall 30MW<sub>AC</sub> PV plant is illustrated below in the Figure 5-1.



**Figure 5-1: Plant layout of 30MW<sub>AC</sub>**

All the PV modules are orientated towards South. The mounting structure provides support for two rows of panels in portrait orientation.





**Figure 5-2: Side view of typical module mounting structure configuration**

The selected tilt for the 30MW<sub>AC</sub> plant is 10°. The 30MW<sub>AC</sub> plant is designed with a pitch of 6m.

Based on regional experience of detail designing, SgurrEnergy considers the selected tilt angle and pitch is optimized for maximum irradiation on the collector plane, minimum loss due to inter row shading, minimum ohmic losses and ease of maintenance.

21 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.2. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

## 5.2 String Sizing

The plant layout provided by the Developer indicate twenty one 310W<sub>p</sub> Talesun polycrystalline modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage ( $V_{OC}$ ) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum  $V_{OC}$  of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy in validating string configuration. Subsequent to calculating open circuit voltage ( $V_{OC}$  max), maximum power voltage ( $V_{mp}$  min) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 42°C and 15°C respectively for system design validation to be fair and representative for the PV plant site.

The results of string sizing validation are presented in Table 5-1. Results indicate that  $V_{OC}$  max at the minimum ambient temperature is within the maximum system voltage of 1,000V for the selected ABB inverters.

**Table 5-1: String Sizing for Talesun PV Modules**

Parameters	Talesun 310W <sub>p</sub>
PV module power ( $W_p$ )	310
Modules per string	21





Inverters	ABB PVS-800-57-1000kW-C
Maximum Open-circuit voltage ( $V_{oc}$ max) at minimum ambient temperature of 15°C	976.5V
Minimum power voltage ( $V_{mp}$ min) at maximum ambient temperature of 42°C	890.4V

### 5.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with Talesun Solar and ABB inverter is presented in Table 5-2.

**Table 5-2: Inverter Compatibility with Talesun 310W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	Talesun 310W <sub>p</sub>	
Modules per string	21	Acceptable
Strings per inverter	184	Acceptable
Maximum power, $P_{mpp}$ at STC (kW <sub>p</sub> )	1,197.8	Nominal power ratio is 1.19, this is within the inverter bus current carrying capacity.
Maximum power voltage, $V_{mpp}$ at STC (V)	766.5	Acceptable.
Maximum power current, $I_{mpp}$ at STC (A)	1564	Acceptable
Open-circuit voltage, $V_{oc}$ at STC (V)	945	Acceptable.
Minimum MPP voltage at 42°C ambient temperature (V)	709.8	Acceptable: Inverter MPPT ranges 600- 850V.
Maximum MPP voltage at 15°C ambient temperature (V)	798	Acceptable: Inverter MPPT ranges 600- 850V.
Maximum open circuit voltage, $V_{oc}$ at 15°C (V)	976.5	Acceptable: Maximum inverter voltage 1000.

Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.



## 6 Resource assessment

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SEI has sourced monthly horizontal plane irradiation data for the Project site from:

- **NASA's Surface Meteorology and Solar Energy data set**; holds satellite derived monthly data for a grid of 0.5° × 0.5° covering the globe for a thirty-four-year period (1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.

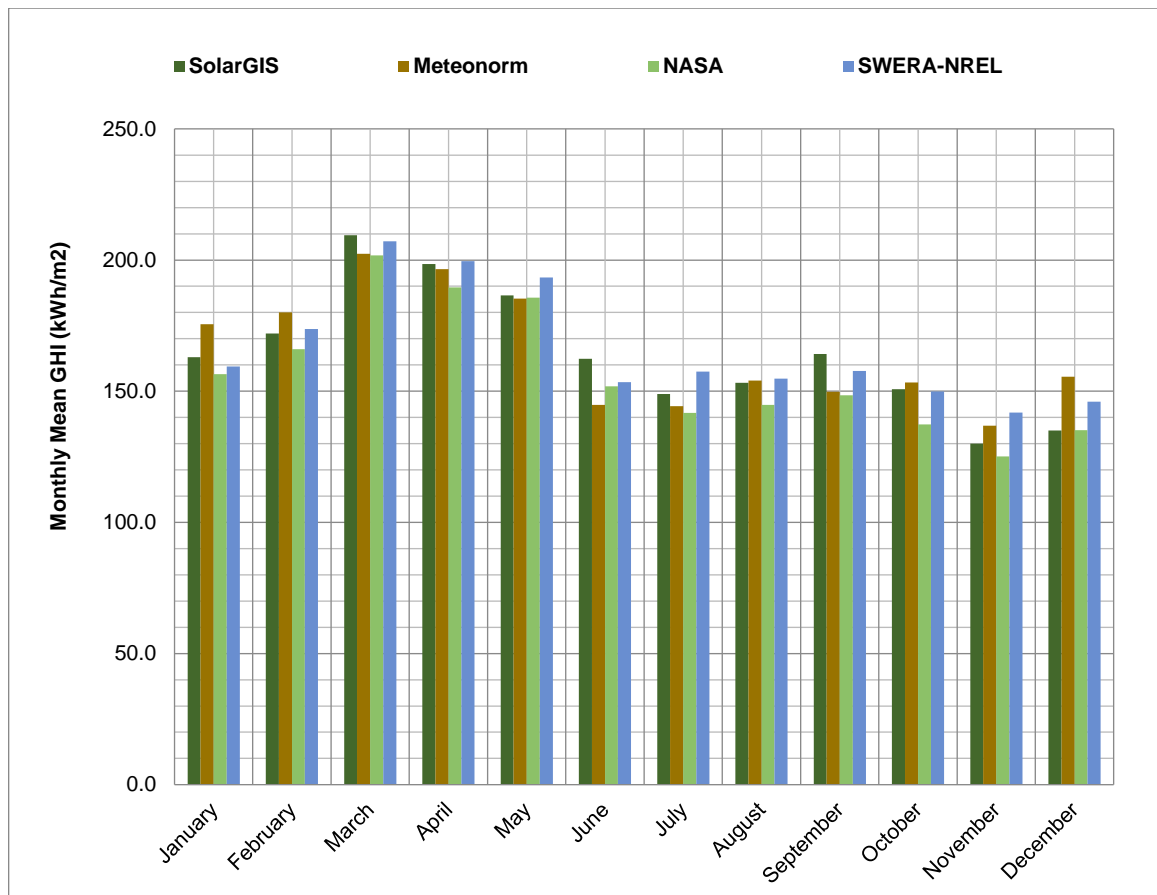




- The **METEONORM (version 7.3)** global climatological database and synthetic weather generator; contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.
- **SolarGIS:** SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km × 4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by IEA (International Energy Agency) SHC Collaboration Agreement, and EU FP6 project MESoR in terms of bias and RMSE.

SEI has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS data for the site. The comparison is graphically illustrated Table6-1





**Figure 6-1: Monthly Global Horizontal Irradiation**

**Table6-1: Comparison of Solar Irradiation Datasets for the site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	1,973.9
Meteonorm 7.3	14km × 14km	4.0%	1,978.2
NASA	55km × 55km	Unknown	1,884.0
NREL (SWERA)	40km × 40km	Unknown	1,994.5

The comparison of solar data for Project site location illustrated in Table6-1 indicates NREL (SWERA) dataset to give the highest irradiation levels. The next highest irradiation is given by NASA followed by Meteonorm 7.3 and SolarGIS.

The irradiation values given by Meteonorm 7.3 typically provide a combination of ground and satellite measured data. Meteonorm 7.3 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as 7% for the proposed site.

The NASA-SSE data source provides purely satellite measured data for a grid covering 0.5° × 0.5° on the earth's surface and generally more suited for initial site selection.

The NREL (SWERA) data illustrated has been obtained for a location approximately 9.96 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data

The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also



been compared with other data sources globally. The IEA (International Energy Agency) validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>3</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)
- Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 6%.

SEI is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 6.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 6-2 and shown graphically in Figure 6-2. Diffuse irradiation accounts for 4% of the total irradiation. Table 6-2 illustrates direct and diffuse daily irradiation on a horizontal plane for the proposed site. SolarGIS irradiation data is presented in Table 6-2.

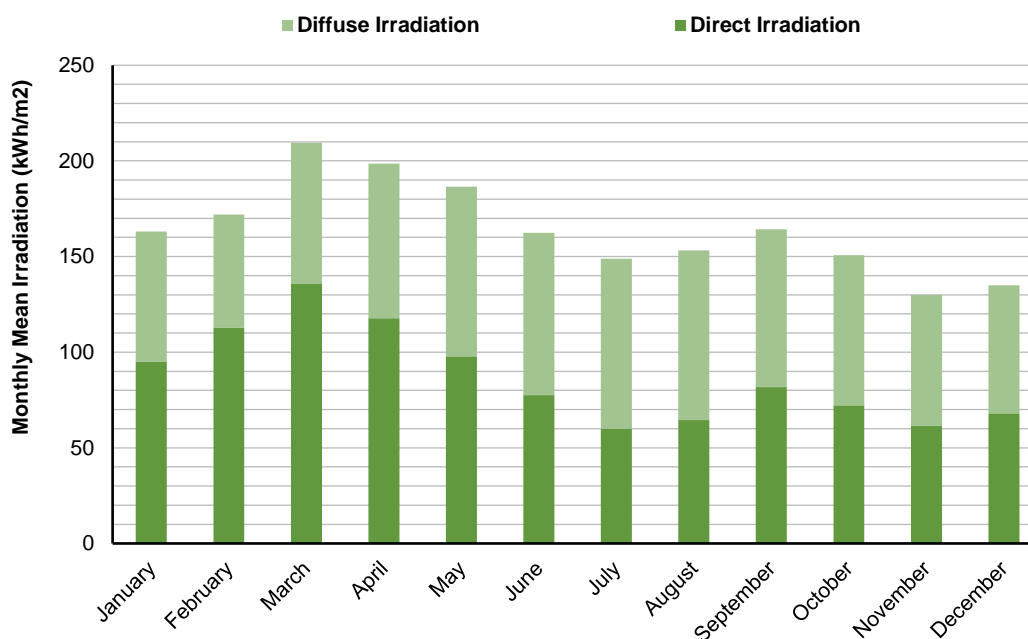
**Table 6-2: SolarGIS Irradiation Data for the Project sites**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	163.0	67.9	8.3%
February	172.0	59.4	8.7%
March	209.5	73.8	10.6%
April	198.5	80.7	10.1%
May	186.5	88.7	9.4%
June	162.4	84.9	8.2%
July	148.9	89.0	7.5%
August	153.2	88.7	7.8%
September	164.2	82.5	8.3%
October	150.7	78.4	7.6%

<sup>3</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>



Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
November	130.0	68.4	6.6%
December	135.0	67.0	6.8%
<b>Annual Sum</b>	<b>1,973.9</b>	<b>929.2</b>	<b>-</b>



**Figure 6-2: Monthly Direct and Diffuse Irradiation on a horizontal plane for the project site**

## 6.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.1.4), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -6-3 represents the monthly GTI profile.

**Table -6-3: Monthly Global Tilted Irradiation Data**

Month	GTI (kWh/m <sup>2</sup> )
January	178.9
February	184.9
March	216.2
April	196.9
May	179.5
June	154.7
July	143.2
August	150
September	166.1



Month	GTI (kWh/m <sup>2</sup> )
October	157.9
November	139
December	147.4
<b>Annual Sum</b>	<b>2014.8</b>

### 6.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 6-4 below. The average wind speed of 1.3 m/s was measured at 10 m height from ground level for the proposed project site location.

**Table 6-4: Simulated Wind Speed for site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	1.5
February	1.4
March	1.5
April	1.7
May	2.2
June	2.4
July	2.2
August	2.1
September	1.7
October	1.2
November	1.3
December	1.6
<b>Yearly Average</b>	<b>1.7</b>

### 6.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.

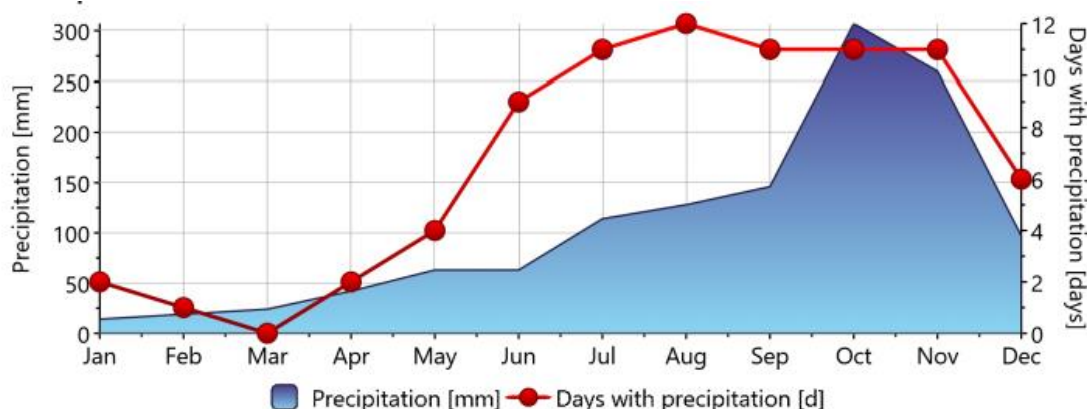


**Table 6-5: SolarGIS Temperature Data for Site (1999 – 2018)**

Months	Average Monthly Temperature (°C)
January	22.2
February	24.4
March	27.4
April	30.4
May	31.7
June	29.8
July	28.8
August	28.2
September	27.5
October	25.6
November	23.5
December	22.0
<b>Annual Average</b>	<b>26.8</b>

## 6.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.3 as illustrated in Figure 6-3. These figures show that the identified site is situated in a region that has marginal rainfall.

**Figure 6-3 Meteonorm Predicted Precipitation for the site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

Frequency of module cleaning depends on the rainfall frequency and the prevalence of dust and pollution in the local vicinity. Typical cleaning techniques include water cleaning, dry brushes or vehicle-based mechanical cleaning.

The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 1.5% has been considered by considering cleaning frequency of twice a month.



## 7 Energy Yield Analysis

SgurrEnergy has computed the annual energy yields for the 30 MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

Parameter	Description
Modules	Talesun Solar (TP672P-310)
Inverters	ABB Central Inverters – 1.0MW <sub>AC</sub> (PVS800-57-1000kW-C)
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	36.0

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 7.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in Table 7-1 below.

**Table 7-1: Description of Energy Yield Losses**

Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.



Loss	Description
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 30 MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 7.2 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 30 MW<sub>p</sub> solar PV Plant with Talesun Solar modules and ABB inverters. Table 7-2 summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.





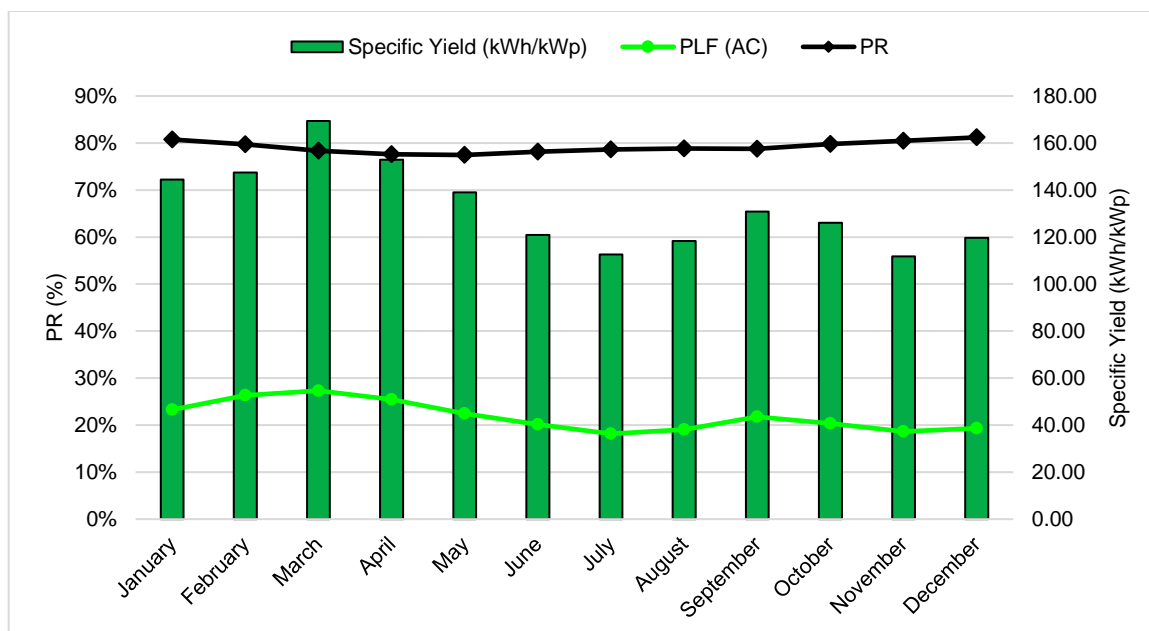
**Table 7-2: Energy Yield for the 30 MW<sub>AC</sub> Solar PV Plant**

Parameters	Description
PV Module Technology	Polycrystalline
DC Capacity (MW <sub>p</sub> )	36.01
AC Capacity (MVA)	30
Contracted Capacity (MW)	30
P <sub>NOM</sub> Ratio	1.20
Tilt (°)	10
Pitch (m)	6
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1,973.90
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	2,014.70
Transposition Factor	1.02
<b>Losses</b>	
Horizon Shading	0.00%
Incident Irradiation Below Threshold	0.00%
Near Shading	0.82%
Incident Angle	2.44%
Soiling	1.50%
Low Irradiance	0.40%
Module Temperature	8.69%
Electrical Shadings	0.00%
Module Quality	0.00%
First year Degradation	1.50%
Module Mismatch	1.00%
DC Ohmic	1.05%
Inverter Performance	1.72%
Availability	1.00%
AC Ohmic	0.55%
Transformer (LV/MV)	1.07%
Transformer (MV/HV)	-
Transmission Line	0.13%
Auxiliary Consumption	0.60%
Curtailment	
<b>Total Annual Loss Factor</b>	<b>0.791</b>
<b>Fifth Year P50 Energy Yield (MWh/annum)</b>	<b>56,232.22</b>
<b>Fifth Year Specific Yield (kWh/kW<sub>p</sub>)</b>	<b>1561.42</b>
<b>Fifth Year CUF on AC Installed Capacity</b>	<b>21.39%</b>



Parameters	Description
<b>Fifth Year CUF on Contracted Capacity</b>	<b>21.39%</b>
<b>Fifth Year CUF on DC Installed Capacity</b>	<b>17.82%</b>
<b>Fifth Year Performance Ratio</b>	<b>77.49%</b>

Graphical representation of the monthly generation, performance ratio and CUF for 50 MW<sub>AC</sub> evaluated is illustrated graphically in the Figure 7-1.



**Figure 7-1: Monthly Energy Yield for 30 MW<sub>AC</sub>**

### 7.3 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 7.3.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

#### 7.3.2 Inter – Annual Variation in the Solar Resource

Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.

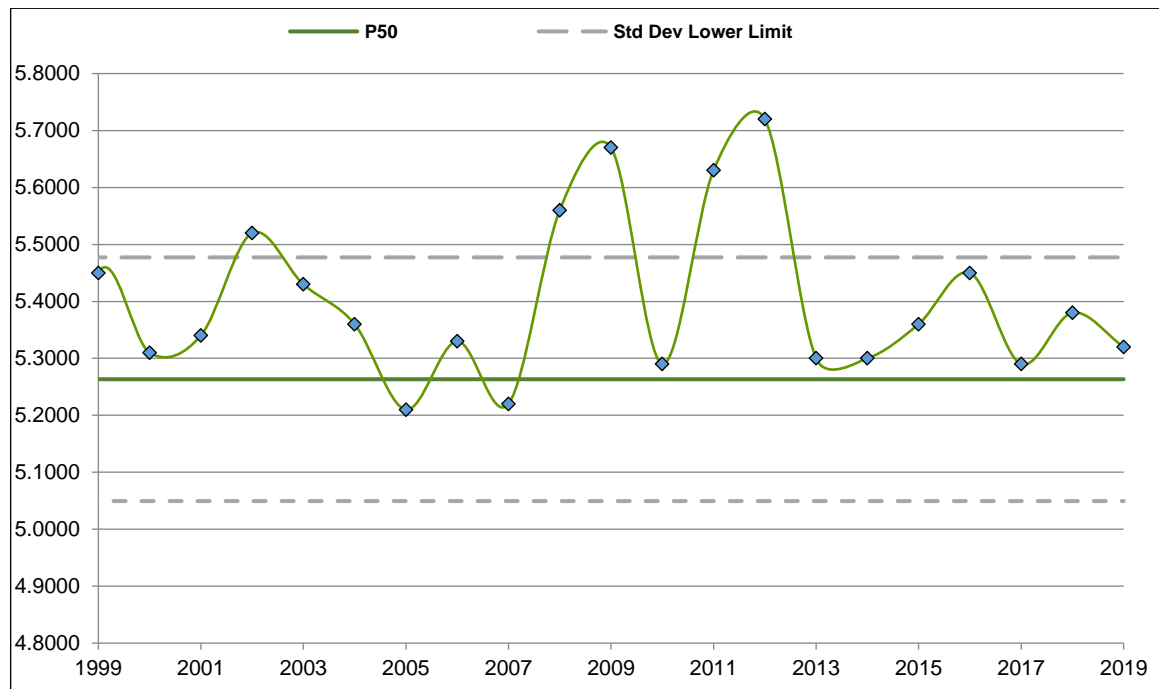
The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database



for the proposed site location which is used to estimate the standard deviation of variation in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 7-3.

**Table 7-3: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	4.07



**Figure 7-2: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in Figure 7-2.

SgurrEnergy uses a coefficient of variation of 4.07 % to quantify the inter-annual variation in the solar resource.

### 7.3.3 Modelling Uncertainty

The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

### 7.3.4 Total Uncertainty (P75, P90 and P99 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.



**Table 7-4: Life Cycle P50, P75 and P90 Generation Prediction for 30 MW<sub>AC</sub>**

Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>4</sup> (MWh/annum)	P90 Generation Prediction <sup>5</sup> (MWh/annum)
5	56,232.22	53,837.08	51,681.39
6	55,951.05	53,567.90	51,422.99
7	55,671.30	53,300.06	51,165.87
8	55,392.94	53,033.56	50,910.04
9	55,115.98	52,768.39	50,655.49
<b>10</b>	<b>54,840.40</b>	<b>52,504.55</b>	<b>50,402.21</b>
11	54,566.20	52,242.03	50,150.20
12	54,293.36	51,980.82	49,899.45
13	54,021.90	51,720.91	49,649.95
14	53,751.79	51,462.31	49,401.70
15	53,483.03	51,205.00	49,154.70
16	53,215.61	50,948.97	48,908.92
17	52,949.54	50,694.23	48,664.38
18	52,684.79	50,440.76	48,421.06
19	52,421.36	50,188.55	48,178.95
<b>20</b>	<b>52,159.26</b>	<b>49,937.61</b>	<b>47,938.06</b>
21	51,898.46	49,687.92	47,698.37
22	51,638.97	49,439.48	47,459.87
23	51,380.77	49,192.28	47,222.57
24	51,123.87	48,946.32	46,986.46
<b>25</b>	<b>50,868.25</b>	<b>48,701.59</b>	<b>46,751.53</b>

<sup>4</sup> The P75 values have been calculated over 10-year averages<sup>5</sup> The P90 values have been calculated over 10-year averages

## 8 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 0.6% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) and henceforth. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Developer, SgurrEnergy understands that the 30MW SPSPPL solar PV plant was commissioned on 21<sup>st</sup> March 2016. SgurrEnergy was provided with plant and grid availability records from March 2016 to March 2021<sup>6</sup> for the solar PV plant. However, the irradiation measurement records were provided from April 2016 to March 2021.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from April 2016 to March 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

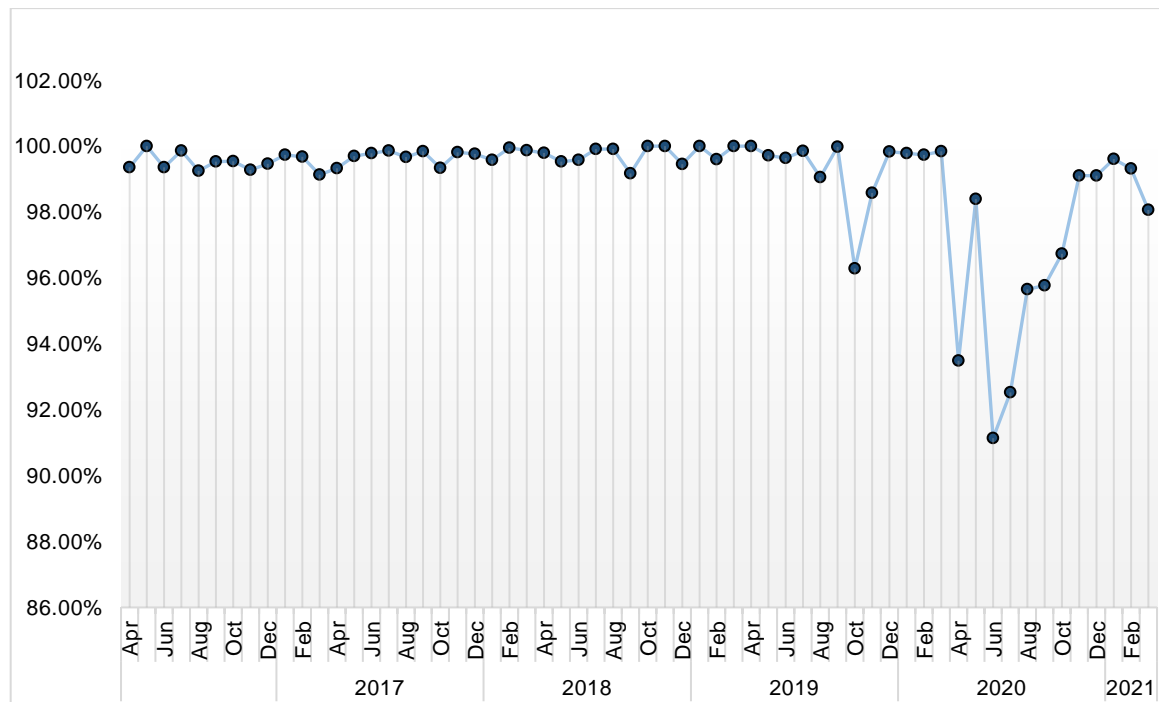
The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Developers control.

The monthly records of the grid availability from April 2016 to March 2021 have been graphically illustrated in Figure 8-1 below.

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<sup>6</sup> SgurrEnergy was provided with both the plant and grid availability records until March 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.





**Figure 8-1: Grid Availability**

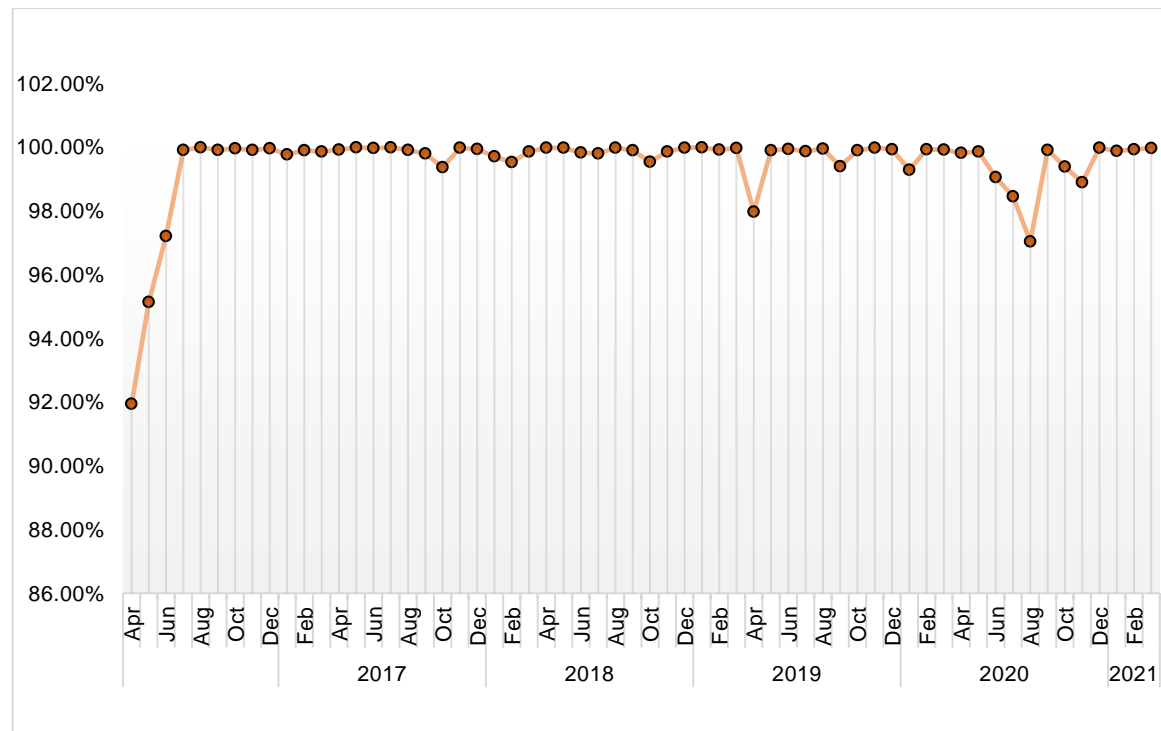
From the above illustration, SgurrEnergy notes that the grid availability was above 99% for substantial amount of time over the operational period of the plant. However, the unavailability loss experienced due to grid anomalies has increased significantly from April 2020. The resultant overall grid availability of the PV plant for the period evaluated was 98.98%.

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the SPSPPL solar PV plant is graphically illustrated below in Figure 8-2.





**Figure 8-2: Plant Availability**

Based on the above illustrations, SgurrEnergy notes the plant availability for the SPSPPL solar PV plant is notably inconsistent for all the months ranging between 91.94% to 99.99%. However, for the initial three months of PV plant operation, unavailability due to plant downtime was significantly higher when compared to other months.

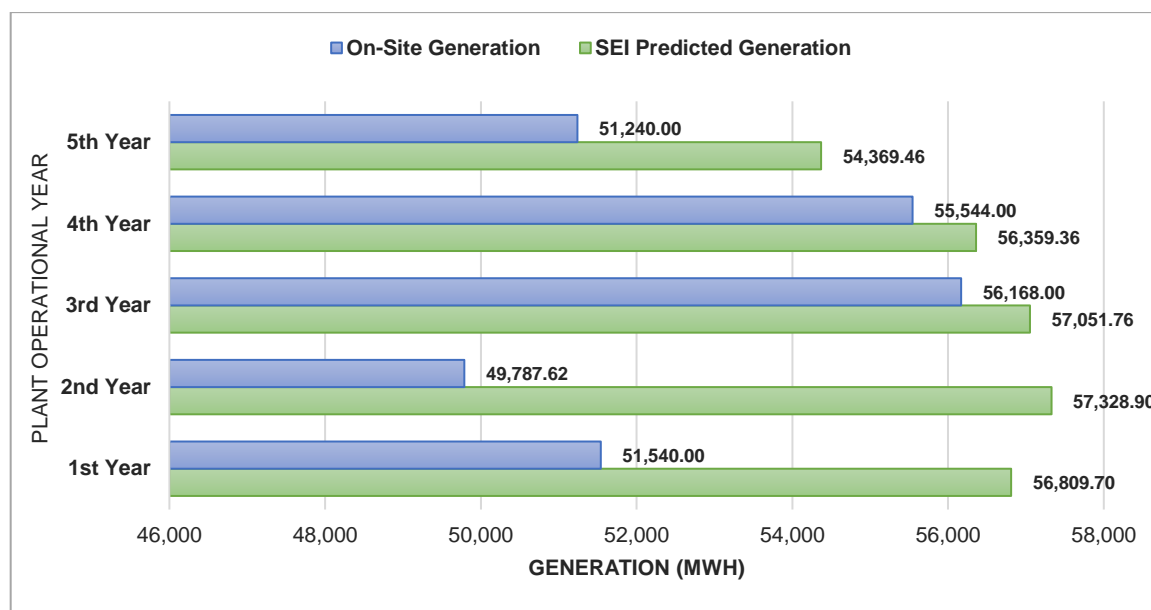
Apart from this, the plant experienced minor downtime; and SgurrEnergy notes the plant availability to be exceeding 97% for all the months. The resultant average plant availability of the PV plant for the period evaluated was 99.47% which is considered to be within expected range.

### 1.1 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Developer. To make the operational energy yield predictions more representative, SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Developer. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Developer.

The yearly comparison of the generation data is illustrated below in Figure 8-3.





**Figure 8-3: Generation Comparison**

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 8-1.

**Table 8-1: PV Plant Performance – SPSPL 30MW**

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>7</sup> (%)
Apr 2016 -Mar 2017	56,809.70	51,540.00	-9.28%
Apr 2017 -Mar 2018	57,328.90	49,787.62	-13.15%
Apr 2018 -Mar 2019	57,051.76	56,168.00	-1.55%
Apr 2019 -Mar 2020	56,359.36	55,544.00	-1.45%
Apr 2020 -March 2021	54,369.46	51,240.00	-5.76%
<b>Cumulative Period</b>	<b>2,81,919.18</b>	<b>2,64,279.62</b>	<b>-6.26%</b>

Based on the above comparison, SgurrEnergy notes that the PV plant is generating lower than the expected yield. However, SgurrEnergy considers that the variations in the energy yield can be attributed to lower irradiation level experienced on the Project site. The irradiation levels significantly impact the actual generation from the PV plant as the system losses may vary significantly due to slight change in the irradiation.

In order to understand the deviation in the irradiation pattern, SgurrEnergy has compared the monthly incident irradiation data provided by the Developer with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation. The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 8-4.

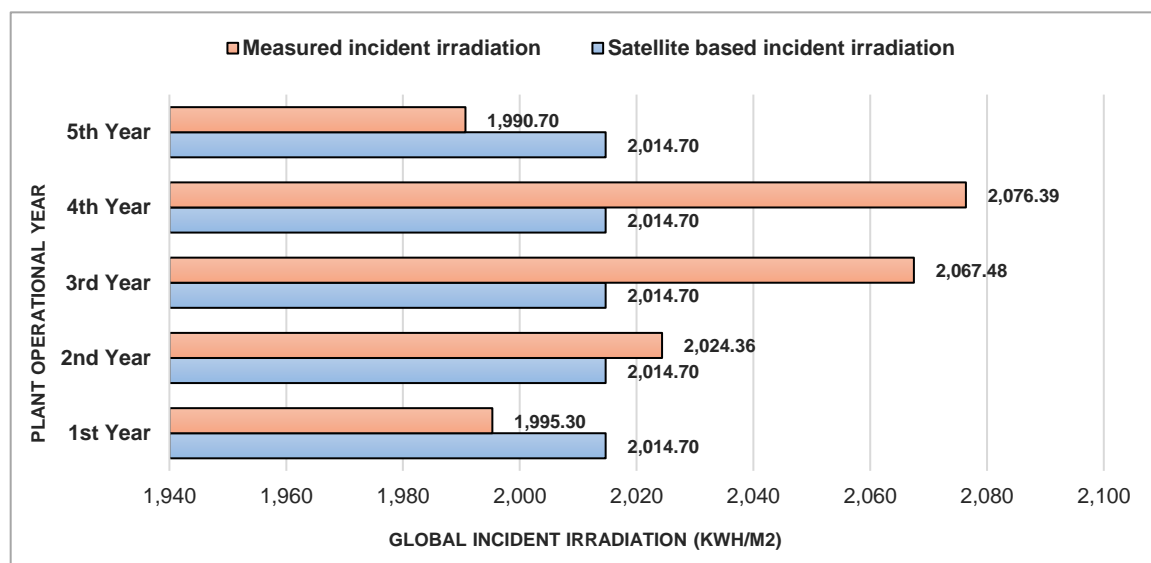
<sup>7</sup> Positive values indicate higher generation, while negative values indicate lower generation





**Table 8-2: Irradiation Comparison– SPSPPL 30MW**

PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>8</sup> (%)
Apr 2016 -Mar 2017	2,014.70	1,995.30	-0.96%
Apr 2017 -Mar 2018	2,014.70	2,024.36	0.48%
Apr 2018 -Mar 2019	2,014.70	2,067.48	2.62%
Apr 2019 -Mar 2020	2,014.70	2,076.39	3.06%
Apr 2020 -March 2021	2,014.70	1,990.70	-1.19%
<b>Cumulative Period</b>	<b>10,073.50</b>	<b>10,154.22</b>	<b>0.80%</b>

**Figure 8-4: Irradiation Comparison**

Based on the above illustrations, it is observed that the overall recorded generation is approximately 6.26% lower than the generation predicted on site. Correspondingly, it has also been observed that the irradiation measured on site is approximately 0.80% higher than the predicted irradiation.

SgurrEnergy thus infers that the PV plant is underperforming based on the conditions experienced on site.

<sup>8</sup> Positive values indicate higher irradiation, while negative values indicate lower irradiation



## 9 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar PV plants as having a lifetime of 25-40 years<sup>9</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>10</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the PV plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement.

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<sup>9</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>10</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>



Virescent Infrastructure


50MW(AC) Rajapalayam Solar PV Plant  
Shapoorji Pallonji Suryaprakash Pvt Ltd  
Technical Assessment Report

May 2021



**Report Details**

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**Amendment Records**

Revision Number	Date	Purpose of Revision	Summary of Amendments
A1	04.02.2021	First Draft	-
B1	09.02.2021	For Client Issue	-
B2	19.02.2021	For Client Issue	Minor Changes
B3	22.02.2021	For Client Issue	Finalisation of Report
B4	28.05.2021	For Client Issue	Generation Analysis Updated

SF/04/023

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## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 50MW<sub>AC</sub> Shapoorji Pallonji Suryaprakash Pvt Ltd (SEPEPL) solar PV plant (the Project). The Project is located near the Rajapalyam village, in Virudhunagar district of Tamil Nadu.

The summary of the technical assessment is captured in the below table.

**Table 1-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	<p>The project site lies around the coordinates 9°19'27.97"N and 77°35'38.85"E and is located near the Rajapalyam village, in Virudhunagar district of Tamil Nadu.</p> <p>Project is contracted for generating 50MW<sub>AC</sub> power. The Owner has utilised approximately 224 acres of land for the project.</p> <p>Project is implemented with poly-crystalline modules (JA Solar) and central inverters (Sineng). The module mounting structure is implemented with a tilt of 8° for a pitch of 6m.</p> <p>The power generated from the SPSPL 50MW<sub>AC</sub> PV plant is fed to 230/110kV Nallamanaickenpatti substation, through a single circuit transmission line.</p> <p>The total DC installed capacity stands at 54MW<sub>p</sub>. The AC installed capacity stands at 50MW<sub>AC</sub> with 40 inverters of capacity 1,250kW each.</p>
2	PV Module	<p>SgurrEnergy has conducted a desktop review of JA Solar assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard. SgurrEnergy considers the warranty period to be in line with the industry standards. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.</p>
3	Inverter	<p>Sineng is considered to have good track record for supplying central inverters. Certificates mentioned in the technical specification datasheet indicate Sineng to hold adequate certifications. Technical characteristics are acceptable, with a good efficiency level for central inverters. Standard warranty of five years is provided for the inverters, which is in line with the industry requirement. Overall, SgurrEnergy does not raise any concern on the utilization of Sineng inverters for the Project.</p>
4	Inverter Transformer	<p>The inverter transformers (5000kVA) and power transformers (24/40MVA) used within the project are manufactured by Shilchar Technologies Limited and ECO Limited, respectively. The manufacturers have a good track record of supplying transformers to distinguished customers in Indian as well as in the global market. SgurrEnergy has reviewed the transformers based on the information available and considers the transformers</p>



Sr. No.	Parameter	Comment
		utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project
5	String Sizing	The $V_{oc}$ does not exceed the inverter input voltage for the site, and therefore, SgurrEnergy considers the number of modules in series to be acceptable for the PV Project.
6	Permits and Approvals	PPA signed between Shapoorji Pallonji Suryaprakash Pvt Ltd and Tamil Nadu Generation and Distribution Corporation Limited.. PPA term is 25 years from the Commercial Operation Date. Documents such as CEIG certificate, commissioning certificate, consent to operate etc. have not been provided.
7	Resource Assessment	For resource analysis, SgurrEnergy has compared various satellite datasets. For the satellite databases, SgurrEnergy has compared Meteonorm 7, NASA, SWERA and SolarGIS data to find the most suitable solar resource for long-term energy yield prediction. Owing to low uncertainty and high resolution, SgurrEnergy considers SolarGIS dataset to be the most representative satellite database among all the satellite databases for long-term energy yield assessment.
8	Operational Analysis and Generation Comparison	<p>SgurrEnergy was provided with plant and grid availability records from December 2018 to December 2020 for the solar PV plant. In addition, the irradiation measurement records were also provided from November 2018 to December 2020.</p> <p>SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Client for the period from December 2018 to December 2020.</p> <p>Overall the average grid availability experienced on site for the operational period was calculated to be 97.02% which is considered to be lower than the expected range. Correspondingly the average plant availability is noted to be 99.88% which is considered to be within expected range.</p> <p>Furthermore, SgurrEnergy observed that the overall recorded generation is approximately 1.03% higher than the generation predicted on site. Overall SgurrEnergy considers the PV plant to be performing in line with SgurrEnergy's prediction.</p>
9	Allied Components and Systems	<p>The 50MW<sub>AC</sub> solar PV plant is designed with JA solar (325/330Wp) solar PV modules and Sineng 1250kW central inverter.</p> <p>The project has been implemented with 10 inverter station comprising of four inverters each. The AC capacity of each inverter station is 5MW<sub>AC</sub>. The 11kV output of each inverter station combined at 11kV main HT panel located within Main control room (MCR). Further the power is fed from main HT panel to 11/110kV plant end switchyard.</p> <p>Power is then evacuated to the 230/110kV Nallamanaichenpatti substation located approximately 10kms from the Project site through Panther ACSR single circuit overhead cable.</p>
10	Energy Yield Assessment	Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy



Sr. No.	Parameter	Comment												
		yield predictions for third year of plant operation for the 50MWAC PV plant.												
		<table><tr><td>Global Horizontal Irradiation (kWh/m2)</td><td>1,967.60</td></tr><tr><td>Global Inclined Irradiation (kWh/m2)</td><td>1,991.20</td></tr><tr><td>Third Year P50 Energy Yield (MWh/annum)</td><td>84,172.94</td></tr><tr><td>Specific Yield (kWh/kWp)</td><td>1558.32</td></tr><tr><td>Performance Ratio (PR)</td><td>78.25%</td></tr><tr><td>PLF on Contracted Capacity (50MWAC)</td><td>19.21%</td></tr></table>	Global Horizontal Irradiation (kWh/m2)	1,967.60	Global Inclined Irradiation (kWh/m2)	1,991.20	Third Year P50 Energy Yield (MWh/annum)	84,172.94	Specific Yield (kWh/kWp)	1558.32	Performance Ratio (PR)	78.25%	PLF on Contracted Capacity (50MWAC)	19.21%
Global Horizontal Irradiation (kWh/m2)	1,967.60													
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Third Year P50 Energy Yield (MWh/annum)	84,172.94													
Specific Yield (kWh/kWp)	1558.32													
Performance Ratio (PR)	78.25%													
PLF on Contracted Capacity (50MWAC)	19.21%													



## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
Km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
M	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon



MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation



## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

KKR global was founded in 1976 and the company had expanded its presence in India in 2009. The company is a global investment firm that manages multiple alternative asset classes, including private equity, credit and real assets with strategic partners that manage hedge funds. As of 30 September 2020, KKR has a team of over 1,600 employees, consultants, investment professionals and senior advisors working across 16 industries in offices around the world.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 258MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of six Solar PV plants, as presented within Table 1-1.

**Table 1-1: Portfolio Key Summary**

Project Name	SEPEPL – 80MW <sub>AC</sub>	SEPEPL – 50MW <sub>AC</sub>	SPSPL – 50MW <sub>AC</sub>	SPSPPL – 30MW <sub>AC</sub>	TNSPEPL – 5MW <sub>AC</sub> + 8MW <sub>AC</sub> + 10MW <sub>AC</sub>	UMD- 12MW <sub>AC</sub> + 13MW <sub>AC</sub> +
Site Location	18.926°N, 76.395°E, Parli, Maharash- tra, India	21.028°N, 75.985°E, Muktainagar Maharashtra ,India	9.324°N, 77.594°E. Rajapalyam, Tamil Nadu,India	12.344°N, 78.945°E Tiruvanna m-alai, Tamil Nadu, India.	5MW <sub>AC</sub> – 10.491°N, 78.063°E Dindigul, Tamil Nadu, India 8MW <sub>AC</sub> – 9.437°N, 78.172°E Aruppukkotai Tamil Nadu, India 10MW <sub>AC</sub> – 9.118°N, 78.107°E Vilathikulam, Tamil Nadu, India	12MW <sub>AC</sub> - 9.554°N, 77.884°E Amathur, Tamil Nadu, India 13MW <sub>AC</sub> - 9.093°N, 77.780°E Kovilpatti, Tamil Nadu, India
Owner / Special Purpose Vehicle (SPV)	Solar Edge Power and Energy Private Limited (SEPEPL)		Shapoorji Pallonji Suryaprakas h Private Limited (SPSPL)	Shapoorji Pallonji Solar PV Private Limited	TN Solar Power Energy Private Limited	Universal Mine Developers and Service Providers Private Limited
DC / AC Capacity	104.0MW <sub>P</sub> / 80.0MW <sub>AC</sub>	65.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	54.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	36.0MW <sub>P</sub> / 30.0MW <sub>AC</sub>	5MW <sub>AC</sub> – 6.0MW <sub>P</sub> / 5.0MW <sub>AC</sub> 8MW <sub>AC</sub> – 9.6MW <sub>P</sub> / 8.0MW <sub>AC</sub> 10MW <sub>AC</sub> – 12.0MW <sub>P</sub> / 10.0MW <sub>AC</sub>	12MW <sub>AC</sub> - 14.4MW <sub>P</sub> / 12MW <sub>AC</sub> 13MW <sub>AC</sub> - 15.6MW <sub>P</sub> / 13MW <sub>AC</sub>
Commissioning date	50MW <sub>AC</sub> – 08 April 2018 30MW <sub>AC</sub> – 22 April 2018	26 April 2018	26 September 2018	26 March 2016	5MW <sub>AC</sub> – 28 December 2015 8MW <sub>AC</sub> – 28 September 2015 10MW <sub>AC</sub> – 31 October 2015	12MW <sub>AC</sub> – 16 November 2015 13MW <sub>AC</sub> – 21 March 2016

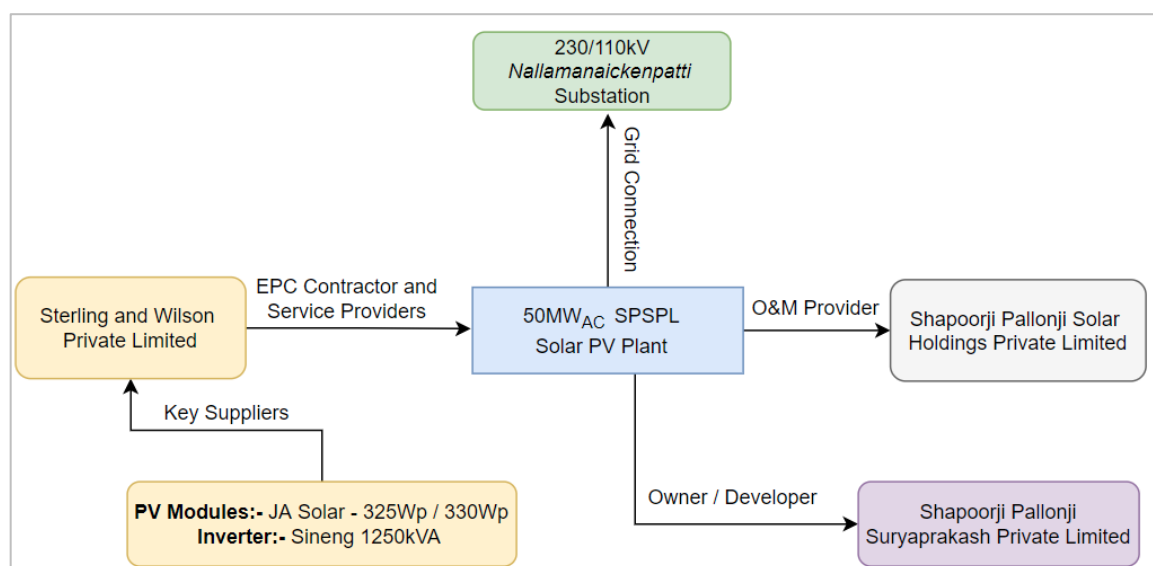


This report presents the technical appraisal of the 50MW<sub>AC</sub> SPSPL Solar PV plant (The Project) developed by Shapoorji Pallonji Suryaprakash Private Limited (SPSPL) near *Thenkarai* village, *Rajapalyam* taluk, *Virudhunagar* district of the Tamil Nadu state.

The purpose of this report is to provide a technical appraisal of PV plant under evaluation. The report focuses on the following key aspects:

- System Overview.
- Major Components.
- System Design Appraisal.
- Allied Components and Systems.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project, based on information made available by the Client through online data room and site assessment. Figure 1-1 illustrates the project structure indicating key project participants.



**Figure 1-1: Project Structure**

The main Project characteristics are summarised in table below.

**Table 1-2: Project Key Summary**

Project Information	
<b>Project Name</b>	50MW <sub>AC</sub> SPSPL Solar PV plant
<b>Location</b>	<i>Rajapalyam</i> , Tamil Nadu
<b>Developer</b>	Shapoorji Pallonji Suryaprakash Private Limited
<b>DC/ AC capacity</b>	54MW <sub>P</sub> / 50MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: JA Solar Inverters: Sineng
<b>MMS Configuration</b>	Fixed Tilt: 8°, Azimuth: 0°
<b>Commissioning Status</b>	Commissioning was achieved on 26 September 2018

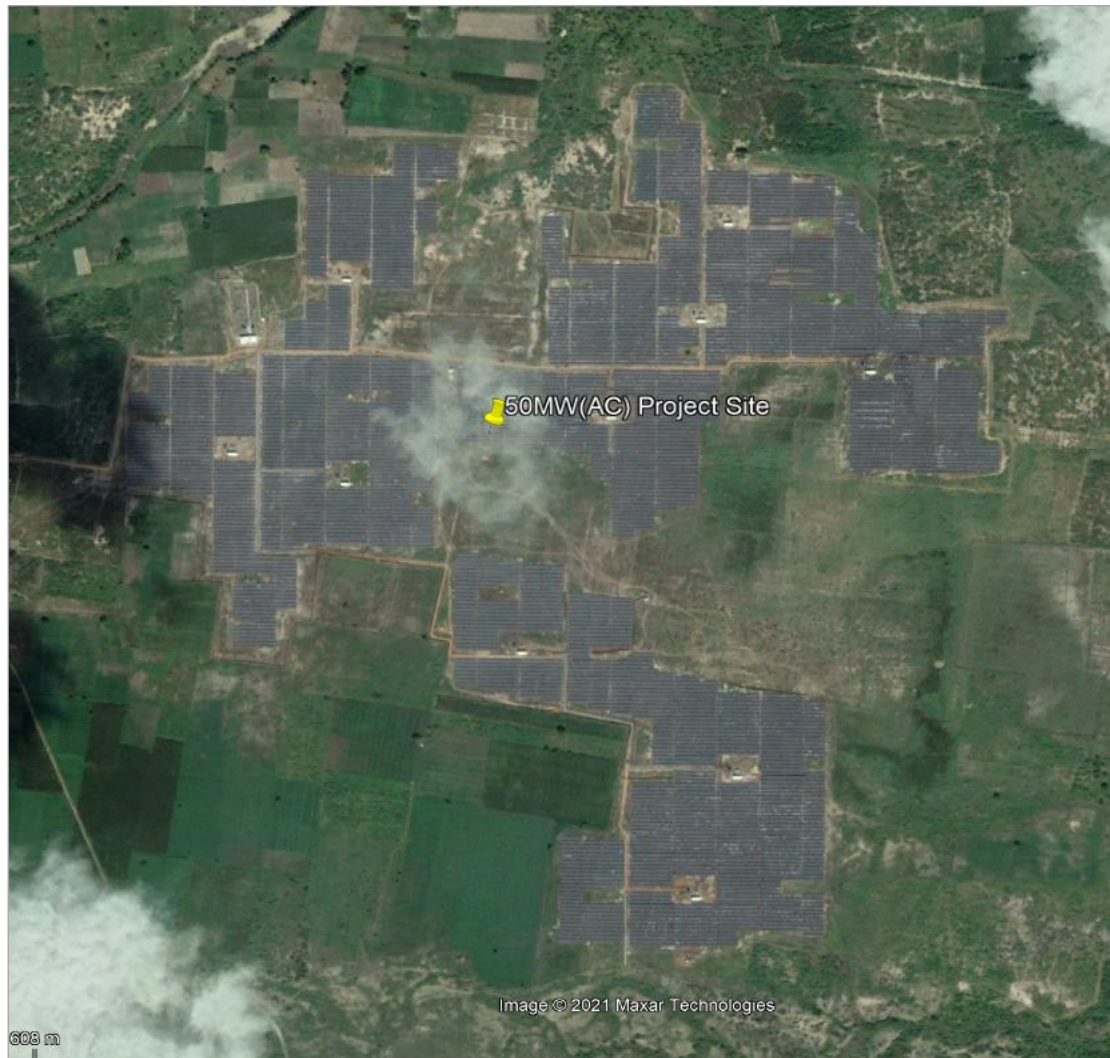




## 2 50MW<sub>AC</sub> Solar PV Plant Overview

The project site lies around the coordinates 9°19'27.97"N and 77°35'38.85"E. Satellite imageries of 50MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1. The Owner has utilised approximately 224 acres of land project. The Project site is located near the *Rajapalayam* village, in Virudhunagar district of Tamil Nadu.

Project is contracted for generating 50MW<sub>AC</sub> power; SgurrEnergy therefore interprets 50MW<sub>AC</sub> as the maximum AC installed capacity for the solar PV plant.



**Figure 2-1: Satellite image of 50MW<sub>AC</sub> plant**

### 2.1 50MW<sub>AC</sub> Project Summary

Solar PV plant is modular in nature; therefore, SPSPL 50MW<sub>AC</sub> solar PV plants is implemented by adopting modularity in designs. 5MW<sub>AC</sub> is the typical inverter station considered for implementing SPSPL 50MW<sub>AC</sub> solar PV plant.

Table 2-1 presents the summary of 50MW<sub>AC</sub> PV plant

**Table 2-1: Summary of 50MW<sub>AC</sub> Plant Configurations**

General	
PV Module Technology	Poly-crystalline
Inverter Technology	Central Inverters





General	
Installed DC Peak Capacity (MW <sub>p</sub> )	54
Installed AC Capacity (MW)	50
Mounting Type	Fixed Tilt
Tilt Angle (°)	8°
Pitch (m)	6
PV Modules	
PV Module Manufacturer	JA Solar
Model	JAP72S01-325/SC JAP72S01-330/SC
Wattage (W <sub>p</sub> )	325W <sub>p</sub> / 330W <sub>p</sub>
Number of Modules per String	30
Inverter	
Inverter Manufacturer / Model	Sineng / EP-1250-HA
Inverter Nominal AC Output	1,250kW
Number of Inverters	40
Mounting Structure	
Mounting Structure Details (rows × columns)	2 × 30
Orientation of Modules	Portrait

The 50MW<sub>AC</sub> plant is implemented with a total of 40 inverter stations, each of capacity 5MW<sub>AC</sub>. Each inverter station is comprising of three winding transformers to accommodate 4 × 1,250kVA inverters taking the individual inverter station size to 5MW<sub>AC</sub>. Each inverter station is comprising of a physical block connecting to 5.4MW<sub>p</sub> of installed photovoltaic array. The output of 5MW<sub>AC</sub> inverter station is connected to 0.550/0.550/11kV three winding transformer of 5MVA for stepping up the voltage to 11kV.

The medium voltage 11kV output of all the inverter stations are placed in main control room (MCR), these are combined to form a solar PV plant of 50MW<sub>AC</sub>. The 11kV output is stepped up to 110kV by means of two 24/40MVA, ONAN/ONAF transformers at HV substation is built within the plant premises.

The power generated by the SPSPL 50MW<sub>AC</sub> PV plant is fed to 230/110kV *Nallamanaickenpatti* substation located approximately 10km from the Project site, using Single Circuit Panther ACSR conductor. The point of interconnection is at the 230/110kV *Nallamanaickenpatti* substation.

ABT / revenue metering is at 230/110kV *Nallamanaickenpatti* substation; therefore, transmission line losses are accounted in the Owner's scope.



SgurrEnergy has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions.

## 2.2 PV modules – JA Solar Holding Co., Ltd

The PV modules selected for the Project are supplied by JA Solar Holding Co., Ltd. SgurrEnergy has conducted a technical review of the supplier and proposed module specification with regards their suitability for use on the Project.

### 2.2.1 Company Profile

JA Solar Holding Company Ltd. listed on NASDAQ (NASDAQ: JASO), was found in the year 2005 and started operation in 2006. The Company has 12 manufacturing bases and has production capacity of more than 11.5GW, 11GW, and 11GW for silicon wafer, solar cells, and solar modules, respectively.

JA solar has 20 branches around the world and employs more than 22,000 employees worldwide. As of December 2019, JA solar provides services in more than 135 countries and to more than 33,000 clients worldwide. As of second quarter 2020, JA solar had a cumulative shipment of more than 50GW. As of December 2019, JA solar had more than 779 authorized patents of independent R&D and 107 invention patents under its name. The Company's net revenue was RMB 21.16 billion in 2019.

Few of the commissioned solar power plants using JA modules are listed in Table 2-2.

**Table 2-2: Project References of JA Solar**

Sr. No.	Project and Location	Capacity (MW)
1	Bahia, Brazil	255.0
2	Northern Cooks, Australia	172.8
3	Cadiz, Philippines	132.5
4	Maharashtra, India	130.0
5	Three Gorges, Datong	100.0
6	Bahawalpur, Pakistan	100.0
7	Lincheng Country, Xingtai City, Hebei Province	100.0
8	Dunhuang, Gansu Province	100.0
9	Utah, USA	80.0
10	New South Wales, Australia	70.0
11	Maharashtra, India	70.0
12	Telangana, India	69.0
13	Bole, Xinjiang	60.0
14	San Carlos, Philippines	59.0
15	MP, India	57.0
16	Charanka Gujrat, India	53.0
17	Datong, Shanxi Province	50.0
18	Southwark, UK	49.0



Sr. No.	Project and Location	Capacity (MW)
19	Karnataka, India	43.0
20	Xiayu, Hebei Province	42.0
21	Yinchuan, Ningxia Province	40.0
22	Georgia, USA	38.7
23	Arawa Desert and Negev Desert, Israel	35.0
24	Hefeng, Tacheng, Xinjiang	30.0
25	Karnataka, India	23.0
26	Bulgaria	21.0
27	Haryana, India	21.0
28	Campania, Italy	20.0
29	Corp 184, Xinjiang	20.0
30	Telangana, India	18.0
31	Toshka, Egypt	10.1
32	Volkswagen Chattanooga Plant, USA	9.6
33	Antalya, Turkey	6.7
34	Kenitra, Morocco	2.0
35	ABC Bank, Jordan	1.5

JA is considered a Tier 1 supplier by Bloomberg (Q4, 2020). A Tier 1 supplier is defined as a module manufacturer who has *‘provided products to five different projects, which have been financed non-recourse by five different (non-development) banks, in the past two years.*

Whilst the Bloomberg tiering system does not reflect on a product’s technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers JA solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

### 2.2.2 Main Technical Characteristics of JAP72S01/SC

JA Solar, JAP72S01/SC modules of 330W<sub>P</sub> and 325W<sub>P</sub> capacity have been utilized for the Project. These modules have an efficiency of 16.7% and 17% for 325W<sub>P</sub> and 330W<sub>P</sub> capacity modules, respectively, and a peak power tolerance of 0~+5W. The modules have a temperature coefficient (P<sub>max</sub>) of -0.41%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy’s expectation for c-Si technology. The technical characteristics of JAP72S01/SC are presented in Table 2-3.

**Table 2-3: Technical specifications of JAP72S01/SC**

Specifications	JAP72S01-325/SC	JAP72S01-330/SC
Technology	Polycrystalline	
Nominal power (P <sub>MPP</sub> )	325W <sub>P</sub>	330W <sub>P</sub>
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	37.39V	37.65V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	8.69A	8.77A
Open circuit voltage (V <sub>OC</sub> )	46.38V	46.40V
Short circuit current (I <sub>SC</sub> )	9.17A	9.28A



Specifications	JAP72S01-325/SC	JAP72S01-330/SC
Efficiency (%)	16.70%	17.00%
Maximum System Voltage	1,500V (DC)	
Power tolerance (%)	0~+5W	
Dimensions (length × breadth × width) (mm)	1960 × 991 × 40	
Module area (m <sup>2</sup> )	1.94m <sup>2</sup>	
Weight (kg)	22kg±3%	
Temperature coefficient at P <sub>MAX</sub>	-0.41%/°C	
Operating temperature	-40°C to +85°C	
Maximum reverse current	20A	
Maximum mechanical load	5400Pa	
Maximum snow load	2400Pa	
Product warranty	12 years	
Power output guarantee	25 years	
Module technical characteristics are given at STC (1,000W/m <sup>2</sup> irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet)		

The maximum system voltage is 1,500V. The maximum reverse current is 20A. Overall, the module characteristics can be considered to be in line with market standard and JA Solar are listed as Tier 1 suppliers by Bloomberg since 2014.

### NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>1</sup> characteristics of selected JAP72S01/SC modules of 325W<sub>P</sub> and 330W<sub>P</sub> capacity is given in Table 2-4 corresponding to realistic operating conditions as compared to STC. It is affected by module materials used as well as the packing density of module materials. The NOCT for the module is 45±2°C. This is comparable with other manufacturers and demonstrates the module is effective at heat dissipation.

**Table 2-4: PV Module NOCT Characteristics of JAP72S01/SC**

Model	JAP72S01-325/SC	JAP72S01-330/SC
Maximum Power (P <sub>MAX</sub> )	241W <sub>P</sub>	244W <sub>P</sub>
Max Power Voltage (V <sub>MPP</sub> )	34.82V	35.03V
Max Power Current (I <sub>MPP</sub> )	6.91A	6.97A
Open Circuit Voltage (V <sub>OC</sub> )	43.24V	43.41V
Short Circuit Current (I <sub>SC</sub> )	7.35A	7.40A

### 2.2.3 Certification of Modules

General review of datasheet indicates JA Solar PV modules manufactured in facilities with the following certifications:

<sup>1</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C.



- ISO 14001 certification for environmental management systems
- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certification mentioned in the datasheet of the modules under evaluation within Table 2-5.

**Table 2-5: Certification for PV Module- JA Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
IEC 60068	Environmental Testing
IEC 61701	Resistance to salt mist and corrosion
IEC 62716	Ammonia Corrosion Testing
IEC 62804	Testing Modules for Potential Induced Degradation
UL 1703	Standard for safety for flat-plate photovoltaic modules

#### 2.2.4 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of six months from the dispatch from the JA solar factory or the delivery date to site.

##### 2.2.4.1 Product Warranty

JA Solar provides a limited product warranty of 12 years, beginning on the earlier of module purchase date or one-year anniversary from the production date. If module fail to conform to this warranty, during the period ending of 12 years from the date of sale to the customer of the JA solar product, JA solar will at its opinion, either repair or replace the product, or refund the purchase price as paid by the customer. The repair or replacement or refund the customer at the current comparable market price of such module.

SgurrEnergy considers twelve-year product warranty provided by JA solar to be in line with the industry standard.

##### 2.2.4.2 Linear Power-Output Warranty

According to the datasheet JA solar warrants that the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.7% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 80% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, JA solar will either repair, replace or provide additional modules to make up for the loss in power output.

#### 2.3 Inverters – Sineng Electric

The project has utilized Sineng EP-1250-HA central inverter for the project under evaluation.



### 2.3.1 Company background

Sineng Electric is a Chinese company headquartered in Wuxi, specialising in manufacturing and marketing of power electronic products. The company was established in 2012 with a focus on PV inverters manufacturing.

According to I Markit 2017 Report, Sineng Electric is the world's sixth-largest solar inverter manufacturer. The company has an annual capacity of more than 13GW.<sup>2</sup>

The company has offices in India, China, and Australia with two factories situated in Wuxi, China and Bengaluru, India, respectively. Each of which has a manufacturing capacity of 3GW annually.

### 2.3.2 Track Record

Table 2-6 lists the customer details along with project locations where Sineng inverters have been installed.

**Table 2-6: Sineng Inverter Track Record**

Sr, No.	Customer Name	Project Capacity (MW <sub>AC</sub> )	Inverter Model	Project location
1	Softbank	300	EP-3125-HB-UD	Rajasthan, India
2	B.Grimm Power	215	EP-5000-HA-OD/22	Phu Yen, Vietnam
3	Tata Power	200	EP-3125-HB-UD	Gujarat, India
4	L&T Construction Limited (NLC)	100	EP-2500-HA-OD	Tamil Nadu, India
5	Sprng Energy	100	EP-3125-HA-UD	Andhra Pradesh, India
6	AVAADA Energy PVT Ltd.	100	EP-3125-HA-UD	Karnataka, India
7	ABG	100	EP-3125-HA-UD	Rajasthan, India
8	Shapoorji Pallonji	80	EP-2500-HA-UD	Maharashtra, India
9	Boviet Solar	80	EP-2500-AI-OD/22	Tay Ninh, Vietnam
10	Super Energy	80	EP-2500-HA-OD/22	Binh Thuan, Vietnam
11	ABG	75	EP-3125-HA-UD	Orissa, India
12	Bamboo Capital	75	EP-6250-HA-UD/22	Long An, Vietnam
13	Shanghai electric Cuba Mariel Project	62	EP-0500-A	Mariel special zone, Cuba
14	L&T Construction Limited	55	EP-2500-HA-UD	Tamil Nadu, India
15	Sterling & Wilson	50	EP-1250-HA	Tamil Nadu, India
16	Refex Energy Ltd (NLC)	50	EP-1250-HA	Tamil Nadu, India
17	Amara Raja Power System Limited	50	EP-3125-HA-UD	KRDEL-Pavagada, India
18	Truong Thanh-Binh Thuan Solar	45	EP-2500-HA-UD	Binh Thuan, Vietnam

<sup>2</sup> <http://en.si-neng.com/About/about.html>



Sr, No.	Customer Name	Project Capacity (MW <sub>AC</sub> )	Inverter Model	Project location
19	Vietnam Shenglong Investment	44	EP-6250-HA-UD/22	Phu Yen, Vietnam
20	Eco Seido	40	EP-6250-HA-UD/22	Binh Thuan, Vietnam
21	Bamboo Capital	31.25	EP-6250-HA-UD/22	Long An, Vietnam
22	Power Plus	30	EP-2500-HA-OD/22	Binh Thuan, Vietnam
23	Tata Power	25	EP-2500-A-OD	Karnataka, India
24	L&T Construction Limited	20	EP-2500-HA-UD	UP, India
25	Shapoorji Pallonji	20	EP-2500-HA-UD	Maharashtra, India
26	ABG/Oriano	12.5	EP-3125-HA-UD	Karnataka, India
27	BMENERGY Co.,ltd.	11.536	SP-36K-L/50K/SP-60K-L	Incheon, Korea
28	Bosch Limited	9	EP-2500-HA-UD/3125	RAIGARH, India
29	Energia Mori Solar	5.5	EP-1000-A-OD	Januaba, Brazil
30	Energia Mori Solar	5.5	EP-1000-A-OD	Corinto, Brazil
31	Energia Mori Solar	5.5	EP-1000-A-OD	Manga, Brazil
32	Jakson Limited	3.75	EP-1250-AI	UP, India
33	AMP Solar	2.5	EP-2500-A-OD	Kerala, India
34	Cleanmax Solar	2	CP-2000-B-OD	Rajasthan, India
35	Azure Power	1	CP-1000-B-OD	Rajasthan, India

### 2.3.3 Technical Characteristics

The technical specification of Sineng EP-1250-HA inverter is listed in Table 2-7. The inverter series is a line of central inverters designed for utility-scale PV applications. These inverters are designed to operate with DC inputs up to 1,500 V. They incorporate maximum power point tracking (MPPT) and grid management features to meet utility requirements.

The inverter is designed for outdoor use with an IP54 ingress protection class. According to the technical specifications mentioned in the datasheet, SgurrEnergy understands that the inverters perform optimally at ambient air temperatures between -30°C to 60°C having a relative humidity of 95%.

The Sineng EP-1250-HA inverter has a maximum efficiency of 99.02% and a European efficiency of 98.48%. The main technical characteristics of this inverter are illustrated in Table 2-7.

**Table 2-7: Sineng Electric EP-1250-HA Inverter Specifications**

Parameter	Value
Inverter	EP-1250-HA
Type	Central Inverter – Outdoor
<b>Input Data</b>	





Parameter	Value
PV Voltage Range, MPP (V)	800 – 1300V
Maximum DC Voltage (V)	1500V
Maximum Input Current (A)	1754A
<b>Output Data</b>	
Nominal AC Power (kW)	1250kW
Maximum AC Power (kW)	1375kW@25°C 1312kW@50°C
Maximum AC Current (A)	1443A
Nominal AC Voltage (V)	550V
AC Grid Frequency (Hz)	50Hz
Maximum THD	< 3%
<b>Operating Performance</b>	
Maximum Efficiency (%)	99.02%
Euro Efficiency (%)	98.48%
<b>Power Consumption</b>	
Own Consumption in Operation(W)	< 1700W
Self-Consumption at standby	< 40W
<b>Other</b>	
Dimensions (W × H × D) (mm)	2226mm × 2050mm × 725mm
Weight (kg)	1250kg
Environmental Protection Rating	IP20
Operating Temperature Range (°C)	- 30 to 60°C
Relative Humidity (%)	95%

The following protection devices are included within the inverter design:

- Surge protection device of Type 1+2 for both AC & DC and auxiliary circuits
- Grid Monitoring, Surge arrester for auxiliary power supply
- Insulation monitoring & GFDI
- Emergency stop switch
- Dynamic Reactive Power Control
- Anti-islanding protection
- DC reverse-polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection
- Over frequency & under frequency protection

Sineng inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components. Further technical parameters include an operational altitude of up to 4,000m.

#### 2.3.4 Certification





Sineng is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. Sineng inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information made available by the Client, SgurrEnergy has summarized the certification of Sineng inverter within Table 2-8.

**Table 2-8: Description of Certification of Sineng Inverters**

Certification	Description
IEC 60068-2/ IEC 62093	Environmental testing of inverters to assess their ability to perform and survive under conditions such as transportation, storage, operational environments, extreme cold and heat
IEC 61683	Procedure for the measurement of the efficiency of inverters
IEC 61000-6-2/ IEC 61000-6-4	Electromagnetic compatibility (EMC) – Immunity for industrial environments
IEC 62116/ IEEE 1547/ UL 1741	Procedure to evaluate the performance of islanding prevention measures used with utility-interconnected Photovoltaic Inverters
IEC 61727/ IEEE 519	Testing procedure for Flicker, DC injection, Harmonics and waveform distortion, Power factor, Loss of utility voltage, Over/under voltage and frequency, Islanding protection and Response to utility recovery

### 2.3.5 Warranties

SgurrEnergy was not provided with a sample of inverter warranty document. Given the industry standard warranty of 60 months, SgurrEnergy does not raise any concern over the use of inverter for the Solar PV Plant.

## 2.4 Transformers

The solar PV plant is implemented with two level transformation. Power at low voltage from inverters is stepped up to 11kV using 5000kVA transformers of Shilchar make inverter transformers, and further to 110kV using 24/40MVA power transformer manufactured by EMCO Limited.

### 2.4.1 Inverter Transformer- Shilchar Technologies Limited

The inverter transformer used for the project are manufactured by Shilchar Technologies Limited.

Established in 1990 and headquartered in Gujrat, India, Shilchar is one of the prominent manufacturers of Power & Distribution transformers. As of April 2020, the Company has commissioned the manufacturing facility capable of manufacturing up to 50MVA, 132KV class transformer and up to 4000MVA transformers annually.

Shilchar Technologies is an ISO 90001:2015, ISO 14001:2015 and ISO 45001:2018 certified company providing services to wide range of industries across the world including utility sector to renewable energy. The Company has a dedicated marketing team to cater



services required in 20 different countries in the world. Since 2011, 40% of the revenue generated by Shilchar is through export.

The Company manufactures and has type tested various 3-winding, 4-winding, and 5-winding transformer with copper and aluminium conductor. The highest rating type tested by Shilchar is 12.5MVA, 5 winding Inverter Duty Transformer (IDT). The Company has supplied nearly 4GWs of transformers for solar application throughout the world including in Philippines, Egypt, Kenya, and Chile.

#### 2.4.1.1 Technical Specifications

The 5000kVA Inverter transformers used in the project are outdoor type, three-winding (copper wound), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 2-9.

**Table 2-9: Technical Specification of Shilchar Transformer**

Technical Parameters	Description
Rated Power	5000kVA
Rated HV	11kV
Rated LV	550-550V
Tapping on HV	-5% to +5% (steps of 2.5%)
Phases	3
Frequency	50Hz
Vector group	Yd11d11
Impedance	6% ( $\pm 10\%$ )
Cooling Strategy	ONAN
Oil temperature rise	50°C
Winding temperature rise	55°C
Winding material	Copper

SgurrEnergy considers the overall the technical specification to be adequate for the PV projects and in line with the industry accepted standards.

#### 2.4.1.2 Temperature Rise Detection and Protection

Inverter transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

#### 2.4.1.3 Warranties and Guaranties

Based on the information available in public domain, SgurrEnergy understands the Shilchar transformers have been provided with a warranty of 60 months from date of



dispatch. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards.

#### 2.4.2 Power Transformer- EMCO Limited

The power transformer used for the project are manufactured by EMCO Limited.

Established in 1964 and headquartered in Maharashtra, India, EMCO is one of the prominent products and service provider in power generation, transmission, & Distribution utilities and industry. As of December 2018, EMCO's range of manufacturing extended from 1MVA up to 500MVA, 400kV.

As of December 2018, EMCO had 4 manufacturing plants at Thane, Jalgaon, Dadra, Vadodara, and 15 offices across India. is an ISO 90001:2015, ISO 14001:2015 and ISO 18001 certified company providing services to wide range of industries across the world including utility sector to renewable energy. The Company has a dedicated marketing team to cater services required in 50 different countries across Americas, Europe, Middle East, Africa, Asia Pacific, and the Indian Subcontinent.

EMCO's clientele includes power utilities, steel mills, cement plants, petro-chemical industries, fertilizer plants, independent power plants, etc.

##### 2.4.2.1 Technical Specifications

The 24/40MVA Power transformers used in the project are outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN/ONAF type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 2-10.

**Table 2-10: Technical Specification of EMCO Transformer**

Technical Parameters	Description
Rated Power	24/40MVA
Rated HV	110kV
Rated LV	11kV
Tapping on HV	+10% to -15% (steps of 1.25%)
Phases	3
Frequency	50Hz
Vector group	YNd1
Impedance	11.8%
Cooling Strategy	ONAN/ ONAF
Oil temperature rise	50°C
Winding temperature rise	55°C

SgurrEnergy considers the overall the technical specification to be adequate for the PV projects and in line with the industry accepted standards.

##### 2.4.2.2 Temperature Rise Detection and Protection

The 24/40MVA Power transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and



winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

## 2.5 Conclusion on Major Plant Components

### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of JA Solar assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.

Further, according to the warranty documents available in public domain for JA Solar modules, SgurrEnergy considers the warranty terms and conditions offered by the module manufacturer to be in-line with the industry standard and raises no major concern regarding the warranties offered. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.

### Inverters

SgurrEnergy has conducted review of the Sineng EP-1250-HA central inverter Sineng EP-1250-HA central inverter has the required certification for use in solar PV plants. In-house testing of the inverter and individual components is relatively extensive during the R&D phase with functional and temperature cycling testing of each manufactured inverter. Sineng offers a product warrant of 5 years which is in line with the current industry standards.

In conclusion, Sineng can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters. In conclusion, SgurrEnergy does not raise any major concerns about the inverters used in the project.

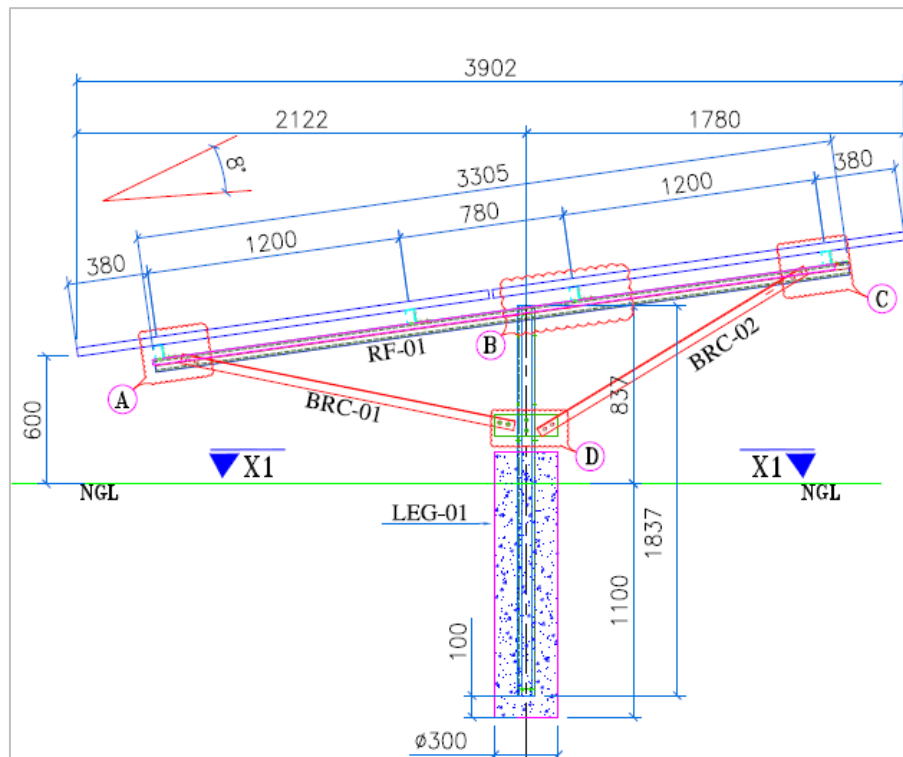
### Transformers

The inverter transformers and power transformers used within the project are manufactured by Shilchar Technologies Limited and EMCO Limited, respectively. Both the manufacturers have a good track record of supplying transformers for solar application throughout the world including. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over their use in the project.

## 2.6 Module Support Structures

The Array Layout provided by the Client for the JA Solar modules indicates the fixed tilt module mounting structure is inclined at 8° tilt angle. Based on the information provided in the GA drawing of the MMS, the technical specification has been summarized below. SgurrEnergy envisages that the MMS design is identical for the other PV modules used in the project. Figure 2-2 illustrates the module mounting structure configuration provided by the Client for the JA Solar modules.





**Figure 2-2: Side view of the module mounting structure configuration**

Table 2-11 summarizes the technical specification of the module mounting structure.

**Table 2-11: Specification of MMS**

MMS Part	Material	Grades - Standard	Thickness (mm)	Minimum Yield Stress (MPa)
Rafter	Cold Formed	ASTM A 792/A 792M-09	1.2	550
Purlin	Cold Formed	ASTM A 792/A 792M-09	1.2	550
Leg	Cold Formed	E350- IS: 2062:2011	2.5	350
Bracing	Cold Formed	E350- IS: 2062:2011	1.6	550

Material used is a combination of hot-dipped galvanised mild steel and pre-galvanised cold rolled sheets sheared to form structural members for module mounting. The pre-galvanised sheets post process is appropriately coated with anti-corrosion compounds for the project life cycle.

SgurrEnergy was not provided with the information regarding type of pile used in the project. Further based on the information provided under GA drawing of the MMS, SgurrEnergy understands that the Owner has considered the wind speed of 39m/s according to IS 875 (part 3) – 1987.

The structure designed has two rows of modules placed in portrait orientation with 30 modules in each row. In total there shall be 60 modules in one mounting structure. The layout is designed with a pitch <sup>3</sup>(distance between the fronts of one row to the front of the next row) of 6m.

<sup>3</sup> Pitch: Distance between the fronts of one row to the front of the next row

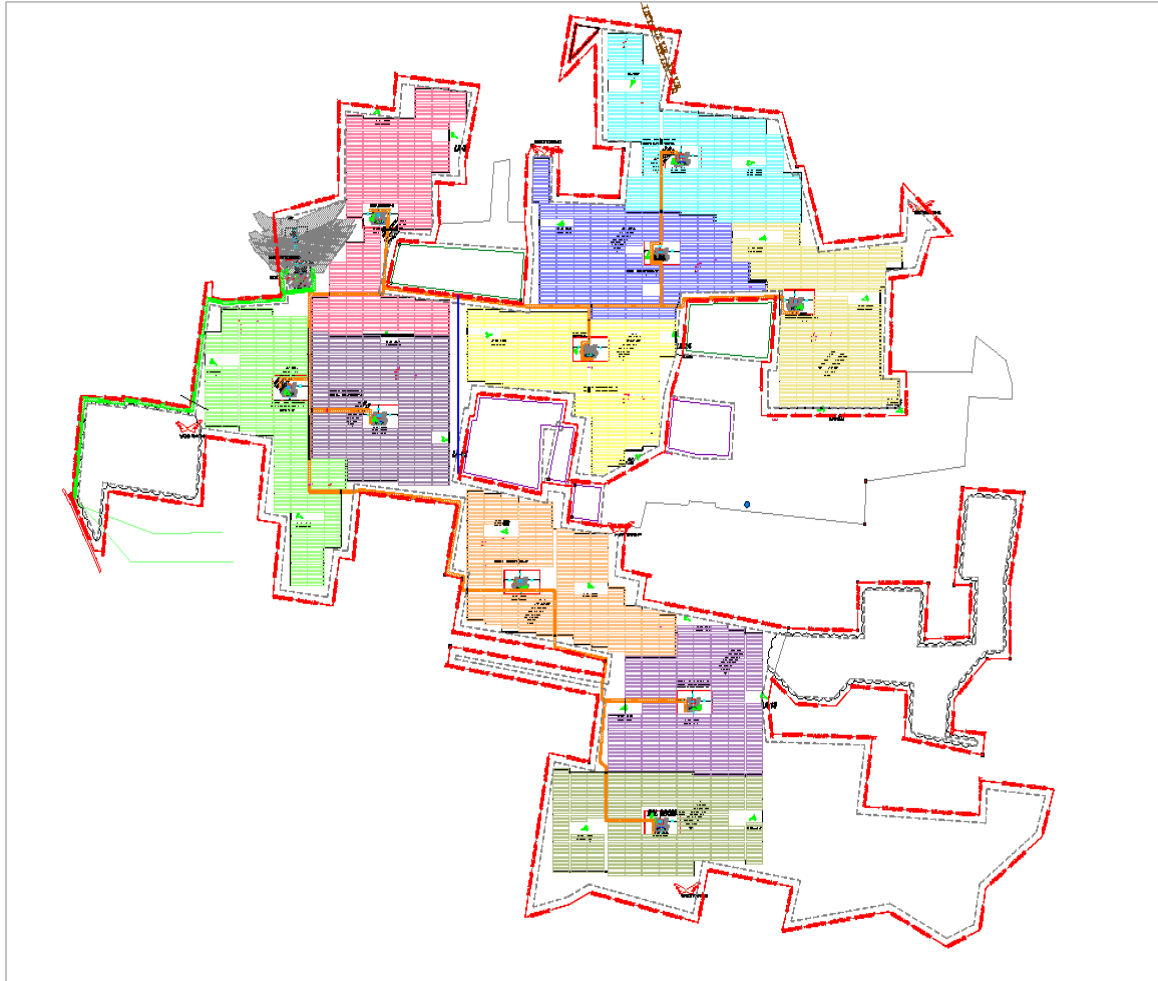


### 3 System Design Appraisal

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

#### 3.1 Plant Layout Design

SgurrEnergy was provided with as built plant layout and electrical schematics. SgurrEnergy has verified the plant configuration with electrical schematics provided by the Client. The PV plant is JA Solar (325W<sub>p</sub> / 330W<sub>p</sub>) PV modules. The total DC installed capacity stands at 54MW<sub>p</sub>. The AC installed capacity stands at 50MW<sub>AC</sub> with 40 inverters of capacity 1,250kW each. Overall 50MW<sub>AC</sub> PV plant is illustrated below in the Figure 3-1.

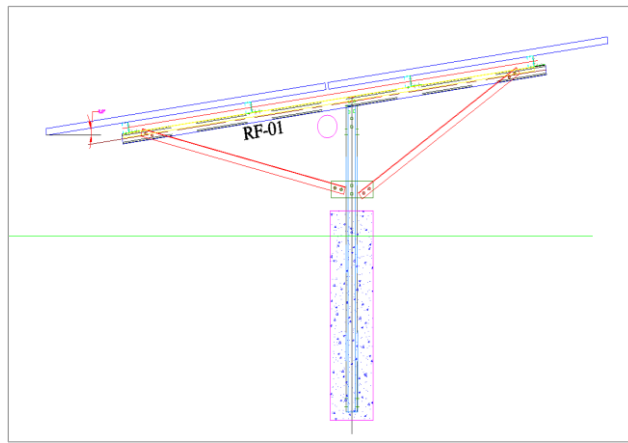


**Figure 3-1: Plant layout of 50MW<sub>AC</sub>**

All the PV modules are orientated towards South. The mounting structure provides support for two rows of panels in portrait orientation.







**Figure 3-2: Side view of typical module mounting structure configuration**

The selected tilt for the 50MW<sub>AC</sub> plant is 8°. The 50MW<sub>AC</sub> plant is designed with a pitch of 6m.

Based on regional experience of detail designing, SgurrEnergy considers the selected tilt angle and pitch is optimized for maximum irradiation on the collector plane, minimum loss due to inter row shading, minimum ohmic losses and ease of maintenance.

30 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.08. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.

### 3.2 String Sizing

The plant layout provided by the Client indicate thirty 325W<sub>p</sub> and 330W<sub>p</sub> JA Solar polycrystalline modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage ( $V_{OC}$ ) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum  $V_{OC}$  of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy in validating string configuration. Subsequent to calculating open circuit voltage ( $V_{OC}$  max), maximum power voltage ( $V_{mp}$  min) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 40°C and 15°C respectively for system design validation to be fair and representative for the PV plant site.

The results of string sizing validation are presented in Table 3-1. Results indicate that  $V_{OC}$  max at the minimum ambient temperature is within the maximum system voltage of 1,500V for the selected Sineng inverters.

**Table 3-1: String Sizing for JA Solar PV Modules**

Parameters	JA 325W <sub>p</sub>	JA 330W <sub>p</sub>
PV module power (W <sub>p</sub> )	325	330
Modules per string	30	
Inverters	Sineng EP-2500-HA	



Parameters	JA 325W <sub>p</sub>	JA 330W <sub>p</sub>
Maximum Open-circuit voltage (V <sub>oc</sub> max) at minimum ambient temperature of 15°C	1437V	1440V
Minimum power voltage (V <sub>mp</sub> min) at maximum ambient temperature of 40°C	1320V	1320V

### 3.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with JA Solar and Sineng inverter is presented in Table 3-2. SgurrEnergy has selected the highest rated JA Solar module (330W<sub>p</sub>) their compatibility with Sineng inverters, as SgurrEnergy considers this to be representative for all the JA Solar PV modules installed on site.

**Table 3-2: Inverter Compatibility with JA Solar 330W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	JA Solar 330W <sub>p</sub>	
Modules per string	30	Acceptable
Strings per inverter	138	Acceptable
Maximum power, P <sub>mpp</sub> at STC (kWp)	1,366.2	Nominal power ratio is 1.09, this is within the inverter bus current carrying capacity.
Maximum power voltage, V <sub>mpp</sub> at STC (V)	1,129.5	Acceptable.
Maximum power current, I <sub>mpp</sub> at STC (A)	1,210.3	Acceptable
Open-circuit voltage, V <sub>oc</sub> at STC (V)	1392	Acceptable.
Minimum MPP voltage at 40°C ambient temperature (V)	1059	Acceptable: Inverter MPPT ranges 800 - 1300V.
Maximum MPP voltage at 15°C ambient temperature (V)	1,179	Acceptable: Inverter MPPT ranges 800 - 1300V.
Maximum open circuit voltage, V <sub>oc</sub> at 15°C (V)	1440	Acceptable: Maximum inverter voltage 1500V.

Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.





## 4 Allied Components and Systems

### 4.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

### 4.2 PV Power Transfer

SgurrEnergy has reviewed the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear and plant substation as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

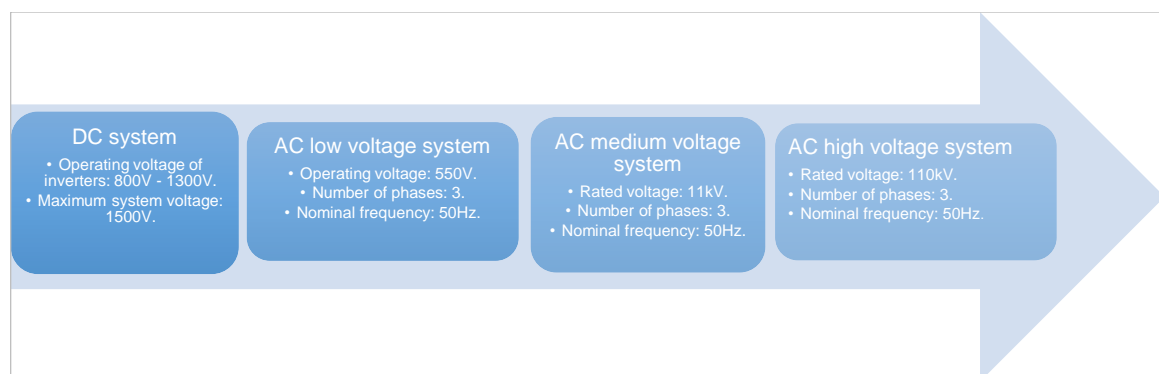
- “SWLB-SP-TN-50MW-E-DWG-DCSLD-100B”, revision 3, dated 15.05.18.
- “SWLB-SP-TN-50MW-E-DWG-SLD-100”, dated 10.05.18.
- “SPI-E-SYD-SLD-001”, dated 18.04.18
- “SWLB-SP-TN-50MW-E-DWG-AL-101”, revision 6 dated 17.12.18.

The 50MW<sub>AC</sub> solar PV Plant is designed with 325W<sub>P</sub>/ 330W<sub>P</sub> JA solar PV modules and 1250kW Sineng inverters. Modules are interconnected to form a string of 30 modules. Each string forms a single output that feeds as a single input to the 14 input combiner boxes. Six string combiner boxes are further connected to the inverter.

The 50MW<sub>AC</sub> solar PV plant has been configured with 40 Sineng 1250kW central inverters and 10 inverter stations, each comprises of four inverters. Set of four inverters are connected to 0.550/0.550/11kV three winding, 5MVA transformer that steps up the voltage to 11kV for all inverter stations. The power from the HV side of the 11kV inverter transformer is transferred to 11kV HT panel.

The output power of each 11kV HT panel is connected to 11kV main HT panel located in the main control room. Further from the control room power is fed to two 24/40MVA ONAN/ONAF two winding power transformers to step up the voltage at 110kV. Power from this transformer is then evacuated to the 230/110kV Nallamanaichenpatti substation located approximately 10kms from the Project site.

Figure below illustrates a power flow summary for the 50MW<sub>AC</sub> Solar PV plant.



**Figure 4-1: Power flow of 50MW<sub>AC</sub> PV plant**

### 4.3 Cabling

#### 4.3.1 DC Cabling

DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. Modules are interconnected in series with solar grade cables that



are tied along with the module mounting structures. Modules are interconnected in leap-frog scheme to form a string of 30 PV modules connected in series.

Y harness equipped with 15A fuse has been used to pre-combine the string of PV module. Single core 6mm<sup>2</sup> multi-stranded copper PV cables connect Y- harness output to String Combiner Box (SCB).

These combiner boxes are equipped with 30A fuse for each of the string connection and a 400A disconnect switch on output side. Power from string combiner box is further transferred to the inverter using 2 runs, 1C, 300mm<sup>2</sup>, 1.5kV aluminium XLPE ((2R X 1C X 300sqmm, 1.5kV AL. XLPE Armoured) cables.

#### 4.3.2 AC Cabling

Three phase AC output from four inverters are connected to the LV winding of a three winding 5MVA transformer using 12 Runs single core 300mm<sup>2</sup> Aluminium Armoured XLPE (12R (4R/Ph) X1C x 300mm<sup>2</sup> Al. Ar. XLPE) cable. The inverter transformers step up the voltage to 11kV.

Power is fed from the high voltage side of each transformer using 2R,3C, 300mm<sup>2</sup>, 11kV Al XLPE armoured cable to the 11kV HT panel in the inverter station using a radial feeder arrangement.

The 11kV output of each inverter station is transmitted to 11kV main HT panel located within Main control room using 2R,3C, 300mm<sup>2</sup>, 11kV(UE) Al XLPE armoured HT cables.

The power from main control room is fed to 110/11kV, 24/40MVA power transformer through 12 Runs single core, 400mm<sup>2</sup>, 11kV Aluminium XLPE Armoured (4R/Ph x 1C x 400sqmm 11kV[E], Al, XLPE, Ar.) cable to step up the voltage at 110kV.

Power at 110kV is then evacuated using Panther ACSR single circuit at 230/110kV Nallamanaichenpatti substation located approximately 10kms from the Project site.

#### 4.4 Inverter Station

The 50MW<sub>AC</sub> solar PV plant has been configured with 40 inverters and 10 inverter station each comprises of four inverters. Set of four inverters are connected to a 5,000kVA three winding transformer with allied switchgears that steps up the voltage to 11kV for all inverter stations. Further the power from the HV side of the transformer is fed to the 11kV outdoor type HT panel through radial feeder arrangement.

11kV outdoor type HT panel comprises of 325/1-1A current transformer, 11kV/110V fixed type potential transformer, 11kV EDO TP, 630A Vacuum Circuit Breaker and other electrical protection system.

#### 4.5 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed 5MVA, 11kV/2x0.550kV, Yd11d11 three-winding transformer has been used in the project. These inverter duty transformers step up the voltage to 11kV.

The inverter duty transformers output is connected to 11kV HT panels located within inverter station. The energy from all the inverter stations 11kV HT panels are radially combined at 110/11kV main HT panel located within main control room.

#### 4.6 11kV Main HT Panel

A 11kV main HT panel comprises of inverter station incoming feeders, auxiliary transformer feeders, bus coupler feeder, two outgoing feeders and two spare feeders. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class. All feeders have been provided with relay and metering unit. The 11kV main HT panel outgoing and incoming feeders are provided with instantaneous and IDMT



(50/51) O/C relay instantaneous and IDMT (50N/51N) E/F relay protections. The 11kV outgoing feeders are provided with 0.2S class instrument transformers.

Power is fed from 11kV main HT panel to power transformers located within 110/11kV plant end switchyard through two feeders.

#### 4.7 110/11kV Switchyard

The 11kV main HT panel outgoing feeders are connected to two 24/40MVA, ONAN/ONAF, YNd1, 110/11kV, power transformer located in 110/11kV plant end switchyard.

The 110/11kV switchyard is observed to be equipped with SF<sub>6</sub> circuit breaker, instrument transformers with metering & protection cores. The 110kV outgoing cable is protected with cable differential protection, which is considered to be standard engineering practice.

Further, each transformer line feeders are equipped with 0.2S instrument transformers with ABT main and check meters for measurement purpose, and isolators at incoming line for maintenance. The 96kV, 10kA lightning arrester is provided at 110kV incoming feeders to discharge surge currents caused by lightning strokes.

The power is fed from the high voltage side of each power transformer to the 110kV, 1250A, TP 40kA per 1second twin ACSR Moose conductor busbar.

Subsequently energy from 110/11kV plant end switchyard single feeder is evacuated to 110kV, Nallamanaichenpatti at 110kV level through Panther ACSR single circuit overhead cable.

#### 4.8 Auxiliary Power Supply

SgurrEnergy had reviewed the electrical schematics shared for the projects to evaluate auxiliary system. The inverter stations of all blocks are equipped with 10kVA auxiliary transformers.

#### 4.9 Power transformer

The 110/11kV AIS switchyard comprises of two 24/40MVA, 110/11kV, YNd1 two winding transformer. These power transformers step up the voltage to 110kV.

The power transformer output is connected to 110kV, 1250A, TP 40kA/1sec, Twin Moose conductor busbar. Further the combined power of both the feeders is further evacuate to 110kV Nallamanaichenpatti substation.

#### 4.10 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying, and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are normally mounted on individual structures.

Following the review of 110kV SLD, SgurrEnergy observed 145kV, 3150A, 40kA/3sec SF<sub>6</sub> motorized circuit breaker has been used in the project.

#### 4.11 Isolators

Isolators are used to transfer load from one bus to another and also to isolate equipment for maintenance.

Based on the review of 110kV SLD, SgurrEnergy observed motorized type 110kV, 1250A isolator with and without earth switch has been used in the project.



#### 4.12 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.

The current transformers with accuracy class of 0.2s for metering and class 5P and PS for protection has been used in 50MW<sub>AC</sub> solar PV plant. The potential transformers with accuracy class of 0.2 for metering and class 3P for protection has been used in the project.

#### 4.13 Lightning Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes on the lines entering the substation. The apparatus most commonly used for this purpose is the lightning arrester. Transformer is the costliest equipment in substation and it is normal practice to install lightning arrester near to the transformer. Additional lightning arresters is provided on various lines for protection of the equipment.

Following the review, SgurrEnergy observed 96kV, 10kA, CL-03 gapless Metal Oxide lightning arrestor has been used in the switchyard.

#### 4.14 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy is provided at the inverter station for each of the feeder sections. These meters are digital with an RS 232 port for remote monitoring. These usually have an accuracy class of 0.5.

Similarly, HV side is equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point is 0.2S.



## 5 Resource assessment

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SgurrEnergy has sourced monthly horizontal plane irradiation data for the Project site from:

- **NASA's Surface Meteorology and Solar Energy data set**; holds satellite derived monthly data for a grid of 0.5° × 0.5° covering the globe for a thirty-four-year period



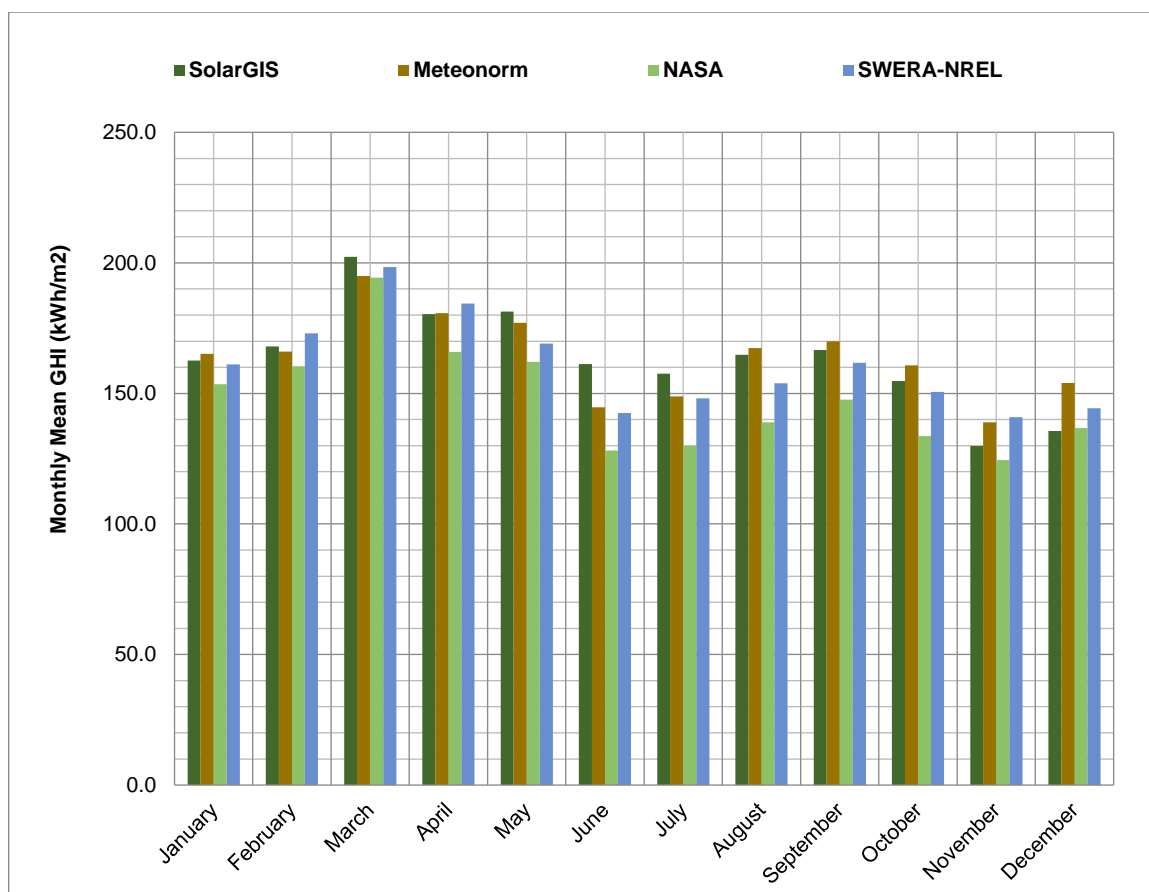
(1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.

- **The *METEONORM (version 7.3)* global climatological database and synthetic weather generator;** contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.
- **SolarGIS:** SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km x 4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by *IEA (International Energy Agency) SHC Collaboration Agreement, and EU FP6 project MESoR* in terms of bias and RMSE.

SgurrEnergy has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS data for the site. The comparison is graphically illustrated Table5-1







**Figure 5-1: Monthly Global Horizontal Irradiation**

**Table5-1: Comparison of Solar Irradiation Datasets for the site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	1,965.0
Meteonorm 7.3	14km × 14km	4.0%	1,968.4
NASA	55km × 55km	Unknown	1,775.6
NREL (SWERA)	40km × 40km	Unknown	1,928.1

The comparison of solar data for Project site location illustrated in Table5-1 indicates NASA dataset to give the highest irradiation levels. The next highest irradiation is given by Meteonorm 7.3 followed by SolarGIS and NREL (SWERA).

The irradiation values given by Meteonorm 7.3 typically provide a combination of ground and satellite measured data. Meteonorm 7.3 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as 7% for the proposed site.

The NASA-SSE data source provides purely satellite measured data for a grid covering 0.5° × 0.5° on the earth's surface and generally more suited for initial site selection.

The NREL (SWERA) data illustrated has been obtained for a location approximately 17.18 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data

The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also



been compared with other data sources globally. The IEA (International Energy Agency) validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>4</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)
- Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 6%.

SgurrEnergy is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 5.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 5-2 and shown graphically in Figure 5-2. Diffuse irradiation accounts for 47.61% of the total irradiation. Table 5-2 illustrates direct and diffuse daily irradiation on a horizontal plane for the proposed site. SolarGIS irradiation data is presented in Table 5-2.

**Table 5-2: SolarGIS Irradiation Data for the Project sites**

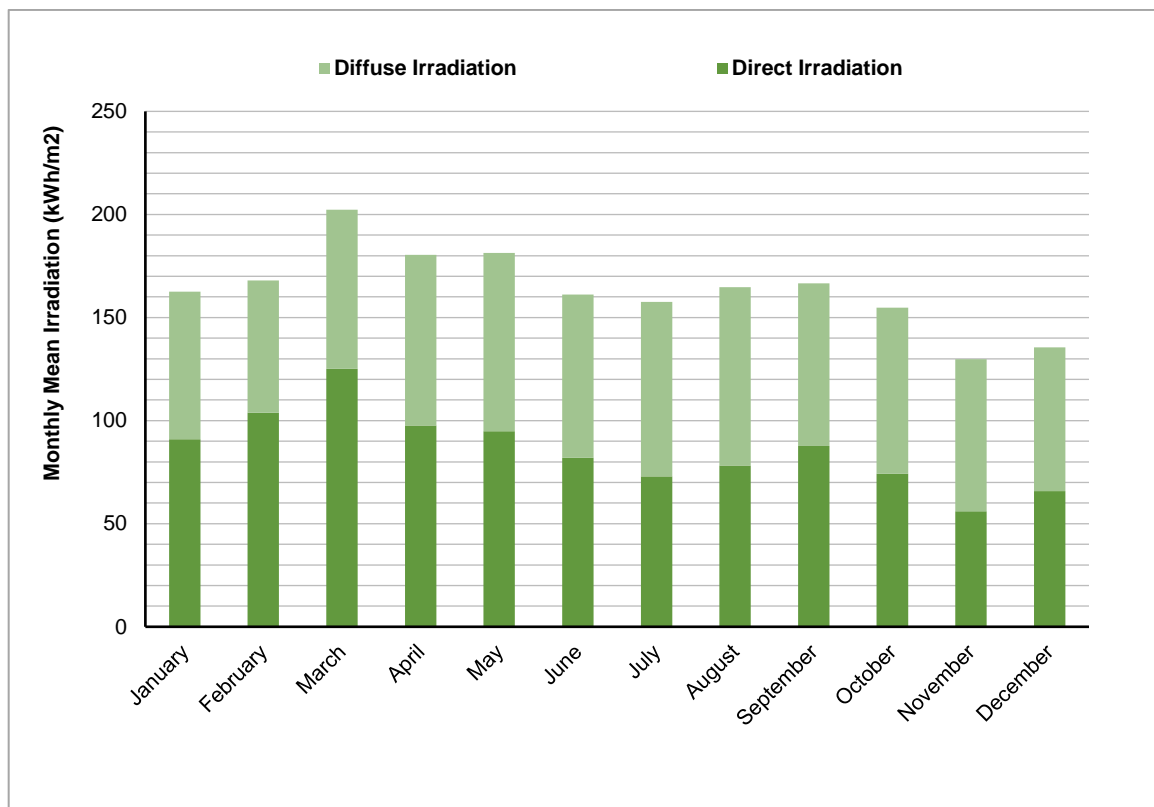
Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	162.6	71.6	8.3%
February	168.0	64.1	8.5%
March	202.3	77.2	10.3%
April	180.4	82.8	9.2%
May	181.3	86.5	9.2%
June	161.2	79.2	8.2%
July	157.6	84.6	8.0%
August	164.8	86.5	8.4%
September	166.6	78.9	8.5%
October	154.8	80.6	7.9%
November	129.8	73.8	6.6%

<sup>4</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>





Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
December	135.6	69.8	6.9%
<b>Annual Sum</b>	1,965.0	935.6	-



**Figure 5-2: Monthly Direct and Diffuse Irradiation on a horizontal plane for the project site**

## 5.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.1.4), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -5-3 represents the monthly GTI profile.

**Table -5-3: Monthly Global Tilted Irradiation Data**

Month	GTI (kWh/m <sup>2</sup> )
January	172.70
February	175.60
March	206.10
April	178.30
May	175.40
June	157.50
July	154.10
August	160.70
September	166.80



Month	GTI (kWh/m <sup>2</sup> )
October	163.40
November	136.60
December	144.00
<b>Annual Sum</b>	<b>1,991.20</b>

### 5.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 5-4 below. The average wind speed of 1.5 m/s was measured at 10 m height from ground level for the proposed project site location.

**Table 5-4: Simulated Wind Speed for site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	1
February	1.1
March	1.3
April	1.3
May	1.7
June	1.9
July	2.2
August	2.2
September	1.8
October	1.2
November	0.8
December	0.9
<b>Yearly Average</b>	<b>1.5</b>

### 5.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.

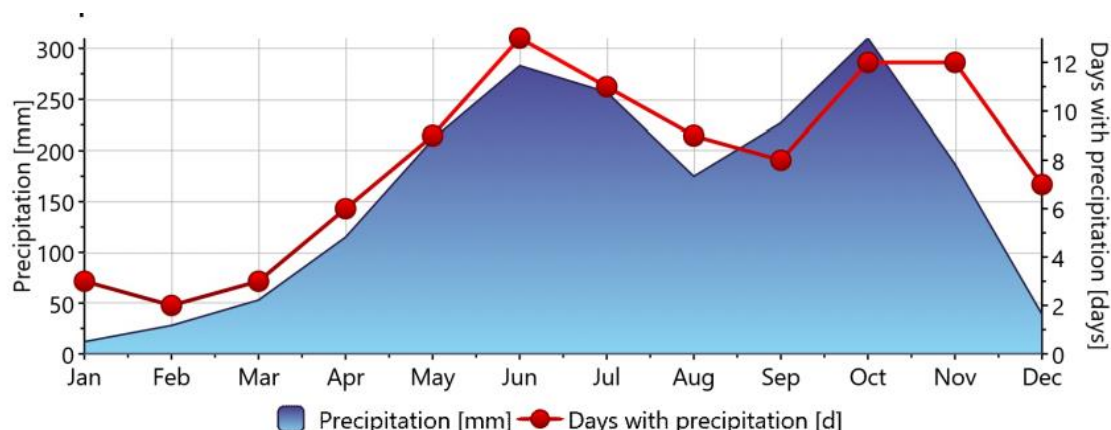


**Table 5-5: SolarGIS Temperature Data for Site (1999 – 2018)**

Months	Average Monthly Temperature (°C)
January	24.7
February	26.3
March	28.5
April	29.7
May	29.7
June	27.7
July	27.1
August	27.3
September	27.6
October	26.6
November	25.1
December	24.3
<b>Annual Average</b>	27.1

### 5.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.3 as illustrated in Figure 5-3. These figures show that the identified site is situated in a region that has marginal rainfall.

**Figure 5-3 Meteonorm Predicted Precipitation for the site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

Frequency of module cleaning depends on the rainfall frequency and the prevalence of dust and pollution in the local vicinity. Typical cleaning techniques include water cleaning, dry brushes or vehicle-based mechanical cleaning.

The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 1.5% has been considered by considering cleaning frequency of twice a month.



## 6 Energy Yield Analysis

SgurrEnergy has computed the annual energy yields for the 50 MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

Parameter	Description
Modules	JA SOLAR (JAP72S01-325/SC, JAP72S01-330/SC)
Inverters	SINENG– 1.25MW <sub>AC</sub> (EP-1250-HA)
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	54.01

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 6.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in Table 6-1 below.

**Table 6-1: Description of Energy Yield Losses**

Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.



Loss	Description
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 50 MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 6.2 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 50 MW<sub>p</sub> solar PV Plant with JA solar modules and SINENG inverters. Table 6-2 summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.

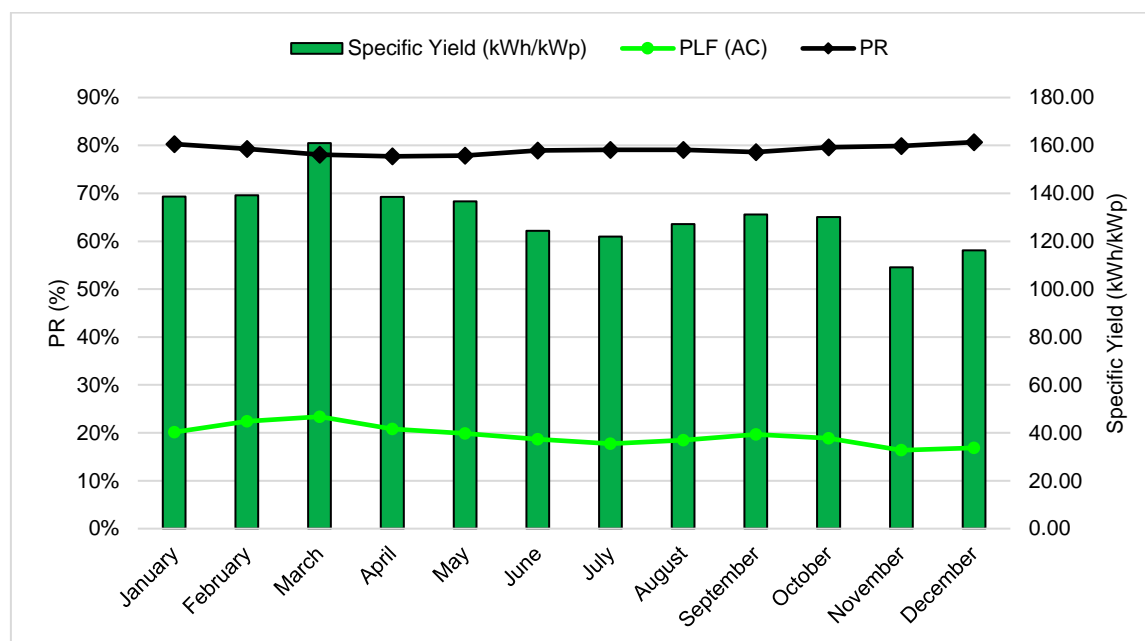


**Table 6-2: Energy Yield for the 50MW<sub>AC</sub> Solar PV Plant**

Parameters	Description
PV Module Technology	Polycrystalline
DC Capacity (MW <sub>p</sub> )	54.01
AC Capacity (MVA)	50.0
Contracted Capacity (MW)	50.0
P <sub>NOM</sub> Ratio	1.080
Tilt (°)	8
Pitch (m)	6
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1,967.60
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	1,991.20
Transposition Factor	1.01
<b>Losses</b>	
Horizon Shading	0.00%
Incident Irradiation Below Threshold	0.00%
Near Shading	0.54%
Incident Angle	2.50%
Soiling	1.50%
Low Irradiance	0.05%
Module Temperature	9.44%
Electrical Shadings	0.00%
Module Quality	0.00%
First year Degradation	1.50%
Module Mismatch	1.00%
DC Ohmic	1.04%
Inverter Performance	1.21%
Availability	1.00%
AC Ohmic	0.55%
Transformer (LV/MV)	1.07%
Transformer (MV/HV)	-
Transmission Line	0.39%
Auxiliary Consumption	0.60%
Curtailment	
<b>Total Annual Loss Factor</b>	<b>0.790</b>
<b>Third Year P50 Energy Yield (MWh/annum)</b>	<b>84,172.94</b>
<b>Third Year Specific Yield (kWh/kW<sub>p</sub>)</b>	<b>1558.32</b>
<b>Third Year CUF on AC Installed Capacity</b>	<b>19.21%</b>
<b>Third Year CUF on Contracted Capacity</b>	<b>19.21%</b>
<b>Third Year CUF on DC Installed Capacity</b>	<b>17.78%</b>
<b>Third Year Performance Ratio</b>	<b>78.25%</b>



Graphical representation of the monthly generation, performance ratio and CUF for 50 MW<sub>AC</sub> evaluated is illustrated graphically in the Figure 6-1.



**Figure 6-1: Monthly Energy Yield for 50MW<sub>AC</sub>**

### 6.3 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 6.3.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

#### 6.3.2 Inter – Annual Variation in the Solar Resource

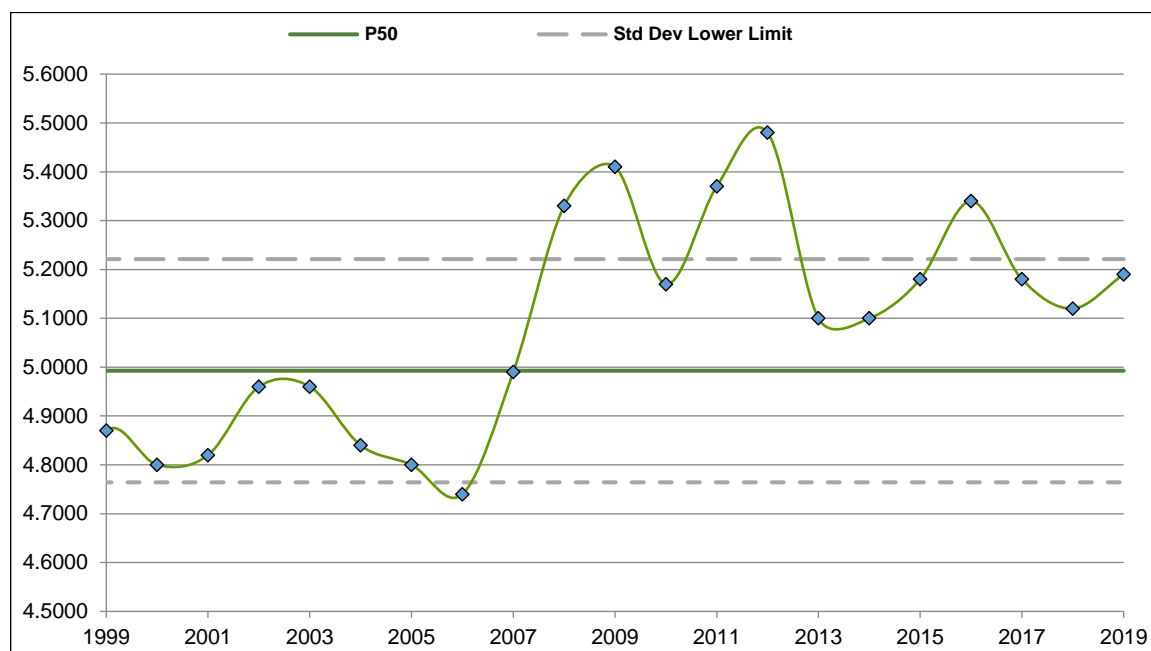
Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.

The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database for the proposed site location which is used to estimate the standard deviation of variation in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 6-3.



**Table 6-3: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	4.58

**Figure 6-2: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in Figure 6-2.

SgurrEnergy uses a coefficient of variation of 4.58% to quantify the inter-annual variation in the solar resource.

### 6.3.3 Modelling Uncertainty

The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

### 6.3.4 Total Uncertainty (P75, P90 and P99 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.

**Table 6-4: Life Cycle P50, P75 and P90 Generation Prediction for 50 MW<sub>AC</sub>**

<b>Year</b>	<b>Annual P50 Generation (MWh/annum)</b>	<b>P75 Generation Prediction<sup>5</sup> (MWh/annum)</b>	<b>P90 Generation Prediction<sup>6</sup> (MWh/annum)</b>
3	84,172.94	80,567.94	77,323.33

<sup>5</sup> The P75 values have been calculated over 10-year averages

<sup>6</sup> The P90 values have been calculated over 10-year averages





Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>5</sup> (MWh/annum)	P90 Generation Prediction <sup>6</sup> (MWh/annum)
4	83,752.08	80,165.10	76,936.71
5	83,333.32	79,764.28	76,552.03
6	82,916.65	79,365.46	76,169.27
7	82,502.07	78,968.63	75,788.42
8	82,089.56	78,573.79	75,409.48
9	81,679.11	78,180.92	75,032.43
<b>10</b>	<b>81,270.72</b>	<b>77,790.01</b>	<b>74,657.27</b>
11	80,864.36	77,401.06	74,283.98
12	80,460.04	77,014.06	73,912.56
13	80,057.74	76,628.99	73,543.00
14	79,657.45	76,245.84	73,175.29
15	79,259.16	75,864.61	72,809.41
16	78,862.87	75,485.29	72,445.36
17	78,468.55	75,107.86	72,083.14
18	78,076.21	74,732.32	71,722.72
19	77,685.83	74,358.66	71,364.11
<b>20</b>	<b>77,297.40</b>	<b>73,986.87</b>	<b>71,007.29</b>
21	76,910.91	73,616.93	70,652.25
22	76,526.36	73,248.85	70,298.99
23	76,143.73	72,882.61	69,947.49
24	75,763.01	72,518.19	69,597.76
<b>25</b>	<b>75,384.19</b>	<b>72,155.60</b>	<b>69,249.77</b>



## 7 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 0.6% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) and henceforth. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Client, SgurrEnergy understands that the 50MW SPSP solar PV plant was commissioned on 26<sup>th</sup> September 2018. SgurrEnergy was provided with plant and grid availability records from December 2018 to March 2021<sup>7</sup> for the solar PV plant. Furthermore, the irradiation measurement records were provided from November 2018 to March 2021.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from December 2018 to March 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Client.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

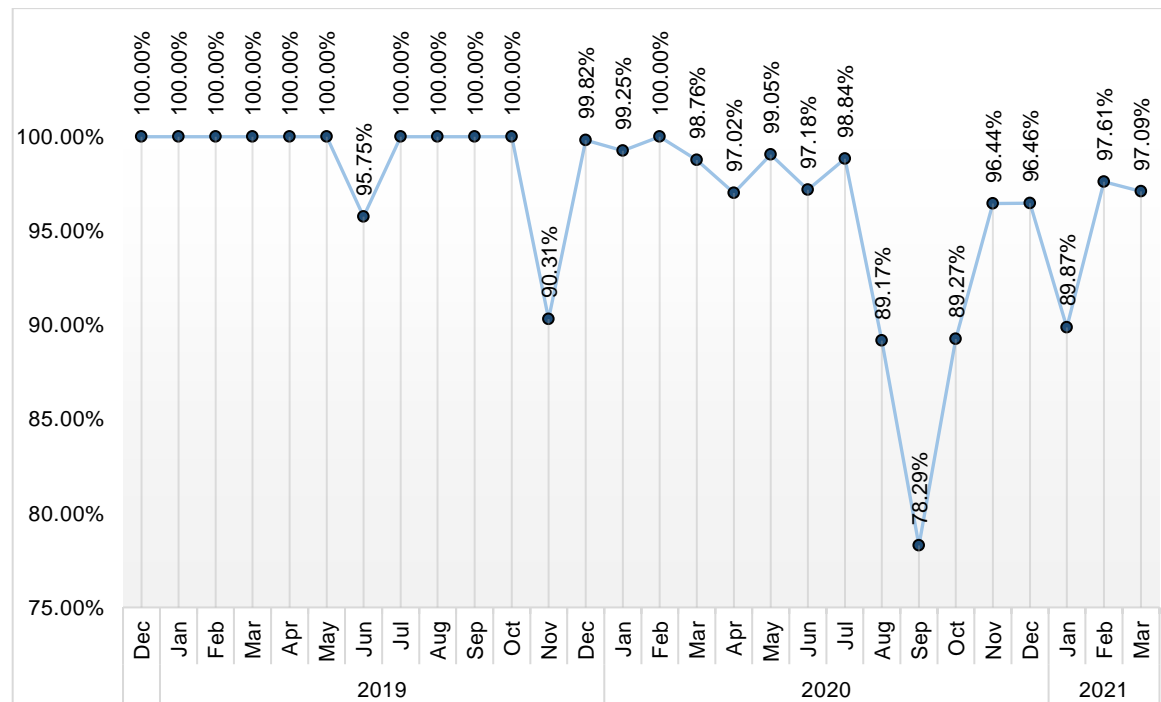
The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Owners control.

The monthly records of the grid availability from December 2018 to March 2021 have been graphically illustrated in Figure 7-1 below.

---

<sup>7</sup> SgurrEnergy was provided with both the plant and grid availability records until March 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.





**Figure 7-1: Grid Availability**

From the above illustration, SgurrEnergy notes that the grid availability was above 99% for substantial amount of time over the first year of PV Plant operation. However, from second year of PV plant operation, the grid availability losses have increased and is fairly inconsistent after year 1. Furthermore, SgurrEnergy observes that the grid availability has dropped significantly over the past few months for the period under evaluation.

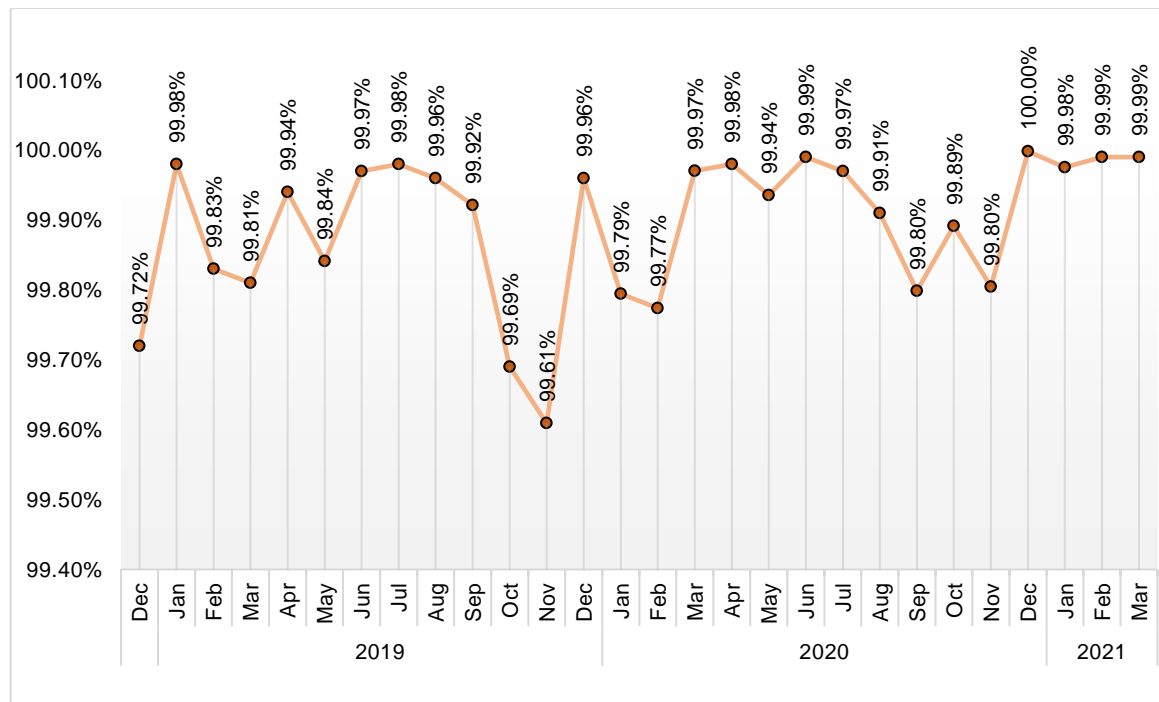
The resultant overall grid availability of the PV plant for the period evaluated was 96.79%. SgurrEnergy considers that the unavailability loss experienced due to grid anomalies for the operational period is significantly higher than the expected value.

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the SPSPL solar PV plant is graphically illustrated below in Figure 7-2.





**Figure 7-2: Plant Availability**

Based on the above illustrations, SgurrEnergy notes the plant availability for the SPSP solar PV plant was above 99% for substantial amount of time over the operational period of the plant.

The resultant average plant availability of the PV plant for the period evaluated was 99.89% which is considered to be within expected range.

## 1.2 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Client. To make the operational energy yield predictions more representative, SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Client. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Client.

The yearly comparison of the generation data is illustrated below in Figure 7-3.



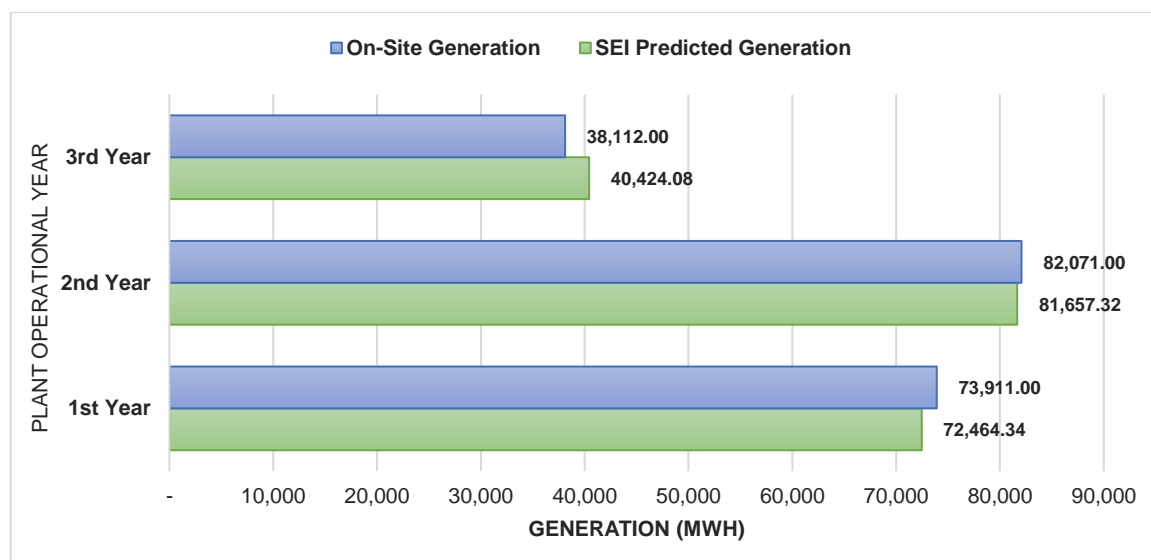


Figure 7-3: Generation Comparison

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 7-1

Table 7-1: PV Plant Performance – SPSPL 50MW

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>8</sup> (%)
Dec 2018 -Sep 2019	72,464.34	73,911.00	2.00%
Oct 2019 -Sep 2020	81,657.32	82,071.00	0.51%
Oct 2020 -March 2021	40,424.08	38,112.00	-5.72%
<b>Cumulative Period</b>	<b>194,545.75</b>	<b>194,094.00</b>	<b>-0.23%</b>

Based on the above presented comparisons, SgurrEnergy notes the plant to be performing higher than SgurrEnergy predictions. Generation of the plant was 0.23% lower than SgurrEnergy's prediction for the period under evaluation. In order to validate the lower generation, SgurrEnergy has compared the monthly incident irradiation data provided by the Client with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation. The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 7-4.

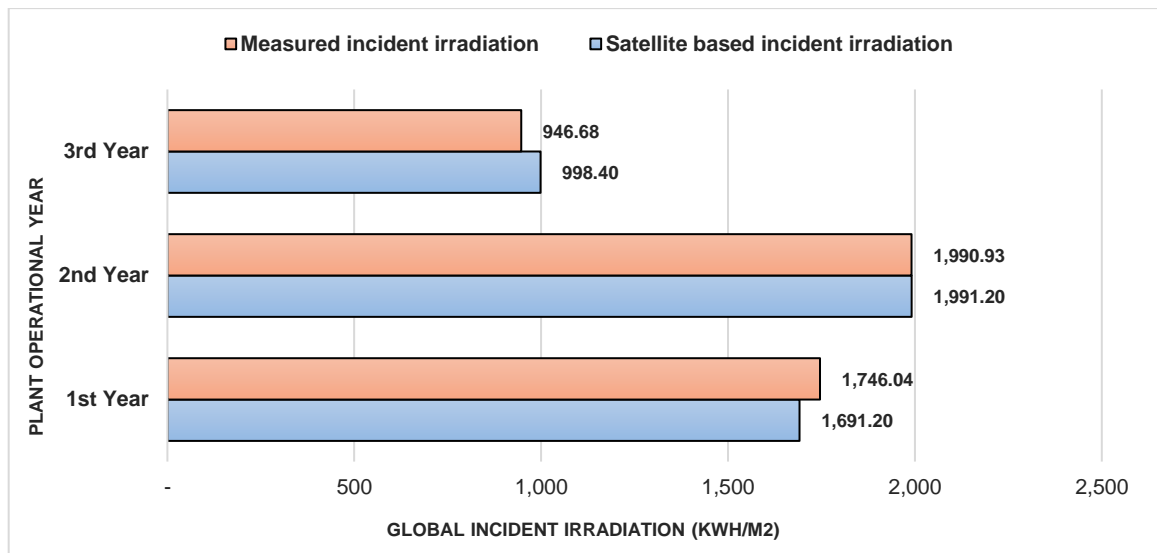
Table 7-2: Irradiation Comparison– SPSPL 50MW

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>9</sup> (%)
Dec 2018 -Sep 2019	1,691.20	1,746.04	3.24%
Oct 2019 -Sep 2020	1,991.20	1,990.93	-0.01%
Oct 2020 -March 2021	998.40	946.68	-5.18%
<b>Cumulative Period</b>	<b>4,680.80</b>	<b>4,683.65</b>	<b>0.06%</b>

<sup>8</sup> Positive values indicate higher generation, while negative values indicate lower generation

<sup>9</sup> Positive values indicate higher irradiation, while negative values indicate lower irradiation





**Figure 7-4: Irradiation Comparison**

Correspondingly, it has also been observed that the measured irradiation is approximately 0.06% higher than the irradiation predicted for the site.

Overall, the comparative analysis indicates the PV plant to be performing in line with SgurrEnergy's prediction.



## 8 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar PV plants as having a lifetime of 25-40 years<sup>10</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>11</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the PV plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement.

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<sup>10</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>11</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>



Virescent Infrastructure

50MW(AC) Muktainagar Solar PV Plant  
Solar Edge Power and Energy Pvt Ltd  
Technical Assessment Report

May 2021





## Report Details

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### Amendment Records

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B4	28.05.2021	For Client Issue	Generation Analysis updated

SF/04/023

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## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 50MW<sub>AC</sub> Solar Edge Power and Energy Private Limited (SEPEPL) solar PV plant (the Project). The Project is located near *Muktainagar* village, in *Beed* district of Maharashtra state. The summary of the technical assessment is captured in the below table.

**Table 1-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	<p>The project site lies around the coordinates 21°1'58.30"N and 75°58'51.63"E and is located near the Muktainagar village, in Beed district of Maharashtra.</p> <p>Project is contracted for generating 50MW<sub>AC</sub> power. The Owner has utilised approximately 255 acres of land for the project.</p> <p>Project is implemented with poly-crystalline modules (Astroenergy, JA Solar and Canadian Solar) and central inverters (ABB). The module mounting structure is implemented with a tilt of 16° for a pitch of 5.50m.</p> <p>The power generated from the SEPEPL 50MW<sub>AC</sub> PV plant is fed to 132/33kV Muktaingar substation, through a single circuit transmission line.</p> <p>The total DC installed capacity stands at 65MW<sub>p</sub>. The AC installed capacity stands at 50MW<sub>AC</sub> with 25 inverters of capacity 2,000kW each.</p>
2	PV Module	<p>SgurrEnergy has conducted a desktop review of JA Solar, Canadian Solar and Astronergy assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard. SgurrEnergy considers the warranty period to be in line with the industry standards. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.</p>
3	Inverter	<p>ABB is considered to have good track record for supplying central inverters. Review of certificates indicate ABB to hold adequate certifications. Technical characteristics are acceptable, with a good efficiency level for central inverters. Standard warranty of five years is provided for the inverters, which is in line with the industry requirement. Overall, SgurrEnergy does not raise any concern on the utilization of ABB inverters for the Project.</p>
4	Inverter Transformer	<p>The inverter transformers (4000kVA) used within the project are manufactured by Shilchar Technologies Limited. The manufacturer has a good track record of supplying transformers to distinguished customers in Indian as well as in the global market. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for</p>



Sr. No.	Parameter	Comment		
		the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project		
5	String Sizing	The V <sub>OC</sub> does not exceed the inverter input voltage for the 30MW <sub>AC</sub> and 50MW <sub>AC</sub> sites, and therefore, SgurrEnergy considers the number of modules in series to be acceptable and adequate for the PV Projects evaluated.		
6	Permits and Approvals	PPA signed between Solar Edge Power and Energy Pvt Ltd and Solar Energy Corporation of India Ltd on 10 February 2017. PPA term is 25 years from the Commercial Operation Date. Documents such as CEIG certificate, commissioning certificate, consent to operate etc. have not been provided.		
7	Allied Components and Systems	<p>The 50MW<sub>AC</sub> PV plant is designed with JA Solar (325/330Wp), Canadian Solar (325/330Wp) and Astroenergy (320Wp) PV modules with ABB 2000kVA central inverter.</p> <p>The project has been implemented in two land parcel, the AC capacity of plot 1 and 2 is 42MW<sub>AC</sub> and 8MW<sub>AC</sub> respectively.</p> <p>The Project has been implemented with twelve inverter station comprising of 2 inverters each. The AC capacity of each inverter station is 4WM<sub>AC</sub>, further one inverter is placed in the Inverter station room (ICR) located near Main control room (MCR).</p> <p>The 33kV output of plot 1 and 2 is combined at 33kV Main switchboard located within plot 1, further the combined power is transferred to 132kV AIS bay located at Muktainagar substation through ACSR zebra single circuit transmission line. The point of interconnection is at the Muktainagar substation.</p>		
8	Operational Analysis and Generation Comparison	<p>SgurrEnergy has compared the solar PV plant's operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Client for the period from September 2018 to December 2020.</p> <p>Overall the average grid availability experienced on site for the operational period was calculated to be 99.90% and correspondingly the average plant availability is noted to be 99.27% which is considered to be within expected range.</p> <p>Furthermore, SgurrEnergy observed that the overall recorded generation is approximately 6.76% lower than the generation predicted on site. SgurrEnergy infers that the drop-in generation can be attributed to the drop-in irradiation for the period of evaluation (September –18 to December –20) as the predicted irradiation is approximately 5.44% higher than the irradiation measured on site.</p>		
9	Energy Yield Analysis	<p>Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for third year of plant operation for the 50 MWAC PV plant.</p> <table><tr><td>Global Horizontal Irradiation (kWh/m2)</td><td>1,957.60</td></tr></table>	Global Horizontal Irradiation (kWh/m2)	1,957.60
Global Horizontal Irradiation (kWh/m2)	1,957.60			





Sr. No.	Parameter	Comment	
		Global Inclined Irradiation (kWh/m <sup>2</sup> )	2,084.30
		Third Year P50 Energy Yield (MWh/annum)	1,03,472.30
		Specific Yield (kWh/kWp)	1593.37
		Performance Ratio (PR)	76.44%
		PLF on Contracted Capacity (50MW <sub>AC</sub> )	23.62.%



## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
m	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon



MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation



## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

KKR global was founded in 1976 and the company had expanded its presence in India in 2009. The company is a global investment firm that manages multiple alternative asset classes, including private equity, credit and real assets with strategic partners that manage hedge funds. As of 30 September 2020, KKR has a team of over 1,600 employees, consultants, investment professionals and senior advisors working across 16 industries in offices around the world.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 258MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of six Solar PV plants, as presented within Table 1-1.

**Table 1-1: Portfolio Key Summary**

Project Name	SEPEPL – 80MW <sub>AC</sub>	SEPEPL – 50MW <sub>AC</sub>	SPSPL – 50MW <sub>AC</sub>	SPSPPL – 30MW <sub>AC</sub>	TNSPEPL – 5MW <sub>AC</sub> + 8MW <sub>AC</sub> + 10MW <sub>AC</sub>	UMD- 12MW <sub>AC</sub> + 13MW <sub>AC</sub> +
Site Location	18.926°N, 76.395°E, Parli, Maharash- tra, India	21.028°N, 75.985°E, Muktainagar Maharashtra ,India	9.324°N, 77.594°E. Rajapalyam, Tamil Nadu,India	12.344°N, 78.945°E Tiruvanna m-alai, Tamil Nadu, India.	5MW <sub>AC</sub> – 10.491°N, 78.063°E Dindigul, Tamil Nadu, India 8MW <sub>AC</sub> – 9.437°N, 78.172°E Aruppukkotai Tamil Nadu, India 10MW <sub>AC</sub> – 9.118°N, 78.107°E Vilathikulam, Tamil Nadu, India	12MW <sub>AC</sub> - 9.554°N, 77.884°E Amathur, Tamil Nadu, India 13MW <sub>AC</sub> - 9.093°N, 77.780°E Kovilpatti, Tamil Nadu, India
Owner / Special Purpose Vehicle (SPV)	Solar Edge Power and Energy Private Limited (SEPEPL)		Shapoorji Pallonji Suryaprakas h Private Limited (SPSPL)	Shapoorji Pallonji Solar PV Private Limited	TN Solar Power Energy Private Limited	Universal Mine Developers and Service Providers Private Limited
DC / AC Capacity	104.0MW <sub>P</sub> / 80.0MW <sub>AC</sub>	65.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	54.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	36.0MW <sub>P</sub> / 30.0MW <sub>AC</sub>	5MW <sub>AC</sub> – 6.0MW <sub>P</sub> / 5.0MW <sub>AC</sub> 8MW <sub>AC</sub> – 9.6MW <sub>P</sub> / 8.0MW <sub>AC</sub> 10MW <sub>AC</sub> – 12.0MW <sub>P</sub> / 10.0MW <sub>AC</sub>	12MW <sub>AC</sub> - 14.4MW <sub>P</sub> / 12MW <sub>AC</sub> 13MW <sub>AC</sub> - 15.6MW <sub>P</sub> / 13MW <sub>AC</sub>
Commissioning date	50MW <sub>AC</sub> – 08 April 2018 30MW <sub>AC</sub> – 22 April 2018	26 April 2018	26 September 2018	26 March 2016	5MW <sub>AC</sub> – 28 December 2015 8MW <sub>AC</sub> – 28 September 2015 10MW <sub>AC</sub> – 31 October 2015	12MW <sub>AC</sub> – 16 November 2015 13MW <sub>AC</sub> – 21 March 2016

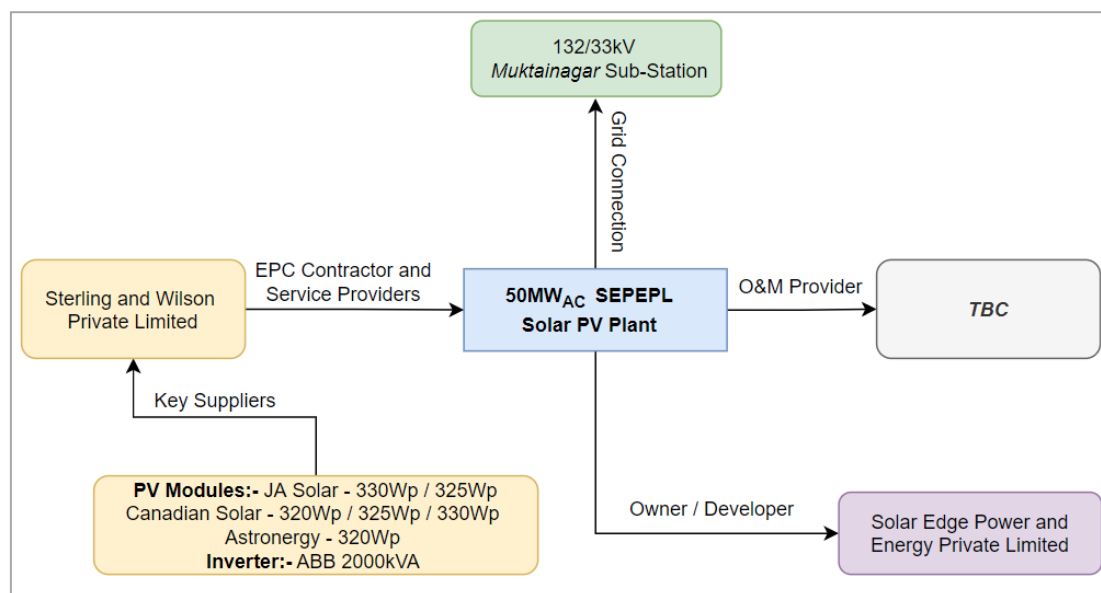


This report presents the technical appraisal of the 50MW<sub>AC</sub> SEPEPL Solar PV plant (The Project) developed by Solar Edge Power and Energy Private Limited (SEPEPL) near *Muktainagar* village, in *Beed* district of Maharashtra state.

The purpose of this report is to provide a technical appraisal of PV plant under evaluation. The report focuses on the following key aspects:

- System Overview.
- Major Components.
- System Design Appraisal.
- Allied Components and Systems.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project, based on information made available by the Client through online data room and site assessment. Figure 1-1 illustrates the project structure indicating key project participants.



**Figure 1-1: Project Structure**

The main Project characteristics are summarised in table below.

**Table 1-2: Project Key Summary**

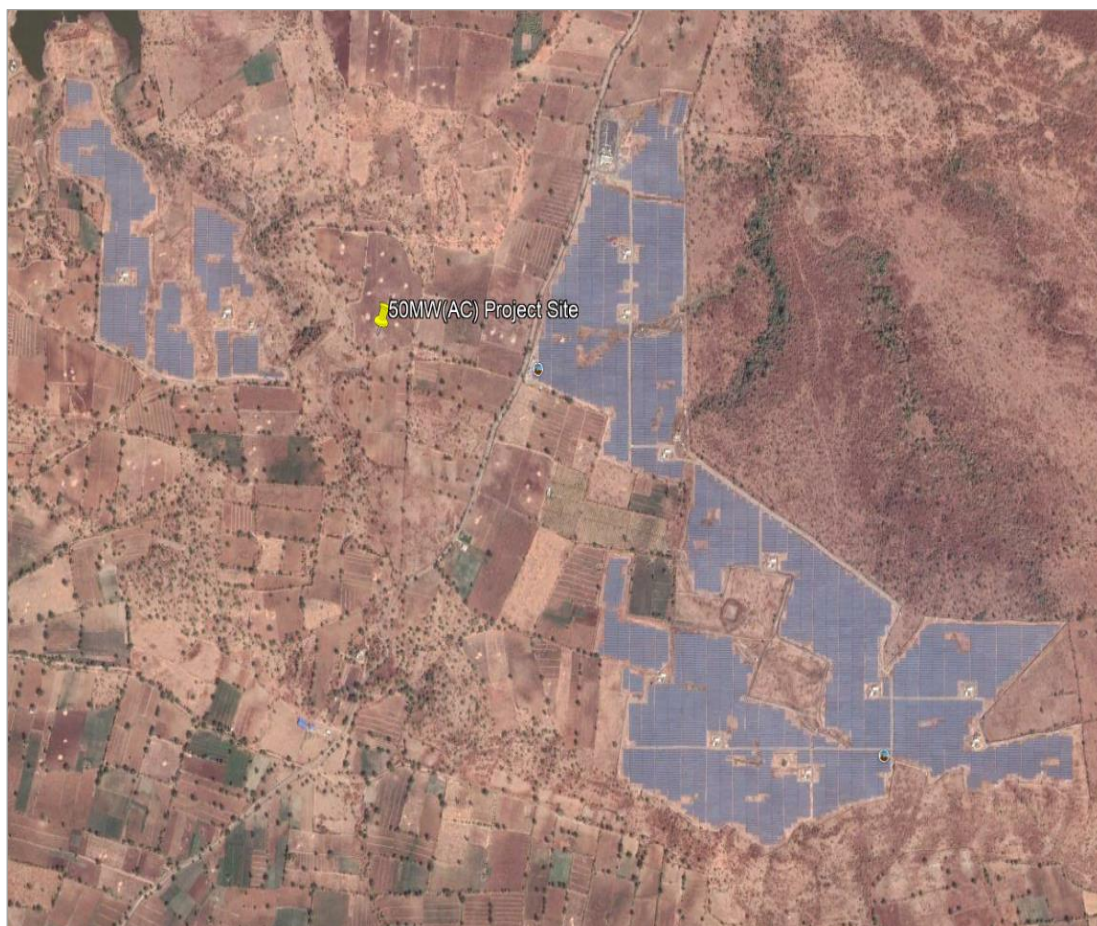
Project Information	
<b>Project Name</b>	50MW <sub>AC</sub> SEPEPL Solar PV plant
<b>Location</b>	<i>Muktainagar</i> , Maharashtra
<b>Owner</b>	Solar Edge Power and Energy Private Limited
<b>DC/ AC capacity</b>	65MWp / 50MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: JA Solar, Canadian Solar, Astronergy Inverters: ABB
<b>MMS Configuration</b>	Fixed Tilt: 16°, Azimuth: 0°
<b>Commissioning Status</b>	Commissioning was achieved on 26 April 2018



## 2 50MW<sub>AC</sub> Solar PV Plant Overview

The project site lies around the coordinates 21°1'58.30"N and 75°58'51.63"E. Satellite imageries of 50MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1. The Owner has utilised approximately 255 acres of land project. The Project site is located near the *Muktainagar* village, in Beed district of Maharashtra.

Project is contracted for generating 50MW<sub>AC</sub> power; SgurrEnergy therefore interprets 50MW<sub>AC</sub> as the maximum AC installed capacity for the solar PV plant.



**Figure 2-1: Satellite image of 50MW<sub>AC</sub> plant**

### 2.1 50MW<sub>AC</sub> Project Summary

Solar PV plant is modular in nature; therefore, SEPEPL 50MW<sub>AC</sub> solar PV plants is implemented by adopting modularity in designs. 4MW<sub>AC</sub> is the typical inverter station considered for implementing SEPEPL 50MW<sub>AC</sub> solar PV plant.

Table 2-1 presents the summary of 50MW<sub>AC</sub> PV plant

**Table 2-1: Summary of 50MW<sub>AC</sub> Plant Configurations**

General	
PV Module Technology	Poly-crystalline
Inverter Technology	Central Inverters
Installed DC Peak Capacity (MW <sub>p</sub> )	65.00
Installed AC Capacity (MW)	50.00
Mounting Type	Fixed Tilt





General			
Tilt Angle	16°		
Pitch	5.50		
PV Modules			
PV Module Manufacturer	Astroenergy	JA Solar	Canadian Solar
Model	CHSM6612P Series	JAM60S08-320/325	CS3K-320/325/330
Wattage (W <sub>p</sub> )	320W <sub>p</sub>	325W <sub>p</sub> / 330W <sub>p</sub>	320W <sub>p</sub> / 325W <sub>p</sub> / 330W <sub>p</sub>
Number of Modules per String	31		
Inverter			
Inverter Manufacturer / Model	ABB / PVS980-58-2000kVA-K		
Inverter Nominal AC Output	2,000kW		
Number of Inverters	25		
Mounting Structure			
Mounting Structure Details (rows × columns)	2 × 31 / 2 × 16		
Orientation of Modules	Portrait		

The 50MW<sub>AC</sub> plant is implemented with a total of 12 inverter stations, each of capacity 4MW<sub>AC</sub> while there is one inverter of capacity 2MW<sub>AC</sub> which is placed in the main control room. Each inverter station is comprising of three winding transformers to accommodate 2 x 2000kVA inverters taking the individual inverter station size to 4MW<sub>AC</sub>. Each inverter station is comprising of a physical block connecting to 5.2MW<sub>p</sub> of installed photovoltaic array. The output of 4MW<sub>AC</sub> inverter station is connected to 0.660/0.660/33kV three winding transformer of 4MVA for stepping up the voltage to 33kV.

The medium voltage 33kV output of all the inverter stations are placed in main control room (MCR), these are combined to form a solar PV plant of 50MW<sub>AC</sub>. The 33kV output is stepped up to 132kV by means of two 25/27.5MVA, ONAN/ONAF transformers at HV substation is built within the plant premises. The output of both these transformers is clubbed at a Single Bus ACSR Zebra Conductor.

The power generated from the SEPEPL 50MW<sub>AC</sub> PV plant is fed to 132/33kV *Muktaingar* substation located approximately 10km from the Project site, through a single circuit transmission line. The point of interconnection is at the 132/33kV *Muktaingar* substation.

ABT / revenue metering is at 132/33kV *Muktaingar* substation; therefore, transmission line losses are accounted in the Owner's scope.



### 3 Review of Major plant components

SgurrEnergy has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions.

#### 3.1 PV modules

The PV modules selected for the Project are supplied by JA Solar Holding Co., Ltd., Canadian Solar and Astronergy. SgurrEnergy has conducted a technical review of the suppliers and proposed module specifications with regard to their suitability for use on the Project.

##### 3.1.1 Company Profile – JA Solar Holding Co., Ltd

JA Solar Holding Company Ltd. listed on NASDAQ (NASDAQ: JASO), was found in the year 2005 and started operation in 2006. The Company has 12 manufacturing bases and has production capacity of more than 11.5GW, 11GW, and 11GW for silicon wafer, solar cells, and solar modules, respectively.

JA solar has 20 branches around the world and employs more than 22,000 employees worldwide. As of December 2019, JA solar provides services in more than 135 countries and to more than 33,000 clients worldwide. As of second quarter 2020, JA solar had a cumulative shipment of more than 50GW. As of December 2019, JA solar had more than 779 authorized patents of independent R&D and 107 invention patents under its name. The Company's net revenue was RMB 21.16 billion in 2019.

Few of the commissioned solar power plants using JA modules are listed in Table 3-1.

**Table 3-1: Project References of JA Solar**

Sr. No.	Project and Location	Capacity (MW)
1	Bahia, Brazil	255.0
2	Northern Cooks, Australia	172.8
3	Cadiz, Philippines	132.5
4	Maharashtra, India	130.0
5	Three Gorges, Datong	100.0
6	Bahawalpur, Pakistan	100.0
7	Lincheng Country, Xingtai City, Hebei Province	100.0
8	Dunhuang, Gansu Province	100.0
9	Utah, USA	80.0
10	New South Wales, Australia	70.0
11	Maharashtra, India	70.0
12	Telangana, India	69.0
13	Bole, Xinjiang	60.0
14	San Carlos, Philippines	59.0
15	MP, India	57.0
16	Charanka Gujrat, India	53.0
17	Datong, Shanxi Province	50.0
18	Southwark, UK	49.0
19	Karnataka, India	43.0





Sr. No.	Project and Location	Capacity (MW)
20	Xiayu, Hebei Province	42.0
21	Yinchuan, Ningxia Province	40.0
22	Georgia, USA	38.7
23	Arawa Desert and Negev Desert, Israel	35.0
24	Hefeng, Tacheng, Xinjiang	30.0
25	Karnataka, India	23.0
26	Bulgaria	21.0
27	Haryana, India	21.0
28	Campania, Italy	20.0
29	Corp 184, Xinjiang	20.0
30	Telengana, India	18.0
31	Toshka, Egypt	10.1
32	Volkswagen Chattanooga Plant, USA	9.6
33	Antalya, Turkey	6.7
34	Kenitra, Morocco	2.0
35	ABC Bank, Jordan	1.5

JA is considered a Tier 1 supplier by Bloomberg (Q4, 2020). A Tier 1 supplier is defined as a module manufacturer who has *provided products to five different projects, which have been financed non-recourse by five different (non-development) banks, in the past two years.*

Whilst the Bloomberg tiering system does not reflect on a product's technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers JA solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

### 3.1.1.1 Main Technical Characteristics of JAM60S08/PR/1000V

JA Solar, JAM60S08/PR/1000V modules of 330W<sub>P</sub> and 325W<sub>P</sub> capacity have been utilized for the Project. These modules have an efficiency of 19.5% and 19.8% for 325W<sub>P</sub> and 330W<sub>P</sub> capacity modules, respectively, and a peak power tolerance of 0~+5W. The modules have a temperature coefficient (P<sub>max</sub>) of -0.36%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy's expectation for c-Si technology. The technical characteristics of JAM60S08/PR/1000V are presented in Table 3-2.

**Table 3-2: Technical specifications of JAM60S08/PR/1000V**

Specifications	JAM60S08-325/PR/1000V	JAM60S08-330/PR/1000V
Technology	Mono PERC Half-cut cell	
Nominal power (P <sub>MPP</sub> )	325W <sub>P</sub>	330W <sub>P</sub>
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	33.65V	33.91V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	9.66A	9.74A
Open circuit voltage (V <sub>OC</sub> )	40.56V	40.84V
Short circuit current (I <sub>SC</sub> )	10.22A	10.29A
Efficiency (%)	19.50%	19.80%



Specifications	JAM60S08-325/PR/1000V	JAM60S08-330/PR/1000V
Maximum System Voltage	1,000V (DC)	
Power tolerance (%)	0~+5W	
Dimensions (length × breadth × width) (mm)	1678 × 991 × 35	
Module area (m²)	1.66m²	
Weight (kg)	18.5kg±3%	
Temperature coefficient at P <sub>MAX</sub>	-0.36%/°C	
Operating temperature	-40°C to +85°C	
Maximum reverse current	20A	
Maximum mechanical load	3600Pa	
Maximum snow load	1600Pa	
Product warranty	12 years	
Power output guarantee	25 years	
Module technical characteristics are given at STC (1,000W/m² irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet)		

The maximum system voltage is 1,000V. The maximum reverse current is 20A. Overall, the module characteristics can be considered to be in line with market standard and JA Solar is listed as Tier 1 suppliers by Bloomberg since 2014.

### NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>1</sup> characteristics of selected JAM60S08/PR/1000V modules of 325W<sub>P</sub> and 330W<sub>P</sub> capacity is given in Table 3-3 corresponding to realistic operating conditions as compared to STC. It is affected by module materials used as well as the packing density of module materials. The NOCT for the module is 45±2°C. This is comparable with other manufacturers and demonstrates the module is effective at heat dissipation.

**Table 3-3: PV Module NOCT Characteristics of JAM60S08/PR/1000V**

Model	JAM60S08-325/PR/1000V	JAM60S08-330/PR/1000V
Maximum Power (P <sub>MAX</sub> )	241W <sub>P</sub>	244W <sub>P</sub>
Max Power Voltage (V <sub>MPP</sub> )	33.54V	33.82V
Max Power Current (I <sub>MPP</sub> )	7.17A	7.22A
Open Circuit Voltage (V <sub>OC</sub> )	37.38V	37.65V
Short Circuit Current (I <sub>SC</sub> )	8.20A	8.25A

#### 3.1.1.2 Certification of Modules

General review of datasheet indicates JA Solar PV modules manufactured in facilities with the following certifications:

- ISO 14001 certification for environmental management systems

<sup>1</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C.



- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certifications available in public domain for the modules under evaluation within Table 3-4.

**Table 3-4: Certification for PV Module- JA Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
IEC 60068	Environmental Testing
IEC 61701	Resistance to salt mist and corrosion
IEC 62804	Testing Modules for Potential Induced Degradation
UL 1703	Standard for safety for flat-plate photovoltaic modules

### 3.1.1.3 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of six months from the dispatch from the JA solar factory or the delivery date to site.

#### 3.1.1.4 Product Warranty

JA Solar provides a limited product warranty of 12 years, beginning on the earlier of module purchase date or one-year anniversary from the production date. If module fail to conform to this warranty, during the period ending of 12 years from the date of sale to the customer of the JA solar product, JA solar will at its opinion, either repair or replace the product, or refund the purchase price as paid by the customer. The repair or replacement or refund the customer at the current comparable market price of such module.

SgurrEnergy considers twelve-year product warranty provided by JA solar to be in line with the industry standard.

#### 3.1.1.5 Linear Power-Output Warranty

According to the datasheet JA solar warrants that the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.7% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 80.7% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, JA solar will either repair, replace or provide additional modules to make up for the loss in power output.

### 3.1.2 Company Profile– Canadian Solar

Canadian Solar (NASDAQ: CSIQ) is a vertically integrated producer of ingot, wafer, solar cell, and solar modules and was established in Ontario, Canada in 2001. Canadian Solar has subsidiaries in 20 countries on six continents. The company has 17 manufacturing facilities in Asia and America. Along with over 14,000 employees around the world, Canadian Solar had reported net revenue of \$914 Million at the end of the third quarter of



2020<sup>2</sup>. The company has achieved shipment of over 52GW of solar module. Canadian Solar also has a portfolio of solar power plants in operation. Canadian Solar is currently have more than 16.3GW pipeline projects worldwide.<sup>3</sup>

As of December 2019, the company has an ingot manufacturing capacity of 1.85GW per annum, wafer-manufacturing capacity of 5GW per annum, cell manufacturing capacity of 9.6GW per annum<sup>4</sup>.

The company also operates three state-of-the-art research centres in Canada and China which focus on improvement of efficiency and performance of its products. These research facilities employ over 515 scientists along with engineers and technicians in order to conduct research to improve the existing technologies. As of March 2020, Canadian Solar has applied for over 2,400 patent and has over 1,500 authorized patents worldwide.

Few of the commissioned solar power plants using Canadian Solar modules are listed in Table 3-5.

**Table 3-5: Track record of Canadian Solar Modules<sup>5</sup>**

Sr. No.	Project Location	Capacity (MW)
1	Tamil Nadu	309.0
2	Ontario, Canada	300.0
3	Dubai, UAE	268.0
4	Finley, Australia	175.0
5	Shizuishan, China	150.0
6	Brandenburg, Germany	148.0
7	Wuhu City, Inner Mongolia, China	100.0
8	Oakey, Australia	100.0
9	Yucheng, China	100.0
10	Goyalri, India	78.0
11	Rovigo, Italy	70.0
12	Yamaguchi, Japan	56.3
13	Yangquan, China	50.0
14	Dai County, China	46.8

Canadian Solar is considered a Tier 1 supplier by Bloomberg (Q4, 2020). A Tier 1 supplier is defined as a module manufacturer who has *'provided products to five different projects, which have been financed non-recourse by five different (non-development) banks, in the past two years'*.

Whilst the Bloomberg tiering system does not reflect on a product's technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers Canadian solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

<sup>2</sup> <https://www.prnewswire.com/news-releases/canadian-solar-reports-third-quarter-2020-results-301176940.html>

<sup>3</sup> <https://www.csisolar.com/aboutus/>

<sup>4</sup> <http://investors.canadiansolar.com/static-files/18a43183-17c4-4646-987f-2572d5e6a588>

<sup>5</sup> <https://www.canadiansolar.com/successful-projects/>



### 3.1.2.1 Technical Characteristics

The Canadian Solar CS3K-MS modules of 320W<sub>P</sub>, 325W<sub>P</sub>, and 335W<sub>P</sub> capacities have been utilized for the project. The 320W<sub>P</sub>, 325W<sub>P</sub>, and 330W<sub>P</sub> modules have efficiencies of 19.3%, 19.6% and 19.9%, respectively and a positive power tolerance of 0~+10W. The selected series has a temperature coefficient (P<sub>max</sub>) of -0.36%/°C. This temperature coefficient is in line with SgurrEnergy's expectation for c-Si technology. Generally, the temperature coefficient of crystalline silicon modules is in the range of -0.35% to -0.50%/°C rise in temperature. The technical characteristic of the shortlisted modules is presented in Table 3-6.

**Table 3-6: Canadian PV Module Technical Characteristics**

Characteristic	CS3K-320MS	CS3K-325MS	CS3K-330MS
Type	Monocrystalline PERC Half-cut cell		
Nominal Power (P <sub>MPP</sub> )	320W <sub>P</sub>	325W <sub>P</sub>	330W <sub>P</sub>
Power Tolerance	0~+10W		
Voltage at P <sub>Max</sub> (V <sub>MPP</sub> )	33.3V	33.0V	33.0V
Current at P <sub>Max</sub> (I <sub>MPP</sub> )	9.6A	9.7A	9.8A
Open Circuit Voltage (V <sub>OC</sub> )	40.1V	40.3V	40.5V
Short Circuit Current (I <sub>SC</sub> )	10.1A	10.2A	10.3A
Fill Factor (%)	78.7%	78.9%	79.2%
Module Efficiency	19.3%	19.6%	19.9%
Temperature Coefficient at P <sub>MPP</sub>	-0.36%/°C		
Maximum System Voltage	1,500V (IEC/UL) or 1,000V (IEC/UL)		
Dimensions	1,675mm x 992mm x 35mm		
Module Area	1.66m <sup>2</sup>		
Weight	18.50kg		
Maximum Snow Load	6,000Pa		
Maximum Wind Load	4,000Pa		
Module technical characteristics are given at STC (1,000W/m <sup>2</sup> irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet			

Modules have a power tolerance of 0~+10W and the fill factor is in the range of 78% to 79%. The datasheet specifies three bypass diodes are installed to reduce the effect of shading losses within the PV system. The maximum system voltage is 1,500V which is standard and the maximum snow and wind loading specifications are in line with industry norms.



## NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>6</sup> characteristics of selected CS3K-MS modules of 320W<sub>P</sub>, 325W<sub>P</sub> and 330W<sub>P</sub> capacities is given in Table 3-7 corresponding to realistic operating conditions as compared to STC. It is affected by module materials used as well as the packing density of module materials. The NOCT for the module is 42±3°C. This is comparable with other manufacturers and demonstrates the module is effective at heat dissipation.

**Table 3-7: PV Module NOCT Characteristics of CS3K-MS**

Model	CS3K-320MS	CS3K-325MS	CS3K-330MS
Maximum Power (P <sub>MAX</sub> )	238W <sub>P</sub>	242W <sub>P</sub>	249W <sub>P</sub>
Max Power Voltage (V <sub>MPP</sub> )	31.0V	31.2V	31.6V
Max Power Current (I <sub>MPP</sub> )	7.7A	7.8A	7.9A
Open Circuit Voltage (V <sub>OC</sub> )	37.6V	37.8V	38.6V
Short Circuit Current (I <sub>SC</sub> )	8.18A	8.24A	8.38A

### 3.1.2.2 Certification of Modules

General review of datasheet indicates Canadian Solar PV modules manufactured in facilities with the following certifications:

- ISO 14001 certification for environmental management systems
- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certification mentioned in the datasheet of the modules under evaluation within Table 3-8.

**Table 3-8: Certification for PV Module- Canadian Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
IEC 60068	Environmental Testing
IEC 61701	Resistance to salt mist and corrosion
IEC 62716	Ammonia Corrosion Testing
UL 1703	Standard for safety for flat-plate photovoltaic modules

### 3.1.2.3 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of the date of installation or 90 days from the delivery date.

<sup>6</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C.



### 3.1.2.4 Product Warranty

PV module, DC connectors and cables are guaranteed to be free from defects in materials and workmanship for a period of 12 years from the warranty start date.

### 3.1.2.5 Linear Power-Output Warranty

According to the datasheet provided, SgurrEnergy understands that Canadian solar warrants the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.6% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 83.1% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, Canadian solar will either repair, replace or provide additional modules to make up for the loss in power output.

### 3.1.3 Company Profile- Astronergy Co., Ltd.

Astronergy Co., Ltd. is a specialized subsidiary of the CHINT group and is engaged in the PV power station development and PV module production. Established in 2006 and headquartered in China, Astronergy has the module production capacity of 5000MW<sub>P</sub> and total registered capital of nearly 9.38 billion CNY.

Astronergy has three production facilities including 600MW solar cell factory in Thailand. The Company has built more than 200MWP of solar power stations worldwide including in the USA, Japan, South Korea, Thailand, Spain, Bulgaria, India, Romania, Turkey, South Africa, and Philippines, etc. Further, the Company has branch offices in the USA, Germany, Japan, South Korea, Spain, and India and can provide localized and customized services to its clients.

Few of the commissioned solar power plants using Astronergy modules are listed in Table 3-9.

**Table 3-9: Project References of Astronergy**

Sr. No.	Project and Location	Capacity (MW)
1	Benban Solar Park, Egypt	165.0
2	Midden Groningen, Netherlands	103.0
3	Italy Rovio	70.0
4	Goonumbla, Australia	69.8
5	South Africa	64.0
6	Brazil	50.0
7	Vietnam Binh Thuan	47.5
8	Vietnam Dami	47.5
9	India	25.0
10	Veendam, Netherlands	15.5
11	Andijk, Netherlands	15.0
12	Bulgaria Bezmer	10.0
13	Boongeo Seom, Korea	10.0
14	Conergy Littlewood, UK	8.0
15	San Giovanni Rotondo, Italy	8.0





Sr. No.	Project and Location	Capacity (MW)
16	OSMANIYE, Turkey	5.3
17	Philippines Bataan	5.0
18	Philippines Buacan	4.0
19	Palacio Cremado, Spain	3.2
20	Depot Park Sacramento, America	3.0

According to the information available in the public domain, Astronergy has been listed as 1<sup>st</sup>-tier PV brand around the world by Bloomberg. Whilst the Bloomberg tiering system does not reflect on a product's technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers Astronergy solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

### 3.1.3.1 Main Technical Characteristics of CHSM6612P/HV-320W<sub>p</sub>

Astronergy, CHSM6612P/HV modules of 320W<sub>p</sub> capacity have been utilized for the Project. These modules have an efficiency of 16.5% and a peak power tolerance of 0~+5W. The modules have a temperature coefficient (P<sub>max</sub>) of -0.408%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy's expectation for c-Si technology. The technical characteristics of CHSM6612P/HV are presented in Table 3-10.

**Table 3-10: Technical specifications of CHSM6612P/HV**

Specifications	CHSM6612P/HV -320
Technology	Polycrystalline
Nominal power (P <sub>MPP</sub> )	320
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	37.02V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	8.65A
Open circuit voltage (V <sub>OC</sub> )	45.45V
Short circuit current (I <sub>SC</sub> )	9.25A
Efficiency (%)	16.5%
Maximum System Voltage	1500V
Power tolerance (%)	0~+5W
Dimensions (length × breadth × width) (mm)	1,960mm x 992mm x 40mm
Module area (m <sup>2</sup> )	1.94m <sup>2</sup>
Weight (kg)	21.9kg
Temperature coefficient at P <sub>MAX</sub>	-0.408%/°C
Maximum series fuse rating	15A
Maximum front load	6,000Pa
Maximum back load	3,600Pa
Product warranty	10years
Power output guarantee	25years

Overall, the module characteristics can be considered to be in line with market standard.

The maximum system voltage is 1,500V and the maximum series fuse current is 15A.





### 3.1.3.2 Certification of Modules

The modules are manufactured in an automated facility certified to ISO9001, ISO14001, and OHSAS18001. According to the information available in public domain, SgurrEnergy has summarised the certification provided for the module within Table 3-11.

**Table 3-11: Certification for PV Module- Astronergy Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
IEC TS 62941	Design and manufacturing of Photovoltaic Solar Modules
UL 1703	Standard for safety for flat-plate photovoltaic modules

### 3.1.3.3 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of 180 days after the manufacturing date or the delivery date to site.

### 3.1.3.4 Product Warranty

According to the datasheet provided by the Client for the PV module, DC connectors and cables are guaranteed to be free from defects in materials and workmanship for a period of 10 years from the warranty start date.

### 3.1.3.5 Linear Power-Output Warranty

Referring the datasheet provided, SgurrEnergy understands that Astronergy solar warrants the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.7% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 80.7% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, Astronergy will either repair, replace or provide additional modules to make up for the loss in power output.

## 3.2 Inverters – ASEA Brown Boveri (ABB)

The project has utilized ABB PVS980-58-2000kVA central inverter for the project under evaluation.

### 3.2.1 Company background

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, ABB is one of the largest engineering companies as well as one of the largest conglomerates in the world. ABB has operations in around 100 countries, with approximately 147,000 employees<sup>7</sup>. Company reported global revenue of around \$34,312 million for 2017.<sup>8</sup>

<sup>7</sup> <https://new.abb.com/news/detail/26838/abb-to-exit-solar-inverter-business>

<sup>8</sup> <https://new.abb.com/investorrelations/company-profile/facts-figures>



The firm's shares are traded on the stock exchanges of Zurich, Stockholm, and New York. ABB is a multinational corporation headquartered in Zurich, Switzerland, operating mainly in robotics and power and automation technology.

On July 9, 2019 the Italian company FIMER acquired ABB's solar inverter business. The takeover of ABB's solar inverter business included 800 employees in 26 countries as well as two manufacturing plants, in Italy and in India, and a R&D facility in Finland.

FIMER was founded in 1942, headquartered in Vimercate, Italy, has been actively working in inverter technology since 1983. As of 2020, the company employs more than 1,100 employees across its three manufacturing facilities and three R&D centres across the globe. As a result of acquisition of ABB's PV inverter line, FIMER ranked the fifth-largest PV inverter globally in 2019.

### 3.2.2 Track Record

ABB India commenced local manufacturing of solar inverters in 2012 and partnered with several customers. ABB is the solar inverter market leader in India holding approximately 24% market share in 2018. ABB has approximately 3,590MW in operation across more than 350 sites in India. ABB India manages close to 40% of the installed bases in India. As on 30 August 2017, ABB India crossed the 5GW threshold for the supply of inverters in the country.

Table 3-12 lists the state-wise installed capacity of ABB inverters in India. However, it is to be noted that the table below doesn't not comprise of the installed capacities till date.

**Table 3-12: ABB Inverter Track Record**

Location	Capacity (MW)
Tamil Nadu	747
Andhra Pradesh	647
Rajasthan	371
Karnataka	305
Madhya Pradesh	271
Maharashtra	261
Punjab	227
Bihar	225
Uttar Pradesh	106
Haryana	62
Kerala	50
Chhattisgarh	28
Odisha	20

ABB India has strategically located its headquarter in Bangalore and offices in other cities Pune, Ahmedabad, Jaipur, Faridabad, Hyderabad, Tamil Nadu and Bhopal in order to facilitate quick spare part availability and minimal response time. ABB aims to provide first response to its customers within 4 hours on weekdays and within 24 hours on weekends and holidays. ABB also provides a Turn-Around-Time of 48 and 72 hours on weekdays and weekends respectively, hence maintaining an average uptime of over 99%.



### 3.2.3 Technical Characteristics

ABB PVS980-58-2000kVA inverter has been selected for technical feasibility of the Project. The technical specification of 2000kW ABB inverter is listed in Table 3-13.

The PVS980-58-2000kVA Series of central inverters designed ideal for large PV Power Plants. PVS980 inverters are designed for fast and easy installation. These inverters are designed to operate with DC inputs up to 1,500 V. They incorporate maximum power point tracking (MPPT) and grid management features to meet utility requirements.

PVS980-58-2000kVA inverter is designed for outdoor use with an IP66 ingress protection class. They have closed loop cooling system based on phase transition and thermosiphon technology with water and dustproof enclosure. They perform optimally at ambient air temperatures between -20°C to 50°C and relative humidity in the range of 5% to 100% with maximum noise level of 88dBA.

The PVS980-58-2000kVA inverter has peak efficiency of 98.8% and a European efficiency of 98.6%.<sup>9</sup>

The main technical characteristics of these inverters are illustrated in Table 3-13.

**Table 3-13: ABB inverter specifications**

<b>ABB Central Inverter Specifications</b>	
Inverter	ABB PVS980-58-2000kVA
Type	Central Inverter
<b>Input Data</b>	
Maximum Input Power (kW <sub>p</sub> )	2909kW <sub>p</sub>
PV voltage range, MPP (V)	850 to 1500V @35°C 850 to 1100V @50°C
Maximum DC voltage (V)	1500V
Maximum input current (A)	2400A
<b>Output Data</b>	
Nominal AC power at 50°C (kVA)	2000kVA
Maximum AC current (A)	1925A
Nominal AC voltage(V)	600V
AC grid frequency (Hz)	50/60Hz
Maximum THD	< 3%
<b>Operating Performance</b>	
Maximum efficiency (%)	98.80%
Euro efficiency (%)	98.60%
<b>Power consumption</b>	
Own consumption in operation(W)	2500W
Standby operation consumption (W)	235W
<b>Other</b>	
Dimensions (W × H × D) (mm)	3180mm x 2443mm x 1522mm

<sup>9</sup> [https://www.fimer.com/sites/default/files/FIMER\\_PVS980-58-from1818to2091\\_EN\\_RevA\\_.pdf](https://www.fimer.com/sites/default/files/FIMER_PVS980-58-from1818to2091_EN_RevA_.pdf)



ABB Central Inverter Specifications	
Weight (kg)	3500kg
Environmental Protection Rating	IP66
Operating temperature range (°C)	-20 to+50°C
Relative humidity (%)	5% to 100%

The following protection devices are included within the inverter design:

- Ground fault monitoring
- Grid Monitoring
- Anti-islanding protection
- DC reverse-polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection
- Remote monitoring solutions

ABB inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components. Further, technical parameters include an operational altitude of up to 4,000m.

### 3.2.4 Certification

ABB is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. ABB inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information available in public domain, SgurrEnergy has summarized the certification of the ABB inverter within Table 3-14.

**Table 3-14: Description of Certification of ABB inverters**

Certification	Description
IEC 60068-2-6/29	Environmental testing of inverters to assess their ability to perform and survive under conditions such as transportation, storage, operational environments, extreme cold and heat
EN 61000-6-2(2005) / EN 61000-6-4(2007)	Electromagnetic compatibility (EMC) – Immunity for industrial environments
IEC 62109-2:2011	Safety of Power Converters
IEC 62920:2017	Electromagnetic compatibility (EMC) requirements for DC to AC power conversion equipment

### 3.2.5 Warranties

SgurrEnergy was not provided with a sample of inverter warranty document. Given the industry standard warranty of 60 months, SgurrEnergy does not raise any concern over the use of inverter for the project.



### 3.3 Transformers – Shilchar Technologies Limited

The power at low voltage from inverters is stepped up to 33kV using 4000kVA transformers of Shilchar Technologies Limited make.

#### 3.3.1 Company Profile

The inverter transformer used for the project are manufactured by Shilchar Technologies Limited.

Established in 1990 and headquartered in Gujrat, India, Shilchar is one of the prominent manufacturers of Power & Distribution transformers. As of April 2020, the Company has commissioned the manufacturing facility capable of manufacturing up to 50MVA, 132KV class transformer and up to 4000MVA transformers annually.

Shilchar Technologies is an ISO 90001:2015, ISO 14001:2015 and ISO 45001:2018 certified company providing services to wide range of industries across the world including utility sector to renewable energy. The Company has a dedicated marketing team to cater services required in 20 different countries in the world. Since 2011, 40% of the revenue generated by Shilchar is through export.

The Company manufactures and has type tested various 3-winding, 4-winding, and 5-winding transformer with copper and aluminium conductor. The highest rating type tested by Shilchar is 12.5MVA, 5 winding Inverter Duty Transformer (IDT). The Company has supplied nearly 4GWs of transformers for solar application throughout the world including in Philippines, Egypt, Kenya and Chile.

#### 3.3.2 Technical Specifications

The 4000kVA Power transformers used in the project are outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 3-15.

**Table 3-15: Technical Specification of Shilchar Transformer**

Technical Parameters	Description
Rated Power	4000kVA
Rated HV	33kV
Rated LV	660-660V
Tapping on HV	-5% to +5% (steps of 2.5%)
Phases	3
Frequency	50Hz
Vector group	Dy11y11
Impedance	7.15% (As per IS)
Cooling Strategy	ONAN
Oil temperature rise	50°C
Winding temperature rise	55°C
Winding material	Copper



SgurrEnergy considers the overall the technical specification to be adequate for the PV projects and in line with the industry accepted standards.

### 3.3.3 Temperature Rise Detection and Protection

Inverter transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.4 Warranties and Guaranties

Based on the information available in public domain, SgurrEnergy understands the Shilchar transformers have been provided with a warranty of 60 months from date of dispatch. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards.

## 3.4 Conclusion on Major Plant Components

### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of JA Solar, Canadian Solar and Astronergy assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.

Further, according to the warranty documents available in public domain for all three module manufacturers, SgurrEnergy considers the warranty terms and conditions offered by all three manufacturers to be in-line with the industry standard and raises no major concern regarding the warranties offered. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.

### Inverters

SgurrEnergy has conducted review of the ABB PVS980-58-2000kVA central inverter ABB PVS980-58-2000kVA central inverter has the required certification for use in solar PV plants. In-house testing of the inverter and individual components is relatively extensive during the R&D phase with functional and temperature cycling testing of each manufactured inverter. ABB offers a product warrant of 5 years which is in line with the current industry standards.

In conclusion, ABB can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters. ABB inverters have more than 3GW of installation worldwide. These inverters are quite known to the Indian market and have installed capacity of more than 1.3GW which demonstrates a good track record in the Indian solar PV market.

### Transformers

The inverter transformers (4000kVA) used within the project are manufactured by Shilchar Technologies Limited. The manufacturer has a good track record of supplying 4GWs of transformers for solar application throughout the world including in Philippines, Egypt, Kenya, and Chile. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical



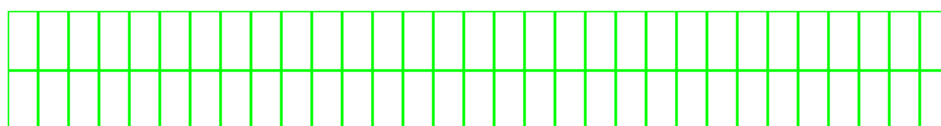
characteristics in line with industry standards and raises no concerns over its use in the project.

### 3.5 Module Support Structures

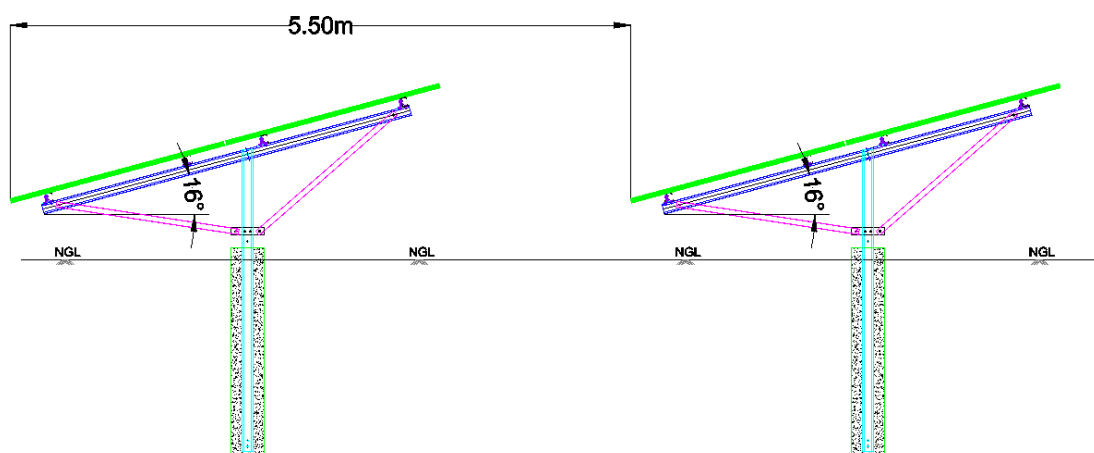
The Array Layout provided by the Client for the AstroEnergy modules indicates the fixed tilt module mounting structure is inclined at 16° tilt angle.

Following the review of MMS GA drawing dated 20.09.2017, SgurrEnergy observed that the structure has been designed with two rows of modules placed in portrait orientation with 31 modules in each row. In total there are 62 modules in one mounting structure. The layout is designed with a pitch<sup>10</sup>(distance between the fronts of one row to the front of the next row) of 5.5m.

Figure 3-1 and Figure 3-2 illustrate the typical mounting structure layout and orientation with pitch respectively.



**Figure 3-1: Typical two in portrait mounting structure with 31 modules in a row**



**Figure 3-2: Tilt angle and pitch of mounting structures**

Based on the information provided in the GA drawing of the MMS, the technical specification has been summarized below. SgurrEnergy envisages that the MMS design is identical for the other PV modules used in the project.

Table below summarizes the technical specification of the module mounting structure.

**Table 3-16: Specification of MMS**

MMS Part	Material	Grades - Standard	Thickness (mm)	Minimum Yield Stress(MPA)
Rafter	Cold Formed	340- ASTM A 653/A 653-00	1.6	340

<sup>10</sup> Pitch: Distance between the fronts of one row to the front of the next row





MMS Part	Material	Grades - Standard	Thickness (mm)	Minimum Yield Stress(MPA)
Purlin	Cold Formed	550 - ASTM A 792/A 792M – 09	0.9	550
Leg	Cold Formed	E350- IS 2062:2011 or equivalent	3.0	350
Bracing	Cold Formed	E350- IS 2062:2011 or equivalent	2.5	350

Material used is a combination of hot-dipped galvanised mild steel and pre-galvanised cold rolled sheets sheared to form structural members for module mounting. The pre-galvanised sheets post process is appropriately coated with anti-corrosion compounds for the project life cycle.

Further based on the information provided under GA drawing of the MMS, SgurrEnergy understands that the Owner has considered the wind speed of 39m/s according to IS 875 (part 3) – 1987.





## 4 System Design Appraisal

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

### 4.1 Plant Layout Design

SgurrEnergy was provided with as built plant layout and electrical schematics. SgurrEnergy has verified the plant configuration with electrical schematics provided by the Client. The PV plant is designed with Astroenergy (320W<sub>p</sub>), JA Solar (325W<sub>p</sub> / 330W<sub>p</sub>), and Canadian Solar (320W<sub>p</sub> / 25W<sub>p</sub> / 330W<sub>p</sub>) PV modules. The total DC installed capacity stands at 65MW<sub>p</sub>. The AC installed capacity stands at 50MW<sub>AC</sub> with 25 inverters of capacity 2,000kW each. Overall 50MW<sub>AC</sub> PV plant is divided into two plots as illustrated below in the Figure 4-1 and Figure 4-2.

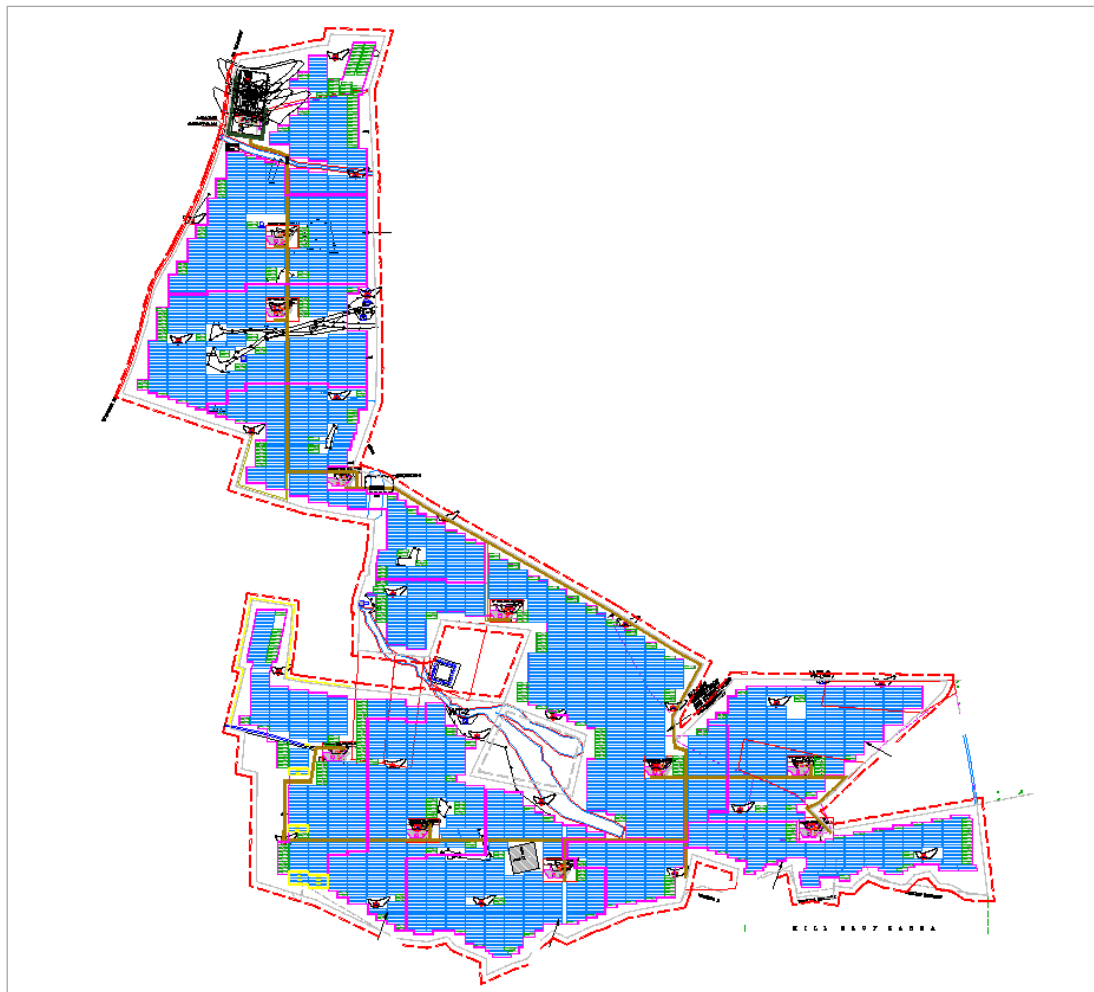
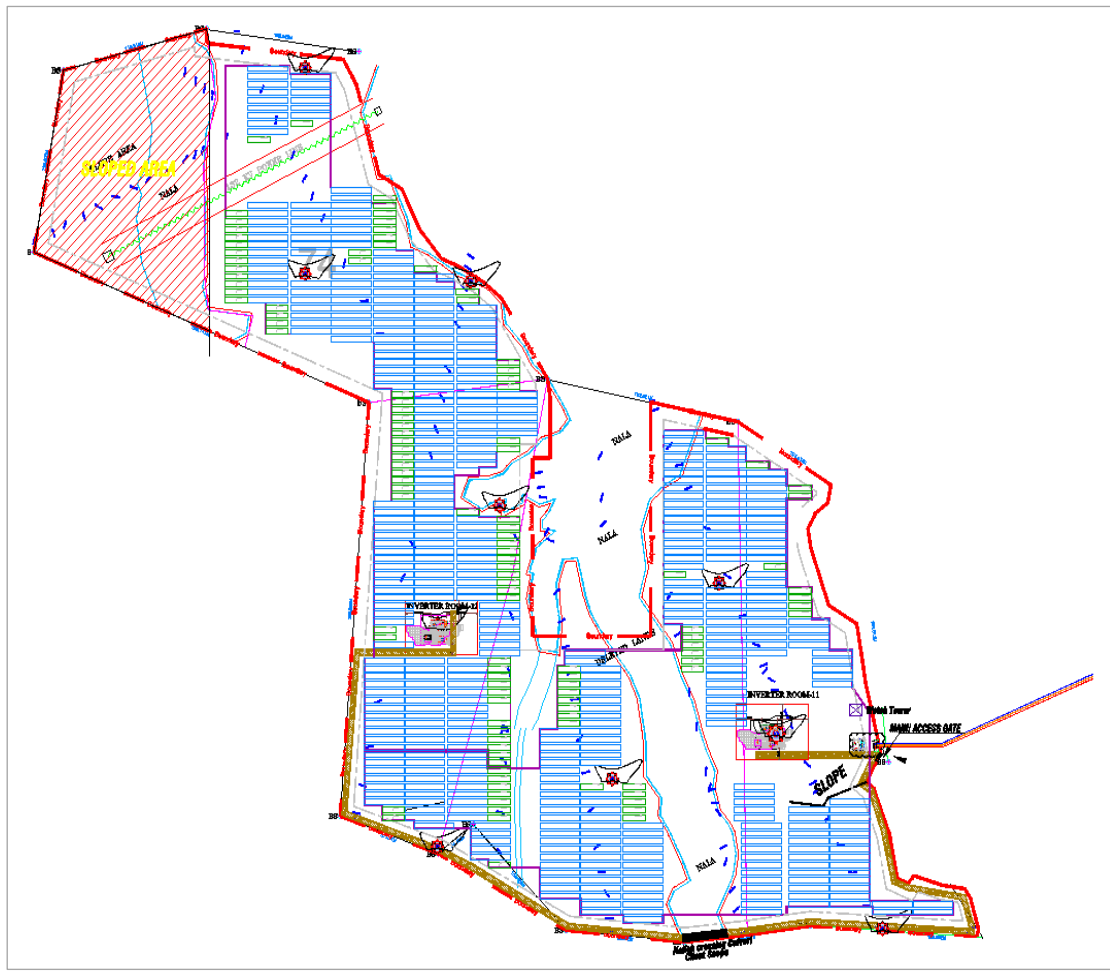


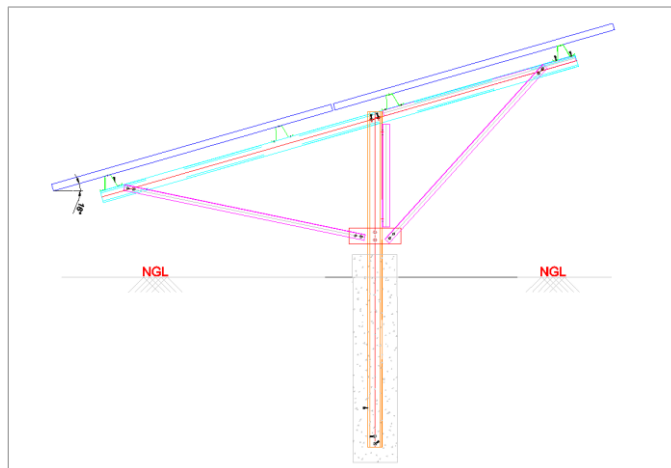
Figure 4-1: Plant layout of plot-1





**Figure 4-2: Plant layout of plot-2**

All the PV modules are orientated towards South. The mounting structure provides support for two rows of panels in portrait orientation.



**Figure 4-3: Side view of typical module mounting structure configuration**

The selected tilt for the 50MW<sub>AC</sub> plant is 16°. The 50MW<sub>AC</sub> plant is designed with a pitch of 5.50m.

Based on regional experience of detail designing, SgurrEnergy considers the selected tilt angle and pitch is optimized for maximum irradiation on the collector plane, minimum loss due to inter row shading, minimum ohmic losses and ease of maintenance.



31 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.30. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.

## 4.2 String Sizing

The plant layout provided by the Owner indicate thirty One 325 W<sub>p</sub>, 330W<sub>p</sub> JA Solar Mono PERC , Thirty One 320W<sub>p</sub>, 325W<sub>p</sub>, 330W<sub>p</sub> Canadian Solar Mono PERC and thirty one 320W<sub>p</sub> Astronergy polycrystalline PV modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage (V<sub>OC</sub>) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum V<sub>OC</sub> of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy in validating string configuration. Subsequent to calculating open circuit voltage (V<sub>OC</sub> max), maximum power voltage (V<sub>mp</sub> min) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 45°C and 10°C respectively for system design validation to be fair and representative for the PV plants' site.

The results of string sizing validation are presented in Table 4-1. Results indicate that V<sub>OC</sub> max at the minimum ambient temperature is within the maximum system voltage of 1,500V for the selected ABB 2,000kW inverters.

**Table 4-1: String Sizing for JA, Canadian Solar and Astronergy PV Modules**

Parameters	JA 325W <sub>p</sub>	JA 330W <sub>p</sub>	Canadian Solar 320W <sub>p</sub>	Canadian Solar 325W <sub>p</sub>	Canadian Solar 330W <sub>p</sub>	Astronergy 320W <sub>p</sub>
PV module power (W <sub>p</sub> )	325	330	320	325	330	320
Modules per string	31					
Inverters	ABB (PVS 980-58-2000KVA)					
Maximum Open-circuit voltage (V <sub>OC</sub> max) at minimum ambient temperature of 10°C	1311.3 V	1320.6V	1302V	1308.2V	1314.4V	1475.6V
Minimum power voltage (V <sub>mp</sub> min) at maximum ambient temperature of 45°C	961V	967.2V	951.7V	957.9V	985.8V	1054V

## 4.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with JA Solar, Canadian Solar and Astronergy module and ABB inverter are



presented in Table 4-2, Table 4-3 and Table 4-4. JA Solar 325W<sub>p</sub> and Canadian Solar 325W<sub>p</sub> modules have been selected to check compatibility with inverters as it has the maximum strings for each inverter among the 320W<sub>p</sub>, 325W<sub>p</sub> and 330W<sub>p</sub> modules.

**Table 4-2: Inverter Compatibility with JA Solar 325W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>JA Solar 325W<sub>p</sub></b>	
Modules per string	31	Acceptable
Strings per inverter	258	Acceptable
Maximum power, P <sub>mpp</sub> at STC (kWp)	2,599.35	Nominal power ratio is 1.29, this is within the inverter bus current carrying capacity.
Maximum power voltage, V <sub>mpp</sub> at STC (V)	1,043.15	Acceptable.
Maximum power current, I <sub>mpp</sub> at STC (A)	2,502.6	Acceptable
Open-circuit voltage, V <sub>oc</sub> at STC (V)	1257.4	Acceptable.
Minimum MPP voltage at 45°C ambient temperature (V)	961	Acceptable: Inverter MPPT ranges 935 - 1500V.
Maximum MPP voltage at 10°C ambient temperature (V)	1,097.4	Acceptable: Inverter MPPT ranges 935 - 1500V.
Maximum open circuit voltage, V <sub>oc</sub> at 10°C (V)	1311.3	Acceptable: Maximum inverter voltage 1500V.

**Table 4-3: Inverter Compatibility with Canadian Solar 325W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>Canadian Solar 325W<sub>p</sub></b>	
Modules per string	31	Acceptable
Strings per inverter	262	Acceptable
Maximum power, P <sub>mpp</sub> at STC (kWp)	2,639.65	Nominal power ratio is 1.31, this is within the inverter bus current carrying capacity.
Maximum power voltage, V <sub>mpp</sub> at STC (V)	1038.500	Acceptable.
Maximum power current, I <sub>mpp</sub> at STC (A)	2544.02	Acceptable
Open-circuit voltage, V <sub>oc</sub> at STC (V)	1249.3	Acceptable.
Minimum MPP voltage at 45°C ambient temperature (V)	957.9	Acceptable: Inverter MPPT ranges 935 - 1500V.
Maximum MPP voltage at 10°C ambient temperature (V)	1097.4	Acceptable: Inverter MPPT ranges 935 - 1500V.



Parameters	Inverter Compatibility	
Maximum open circuit voltage, $V_{oc}$ at 10°C (V)	1308.2V	Acceptable: Maximum inverter voltage 1500V.

**Table 4-4: Inverter Compatibility with Astronergy 320W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>Astronergy 320W<sub>p</sub></b>	
Modules per string	31	Acceptable
Strings per inverter	262	Acceptable
Maximum power, $P_{mpp}$ at STC (kWp)	2,599.04	Nominal power ratio is 1.29, this is within the inverter bus current carrying capacity.
Maximum power voltage, $V_{mpp}$ at STC (V)	1,147.6	Acceptable.
Maximum power current, $I_{mpp}$ at STC (A)	2,266.3	Acceptable
Open-circuit voltage, $V_{oc}$ at STC (V)	1408.9	Acceptable.
Minimum MPP voltage at 45°C ambient temperature (V)	1054.0	Acceptable: Inverter MPPT ranges 935 - 1500V.
Maximum MPP voltage at 10°C ambient temperature (V)	1215.2	Acceptable: Inverter MPPT ranges 935 - 1500V.
Maximum open circuit voltage, $V_{oc}$ at 10°C (V)	1475.6V	Acceptable: Maximum inverter voltage 1500V.

Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.



## 5 Allied Components and Systems

### 5.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

### 5.2 PV Power Transfer

SgurrEnergy has reviewed the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear and plant substation as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

- *Single line diagram of 132/33kV switchyard*, revision 3 – As built, dated 20.06.18.
- *“50MW AC SLD”*, revision 2-As built, dated 20.06.18
- *“50MW DC single line diagram”*, revision 3 As Built dated 25.06.2018.
- *“50MW PV array layout”*, revision 7, As Built dated 01.06.18.
- *“8MW Array Layout Plot-1, revision 2, As built dated 01.06.18.*

The 50MW<sub>AC</sub> solar PV plant has been configured with 320Wp Astroenergy, 325/330Wp JA Solar and 325/330Wp Canadian PV modules and 2000kW ABB central inverters. Modules are interconnected to form a string of 31 modules. Each string forms a single output that feeds as a single input to the 24 input combiner boxes. Eleven string combiner boxes are further connected to the inverter.

Based on the review of plant layout, SgurrEnergy observed that the project has been implemented in two land parcel. The AC capacity of plot 1 and 2 is 42MW<sub>AC</sub> and 8MW<sub>AC</sub> respectively.

The plant is configured with 25 ABB 2000kW central inverter thereby taking the total AC installed capacity to 50MW<sub>AC</sub>. The Project has been implemented with twelve inverter station comprising of 2 inverters each. Further one inverter is placed in the Inverter station room (ICR) located near Main control room (MCR).

Each inverter station of 4MW<sub>AC</sub> capacity consists of two 2000kW inverters; which are further connected to 0.660/0.660/33kV three winding, 4MVA transformer for stepping up the voltage to 33kV. Further one inverter is placed in ICR near MCR which is further connected to 0.660/33kV two winding, 2MVA transformer for stepping up the voltage to 33kV.

Based on the review of Plant layout, SgurrEnergy understands that each of the two solar PV plant sections have independent main control rooms. However, review of 132kV SLD indicates one main control room is provided within plot1 of the 50MW<sub>AC</sub> solar PV plant.

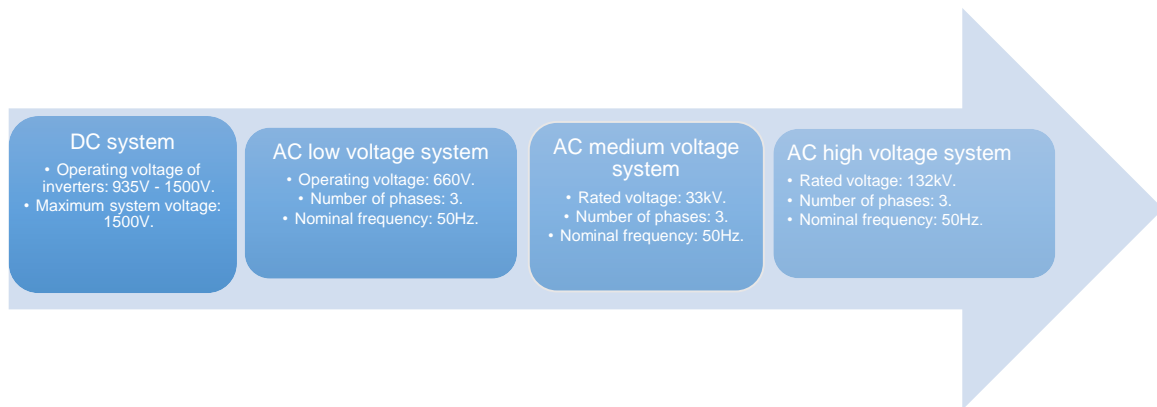
The 33kV SLD, indicates the 33kV output of the inverter station 11 and 12 located in Plot 2 combines through 2 in and 1 out Ring Main Unit (RMU). Further the combined power is further transferred to the 33kV main switchboard located within the 42MW<sub>AC</sub> solar PV plant through 33kV ACSR conductor.

In addition to the 8MW single feeder originating from Plot 2, the main control room of the 42MW<sub>AC</sub> solar PV, also combines the 33kV output of the inverter station located within 42MW<sub>AC</sub> solar PV plant. The combined energy at 33kV is further stepped up to 132kV within the 132/33kV substation through two 25/27.5MVA ONAN/ONAF two winding power transformers.

The combined power of plot 1 and 2 is transferred to 132kV AIS bay located at Muktainagar substation through ACSR zebra single circuit transmission line. The point of interconnection is at Muktainagar substation.



Figure below illustrates a power flow summary for the 50MW<sub>AC</sub> Solar PV plant.



**Figure 5-1: Power flow of 50MW<sub>AC</sub> PV plant**

### 5.3 Cabling

#### 5.3.1 DC Cabling

DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. Modules are interconnected in leap frog scheme to form a string of 31 modules using these leads. Each string forms a single input to the string combiner box. 4mm<sup>2</sup> multi-stranded copper PV cables have been used to connect each string to the string combiner box. These combiner boxes are equipped with 15A fuse for each of the string connection and a 400A disconnect switch on output side. Power from string combiner box is further transferred to the inverter using 2 runs, 1C, 300mm<sup>2</sup>, 1.5kV aluminium XLPE ((2R X 1C X 300Sqmm, 1.5kV AL. XLPE Armoured) cables.

#### 5.3.2 AC Cabling

AC output from each inverter is connected using 15 Runs single core 300mm<sup>2</sup> Aluminium Armoured XLPE PVC cable (15R (5R/PH) X1C x 300mm<sup>2</sup> Al. Ar. XLPE, PVC Cable) to the LV side of the inverter transformer. Further 1R,3C, 185mm<sup>2</sup> 33kV Al XLPE armoured cables are utilised to connect inverter transformer and the 33kV circuit breaker in outdoor type 33kV HT panel located in inverter station. The 33kV output of the inverter station is combined through 2 input and 1 out RMU panel.

In order to facilitate the transmission of power from plot 2 to plot 1, 33kV Double Pole structures have been provided in each of the plots.

The combined power from 33kV HT panel (Block 11 and 12) is transmitted to 33kV Double Pole structure located within plot 2 through 1R,3C, 185mm<sup>2</sup> 33kV Al XLPE armoured cables. Further the power from DP structure of plot 2 is transferred to the 33kV DP structure of plot 1 through 33kV single circuit ACSR conductor overhead line.

The combined energy is further transferred from DP structure of plot 1 to Main control room (MCR) located within plot 1 through single Run, 3 Core, 185mm<sup>2</sup>, 33kV Aluminium XLPE PV Armoured (1RX3CX185mm<sup>2</sup>, 33kV Al. XLPE, PVC, Ar) cable.

The power from the Main switchboard panel is transferred to two 33/132kV, 25/27.5MVA power transformer through 12 Runs single core, 300mm<sup>2</sup>, 33kV Aluminium XLPE PVC Armoured (6R {2R/PH} x 1C x 630sqmm 33kV[E], Al, XLPE, PVC, Ar.) cable.

The combined power from solar PV plant is transferred to 132kV AIS bay located at Muktainagar substation through ACSR zebra single circuit transmission line. The point of interconnection will be at the Muktainagar substation.





## 5.4 Inverter Station

ABB make 2000kW indoor type central inverters have been used in PV plant under evaluation. The 50MW<sub>AC</sub> solar PV plant consist of 12 inverter station with one inverter placed in ICR located near MCR of plot 1.

Inverter station comprises of two 2000kW central inverter and one 0.660/0.660/33kV, 4MVA, 3 winding inverter duty transformer with allied switchgears. The plant has two type of panel further two blocks of 4MW<sub>AC</sub> are connected through ring mail unit (RMU).

The odd number of inverter blocks consist of 2in 1 out RMU Panel whereas even number of blocks consist of ICOG panel. 33kV outdoor type HT panel comprises of 100/1-1A current transformer, 33kV/110V fixed type potential transformer, 33kV EDO TP, 630A Vacuum Circuit Breaker and other electrical protection system.

## 5.5 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed two type of inverter duty transformer has been used in the project. The inverter station comprises of 4MVA, 33kV/2x0.66kV, Dy11y11, three winding transformer while single inverter placed in ICR is connected to 2MVA, 33kV/660V, Dy11 two winding transformer. These inverter duty transformers step up the voltage to 33kV.

The inverter duty transformers output is connected to 33kV HT panels located within inverter station. The energy from all the inverter stations ICOG/RMU panels are radially combined at 33kV main switchboard located in main control room.

### 5.5.1 33kV ICOG Panel

ICOG panel of respective inverter station are having independent protection and metering. ICOG panel feeder comprises of dedicated VCB, instrument transformers with metering and protection class. Each feeder has been provided with relay unit, which is fed by protection core from CT. ICOG panels are provided with voltage presence indicator (VPIS) and multi-functional meter for measurement purpose.

### 5.5.2 33kV RMU Panel

RMU panels are having independent protection and metering for transformer feeder. RMU panel comprises of VCB, load break switches, instrument transformer with metering and protection class. Transformer feeder has been provided with relay unit, which is fed by protection core from CT. Transformer feeder is provided with voltage presence indicator (VPIS) and multi-functional meter for measurement purpose.

The energy from all the inverter stations ICOG/RMU panels are radially combined at 33kV main switchboard located in main control room.

## 5.6 33kV Main Switchboard

The 33kV main switchboard of 50MW<sub>AC</sub> solar PV plant, comprises of inverter station incoming feeders, auxiliary transformer feeders, bus coupler feeder, two outgoing feeders and one spare feeder. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class. All feeders have been provided with relay and metering unit. The 33kV main switch board outgoing and incoming feeders are provided with instantaneous and IDMT (50/51) O/C relay instantaneous and IDMT (50N/51N) E/F relay protections. The 33kV outgoing feeders are provided with 0.2S class instrument transformers.

The combined power from 33kV HT panel (Block 11 and 12) is transmitted to 33kV Double Pole structure located within plot 2. Further the power from DP structure of plot 2 is transferred to the 33kV DP structure of plot 1 through 33kV single circuit ACSR conductor overhead line.





The combined energy is further transferred from DP structure of plot 1 to Main control room (MCR) located within plot 1.

The combined power is transferred to 132kV AIS bay located at Muktainagar substation through ACSR zebra single circuit transmission line. The point of interconnection will be at the Muktainagar substation.

### 5.7 132/33kV Switchyard

The 33kV main switchboard panel outgoing feeders are connected to two 25/27.5MVA, ONAN/ONAF, YNyn0, 132/33kV, power transformers located in 132/33kV plant end switchyard.

The 132/33kV switchyard is observed to be equipped with SF<sub>6</sub> circuit breaker, instrument transformers with metering & protection cores. The 132kV outgoing cable is protected with cable differential protection.

Each transformer line feeders are equipped with 0.2S instrument transformers with ABT main and check meters for measurement purpose, and isolators at incoming line for maintenance. The 120kV, 10kA surge arrestor is provided at 132kV incoming feeders to discharge surge currents caused by lightning strokes and switching operation of equipment's. Further the outgoing feeder is equipped with 132kV, 12.5kA surge arrestor.

Subsequently energy from 132/33kV plant end switchyard single feeder is evacuated to 132kV, Muktainagar substation at 132kV level through overhead cable.

### 5.8 Auxiliary Power Supply

SgurrEnergy had reviewed the electrical schematics shared for the projects to evaluate auxiliary system. The inverter stations of all blocks are equipped with 20kVA auxiliary transformers. Further two 100/160kVA transformers are provided in the 33kV main switchboard located in plot 1 of the 50MW<sub>ac</sub> solar PV plant.

### 5.9 Power transformer

The 132/33kV AIS switchyard located within the solar PV plant comprises of two 25/27.5MVA, 132/33kV, YNyn0 two winding transformer. These power transformers step up the voltage to 132kV.

The power transformer output is connected to 132kV, 1250A, TP, 31.5kA/1sec, Twin ACSR Zebra conductor busbar. Further the combined power of both the feeders will further evacuate to the 132kV Muktainagar substation.

### 5.10 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are normally mounted on individual structures.

Following the review of 132kV SLD, SgurrEnergy observed 145kV, 2000A, 40kA/3sec SF<sub>6</sub> motorized circuit breaker has been used in the project.

### 5.11 Isolators

Isolators are used to transfer load from one bus to another and also to isolate equipment for maintenance.

Based on the review of 132kV SLD, SgurrEnergy observed manual type 132kV, 1250A, 31.5kA/3sec isolator with and without earth switch has been used in the project.



### 5.12 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.

The current transformers and potential transformer with accuracy class of 0.2s for metering has been used in the project.

### 5.13 Surge Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes on the lines entering the substation. The apparatus most commonly used for this purpose is the surge arrester. Transformer is the most costly equipment in substation and it is normal practice to install surge arrester near to the transformer. Additional surge arresters are provided either on bus or on various lines for protection of the equipment.

Following the review, SgurrEnergy observed 120kV, 10kA, CL-03 gapless Metal Oxide Surge arrestor has been used in the switchyard.

### 5.14 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy is provided at the medium voltage switchboards for each of the feeder sections. These meters are digital with an RS 485 port for remote monitoring.

Similarly, HV side is equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point is 0.2S.



## 6 Resource assessment

### Satellite Based Resource Evaluation -

For resource analysis, SgurrEnergy has compared various satellite datasets. For the satellite databases, SgurrEnergy has compared Meteonorm 7, NASA, SWERA and SolarGIS data to find the most suitable solar resource for long-term energy yield prediction. Owing to low uncertainty and high resolution, SgurrEnergy considers SolarGIS dataset to be the most representative satellite database among all the satellite databases for long-term energy yield assessment.

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled

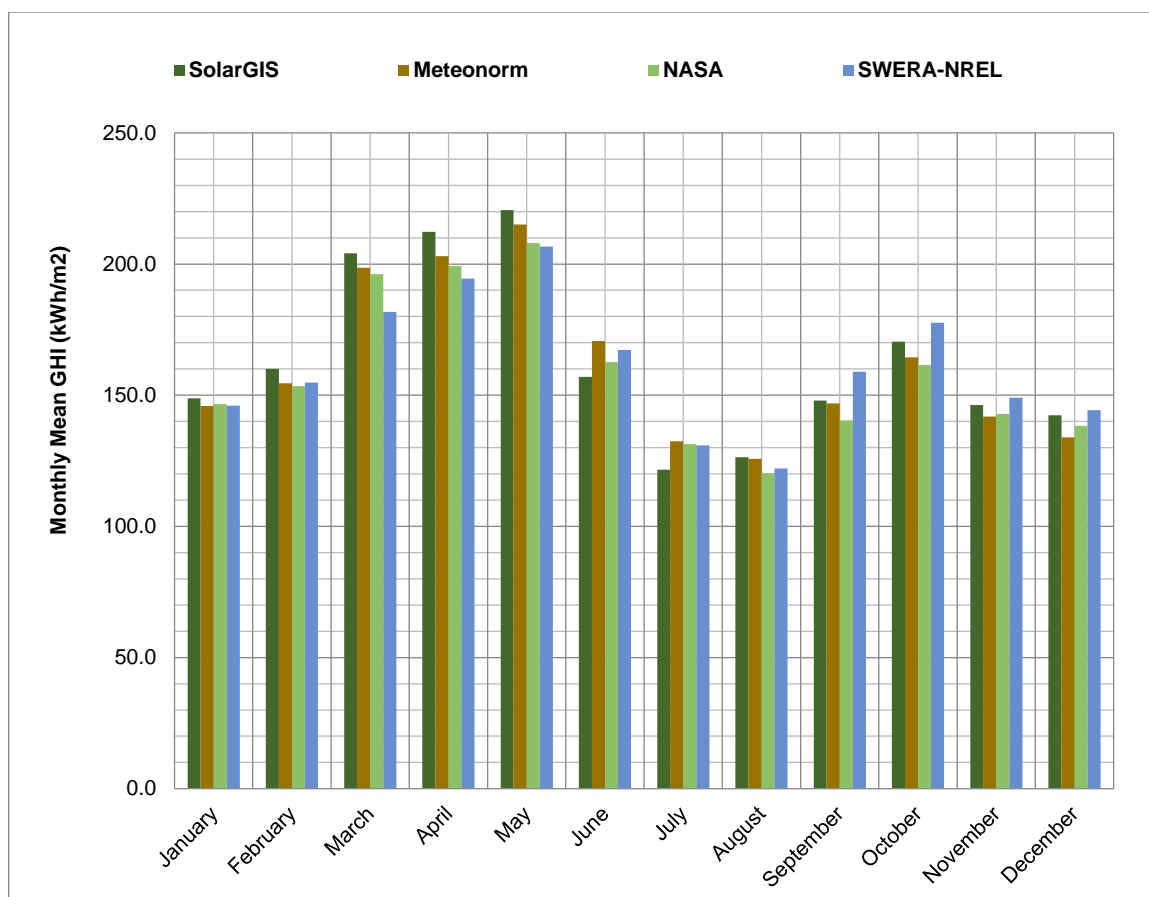


meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SgurrEnergy has sourced monthly horizontal plane irradiation data for the Project site from:

- **NASA's Surface Meteorology and Solar Energy data set;** holds satellite derived monthly data for a grid of  $0.5^{\circ} \times 0.5^{\circ}$  covering the globe for a thirty-four-year period (1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.
- **The *METEONORM (version 7.3)* global climatological database and synthetic weather generator;** contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.
- **SolarGIS:** SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km  $\times$  4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by IEA (*International Energy Agency*) *SHC Collaboration Agreement*, and EU FP6 project *MESoR* in terms of bias and RMSE.

SgurrEnergy has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS data for the site. The comparison is graphically illustrated Table6-1





**Figure 6-1: Monthly Global Horizontal Irradiation**

**Table6-1: Comparison of Solar Irradiation Datasets for the site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	1,957.6
Meteonorm 7.3	14km × 14km	4.0%	1,933.0
NASA	55km × 55km	Unknown	1,900.7
NREL (SWERA)	40km × 40km	Unknown	1,933.8

The comparison of solar data for Project site location illustrated in Table6-1 indicates SolarGIS dataset to give the highest irradiation levels. The next highest irradiation is given by NREL (SWERA) followed by Meteonorm 7.3 and NASA

The irradiation values given by Meteonorm 7.3 typically provide a combination of ground and satellite measured data. Meteonorm 7.3 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as % for the proposed site.

The NASA-SSE data source provides purely satellite measured data for a grid covering 0.5° × 0.5° on the earth's surface and generally more suited for initial site selection.

The NREL (SWERA) data illustrated has been obtained for a location approximately 10.84 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data



The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also been compared with other data sources globally. The IEA (International Energy Agency) validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>11</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)
- Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 4%.

SgurrEnergy is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 6.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 6-2 and shown graphically in Figure 6-2. Diffuse irradiation accounts for 46.15% of the total irradiation. Table 6-2 illustrates direct and diffuse daily irradiation on a horizontal plane for the proposed site. SolarGIS irradiation data is presented in Table 6-2.

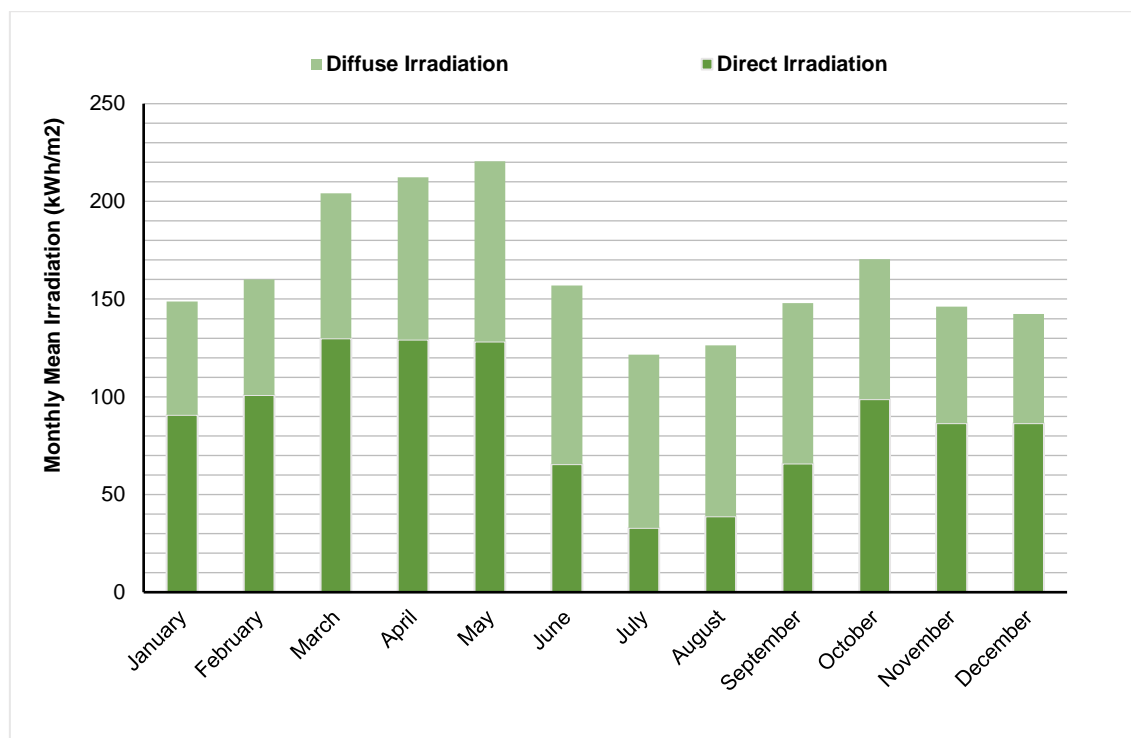
**Table 6-2: SolarGIS Irradiation Data for the Project site**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	148.8	58.0	7.6%
February	160.0	59.1	8.2%
March	204.1	74.1	10.4%
April	212.3	83.1	10.8%
May	220.6	92.4	11.3%
June	157.0	91.5	8.0%
July	121.6	88.7	6.2%
August	126.3	87.4	6.5%
September	148.0	82.2	7.6%

<sup>11</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>



Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
October	170.4	71.6	8.7%
November	146.2	59.7	7.5%
December	142.3	55.8	7.3%
<b>Annual Sum</b>	<b>1,957.6</b>	<b>903.5</b>	<b>-</b>



**Figure 6-2: Monthly Direct and Diffuse Irradiation on a horizontal plane for the project site**

## 6.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.1.4), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -6-3 represents the monthly GTI profile.

**Table -6-3: Monthly Global Tilted Irradiation Data**

Month	GTI (kWh/m <sup>2</sup> )
January	181.8
February	183.3
March	213.8
April	202.5
May	199.1
June	141.4
July	119.7
August	126.5





Month	GTI (kWh/m <sup>2</sup> )
September	152.0
October	181.9
November	175.0
December	181.0
<b>Annual Sum</b>	<b>2057.9</b>

### 6.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 6-4 below. The average wind speed of 1.3 m/s was measured at 10.84 km height from ground level for the proposed project site location.

**Table 6-4: Simulated Wind Speed for site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	0.7
February	0.9
March	1
April	1.2
May	2.2
June	2.3
July	2.1
August	1.9
September	1.1
October	0.6
November	0.6
December	0.5
<b>Yearly Average</b>	<b>1.3</b>

### 6.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.



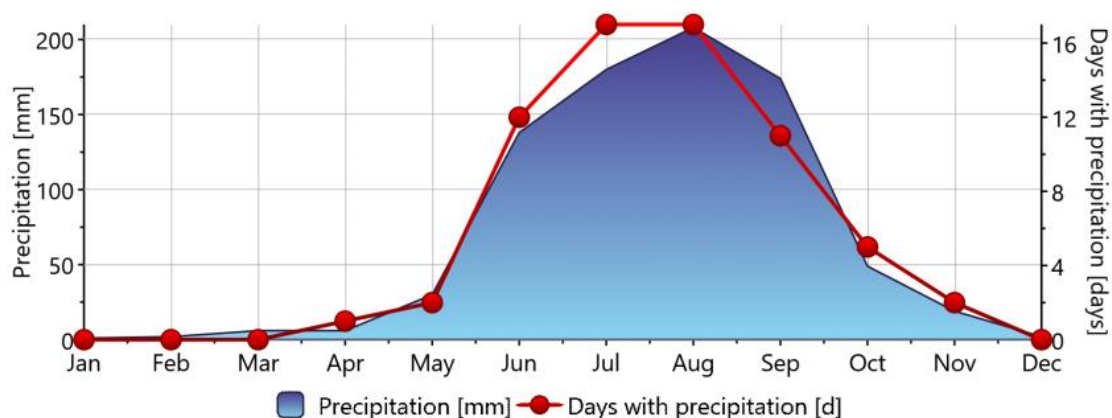


**Table 6-5: SolarGIS Temperature Data for Site (1999 – 2018)**

Months	Average Monthly Temperature (°C)
January	22.2
February	25.1
March	29.2
April	32.8
May	33.9
June	29.9
July	26.5
August	25.1
September	25.4
October	24.4
November	22.4
December	21.1
<b>Annual Average</b>	<b>26.5</b>

### 6.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.3 as illustrated in Figure 6-3. These figures show that the identified site is situated in a region that has marginal rainfall.

**Figure 6-3 Meteonorm Predicted Precipitation for the site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 1.5% has been considered by considering cleaning frequency of twice a month.



## 7 Annual Energy yields

SgurrEnergy has computed the annual energy yields for the 50 MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

Parameter	Description
Modules	Astronergy (CHSM6612P/HV-320) JA Solar (JAM60-S09-330-PR, JAM60-S09-325-PR) Canadian Solar (CS3K-325MS 1500V, CS3K-330MS 1500V, CS3K-320MS 1500V)
Inverters	ABB Central Inverters – 2.0MW <sub>AC</sub> (PVS980-58-2000kVA-K)
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	64.9

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 7.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in Table 7-1 below.

**Table 7-1: Description of Energy Yield Losses**



Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 50 MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 7.2 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 50 MW<sub>p</sub> solar PV Plant with JA, Astronergy and Canadian Solar modules and ABB inverters.



Table 7-2 summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.

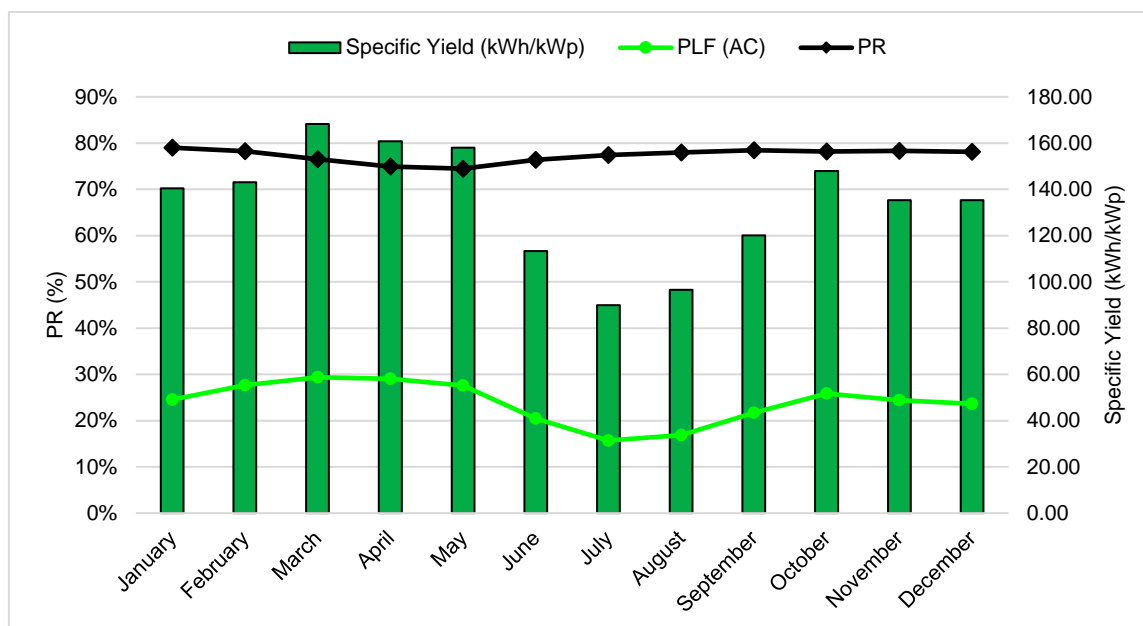
**Table 7-2: Energy Yield for the 50MW<sub>AC</sub> Solar PV Plant**

Parameters	Description
PV Module Technology	Polycrystalline, Monocrystalline PERC
DC Capacity (MW <sub>p</sub> )	64.9
AC Capacity (MVA)	50
Contracted Capacity (MW)	50
P <sub>NOM</sub> Ratio	1.30
Tilt (°)	16
Pitch (m)	5.5
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1,957.60
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	2,084.30
Transposition Factor	1.06
<b>Losses</b>	
Horizon Shading	0.00%
Incident Irradiation Below Threshold	0.00%
Near Shading	2.28%
Incident Angle	2.23%
Soiling	1.50%
Low Irradiance	0.86%
Module Temperature	8.76%
Electrical Shadings	0.22%
Module Quality	0.00%
First year Degradation	1.50%
Module Mismatch	1.00%
DC Ohmic	1.09%
Inverter Performance	1.79%
Availability	1.00%
AC Ohmic	0.56%
Transformer (LV/MV)	1.08%
Transformer (MV/HV)	-
Transmission Line	0.29%
Auxiliary Consumption	0.60%
Curtailment	
<b>Total Annual Loss Factor</b>	<b>0.772</b>
<b>Third Year P50 Energy Yield (MWh/annum)</b>	<b>1,03,472.30</b>
<b>Third Year Specific Yield (kWh/kW<sub>p</sub>)</b>	<b>1593.37</b>
<b>Third Year CUF on AC Installed Capacity</b>	<b>23.62%</b>
<b>Third Year CUF on Contracted Capacity</b>	<b>23.62%</b>
<b>Third Year CUF on DC Installed Capacity</b>	<b>18.18%</b>



Parameters	Description
Third Year Performance Ratio	76.44%

Graphical representation of the monthly generation, performance ratio and CUF for 50 MW<sub>AC</sub> evaluated is illustrated graphically in the Figure 7-1.



**Figure 7-1: Monthly Energy Yield for 50 MW<sub>AC</sub>**

### 7.3 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 7.3.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

#### 7.3.2 Inter – Annual Variation in the Solar Resource

Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.

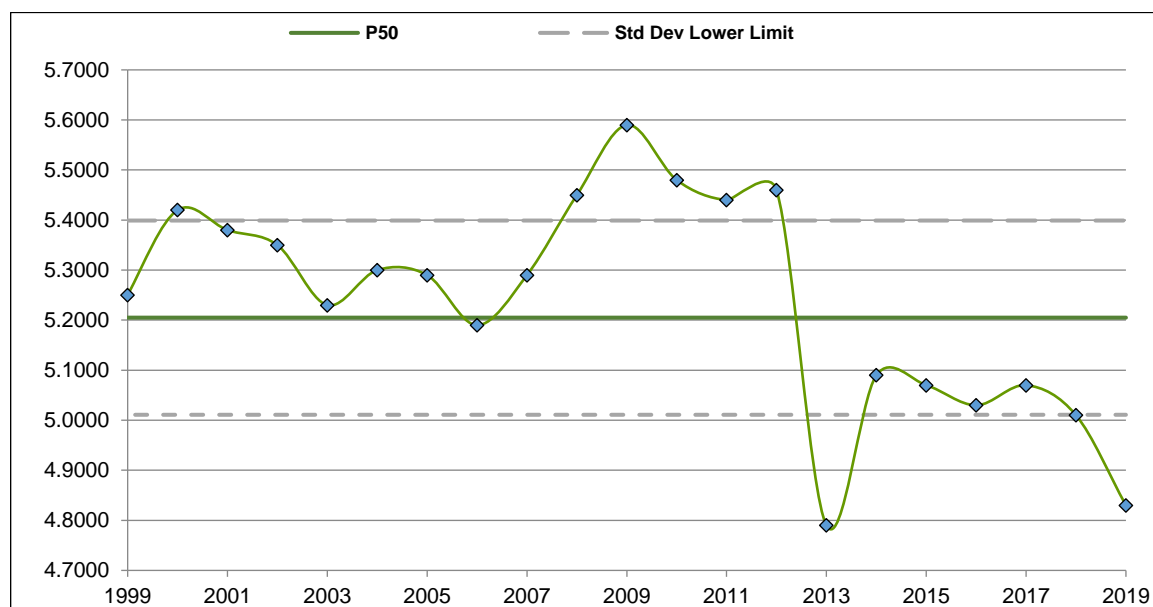
The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database for the proposed site location which is used to estimate the standard deviation of variation



in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 7-3.

**Table 7-3: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	3.73



**Figure 7-2: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in Figure 7-2.

SgurrEnergy uses a coefficient of variation of 3.73 % to quantify the inter-annual variation in the solar resource.

### 7.3.3 Modelling Uncertainty

The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

### 7.3.4 Total Uncertainty (P75, P90 and P99 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.



**Table 7-4: Life Cycle P50, P75 and P90 Generation Prediction for 50 MW<sub>AC</sub>**

Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>12</sup> (MWh/annum)	P90 Generation Prediction <sup>13</sup> (MWh/annum)
3	1,03,472.30	99,079.72	95,126.27
4	1,02,954.94	98,584.32	94,650.64
5	1,02,440.16	98,091.40	94,177.38
6	1,01,927.96	97,600.95	93,706.50
7	1,01,418.32	97,112.94	93,237.97
8	1,00,911.23	96,627.38	92,771.78
9	1,00,406.67	96,144.24	92,307.92
<b>10</b>	<b>99,904.64</b>	<b>95,663.52</b>	<b>91,846.38</b>
11	99,405.12	95,185.20	91,387.15
12	98,908.09	94,709.28	90,930.21
13	98,413.55	94,235.73	90,475.56
14	97,921.48	93,764.55	90,023.18
15	97,431.88	93,295.73	89,573.06
16	96,944.72	92,829.25	89,125.20
17	96,459.99	92,365.10	88,679.57
18	95,977.69	91,903.28	88,236.18
19	95,497.80	91,443.76	87,794.99
<b>20</b>	<b>95,020.32</b>	<b>90,986.54</b>	<b>87,356.02</b>
21	94,545.21	90,531.61	86,919.24
22	94,072.49	90,078.95	86,484.64
23	93,602.13	89,628.56	86,052.22
24	93,134.11	89,180.41	85,621.96
<b>25</b>	<b>92,668.44</b>	<b>88,734.51</b>	<b>85,193.85</b>

<sup>12</sup> The P75 values have been calculated over 10-year averages<sup>13</sup> The P90 values have been calculated over 10-year averages

## 8 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 0.6% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) and henceforth. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Client, SgurrEnergy understands that the 50MW SEPEPL solar PV plant was commissioned on 26<sup>th</sup> April 2018. SgurrEnergy was provided with plant and grid availability records from April 2018 to March 2021<sup>14</sup> for the solar PV plant. However, the irradiation measurement records were provided from September 2018 to March 2021.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from September 2018 to March 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Client.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Owners control.

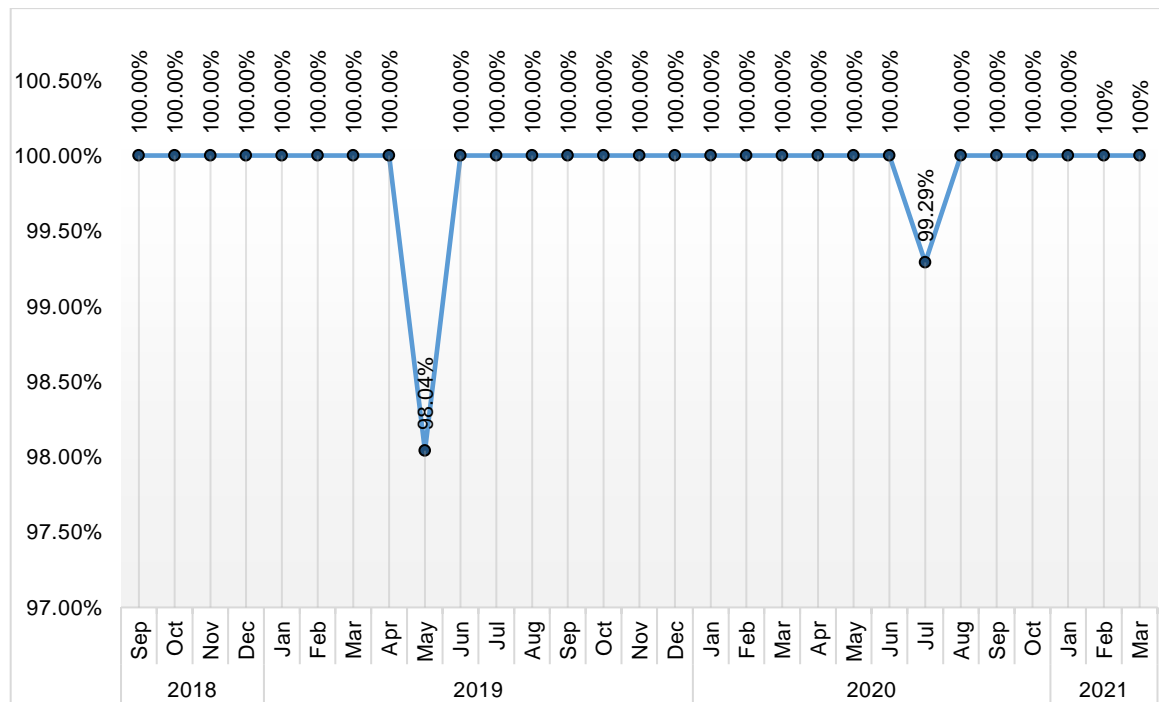
The monthly records of the grid availability from September 2018 to March 2021 have been graphically illustrated in Figure 8-1 below.

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<sup>14</sup> SgurrEnergy was provided with both the plant and grid availability records until March 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.







**Figure 8-1: Grid Availability**

From the above illustration, SgurrEnergy notes that the unavailability loss experienced due grid anomalies are minimal over the operational period and are within expected range. However, for the month of May 2019 the unavailability due to grid was slightly higher when compared to other months. The downtime due to grid unavailability was comparatively less severe during the remaining months for which the grid availability was noted to be exceeding 99.29%.

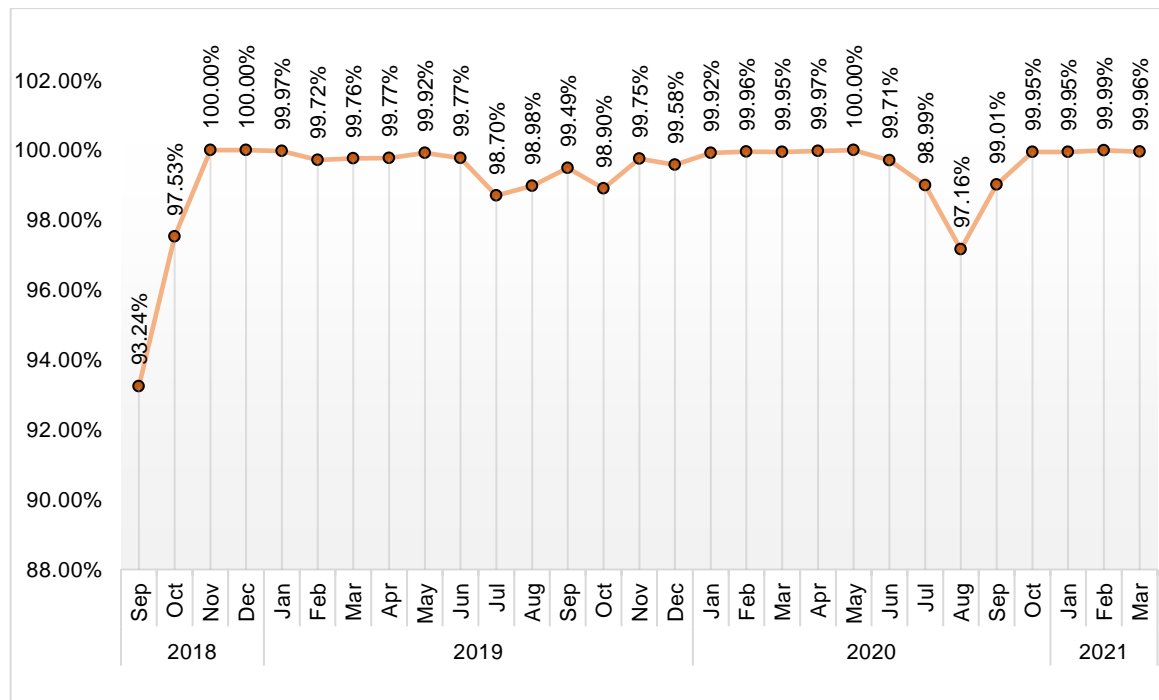
Overall, the average grid availability experienced on site for the operational period was calculated to be 99.91%

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the SEPEPL solar PV plant is graphically illustrated below in Figure 8-2.





**Figure 8-2: Plant Availability**

Based on the above illustrations, SgurrEnergy notes the plant availability for the SEPEPL solar PV plant is notably inconsistent for all the months ranging between 93.24% to 100%. For the month of September 2018, the unavailability due to plant downtime was significantly higher when compared to other months.

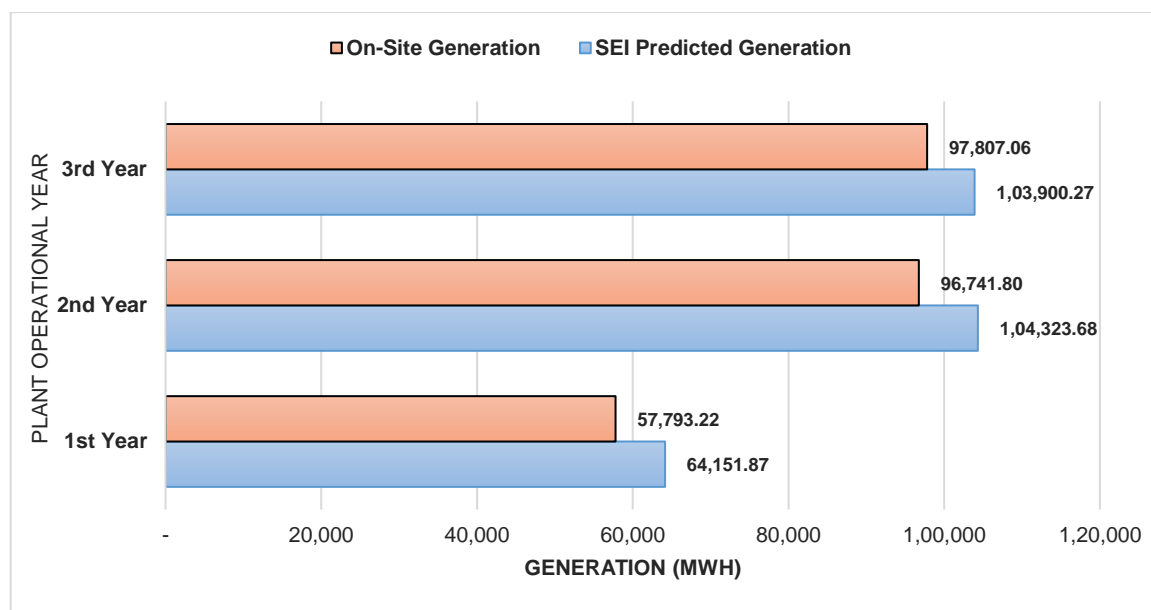
Apart from this, the plant experienced minor downtime; and SgurrEnergy notes the plant availability to be exceeding 97% for all the months. The resultant average plant availability of the PV plant for the period evaluated was 99.34% which is considered to be within expected range.

## 1.2 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Owner. To make the operational energy yield predictions more representative, SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Owner. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Owner.

The yearly comparison of the generation data is illustrated below in Figure 8-3.





**Figure 8-3: Generation Comparison**

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 8-1

**Table 8-1: PV Plant Performance – SEPEPL 50MW**

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>15</sup> (%)
Sep 2018 -Mar 2019	64,151.87	57,793.22	-9.91%
Apr 2019 -Mar 2020	104,323.68	96,741.80	-7.27%
Apr 2020 -Mar 2021	103,900.27	97,807.06	-5.86%
<b>Cumulative Period</b>	<b>272,375.81</b>	<b>252,342.09</b>	<b>-7.36%</b>

Based on the above comparison, SgurrEnergy notes that the PV plant is generating lower than the expected yield. However, SgurrEnergy considers that such variations in the energy yield can be attributed to lower irradiation level experienced on the Project site. The irradiation levels significantly impact the actual generation from the PV plant as the system losses may vary significantly due to slight change in the irradiation.

In order to understand the deviation in the irradiation pattern, SgurrEnergy has compared the monthly incident irradiation data provided by the Client with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation. The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 8-4.

**Table 8-2: Irradiation Comparison– SEPEPL 50MW**

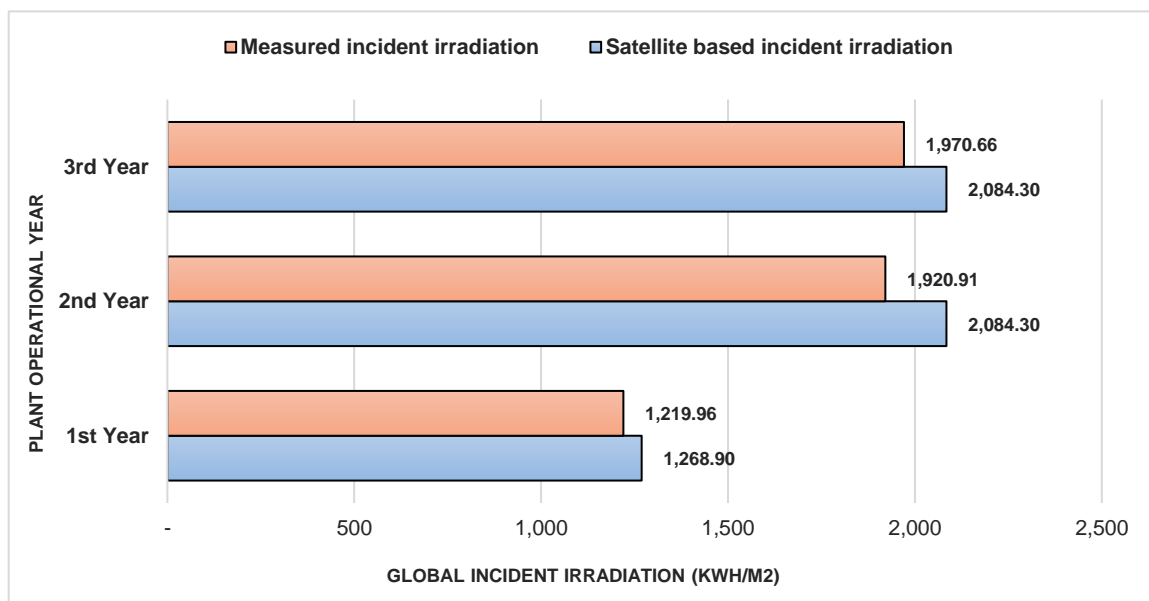
PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>16</sup> (%)
Sep 2018 -Mar 2019	1,268.90	1,219.96	-3.86%
Apr 2019 -Mar 2020	2,084.30	1,920.91	-7.84%

<sup>15</sup> Positive values indicate higher generation, while negative values indicate lower generation

<sup>16</sup> Positive values indicate higher irradiation, while negative values indicate lower irradiation



PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>16</sup> (%)
Apr 2020 -Mar 2021	2,084.30	1,970.66	-5.45%
<b>Cumulative Period</b>	<b>5,437.50</b>	<b>5,111.54</b>	<b>-5.99%</b>



**Figure 8-4: Irradiation Comparison**

Based on the above illustration, it is observed that the overall recorded generation is approximately 7.36% lower than the generation predicted on site. Correspondingly, it has also been observed that the predicted irradiation is approximately 5.99% higher than the irradiation measured on site.

Based on the comparative analysis, the drop-in generation can be attributed to the drop-in irradiation for the period of evaluation (September –18 to March – 21).



## 9 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar PV plants as having a lifetime of 25-40 years<sup>17</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>18</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the PV plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement.

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<sup>17</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>18</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>



Virescent Infrastructure

80MW(AC) Parli Solar PV Plant  
Solar Edge Power and Energy Pvt Ltd  
Technical Assessment Report

May 2021



**Report Details**

<b>Prepared for:</b>	Virescent Infrastructure
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### Amendment Records

Revision Number	Date	Purpose of Revision	Summary of Amendments
A1	28.01.2021	First Draft	-
A2	02.02.2021	Second Draft	Sections Updated
B1	09.02.2021	For Client Issue	-
B2	19.02.2021	For Client Issue	Minor Changes
B3	22.02.2021	For Client Issue	Finalisation of Report
B4	28.05.2021	For Client Issue	Generation Analysis updated

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## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
Km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
M	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon



MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation



## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 80MW<sub>AC</sub> (50+30) Solar Edge Power and Energy Private Limited (SEPEPL) solar PV plant (the Project). The Project is located near Parli village in the Beed district of the Maharashtra state. The Project is developed by Solar Edge Power and Energy Private Limited (SEPEPL). The plant is operational since April 2018. The summary of the technical assessment is captured in the below table.

**Table 0-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	<p>The project site of 50MW<sub>AC</sub> and 30MW<sub>AC</sub> lies around the coordinates 18°55'34.52"N, 76°23'46.97"E and 18°55'25.59"N, 76°21'20.58"E respectively and is located near the Parli village, in Beed district of Maharashtra.</p> <p>Project is contracted for generating 80MW<sub>AC</sub> power. The Owner has utilised approximately 464 acres of land for the project.</p> <p>Project is implemented with poly-crystalline modules (Astroenergy, JA Solar and Canadian Solar) and central inverters (ABB). The module mounting structure is implemented with a tilt of 16° for a pitch of 6 and 5m.</p> <p>The power generated from the SEPEPL 80MW<sub>AC</sub> PV plant is fed to Pangari substation, through a single circuit transmission line.</p> <p>The total DC installed capacity stands at 104.02MW<sub>p</sub>. The AC installed capacity stands at 80MW<sub>AC</sub> with 40 inverters of capacity 2,000kW each.</p>
2	PV Module	<p>SgurrEnergy has conducted a desktop review of JA Solar, Canadian Solar and Astronergy assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard. SgurrEnergy considers the warranty period to be in line with the industry standards. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.</p>
3	Inverter	<p>ABB is considered to have good track record for supplying central inverters. Review of certificates indicate ABB to hold adequate certifications. Technical characteristics are acceptable, with a good efficiency level for central inverters. Standard warranty of five years is provided for the inverters, which is in line with the industry requirement. Overall, SgurrEnergy does not raise any concern on the utilization of ABB inverters for the Project.</p>
4	Inverter Transformer	<p>The inverter transformers (4000kVA) used within the project are manufactured by Shilchar Technologies Limited. The manufacturer has a good track record of supplying transformers to distinguished customers in Indian as well as in the global</p>



Sr. No.	Parameter	Comment						
		market. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project						
5	Plant Layout Design	<p>The 30MWAC PV plant is designed with JA Solar (325Wp), and Canadian Solar (330Wp) PV modules. Similarly, the 50MWAC PV plant is designed with Astroenergy (320Wp), and Canadian Solar (320Wp / 25Wp / 330Wp) PV modules. The total DC installed capacity stands at 104.02MWp (64.63+39.39). The AC installed capacity stands at 80MWAC (50+30) with 40 inverters of capacity 2,000kW each. Overall 80MWAC (50+30) PV plant is designed into two separate plots.</p> <p>The selected tilt for the 50MWAC and 30MWAC plant is 16°. The 50MWAC plant is designed with a pitch of 6m and 30MWAC plant is designed with a pitch of 5m.</p> <p>31 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.30. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.</p>						
6	String Sizing	The V <sub>OC</sub> does not exceed the inverter input voltage for the 30MW <sub>AC</sub> and 50MW <sub>AC</sub> sites, and therefore, SgurrEnergy considers the number of modules in series to be acceptable and adequate for the PV Projects evaluated.						
7	Permits and Approvals	PPA signed between Solar Edge Power and Energy Pvt Ltd and Solar Energy Corporation of India Ltd on 10 February 2017. PPA term is 25 years from the Commercial Operation Date. Documents such as CEIG certificate, commissioning certificate, consent to operate etc. have not been provided.						
8	Allied Components and Systems	Review of Allied Components and systems have been presented in Section 5.						
9	Operational Analysis and Generation Comparison	Operational Analysis and Generation Comparison have been presented in Section 8.						
10	Energy Yield Analysis	<p>Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for third year of plant operation for the 30MWAC PV plant.</p> <table><tr><td>Global Horizontal Irradiation (kWh/m2)</td><td>1,950.10</td></tr><tr><td>Global Inclined Irradiation (kWh/m2)</td><td>2059.4</td></tr><tr><td>Third Year P50 Energy Yield (MWh/annum)</td><td>62,919.13</td></tr></table>	Global Horizontal Irradiation (kWh/m2)	1,950.10	Global Inclined Irradiation (kWh/m2)	2059.4	Third Year P50 Energy Yield (MWh/annum)	62,919.13
Global Horizontal Irradiation (kWh/m2)	1,950.10							
Global Inclined Irradiation (kWh/m2)	2059.4							
Third Year P50 Energy Yield (MWh/annum)	62,919.13							





Sr. No.	Parameter	Comment	
		Specific Yield (kWh/kWp)	1596.93
		Performance Ratio (PR)	77.54%
		PLF on Contracted Capacity (30MWAC)	23.94%
		Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for third year of plant operation for the 50MWAC PV plant.	
		Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1948.1
		Global Inclined Irradiation (kWh/m <sup>2</sup> )	2058
		Third Year P50 Energy Yield (MWh/annum)	1,02,278.79
		Specific Yield (kWh/kWp)	1582.52
		Performance Ratio (PR)	76.89%
		PLF on Contracted Capacity (50MWAC)	23.35%



## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

KKR global was founded in 1976 and the company had expanded its presence in India in 2009. The company is a global investment firm that manages multiple alternative asset classes, including private equity, credit and real assets with strategic partners that manage hedge funds. As of 30 September 2020, KKR has a team of over 1,600 employees, consultants, investment professionals and senior advisors working across 16 industries in offices around the world.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 258MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of six Solar PV plants, as presented within Table 1-1.

**Table 1-1: Portfolio Key Summary**

Project Name	SEPEPL – 80MW <sub>AC</sub>	SEPEPL – 50MW <sub>AC</sub>	SPSPL – 50MW <sub>AC</sub>	SPSPPL – 30MW <sub>AC</sub>	TNSPEPL – 5MW <sub>AC</sub> + 8MW <sub>AC</sub> + 10MW <sub>AC</sub>	UMD- 12MW <sub>AC</sub> + 13MW <sub>AC</sub> +
Site Location	18.926°N, 76.395°E, Parli, Maharash- tra, India	21.028°N, 75.985°E, Muktainagar Maharashtra ,India	9.324°N, 77.594°E. Rajapalyam, Tamil Nadu,India	12.344°N, 78.945°E Tiruvanna m-alai, Tamil Nadu, India.	5MW <sub>AC</sub> – 10.491°N, 78.063°E Dindigul, Tamil Nadu, India 8MW <sub>AC</sub> – 9.437°N, 78.172°E Aruppukkotai Tamil Nadu, India 10MW <sub>AC</sub> – 9.118°N, 78.107°E Vilathikulam, Tamil Nadu, India	12MW <sub>AC</sub> - 9.554°N, 77.884°E Amathur, Tamil Nadu, India 13MW <sub>AC</sub> - 9.093°N, 77.780°E Kovilpatti, Tamil Nadu, India
Owner / Special Purpose Vehicle (SPV)	Solar Edge Power and Energy Private Limited (SEPEPL)		Shapoorji Pallonji Suryaprakas h Private Limited (SPSPL)	Shapoorji Pallonji Solar PV Private Limited	TN Solar Power Energy Private Limited	Universal Mine Developers and Service Providers Private Limited
DC / AC Capacity	104.0MW <sub>P</sub> / 80.0MW <sub>AC</sub>	65.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	54.0MW <sub>P</sub> / 50.0MW <sub>AC</sub>	36.0MW <sub>P</sub> / 30.0MW <sub>AC</sub>	5MW <sub>AC</sub> – 6.0MW <sub>P</sub> / 5.0MW <sub>AC</sub> 8MW <sub>AC</sub> – 9.6MW <sub>P</sub> / 8.0MW <sub>AC</sub> 10MW <sub>AC</sub> – 12.0MW <sub>P</sub> / 10.0MW <sub>AC</sub>	12MW <sub>AC</sub> - 14.4MW <sub>P</sub> / 12MW <sub>AC</sub> 13MW <sub>AC</sub> - 15.6MW <sub>P</sub> / 13MW <sub>AC</sub>
Commissioning date	50MW <sub>AC</sub> – 08 April 2018 30MW <sub>AC</sub> – 22 April 2018	26 April 2018	26 September 2018	26 March 2016	5MW <sub>AC</sub> – 28 December 2015 8MW <sub>AC</sub> – 28 September 2015 10MW <sub>AC</sub> – 31 October 2015	12MW <sub>AC</sub> – 16 November 2015 13MW <sub>AC</sub> – 21 March 2016

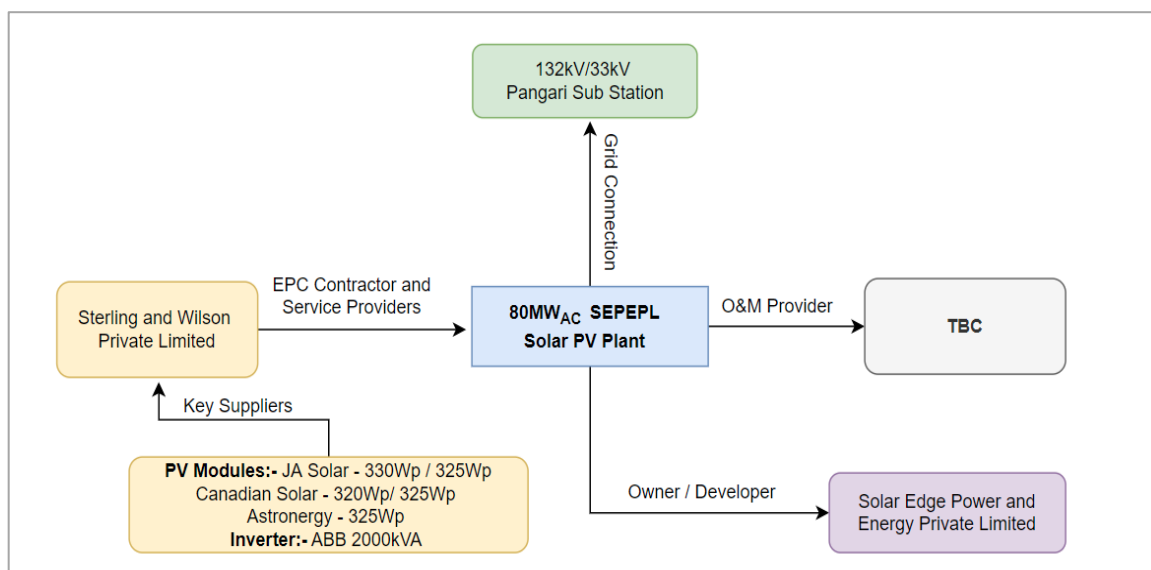


This report presents the technical appraisal of the 80MW<sub>AC</sub> SEPEPL Solar PV plant (The Project) developed by Solar Edge Power and Energy Private Limited (SEPEPL) near *Bhilegaon* village, *Parali* taluk in the *Beed* district of the Maharashtra state.

The purpose of this report is to provide a technical appraisal of PV plant under evaluation. The report focuses on the following key aspects:

- System Overview.
- Major Components.
- System Design Appraisal.
- Allied Components and Systems.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project, based on information made available by the Client through online data room and site assessment. Figure 1-1 illustrates the project structure indicating key project participants.



**Figure 1-1: Project Structure**

The main Project characteristics are summarised in Table 1-2.

**Table 1-2: Project Key Summary**

Project Information	
<b>Project Name</b>	80MW <sub>AC</sub> SEPEPL Solar PV plant
<b>Location</b>	<i>Parli</i> , Maharashtra
<b>Owner</b>	Solar Edge Power and Energy Private Limited
<b>DC/ AC capacity</b>	104MW <sub>p</sub> / 80MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: JA Solar, Canadian Solar, Astronergy Inverters: ABB
<b>MMS Configuration</b>	Fixed Tilt: 16°, Azimuth: 0°



**Project Information****Commissioning Status**

- Commissioning for 50MW<sub>AC</sub> PV plant was achieved on 08 April 2018
- Commissioning for 30MW<sub>AC</sub> PV plant was achieved on 22 April 2018



## 2 Parli 80MW<sub>AC</sub> (50+30) Solar PV Plant Overview

The project site of 50MW<sub>AC</sub> and 30MW<sub>AC</sub> lies around the coordinates 18°55'34.52"N, 76°23'46.97"E and 18°55'25.59"N, 76°21'20.58"E respectively. Satellite imageries of 50MW<sub>AC</sub> and 30MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1 and Figure 2-2.

The Owner has utilised approximately 464 acres (236 acres for 50MW<sub>AC</sub> and 227 acres for 30MW<sub>AC</sub>) of land for the 80MW<sub>AC</sub> solar PV plant. The Project site is in the *Parli* village, of Beed district of Maharashtra.

Project is contracted for generating 80MW<sub>AC</sub> (50+30) power; SgurrEnergy therefore interprets 80MW<sub>AC</sub> (50+30) as the maximum AC installed capacity for the solar PV plant.



Figure 2-1: Satellite image of 50WM<sub>AC</sub>







**Figure 2-2: Satellite image of 30MW<sub>AC</sub>**

### 2.1 80MW<sub>AC</sub> (50+30) Project Summary

Solar PV plant is modular in nature; therefore, SEPEPL 80MW<sub>AC</sub> (50+30) solar PV plants is implemented by adopting modularity in designs. 4MW<sub>AC</sub> is the typical inverter station considered for implementing SEPEPL 80MW<sub>AC</sub> (50+30) solar PV plant.

The 30MW<sub>AC</sub> and 50MW<sub>AC</sub> plants are co-located wherein, the 30MW<sub>AC</sub> PV plant evacuates to 50MW<sub>AC</sub> plant at its main HT panel, further to which the combined power of 80MW<sub>AC</sub> is evacuated to the grid substation.

Table 2-1 presents the summary of 80MW<sub>AC</sub> (50+30) PV plant.

**Table 2-1: Summary of 80MW<sub>AC</sub> (50+30) Plant Configurations**

General		
PV Module Technology	Poly-crystalline	
Inverter Technology	Central Inverters	
Installed DC Peak Capacity (MW <sub>p</sub> )	64.63	39.39
Installed AC Capacity (MW)	50.00	30.00
Mounting Type	Fixed Tilt	
Tilt Angle (°)	16	
Pitch (m)	6	5
PV Modules		



General			
PV Module Manufacturer	Astroenergy	JA Solar	Canadian Solar
Model	CHSM6612P Series	JAM60S08-320/325	CS3K-320/325/330
Wattage (W <sub>p</sub> )	325W <sub>p</sub>	320W <sub>p</sub> / 325W <sub>p</sub>	320W <sub>p</sub> / 325W <sub>p</sub> / 330W <sub>p</sub>
Number of Modules per String	31		
Inverter			
Inverter Manufacturer / Model	ABB / PVS980-58-2000kVA-K		
Inverter Nominal AC Output	2,000kW		
Number of Inverters	25	15	
Mounting Structure			
Mounting Structure Details (rows × columns)	2 × 31 / 2 × 16		
Orientation of Modules	Portrait		

The 30MW<sub>AC</sub> PV plant is implemented with a total of 7 inverter stations, each of capacity 4MW<sub>AC</sub> while there is one inverter of capacity 2MW<sub>AC</sub> which is placed in the main control room. Hence, the output of 4MW<sub>AC</sub> inverter station is connected to 0.660/0.660/33kV three winding transformer of 4MVA for stepping up the voltage to 33kV. The medium voltage 33kV output of all the inverter stations are placed in main control room (MCR), these are combined to form a solar PV plant of 30MW<sub>AC</sub>.

Similarly, the 50MW<sub>AC</sub> PV plant is implemented with a total of 12 inverter stations, each of capacity 4MW<sub>AC</sub> while there is one inverter of capacity 2MW<sub>AC</sub> which is placed in the main control room. Hence, the output of 4MW<sub>AC</sub> inverter station is connected to 0.660/0.660/33kV three winding transformer of 4MVA for stepping up the voltage to 33kV. The medium voltage 33kV output of all the inverter stations are placed in main control room (MCR), these are combined to form a solar PV plant of 50MW<sub>AC</sub>.

The power generated from 30MW<sub>AC</sub> is evacuated using Double Circuit ACSR Wolf conductor of 3.5km and combined at the main HT panel of the 50MW<sub>AC</sub> PV plant. The combined 80MW<sub>AC</sub> output of both the plants is then stepped up to 132kV by means of two 25/30MVA, ONAN/ONAF transformers at HV substation is built within the plant premises.

The power generated by the SEPEPL 80MW<sub>AC</sub> (50+30) PV plant is fed to *Pangari* substation located approximately 11km from the 50WM<sub>AC</sub> Project site, through a 132kV single circuit Panther ACSR conductor. The point of interconnection is at the *Pangari* substation.

ABT / revenue metering is at *Pangari* substation; therefore, transmission line losses are accounted in the Owner's scope.



### 3 Review of Major Plant Components

SgurrEnergy has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions.

#### 3.1 PV modules

The PV modules selected for the Project are supplied by JA Solar Holding Co., Ltd., Canadian Solar and Astronergy. SgurrEnergy has conducted a technical review of the suppliers and proposed module specifications with regard to their suitability for use on the Project.

##### 3.1.1 Company Profile – JA Solar Holding Co., Ltd

JA Solar Holding Company Ltd. listed on NASDAQ (NASDAQ: JASO), was found in the year 2005 and started operation in 2006. The Company has 12 manufacturing bases and has production capacity of more than 11.5GW, 11GW, and 11GW for silicon wafer, solar cells, and solar modules, respectively.

JA solar has 20 branches around the world and employs more than 22,000 employees worldwide. As of December 2019, JA solar provides services in more than 135 countries and to more than 33,000 clients worldwide. As of second quarter 2020, JA solar had a cumulative shipment of more than 50GW. As of December 2019, JA solar had more than 779 authorized patents of independent R&D and 107 invention patents under its name. The Company's net revenue was RMB 21.16 billion in 2019.

Few of the commissioned solar power plants using JA modules are listed in Table 3-1.

**Table 3-1: Project References of JA Solar**

Sr. No.	Project and Location	Capacity (MW)
1	Bahia, Brazil	255.0
2	Northern Cooks, Australia	172.8
3	Cadiz, Philippines	132.5
4	Maharashtra, India	130.0
5	Three Gorges, Datong	100.0
6	Bahawalpur, Pakistan	100.0
7	Lincheng Country, Xingtai City, Hebei Province	100.0
8	Dunhuang, Gansu Province	100.0
9	Utah, USA	80.0
10	New South Wales, Australia	70.0
11	Maharashtra, India	70.0
12	Telangana, India	69.0
13	Bole, Xinjiang	60.0
14	San Carlos, Philippines	59.0
15	MP, India	57.0
16	Charanka Gujrat, India	53.0
17	Datong, Shanxi Province	50.0
18	Southwark, UK	49.0
19	Karnataka, India	43.0





Sr. No.	Project and Location	Capacity (MW)
20	Xiayu, Hebei Province	42.0
21	Yinchuan, Ningxia Province	40.0
22	Georgia, USA	38.7
23	Arawa Desert and Negev Desert, Israel	35.0
24	Hefeng, Tacheng, Xinjiang	30.0
25	Karnataka, India	23.0
26	Bulgaria	21.0
27	Haryana, India	21.0
28	Campania, Italy	20.0
29	Corp 184, Xinjiang	20.0
30	Telengana, India	18.0
31	Toshka, Egypt	10.1
32	Volkswagen Chattanooga Plant, USA	9.6
33	Antalya, Turkey	6.7
34	Kenitra, Morocco	2.0
35	ABC Bank, Jordan	1.5

JA is considered a Tier 1 supplier by Bloomberg (Q4, 2020). A Tier 1 supplier is defined as a module manufacturer who has *provided products to five different projects, which have been financed non-recourse by five different (non-development) banks, in the past two years.*

Whilst the Bloomberg tiering system does not reflect on a product's technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers JA solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

### 3.1.1.1 Main Technical Characteristics of JAM60S08/PR/1000V

JA Solar, JAM60S08/PR/1000V modules of 330W<sub>P</sub> and 325W<sub>P</sub> capacity have been utilized for the Project. These modules have an efficiency of 19.5% and 19.8% for 325W<sub>P</sub> and 330W<sub>P</sub> capacity modules, respectively, and a peak power tolerance of 0~+5W. The modules have a temperature coefficient (P<sub>max</sub>) of -0.36%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy's expectation for c-Si technology. The technical characteristics of JAM60S08/PR/1000V are presented in Table 3-2.

**Table 3-2: Technical specifications of JAM60S08/PR/1000V**

Specifications	JAM60S08-325/PR/1000V	JAM60S08-330/PR/1000V
Technology	Mono PERC Half-cut cell	
Nominal power (P <sub>MPP</sub> )	325W <sub>P</sub>	330W <sub>P</sub>
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	33.65V	33.91V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	9.66A	9.74A
Open circuit voltage (V <sub>OC</sub> )	40.56V	40.84V
Short circuit current (I <sub>SC</sub> )	10.22A	10.29A
Efficiency (%)	19.50%	19.80%



Specifications	JAM60S08-325/PR/1000V	JAM60S08-330/PR/1000V
Maximum System Voltage	1,000V (DC)	
Power tolerance (%)	0~+5W	
Dimensions (length × breadth × width) (mm)	1678 × 991 × 35	
Module area (m²)	1.66m²	
Weight (kg)	18.5kg±3%	
Temperature coefficient at P <sub>MAX</sub>	-0.36%/°C	
Operating temperature	-40°C to +85°C	
Maximum reverse current	20A	
Maximum mechanical load	3600Pa	
Maximum snow load	1600Pa	
Product warranty	12 years	
Power output guarantee	25 years	
Module technical characteristics are given at STC (1,000W/m² irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet)		

The maximum system voltage is 1,000V. The maximum reverse current is 20A. Overall, the module characteristics can be considered to be in line with market standard and JA Solar is listed as Tier 1 suppliers by Bloomberg since 2014.

### NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>1</sup> characteristics of selected JAM60S08/PR/1000V modules of 325W<sub>P</sub> and 330W<sub>P</sub> capacity is given in Table 3-3 corresponding to realistic operating conditions as compared to STC. It is affected by module materials used as well as the packing density of module materials. The NOCT for the module is 45±2°C. This is comparable with other manufacturers and demonstrates the module is effective at heat dissipation.

**Table 3-3: PV Module NOCT Characteristics of JAM60S08/PR/1000V**

Model	JAM60S08-325/PR/1000V	JAM60S08-330/PR/1000V
Maximum Power (P <sub>MAX</sub> )	241W <sub>P</sub>	244W <sub>P</sub>
Max Power Voltage (V <sub>MPP</sub> )	33.54V	33.82V
Max Power Current (I <sub>MPP</sub> )	7.17A	7.22A
Open Circuit Voltage (V <sub>OC</sub> )	37.38V	37.65V
Short Circuit Current (I <sub>SC</sub> )	8.20A	8.25A

#### 3.1.1.2 Certification of Modules

General review of datasheet indicates JA Solar PV modules manufactured in facilities with the following certifications:

- ISO 14001 certification for environmental management systems

<sup>1</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C.



- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certifications available in public domain for the modules under evaluation within Table 3-4.

**Table 3-4: Certification for PV Module- JA Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
IEC 60068	Environmental Testing
IEC 61701	Resistance to salt mist and corrosion
IEC 62804	Testing Modules for Potential Induced Degradation
UL 1703	Standard for safety for flat-plate photovoltaic modules

### 3.1.1.3 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of six months from the dispatch from the JA solar factory or the delivery date to site.

#### 3.1.1.4 Product Warranty

JA Solar provides a limited product warranty of 12 years, beginning on the earlier of module purchase date or one-year anniversary from the production date. If module fail to conform to this warranty, during the period ending of 12 years from the date of sale to the customer of the JA solar product, JA solar will at its opinion, either repair or replace the product, or refund the purchase price as paid by the customer. The repair or replacement or refund the customer at the current comparable market price of such module.

SgurrEnergy considers twelve-year product warranty provided by JA solar to be in line with the industry standard.

#### 3.1.1.5 Linear Power-Output Warranty

According to the datasheet JA solar warrants that the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.7% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 80.7% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, JA solar will either repair, replace or provide additional modules to make up for the loss in power output.

### 3.1.2 Company Profile– Canadian Solar

Canadian Solar (NASDAQ: CSIQ) is a vertically integrated producer of ingot, wafer, solar cell, and solar modules and was established in Ontario, Canada in 2001. Canadian Solar has subsidiaries in 20 countries on six continents. The company has 17 manufacturing facilities in Asia and America. Along with over 14,000 employees around the world, Canadian Solar had reported net revenue of \$914 Million at the end of the third quarter of



2020<sup>2</sup>. The company has achieved shipment of over 52GW of solar module. Canadian Solar also has a portfolio of solar power plants in operation. Canadian Solar is currently have more than 16.3GW pipeline projects worldwide.<sup>3</sup>

As of December 2019, the company has an ingot manufacturing capacity of 1.85GW per annum, wafer-manufacturing capacity of 5GW per annum, cell manufacturing capacity of 9.6GW per annum<sup>4</sup>.

The company also operates three state-of-the-art research centres in Canada and China which focus on improvement of efficiency and performance of its products. These research facilities employ over 515 scientists along with engineers and technicians in order to conduct research to improve the existing technologies. As of March 2020, Canadian Solar has applied for over 2,400 patent and has over 1,500 authorized patents worldwide.

Few of the commissioned solar power plants using Canadian Solar modules are listed in Table 3-5.

**Table 3-5: Track record of Canadian Solar Modules<sup>5</sup>**

Sr. No.	Project Location	Capacity (MW)
1	Tamil Nadu	309.0
2	Ontario, Canada	300.0
3	Dubai, UAE	268.0
4	Finley, Australia	175.0
5	Shizuishan, China	150.0
6	Brandenburg, Germany	148.0
7	Wuhu City, Inner Mongolia, China	100.0
8	Oakey, Australia	100.0
9	Yucheng, China	100.0
10	Goyalri, India	78.0
11	Rovigo, Italy	70.0
12	Yamaguchi, Japan	56.3
13	Yangquan, China	50.0
14	Dai County, China	46.8

Canadian Solar is considered a Tier 1 supplier by Bloomberg (Q4, 2020). A Tier 1 supplier is defined as a module manufacturer who has *'provided products to five different projects, which have been financed non-recourse by five different (non-development) banks, in the past two years'*.

Whilst the Bloomberg tiering system does not reflect on a product's technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers Canadian solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

<sup>2</sup> <https://www.prnewswire.com/news-releases/canadian-solar-reports-third-quarter-2020-results-301176940.html>

<sup>3</sup> <https://www.csisolar.com/aboutus/>

<sup>4</sup> <http://investors.canadiansolar.com/static-files/18a43183-17c4-4646-987f-2572d5e6a588>

<sup>5</sup> <https://www.canadiansolar.com/successful-projects/>



### 3.1.2.1 Technical Characteristics

The Canadian Solar CS3K-MS modules of 320W<sub>P</sub>, 325W<sub>P</sub>, and 335W<sub>P</sub> capacities have been utilized for the project. The 320W<sub>P</sub>, 325W<sub>P</sub>, and 330W<sub>P</sub> modules have efficiencies of 19.3%, 19.6% and 19.9%, respectively and a positive power tolerance of 0~+10W. The selected series has a temperature coefficient (P<sub>max</sub>) of -0.36%/°C. This temperature coefficient is in line with SgurrEnergy's expectation for c-Si technology. Generally, the temperature coefficient of crystalline silicon modules is in the range of -0.35% to -0.50%/°C rise in temperature. The technical characteristic of the shortlisted modules is presented in Table 3-6.

**Table 3-6: Canadian PV Module Technical Characteristics**

Characteristic	CS3K-320MS	CS3K-325MS	CS3K-330MS
Type	Monocrystalline PERC Half-cut cell		
Nominal Power (P <sub>MPP</sub> )	320W <sub>P</sub>	325W <sub>P</sub>	330W <sub>P</sub>
Power Tolerance	0~+10W		
Voltage at P <sub>Max</sub> (V <sub>MPP</sub> )	33.3V	33.0V	33.0V
Current at P <sub>Max</sub> (I <sub>MPP</sub> )	9.6A	9.7A	9.8A
Open Circuit Voltage (V <sub>OC</sub> )	40.1V	40.3V	40.5V
Short Circuit Current (I <sub>SC</sub> )	10.1A	10.2A	10.3A
Fill Factor (%)	78.7%	78.9%	79.2%
Module Efficiency	19.3%	19.6%	19.9%
Temperature Coefficient at P <sub>MPP</sub>	-0.36%/°C		
Maximum System Voltage	1,500V (IEC/UL) or 1,000V (IEC/UL)		
Dimensions	1,675mm x 992mm x 35mm		
Module Area	1.66m <sup>2</sup>		
Weight	18.50kg		
Maximum Snow Load	6,000Pa		
Maximum Wind Load	4,000Pa		
Module technical characteristics are given at STC (1,000W/m <sup>2</sup> irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet			

Modules have a power tolerance of 0~+10W and the fill factor is in the range of 78% to 79%. The datasheet specifies three bypass diodes are installed to reduce the effect of shading losses within the PV system. The maximum system voltage is 1,500V which is standard and the maximum snow and wind loading specifications are in line with industry norms.



## NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>6</sup> characteristics of selected CS3K-MS modules of 320W<sub>P</sub>, 325W<sub>P</sub> and 330W<sub>P</sub> capacities is given in Table 3-7 corresponding to realistic operating conditions as compared to STC. It is affected by module materials used as well as the packing density of module materials. The NOCT for the module is 42±3°C. This is comparable with other manufacturers and demonstrates the module is effective at heat dissipation.

**Table 3-7: PV Module NOCT Characteristics of CS3K-MS**

Model	CS3K-320MS	CS3K-325MS	CS3K-330MS
Maximum Power (P <sub>MAX</sub> )	238W <sub>P</sub>	242W <sub>P</sub>	249W <sub>P</sub>
Max Power Voltage (V <sub>MPP</sub> )	31.0V	31.2V	31.6V
Max Power Current (I <sub>MPP</sub> )	7.7A	7.8A	7.9A
Open Circuit Voltage (V <sub>OC</sub> )	37.6V	37.8V	38.6V
Short Circuit Current (I <sub>SC</sub> )	8.18A	8.24A	8.38A

### 3.1.2.2 Certification of Modules

General review of datasheet indicates Canadian Solar PV modules manufactured in facilities with the following certifications:

- ISO 14001 certification for environmental management systems
- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certification mentioned in the datasheet of the modules under evaluation within Table 3-8.

**Table 3-8: Certification for PV Module- Canadian Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
IEC 60068	Environmental Testing
IEC 61701	Resistance to salt mist and corrosion
IEC 62716	Ammonia Corrosion Testing
UL 1703	Standard for safety for flat-plate photovoltaic modules

### 3.1.2.3 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of the date of installation or 90 days from the delivery date.

<sup>6</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C.



### 3.1.2.4 Product Warranty

PV module, DC connectors and cables are guaranteed to be free from defects in materials and workmanship for a period of 12 years from the warranty start date.

### 3.1.2.5 Linear Power-Output Warranty

According to the datasheet provided, SgurrEnergy understands that Canadian solar warrants the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.6% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 83.1% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, Canadian solar will either repair, replace or provide additional modules to make up for the loss in power output.

### 3.1.3 Company Profile- Astronergy Co., Ltd.

Astronergy Co., Ltd. is a specialized subsidiary of the CHINT group and is engaged in the PV power station development and PV module production. Established in 2006 and headquartered in China, Astronergy has the module production capacity of 5000MW<sub>P</sub> and total registered capital of nearly 9.38 billion CNY.

Astronergy has three production facilities including 600MW solar cell factory in Thailand. The Company has built more than 200MWP of solar power stations worldwide including in the USA, Japan, South Korea, Thailand, Spain, Bulgaria, India, Romania, Turkey, South Africa, and Philippines, etc. Further, the Company has branch offices in the USA, Germany, Japan, South Korea, Spain, and India and can provide localized and customized services to its clients.

Few of the commissioned solar power plants using Astronergy modules are listed in Table 3-9.

**Table 3-9: Project References of Astronergy**

Sr. No.	Project and Location	Capacity (MW)
1	Benban Solar Park, Egypt	165.0
2	Midden Groningen, Netherlands	103.0
3	Italy Rovio	70.0
4	Goonumbla, Australia	69.8
5	South Africa	64.0
6	Brazil	50.0
7	Vietnam Binh Thuan	47.5
8	Vietnam Dami	47.5
9	India	25.0
10	Veendam, Netherlands	15.5
11	Andijk, Netherlands	15.0
12	Bulgaria Bezmer	10.0
13	Boongeo Seom, Korea	10.0
14	Conergy Littlewood, UK	8.0
15	San Giovanni Rotondo, Italy	8.0





Sr. No.	Project and Location	Capacity (MW)
16	OSMANIYE, Turkey	5.3
17	Philippines Bataan	5.0
18	Philippines Buacan	4.0
19	Palacio Cremado, Spain	3.2
20	Depot Park Sacramento, America	3.0

According to the information available in the public domain, Astronergy has been listed as 1<sup>st</sup>-tier PV brand around the world by Bloomberg. Whilst the Bloomberg tiering system does not reflect on a product's technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers Astronergy solar to have a strong track record in delivering PV modules to utility-scale projects worldwide.

### 3.1.3.1 Main Technical Characteristics of CHSM6612P/HV-320W<sub>p</sub>

Astronergy, CHSM6612P/HV modules of 320W<sub>p</sub> capacity have been utilized for the Project. These modules have an efficiency of 16.5% and a peak power tolerance of 0~+5W. The modules have a temperature coefficient (P<sub>max</sub>) of -0.408%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy's expectation for c-Si technology. The technical characteristics of CHSM6612P/HV are presented in Table 3-10.

**Table 3-10: Technical specifications of CHSM6612P/HV**

Specifications	CHSM6612P/HV -320
Technology	Polycrystalline
Nominal power (P <sub>MPP</sub> )	320
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	37.02V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	8.65A
Open circuit voltage (V <sub>OC</sub> )	45.45V
Short circuit current (I <sub>SC</sub> )	9.25A
Efficiency (%)	16.5%
Maximum System Voltage	1500V
Power tolerance (%)	0~+5W
Dimensions (length × breadth × width) (mm)	1,960mm x 992mm x 40mm
Module area (m <sup>2</sup> )	1.94m <sup>2</sup>
Weight (kg)	21.9kg
Temperature coefficient at P <sub>MAX</sub>	-0.408%/°C
Maximum series fuse rating	15A
Maximum front load	6,000Pa
Maximum back load	3,600Pa
Product warranty	10years
Power output guarantee	25years

Overall, the module characteristics can be considered to be in line with market standard. The maximum system voltage is 1,500V and the maximum series fuse current is 15A.





### 3.1.3.2 Certification of Modules

The modules are manufactured in an automated facility certified to ISO9001, ISO14001, and OHSAS18001. According to the information available in public domain, SgurrEnergy has summarised the certification provided for the module within Table 3-11.

**Table 3-11: Certification for PV Module- Astronergy Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
IEC TS 62941	Design and manufacturing of Photovoltaic Solar Modules
UL 1703	Standard for safety for flat-plate photovoltaic modules

### 3.1.3.3 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of 180 days after the manufacturing date or the delivery date to site.

### 3.1.3.4 Product Warranty

According to the datasheet provided by the Client for the PV module, DC connectors and cables are guaranteed to be free from defects in materials and workmanship for a period of 10 years from the warranty start date.

### 3.1.3.5 Linear Power-Output Warranty

Referring the datasheet provided, SgurrEnergy understands that Astronergy solar warrants the modules will not experience a power loss of greater than 2.5% in the first year of operation, at which time the nominal power output shall not be less than the initial nominal power output; and 0.7% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 80.7% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, Astronergy will either repair, replace or provide additional modules to make up for the loss in power output.

## 3.2 Inverters – ASEA Brown Boveri (ABB)

The project has utilized ABB PVS980-58-2000kVA central inverter for the project under evaluation.

### 3.2.1 Company background

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, ABB is one of the largest engineering companies as well as one of the largest conglomerates in the world. ABB has operations in around 100 countries, with approximately 147,000 employees<sup>7</sup>. Company reported global revenue of around \$34,312 million for 2017.<sup>8</sup>

<sup>7</sup> <https://new.abb.com/news/detail/26838/abb-to-exit-solar-inverter-business>

<sup>8</sup> <https://new.abb.com/investorrelations/company-profile/facts-figures>



The firm's shares are traded on the stock exchanges of Zurich, Stockholm, and New York. ABB is a multinational corporation headquartered in Zurich, Switzerland, operating mainly in robotics and power and automation technology.

On July 9, 2019 the Italian company FIMER acquired ABB's solar inverter business. The takeover of ABB's solar inverter business included 800 employees in 26 countries as well as two manufacturing plants, in Italy and in India, and a R&D facility in Finland.

FIMER was founded in 1942, headquartered in Vimercate, Italy, has been actively working in inverter technology since 1983. As of 2020, the company employs more than 1,100 employees across its three manufacturing facilities and three R&D centres across the globe. As a result of acquisition of ABB's PV inverter line, FIMER ranked the fifth-largest PV inverter globally in 2019.

### 3.2.2 Track Record

ABB India commenced local manufacturing of solar inverters in 2012 and partnered with several customers. ABB is the solar inverter market leader in India holding approximately 24% market share in 2018. ABB has approximately 3,590MW in operation across more than 350 sites in India. ABB India manages close to 40% of the installed bases in India. As on 30 August 2017, ABB India crossed the 5GW threshold for the supply of inverters in the country.

Table 3-12 lists the state-wise installed capacity of ABB inverters in India. However, it is to be noted that the table below doesn't not comprise of the installed capacities till date.

**Table 3-12: ABB Inverter Track Record**

Location	Capacity (MW)
Tamil Nadu	747
Andhra Pradesh	647
Rajasthan	371
Karnataka	305
Madhya Pradesh	271
Maharashtra	261
Punjab	227
Bihar	225
Uttar Pradesh	106
Haryana	62
Kerala	50
Chhattisgarh	28
Odisha	20

ABB India has strategically located its headquarter in Bangalore and offices in other cities Pune, Ahmedabad, Jaipur, Faridabad, Hyderabad, Tamil Nadu and Bhopal in order to facilitate quick spare part availability and minimal response time. ABB aims to provide first response to its customers within 4 hours on weekdays and within 24 hours on weekends and holidays. ABB also provides a Turn-Around-Time of 48 and 72 hours on weekdays and weekends respectively, hence maintaining an average uptime of over 99%.



### 3.2.3 Technical Characteristics

ABB PVS980-58-2000kVA inverter has been selected for technical feasibility of the Project. The technical specification of 2000kW ABB inverter is listed in Table 3-13.

The PVS980-58-2000kVA Series of central inverters designed ideal for large PV Power Plants. PVS980 inverters are designed for fast and easy installation. These inverters are designed to operate with DC inputs up to 1,500 V. They incorporate maximum power point tracking (MPPT) and grid management features to meet utility requirements.

PVS980-58-2000kVA inverter is designed for outdoor use with an IP66 ingress protection class. They have closed loop cooling system based on phase transition and thermosiphon technology with water and dustproof enclosure. They perform optimally at ambient air temperatures between -20°C to 50°C and relative humidity in the range of 5% to 100% with maximum noise level of 88dBA.

The PVS980-58-2000kVA inverter has peak efficiency of 98.8% and a European efficiency of 98.6%.<sup>9</sup>

The main technical characteristics of these inverters are illustrated in Table 3-13.

**Table 3-13: ABB inverter specifications**

<b>ABB Central Inverter Specifications</b>	
Inverter	ABB PVS980-58-2000kVA
Type	Central Inverter
<b>Input Data</b>	
Maximum Input Power (kW <sub>p</sub> )	2909kW <sub>p</sub>
PV voltage range, MPP (V)	850 to 1500V @35°C 850 to 1100V @50°C
Maximum DC voltage (V)	1500V
Maximum input current (A)	2400A
<b>Output Data</b>	
Nominal AC power at 50°C (kVA)	2000kVA
Maximum AC current (A)	1925A
Nominal AC voltage(V)	600V
AC grid frequency (Hz)	50/60Hz
Maximum THD	< 3%
<b>Operating Performance</b>	
Maximum efficiency (%)	98.80%
Euro efficiency (%)	98.60%
<b>Power consumption</b>	
Own consumption in operation(W)	2500W
Standby operation consumption (W)	235W
<b>Other</b>	
Dimensions (W × H × D) (mm)	3180mm x 2443mm x 1522mm

<sup>9</sup> [https://www.fimer.com/sites/default/files/FIMER\\_PVS980-58-from1818to2091\\_EN\\_RevA\\_.pdf](https://www.fimer.com/sites/default/files/FIMER_PVS980-58-from1818to2091_EN_RevA_.pdf)



ABB Central Inverter Specifications	
Weight (kg)	3500kg
Environmental Protection Rating	IP66
Operating temperature range (°C)	-20 to+50°C
Relative humidity (%)	5% to 100%

The following protection devices are included within the inverter design:

- Ground fault monitoring
- Grid Monitoring
- Anti-islanding protection
- DC reverse-polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection
- Remote monitoring solutions

ABB inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components. Further, technical parameters include an operational altitude of up to 4,000m.

### 3.2.4 Certification

ABB is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. ABB inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information available in public domain, SgurrEnergy has summarized the certification of the ABB inverter within Table 3-14.

**Table 3-14: Description of Certification of ABB inverters**

Certification	Description
IEC 60068-2-6/29	Environmental testing of inverters to assess their ability to perform and survive under conditions such as transportation, storage, operational environments, extreme cold and heat
EN 61000-6-2(2005) / EN 61000-6-4(2007)	Electromagnetic compatibility (EMC) – Immunity for industrial environments
IEC 62109-2:2011	Safety of Power Converters
IEC 62920:2017	Electromagnetic compatibility (EMC) requirements for DC to AC power conversion equipment

### 3.2.5 Warranties

SgurrEnergy was not provided with a sample of inverter warranty document. Given the industry standard warranty of 60 months, SgurrEnergy does not raise any concern over the use of inverter for the project.



### 3.3 Transformers – Shilchar Technologies Limited

The power at low voltage from inverters is stepped up to 33kV using 4000kVA transformers of Shilchar Technologies Limited make.

#### 3.3.1 Company Profile

The inverter transformer used for the project are manufactured by Shilchar Technologies Limited.

Established in 1990 and headquartered in Gujrat, India, Shilchar is one of the prominent manufacturers of Power & Distribution transformers. As of April 2020, the Company has commissioned the manufacturing facility capable of manufacturing up to 50MVA, 132KV class transformer and up to 4000MVA transformers annually.

Shilchar Technologies is an ISO 90001:2015, ISO 14001:2015 and ISO 45001:2018 certified company providing services to wide range of industries across the world including utility sector to renewable energy. The Company has a dedicated marketing team to cater services required in 20 different countries in the world. Since 2011, 40% of the revenue generated by Shilchar is through export.

The Company manufactures and has type tested various 3-winding, 4-winding, and 5-winding transformer with copper and aluminium conductor. The highest rating type tested by Shilchar is 12.5MVA, 5 winding Inverter Duty Transformer (IDT). The Company has supplied nearly 4GWs of transformers for solar application throughout the world including in Philippines, Egypt, Kenya and Chile.

#### 3.3.2 Technical Specifications

The 4000kVA Power transformers used in the project are outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 3-15.

**Table 3-15: Technical Specification of Shilchar Transformer**

Technical Parameters	Description
Rated Power	4000kVA
Rated HV	33kV
Rated LV	660-660V
Tapping on HV	-5% to +5% (steps of 2.5%)
Phases	3
Frequency	50Hz
Vector group	Dy11y11
Impedance	7.15% (As per IS)
Cooling Strategy	ONAN
Oil temperature rise	50°C
Winding temperature rise	55°C
Winding material	Copper



SgurrEnergy considers the overall the technical specification to be adequate for the PV projects and in line with the industry accepted standards.

### 3.3.3 Temperature Rise Detection and Protection

Inverter transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.4 Warranties and Guaranties

Based on the information available in public domain, SgurrEnergy understands the Shilchar transformers have been provided with a warranty of 60 months from date of dispatch. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards.

## 3.4 Conclusion on Major Plant Components

### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of JA Solar, Canadian Solar and Astronergy assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.

Further, according to the warranty documents available in public domain for all three module manufacturers, SgurrEnergy considers the warranty terms and conditions offered by all three manufacturers to be in-line with the industry standard and raises no major concern regarding the warranties offered. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.

### Inverters

SgurrEnergy has conducted review of the ABB PVS980-58-2000kVA central inverter ABB PVS980-58-2000kVA central inverter has the required certification for use in solar PV plants. In-house testing of the inverter and individual components is relatively extensive during the R&D phase with functional and temperature cycling testing of each manufactured inverter. ABB offers a product warrant of 5 years which is in line with the current industry standards.

In conclusion, ABB can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters. ABB inverters have more than 3GW of installation worldwide. These inverters are quite known to the Indian market and have installed capacity of more than 1.3GW which demonstrates a good track record in the Indian solar PV market.

### Transformers

The inverter transformers (4000kVA) used within the project are manufactured by Shilchar Technologies Limited. The manufacturer has a good track record of supplying 4GWs of transformers for solar application throughout the world including in Philippines, Egypt, Kenya, and Chile. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical



characteristics in line with industry standards and raises no concerns over its use in the project.

### 3.5 Module support structures

The Array Layout provided by the Client indicates the fixed tilt module mounting structure is inclined at 16° tilt angle. Based on the information provided in the GA drawing of the MMS, the technical specification has been summarized below.

Table below summarizes the technical specification of the module mounting structure.

**Table 3-16: Specification of MMS**

MMS Part	Material	Grades - Standard	Thickness (mm)	Minimum Yield Stress (MPa)
Rafter	Cold Formed	340- ASTM A 653/A 653-00	1.6	340
Purlin	Cold Formed	550 - ASTM A 792/A 792M – 09	0.9	550
Leg	Cold Formed	E350- IS 2062:2011 or equivalent	3.0	350
Bracing	Cold Formed	E350- IS 2062:2011 or equivalent	2.5	350

Material used is a combination of hot-dipped galvanised mild steel and pre-galvanised cold rolled sheets sheared to form structural members for module mounting. The pre-galvanised sheets post process is appropriately coated with anti-corrosion compounds for the project life cycle.

SgurrEnergy was not provided with the information regarding type of pile used in the project. Further based on the information provided under GA drawing of the MMS, SgurrEnergy understands that the Owner has considered the wind speed of 39m/s according to IS 875 (part 3) - 1987

The structure designed has two rows of modules placed in portrait orientation with 31 modules in each row. In total there shall be 62 modules in one mounting structure. The layout is designed with a pitch <sup>10</sup>(distance between the fronts of one row to the front of the next row) of 6m.

<sup>10</sup> Pitch: Distance between the fronts of one row to the front of the next row





## 4 System Design Appraisal

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

### 4.1 Plant Layout Design

SgurrEnergy was provided with as built plant layout and electrical schematics. SgurrEnergy has verified the plant configuration with electrical schematics provided by the Client. The 30MW<sub>AC</sub> PV plant is designed with JA Solar (325W<sub>p</sub>), and Canadian Solar (330W<sub>p</sub>) PV modules. Similarly, the 50MW<sub>AC</sub> PV plant is designed with Astroenergy (320W<sub>p</sub>), and Canadian Solar (320W<sub>p</sub> / 25W<sub>p</sub> / 330W<sub>p</sub>) PV modules. The total DC installed capacity stands at 104.02MW<sub>p</sub> (64.63+39.39). The AC installed capacity stands at 80MW<sub>AC</sub> (50+30) with 40 inverters of capacity 2,000kW each. Overall 80MW<sub>AC</sub> (50+30) PV plant is designed into two separate plots as illustrated below in the Figure 4-1 and Figure 4-2.

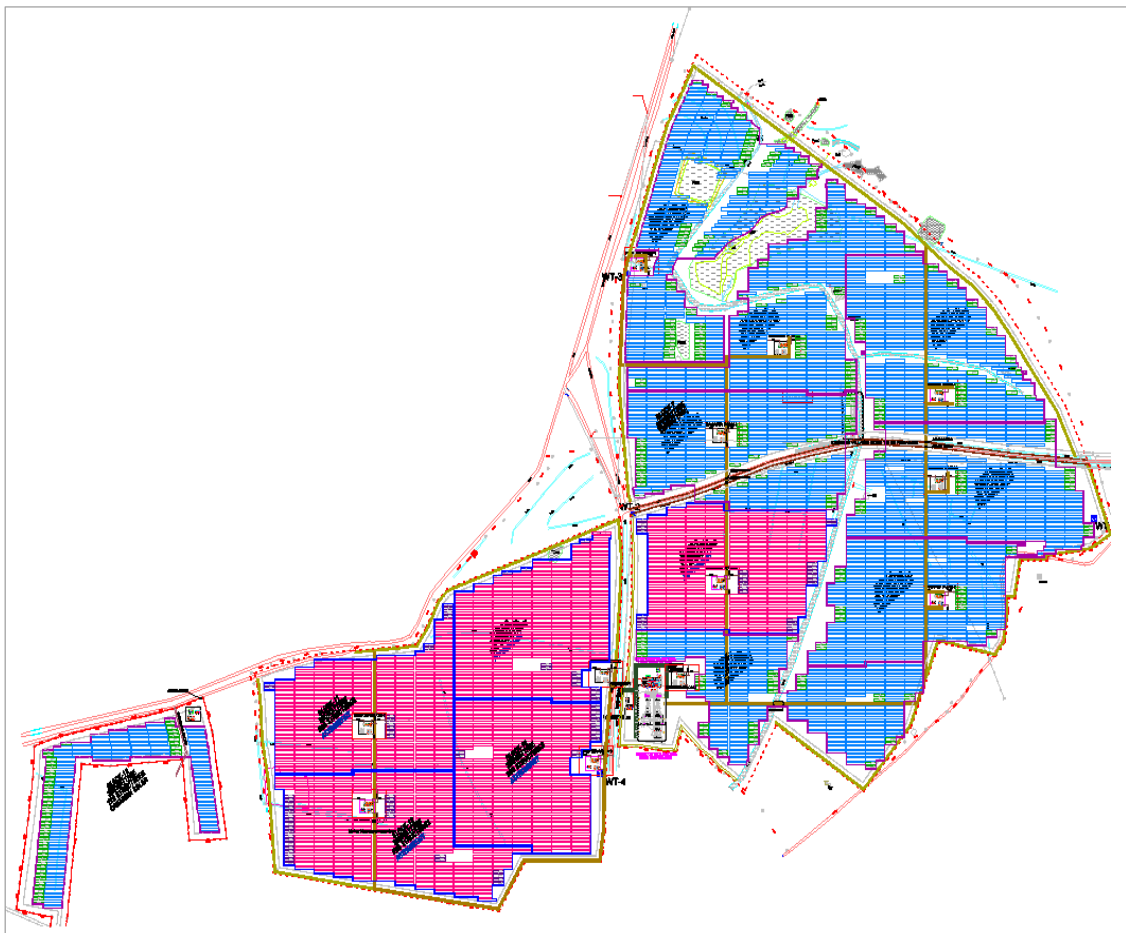
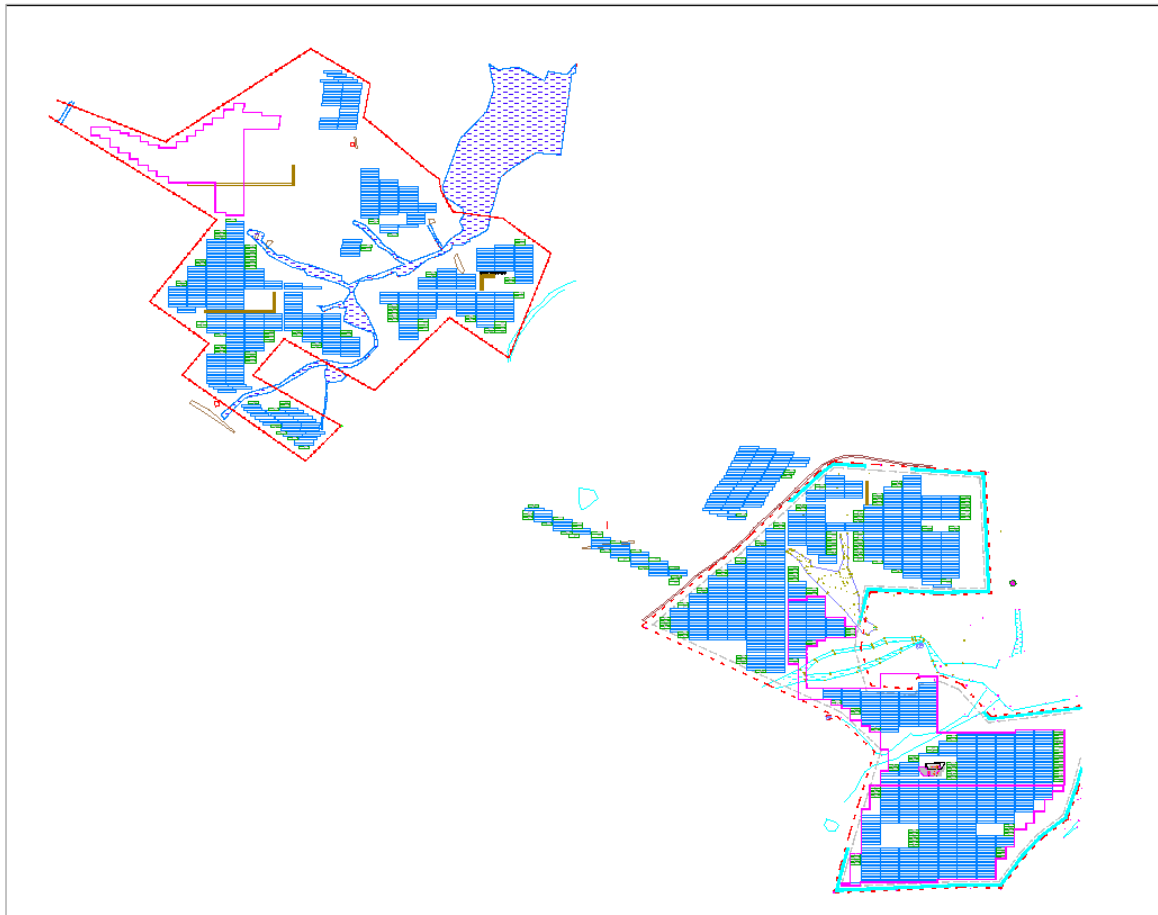


Figure 4-1: Plant layout of 50WM<sub>AC</sub>

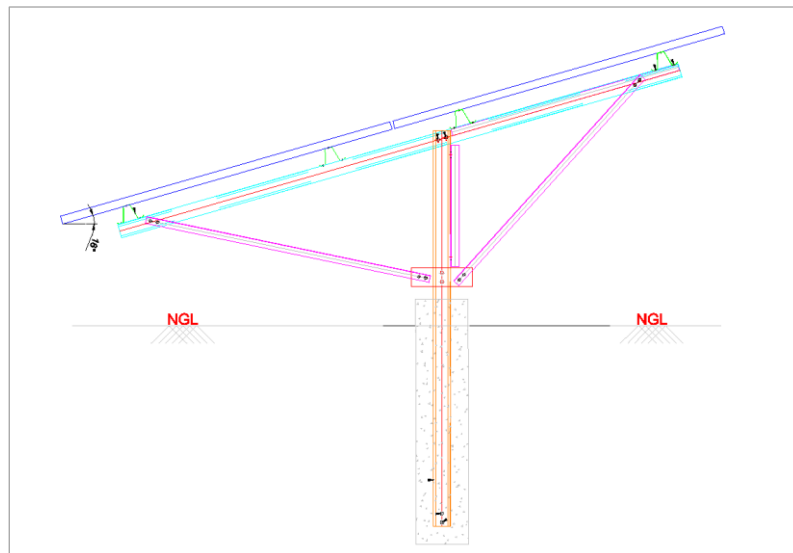






**Figure 4-2: Plant layout of 30MW<sub>AC</sub>**

All the PV modules are orientated towards South. The mounting structure provides support for two rows of panels in portrait orientation.



**Figure 4-3: Side view of typical module mounting structure configuration**

The selected tilt for the 50MW<sub>AC</sub> and 30MW<sub>AC</sub> plant is 16°. The 50MW<sub>AC</sub> plant is designed with a pitch of 6m and 30MW<sub>AC</sub> plant is designed with a pitch of 5m.

Based on regional experience of detail designing, SgurrEnergy considers the selected tilt angle and pitch is optimized for maximum irradiation on the collector plane, minimum loss due to inter row shading, minimum ohmic losses and ease of maintenance.



31 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.30. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.

## 4.2 String Sizing

The plant layout provided by the Client indicate thirty one 325W<sub>p</sub>, 330W<sub>p</sub> JA Solar Mono PERC, Thirty One 320W<sub>p</sub>, 325W<sub>p</sub>, 330W<sub>p</sub> Canadian Solar Mono PERC and thirty one 325W<sub>p</sub> polycrystalline Astroenergy PV modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage (V<sub>OC</sub>) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum V<sub>OC</sub> of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy in validating string configuration. Subsequent to calculating open circuit voltage (V<sub>OC</sub> max), maximum power voltage (V<sub>mp</sub> min) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 45°C and 10°C respectively for system design validation to be fair and representative for the PV plants' site.

The results of string sizing validation are presented in Table 4-1. Results indicate that V<sub>OC</sub> max at the minimum ambient temperature is within the maximum system voltage of 1,500V for the selected ABB 2,000kW inverters.

**Table 4-1: String Sizing for JA, Canadian Solar and Astroenergy PV Modules**

Parameters	JA 325W <sub>p</sub>	JA 330W <sub>p</sub>	Canadian Solar 320W <sub>p</sub>	Canadian Solar 325W <sub>p</sub>	Canadian Solar 330W <sub>p</sub>	Astroenergy 325W <sub>p</sub>
PV module power (W <sub>p</sub> )	325	330	320	325	330	325
Modules per string	31					
Inverters	ABB (PVS 980-58-2000KVA)					
Maximum Open-circuit voltage (V <sub>OC</sub> max) at minimum ambient temperature of 10°C	1311.3V	1320.6V	1302V	1308.2V	1314.4V	1481.8V
Minimum power voltage (V <sub>mp</sub> min) at maximum ambient temperature of 45°C	961V	967.2V	951.7V	957.9V	985.8V	1050.9V

## 4.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with JA Solar, Canadian Solar and Astroenergy module and ABB inverter are



presented in Table 4-2, Table 4-3 and Table 4-4 SgurrEnergy has selected the highest rated JA Solar module (330W<sub>p</sub>) their compatibility with ABB inverters, as SgurrEnergy considers this to be representative for all the JA Solar PV modules installed on site. Canadian Solar 325W<sub>p</sub> modules have been selected to check compatibility with inverters as it has the maximum strings for each inverter among the Canadian solar 320W<sub>p</sub>, 325W<sub>p</sub> and 330W<sub>p</sub> modules.

**Table 4-2: Inverter Compatibility with JA Solar 330W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>JA Solar 330W<sub>p</sub></b>	
Modules per string	31	Acceptable
Strings per inverter	256	Acceptable
Maximum power, P <sub>mpp</sub> at STC (kWp)	2,618.8	Nominal power ratio is 1.30, this is within the inverter bus current carrying capacity.
Maximum power voltage, V <sub>mpp</sub> at STC (V)	1,051.9	Acceptable.
Maximum power current, I <sub>mpp</sub> at STC (A)	2,493.4	Acceptable
Open-circuit voltage, V <sub>oc</sub> at STC (V)	1266.8	Acceptable.
Minimum MPP voltage at 45°C ambient temperature (V)	967.2	Acceptable: Inverter MPPT ranges 935 - 1500V.
Maximum MPP voltage at 10°C ambient temperature (V)	1,100.5	Acceptable: Inverter MPPT ranges 935 - 1500V.
Maximum open circuit voltage, V <sub>oc</sub> at 10°C (V)	1320.6	Acceptable: Maximum inverter voltage 1500V.

**Table 4-3: Inverter Compatibility with Canadian Solar 325W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>Canadian Solar 325W<sub>p</sub></b>	
Modules per string	31	Acceptable
Strings per inverter	258	Acceptable
Maximum power, P <sub>mpp</sub> at STC (kWp)	2,800.8	Nominal power ratio is 1.40, this is within the inverter bus current carrying capacity.
Maximum power voltage, V <sub>mpp</sub> at STC (V)	1038.500	Acceptable.
Maximum power current, I <sub>mpp</sub> at STC (A)	2505.1	Acceptable
Open-circuit voltage, V <sub>oc</sub> at STC (V)	1249.3	Acceptable.
Minimum MPP voltage at 45°C ambient temperature (V)	957.9	Acceptable: Inverter MPPT ranges 935 - 1500V.



Parameters	Inverter Compatibility	
Maximum MPP voltage at 10°C ambient temperature (V)	1097.4	Acceptable: Inverter MPPT ranges 935 - 1500V.
Maximum open circuit voltage, $V_{oc}$ at 10°C (V)	1308.2V	Acceptable: Maximum inverter voltage 1500V.

**Table 4-4: Inverter Compatibility with Astroenergy 325W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>Astroenergy 325W<sub>p</sub></b>	
Modules per string	31	Acceptable
Strings per inverter	258	Acceptable
Maximum power, $P_{mpp}$ at STC (kWp)	2,599.4	Nominal power ratio is 1.29, this is within the inverter bus current carrying capacity.
Maximum power voltage, $V_{mpp}$ at STC (V)	1,150.4	Acceptable.
Maximum power current, $I_{mpp}$ at STC (A)	2,262.6	Acceptable
Open-circuit voltage, $V_{oc}$ at STC (V)	1415.7	Acceptable.
Minimum MPP voltage at 45°C ambient temperature (V)	1050.9	Acceptable: Inverter MPPT ranges 935 - 1500V.
Maximum MPP voltage at 10°C ambient temperature (V)	1212.1	Acceptable: Inverter MPPT ranges 935 - 1500V.
Maximum open circuit voltage, $V_{oc}$ at 10°C (V)	1481.8V	Acceptable: Maximum inverter voltage 1500V.

Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.



## 5 Allied Components and Systems

### 5.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

#### 5.1.1 Inverter Station

TBC

#### 5.1.2 Main Control Room

TBC

### 5.2 PV Power Transfer

SgurrEnergy has reviewed the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear and plant substation as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

- *Single line diagram of 132/33kV switchyard*, revision 1 – for approval, dated 06.06.17.
- *“30MW AC SLD”*, revision 1, dated 22.06.17.
- *“50MW AC SLD”*, revision 0, dated 22.06.17
- *“30MW DC single line diagram”*, revision 3 As Built dated 25.06.2018.
- *“50MW DC single line diagram”*, revision 3 As Built dated 25.06.2018.
- *“30MW PV array layout”*, revision 4, As Built dated 21.06.18.
- *“50MW PV array layout”*, revision 4, As Built dated 12.06.18.

#### **30MW<sub>AC</sub> solar PV Plant: -**

The 30MW<sub>AC</sub> solar PV Plant is designed with 325Wp JA solar and 330Wp Canadian PV modules and 2000kW ABB inverters. Modules are interconnected to form a string of 31 modules. Each string forms a single output that feeds as a single input to the 24 input combiner boxes. Twelve string combiner boxes are further connected to the inverter.

Plant is configured with a total of 15 ABB make central inverters of 2000kW capacity each thereby taking the total AC installed capacity to 30 MW<sub>AC</sub>. The Project has seven inverter station comprising of 2 inverters each. Further one inverter is located in the Main control room (MCR).

#### **50MW<sub>AC</sub> solar PV Plant: -**

The 50MW<sub>AC</sub> solar PV plant is designed with 325/ 320Wp Astroenergy and 325/330Wp Canadian PV modules and 2000kW ABB inverters. Modules are interconnected to form a string of 31 modules. Each string forms a single output that feeds as a single input to the 24 input combiner boxes. Eleven string combiner boxes are further connected to the inverter.

The plant is configured with 25 ABB 2000kW central inverter thereby taking the total AC installed capacity to 50MW<sub>AC</sub>. The Project has been implemented with twelve inverter station comprising of 2 inverters each. Further one inverter is placed in the MCR.

Subsequent to the review of DC and 33kV AC SLD, SgurrEnergy observed that the electrical schematic of both the PV plants under review is identical.



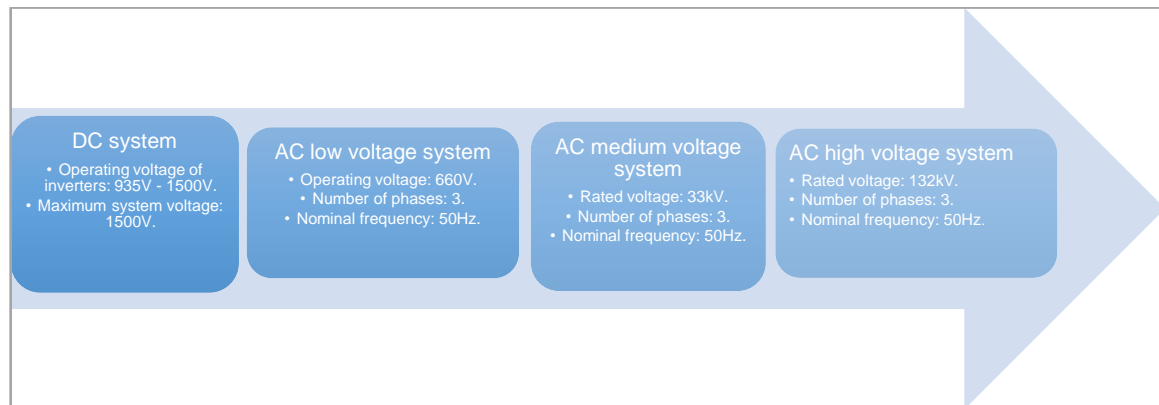
Each inverter station of 4MW<sub>AC</sub> capacity consists of two 2000kW inverters; which are further connected to 0.660/0.660/33kV three winding, 4MVA transformer for stepping up the voltage to 33kV. Further one inverter is placed in MCR which is further connected to 0.660/33kV two winding, 2MVA transformer for stepping up the voltage to 33kV.

Each of the two solar PV plant sections have independent main control rooms. The main control room of the 30MW<sub>AC</sub> solar PV plant combines the 33kV output of the inverter station located within 30MW<sub>AC</sub> solar PV plant. Further the combined power is further transferred to the 33kV main switchboard located within the 50MW<sub>AC</sub> solar PV plant, through two feeders of AC capacity of 16MW and 14MW.

In addition to the two feeders originating from the 30MW<sub>AC</sub> solar PV plant, the main control room of the 50MW<sub>AC</sub> solar PV, also combines the 33kV output of the inverter station located within 50MW<sub>AC</sub> solar PV plant. The combined energy at 33kV is further stepped up to 132kV within the 132/33kV substation through two 50/55MVA ONAN/ONAF two winding power transformers.

The combined power is transferred to Pangari substation located approximately 11kms from the Project site through ACSR panther single circuit transmission line from solar PV plant. The point of interconnection will be at the Pangari substation.

Figure below illustrates a power flow summary for the 80MW<sub>AC</sub> Solar PV plant.



**Figure 5-1: Power flow of 80MW<sub>AC</sub> PV plant**

### 5.3 Cabling

#### 5.3.1 DC Cabling

DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. Modules are interconnected in series with solar grade cables that are tied along with the module mounting structures. Modules are interconnected in leap frog scheme to form a string of 31 modules using these leads. Each string forms a single input to the string combiner box. 4mm<sup>2</sup> multi-stranded copper PV cables have been used to connect each string to the string combiner box. These combiner boxes are equipped with 15A fuse for each of the string connection and a 400A disconnect switch on output side. Power from string combiner box is further transferred to the inverter using 2 runs, 1C, 300mm<sup>2</sup>, 1.5kV aluminium XLPE ((2R X 1C X 300Sqmm, 1.5kV AL. XLPE Armoured) cables.

#### 5.3.2 AC Cabling

AC output from each inverter is connected using 15 Runs single core 300mm<sup>2</sup> Aluminium Armoured XLPE PVC cable (15R (5R/PH) X1C x 300mm<sup>2</sup> Al. Ar. XLPE, PVC Cable) to the LV side of the inverter transformer. Further 1R,3C, 185mm<sup>2</sup> 33kV Al XLPE armoured cables are utilised to connect inverter transformer and the 33kV circuit breaker in outdoor type 33kV HT panel located in inverter station.





In case of 30MW<sub>AC</sub> solar PV plant, cabling between transformer, 33kV main HT panel and 33kV main MV switchboard has been done with single Run 3 core, 185mm<sup>2</sup>, 33kV XLPE insulated aluminium cable.

The 30MW<sub>AC</sub> solar PV plant is consist of two 33kV Double Pole (DP) structure located near MCR, the AC capacity of one DP structure is 16MW<sub>AC</sub> and other is 14MW<sub>AC</sub>, the cumulative power of both the DP structure is 30MW<sub>AC</sub>.

The power from 33kV MV switchboard is to transmitted to 33kV DP structures through two Runs, 3 Core, 185mm<sup>2</sup>, 33kV Aluminium XLPE PV Armoured (2RX3CX185mm<sup>2</sup>, 33kV Al. XLPE, PVC, Ar) cable. Subsequently power from both the DP structure is evacuated to Main HT panel located at 50MW<sub>AC</sub> solar PV plant through 33kV ASCR conductor overhead line.

The power of 50MW<sub>AC</sub> and 30MW<sub>AC</sub> solar PV plant from the Main HT panel located at 50MW<sub>AC</sub> solar PV plant is transferred to 33/132kV, 50/55MVA power transformer through 12 Runs single core, 300mm<sup>2</sup>, 33kV Aluminium XLPE PVC Armoured (12R {4R/PH} x 1C x 300sqmm 33kV[E], Al, XLPE, PVC, Ar.) cable.

Further the combined power of both the solar PV plant is feed to the 132kV Pangri substation through 132kV Transmission line.

#### 5.4 Inverter Station

ABB make 2000kW indoor type central inverters have been used in PV plant under evaluation. The 50MW<sub>AC</sub> solar PV plant consist of 12 inverter station with one inverter in main control room (MCR) whereas in 30MW<sub>AC</sub> solar PV plant consist of 7 inverter station with one inverter located in the MCR.

A typical inverter station comprises of two 2000kW central inverter and one 0.660/0.660/33kV, 4MVA, 3 winding inverter duty transformer with allied switchgears. The plant has two type of panel further the blocks are connected as ring mail unit (RMU).

The odd number of inverter blocks consist of 2in 1 out MV Panel whereas even number of blocks consist of ICOG panel. 33kV outdoor type HT panel comprises of 100/1-1A current transformer, 33kV/110V fixed type line potential transformer, 33kV EDO TP, 630A Vacuum Circuit Breaker and other electrical protection system. The power from inverter duty transformer is transferred to aforesaid MV panel.

#### 5.5 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed two type of inverter duty transformer has been used in the project. The inverter station comprises of 4MVA, 33kV/2x0.66kV, Dy11y11, three winding transformer while single inverter placed in the MCR is connected to 33kV/660V, Dy11 two winding transformer. These inverter duty transformers step up the voltage to 33kV.

The inverter duty transformers output is connected to 33kV HT panels located within inverter station. The energy from all the inverter stations ICOG/RMU panels are radially combined at 11/33kV main switchboard located in main control room.

#### 5.6 33kV Main Switchboard

Each 50MW<sub>AC</sub> and 30MW<sub>AC</sub> solar PV plant comprise of 33kV main switchboard, which comprises of inverter station incoming feeders, auxiliary transformer feeders, bus coupler feeder, two outgoing feeders and one spare feeder. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class. All feeders have been provided with relay and metering unit. The 33kV main switch board outgoing and incoming feeders are provided with instantaneous and IDMT (50/51) O/C relay instantaneous and IDMT (50N/51N) E/F relay protections. The 33kV outgoing feeders are provided with 0.2S class instrument transformers.



Further in 30MW<sub>AC</sub> solar PV plant the power from 33kV MV switchboard is to be transmitted to 33kV Main Switchboard located in the premises of 50MW<sub>AC</sub> solar PV plant through two 33kV ACSR conductor overhead line.

Further the combined power of both the solar PV plant is fed to the 132kV Pangri substation through 132kV Transmission line.

Tariff metering yard has been provided with instrument transformers of 0.2S class, main and check ABT meters at government substation end.

### 5.7 132/33kV Switchyard

The 50MW<sub>AC</sub> solar PV plant comprises of 33kV main switchboard, which comprises of inverter station incoming feeders, auxiliary transformer feeders, bus coupler feeder, two outgoing feeders and one spare feeder. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class. All feeders have been provided with relay and metering unit. The 33kV main switch board outgoing feeders are provided with instantaneous and IDMT (50/51) O/C relay instantaneous, IDMT (50N/51N) E/F relay protections, (63X) transformer fault Auxiliary relay, (64R HV/ LV) HV and LV side of restricted earth fault relay, sensitive earth fault relay (51G), directional over current relay (67), directional earth fault relay (67N), transformer differential relay(67N), transformer differential relay(87T) and other supporting relays.

The 33kV switchboard panel outgoing feeders are connected to respective 50/55MVA, ONAN/ONAF, YNyn0, 132/33kV, power transformers located in 132/33kV plant end switchyard.

The 132/33kV switchyard is observed to be equipped with SF<sub>6</sub> circuit breaker, instrument transformers with metering & protection cores. The 132kV outgoing cable is protected with cable differential protection, which is considered to be standard engineering practice.

Further, each transformer line feeders are equipped with 0.2S instrument transformers with ABT main and check meters for measurement purpose, and isolators at incoming line for maintenance. The 120kV, 10kA surge arrester is provided at 132kV incoming feeders to discharge surge currents caused by lightning strokes and switching operation of equipment's.

Subsequently energy from 132/33kV plant end switchyard single feeder is evacuated to 132kV, Pangri substation at 132kV level through overhead cable.

### 5.8 Auxiliary Power Supply

SgurrEnergy had reviewed the electrical schematics shared for the projects to evaluate auxiliary system. The inverter stations of all blocks are equipped with 20kVA auxiliary transformers. Further two 100kVA transformers are provided in the 33kV main switchboard located in 50MW<sub>AC</sub> solar PV plant.

### 5.9 Bus-Bar Schemes

The bus bar scheme consisted of 132kV, 1250A, TP, 31.5kA per 1 second twin ACSR Zebra conductor. The single bus bar scheme has been considered as cost effective for evacuation at 132kV.

### 5.10 Power transformer

The 132/33kV AIS switchyard located within the premises of 50MW<sub>AC</sub> solar PV plant comprises of two 50/55MVA, 132/33kV, YNyn0 two winding transformer. These power transformers step up the voltage to 132kV.

The power transformer output is connected to 132kV, 1250A, TP, 31.5kA/1sec, Twin ACSR Zebra conductor busbar. Further the combined power of both the feeders will further evacuate to the 132kV Pangri substation.





### 5.11 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are normally mounted on individual structures.

Following the review of 132kV SLD, SgurrEnergy observed 145kV, 1250A, 31.5A/3sec SF6 motorized circuit breaker has been used in the project.

### 5.12 Isolators

Isolators are used to transfer load from one bus to another and also to isolate equipment for maintenance.

Based on the review of 132kV SLD, SgurrEnergy observed manual type 132kV, 1250A, 31.5kA/3sec isolator with and without earth switch has been used in the project.

### 5.13 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.

The current transformers with accuracy class of 0.2s for metering and class 5P and PS for protection has been used in 80MW<sub>AC</sub> solar PV plant. The potential transformers with accuracy class of 0.2 for metering and class 3P for protection has been used in the project.

### 5.14 Surge Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes on the lines entering the substation. The apparatus most commonly used for this purpose is the surge arrester. Transformer is the most costly equipment in substation and it is normal practice to install surge arrester near to the transformer. Additional surge arresters shall be provided either on bus or on various lines for protection of the equipment.

Following the review, SgurrEnergy observed 120kV, 10kA, CL-03 gapless Metal Oxide Surge arrestor has been used in the switchyard.

### 5.15 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy will be provided at the medium voltage switchboards for each of the feeder sections. These meters will be digital with an RS 485 port for remote monitoring. These usually have an accuracy class of 0.5

Similarly, HV side shall also be equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point shall be 0.2S.



## 6 Solar Resource assessment

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SgurrEnergy has sourced monthly horizontal plane irradiation data for the Project site from:

- **NASA's Surface Meteorology and Solar Energy data set**; holds satellite derived monthly data for a grid of 0.5° × 0.5° covering the globe for a thirty-four-year period



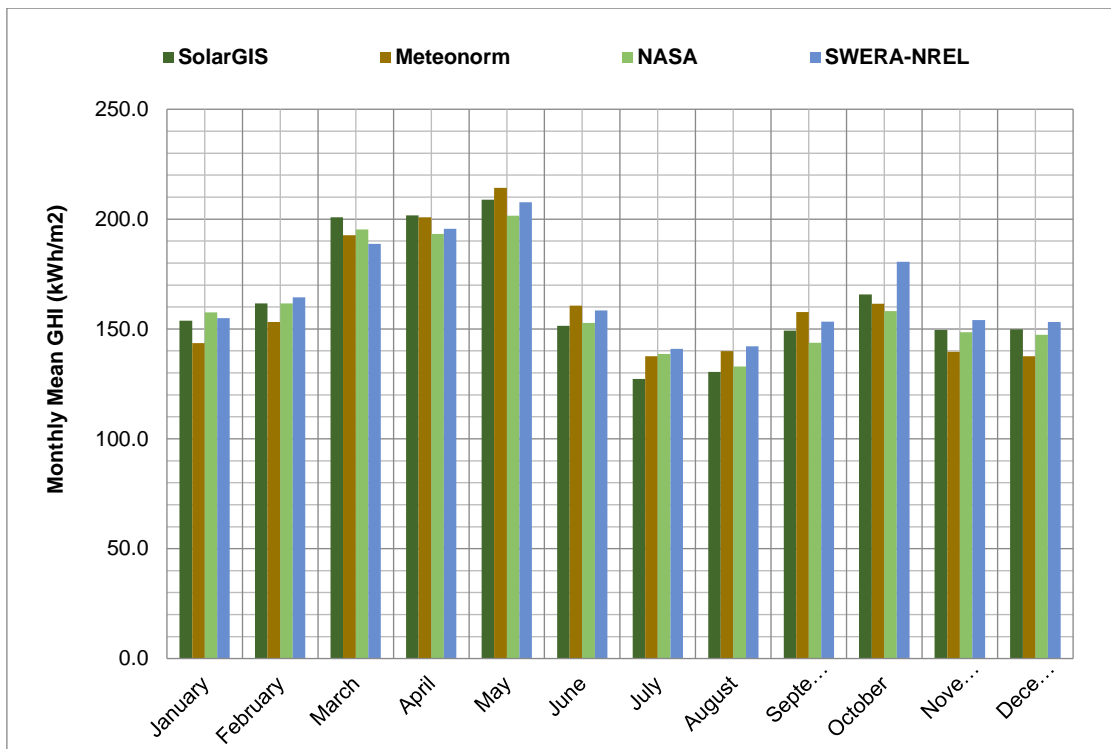
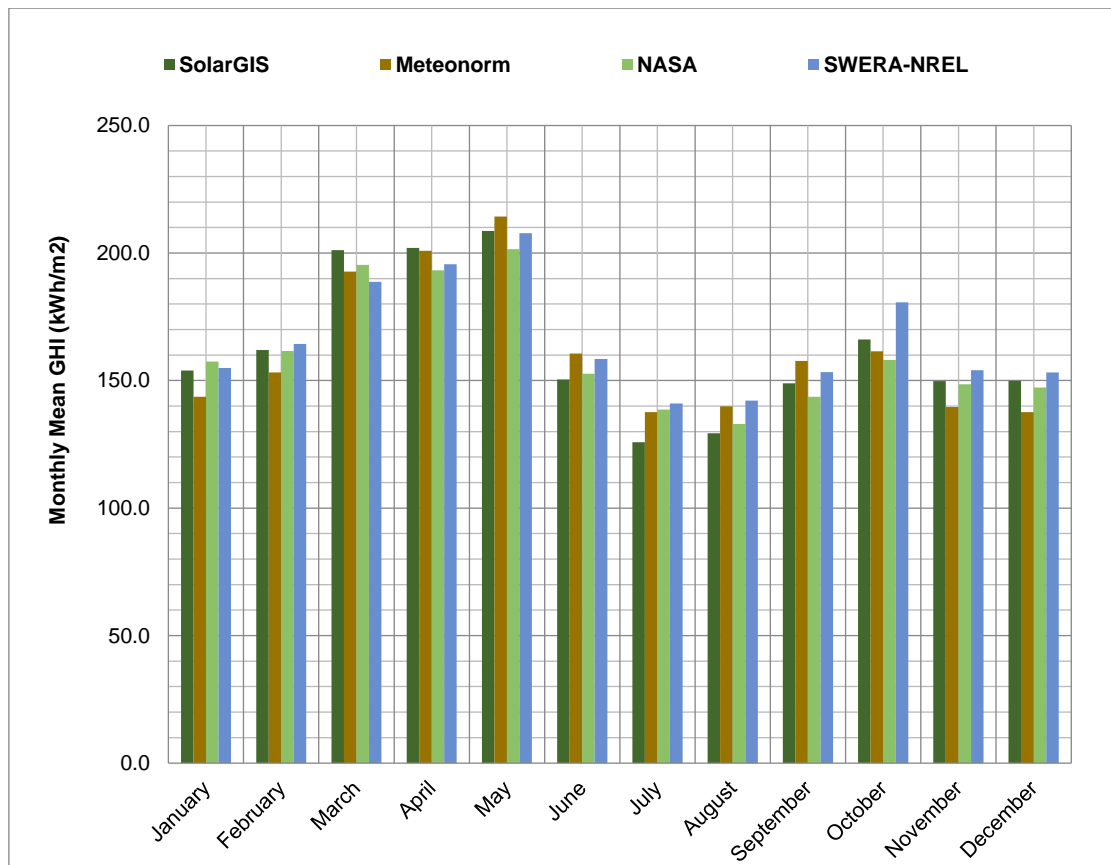
(1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.

- **The *METEONORM (version 7.3)* global climatological database and synthetic weather generator**; contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **SolarGIS**: SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km x 4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by IEA (*International Energy Agency*) *SHC Collaboration Agreement*, and EU FP6 project *MESoR* in terms of bias and RMSE.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.

## 6.1 Solar Resource Assessment

SgurrEnergy has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS and, NREL (SWERA) data for the site. The comparison is graphically illustrated in Figure 6-1 and Figure 6-2 below.



**Figure 6-1: Monthly Global Horizontal Irradiation for 30MW<sub>AC</sub> site****Figure 6-2: Monthly Global Horizontal Irradiation for 50MW<sub>AC</sub> site**

**Table6-1: Comparison of Solar Irradiation Datasets for the 30MW<sub>AC</sub> site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	1,950.1
Meteonorm 7.3	14km × 14km	4.0%	1,939.2
NASA	55km × 55km	Unknown	1,931.0
NREL (SWERA)	40km × 40km	Unknown	1,993.9

**Table6-2: Comparison of Solar Irradiation Datasets for the 50MW<sub>AC</sub> site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	1,948.1
Meteonorm 7.3	14km × 14km	4.0%	1,939.2
NASA	55km × 55km	Unknown	1,931.0
NREL (SWERA)	40km × 40km	Unknown	1,993.9

The comparison of solar data for the 30MW<sub>AC</sub> and 50MW<sub>AC</sub> Project site location illustrated in Table6-1 and Table6-2 indicates NREL (SWERA) dataset to give the highest irradiation levels. The next highest irradiation is given by SolarGIS followed by Meteonorm 7.3 and NASA.

The irradiation values given by Meteonorm 7.3 typically provide a combination of ground and satellite measured data. Meteonorm 7.3 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as 4% for the proposed site.

The NREL (SWERA) data illustrated has been obtained for a location approximately 5.23 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data.

The NASA-SSE data source provides purely satellite measured data for a grid covering 0.5° × 0.5° on the earth's surface and generally more suited for initial site selection.

The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also been compared with other data sources globally. The IEA (International Energy Agency) validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>11</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)

<sup>11</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>



– Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 6%.

SgurrEnergy is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 6.1.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 6-3, Table 6-4 and shown graphically in Figure 6-3 and Figure 6-4. Diffuse irradiation accounts for 48.48% and 48.53% of the total irradiation for the 30MW<sub>AC</sub> and 50MW<sub>AC</sub> sites respectively.

**Table 6-3: SolarGIS Irradiation Data for the 30MW<sub>AC</sub> Project site**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	153.8	61.1	7.9%
February	161.7	63.6	8.3%
March	200.8	82.5	10.3%
April	201.7	89.7	10.3%
May	208.9	96.1	10.7%
June	151.4	91.2	7.8%
July	127.2	92.4	6.5%
August	130.4	90.2	6.7%
September	149.2	84.9	7.7%
October	165.7	75.6	8.5%
November	149.5	60.6	7.7%
December	149.8	57.7	7.7%
<b>Annual Sum</b>	<b>1,950.1</b>	<b>945.5</b>	<b>-</b>

**Table 6-4: SolarGIS Irradiation Data for the 50MW<sub>AC</sub> Project site**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	154.0	61.1	7.9%
February	162.0	63.6	8.3%
March	201.1	82.5	10.3%
April	202.0	90.3	10.4%
May	208.7	96.4	10.7%



Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
June	150.4	90.9	7.7%
July	125.8	91.8	6.5%
August	129.4	89.6	6.6%
September	148.9	84.9	7.6%
October	166.1	75.6	8.5%
November	149.8	60.9	7.7%
December	149.9	58.0	7.7%
<b>Annual Sum</b>	<b>1,948.1</b>	<b>945.5</b>	<b>-</b>

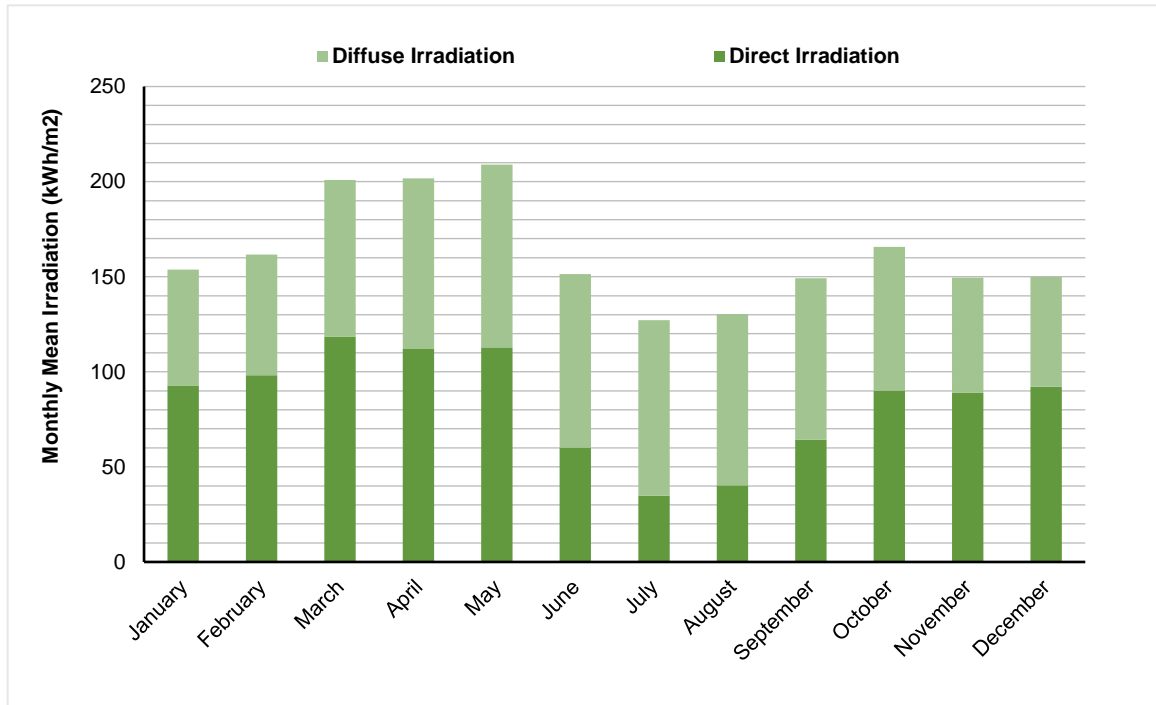
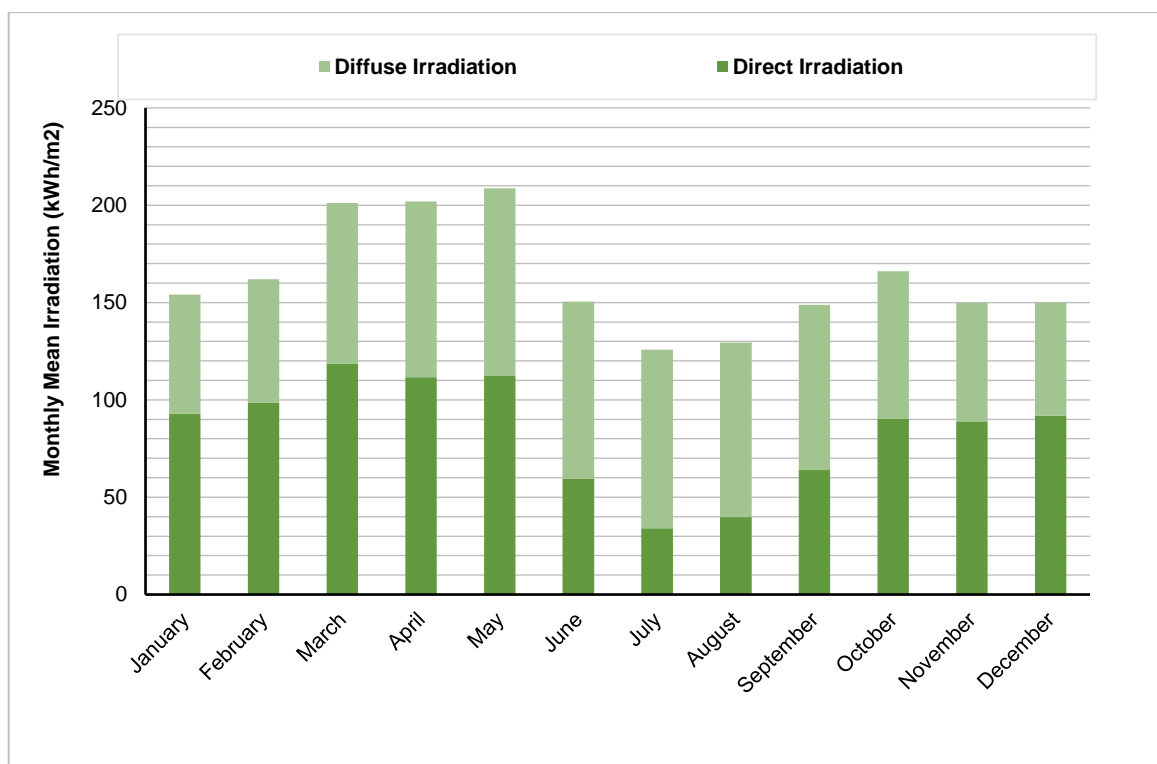


Figure 6-3: Monthly Direct and Diffuse Irradiation on a horizontal plane for the 30MW<sub>AC</sub> site





**Figure 6-4: Monthly Direct and Diffuse Irradiation on a horizontal plane for the 50MW<sub>AC</sub> site**

### 6.1.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.1.1), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -6-5 and Table 6-6 represents the monthly GTI profile for the 30MW<sub>AC</sub> and 50MW<sub>AC</sub> sites respectively.

**Table -6-5: Monthly Global Tilted Irradiation Data for 30MW<sub>AC</sub> site**

Month	GTI (kWh/m <sup>2</sup> )
January	180.9
February	182.7
March	213.4
April	202.5
May	199.7
June	142.5
July	121.1
August	127.7
September	152.7
October	181.3
November	174.3
December	180.6
<b>Annual Sum</b>	<b>2059.4</b>





**Table 6-6: Monthly Global Tilted Irradiation Data for the 50MW<sub>AC</sub> sites**

Month	GTI (kWh/m <sup>2</sup> )
January	181.8
February	183.3
March	213.8
April	202.5
May	199.1
June	141.4
July	119.7
August	126.5
September	152.0
October	181.9
November	175.0
December	181.0
<b>Annual Sum</b>	<b>2057.9</b>

### 6.1.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 6-7 and Table 6-8 below. The average wind speed of 1.3 m/s was measured at 10m height from ground level for the proposed project site location.

**Table 6-7: Simulated Wind Speed for 30MW<sub>AC</sub> site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	0.7
February	0.9
March	1
April	1.2
May	2.2
June	2.3
July	2.1
August	1.9
September	1.1
October	0.6
November	0.6
December	0.5
<b>Yearly Average</b>	<b>1.3</b>

**Table 6-8: Simulated Wind Speed for 50MW<sub>AC</sub> site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	0.7



Month	Average Wind Speed (m/s) – Meteonorm Data
February	0.9
March	1
April	1.2
May	2.2
June	2.3
July	2.1
August	1.9
September	1.1
October	0.6
November	0.6
December	0.5
<b>Yearly Average</b>	<b>1.3</b>

#### 6.1.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.

**Table 6-9: SolarGIS Temperature Data for 30MW<sub>AC</sub> Site (1999 – 2018)**

Months	Average Monthly Temperature (°C)
January	22.2
February	25.0
March	29.1
April	32.7
May	33.8
June	29.8
July	26.4
August	25.0
September	25.3
October	24.4
November	22.4
December	21.0



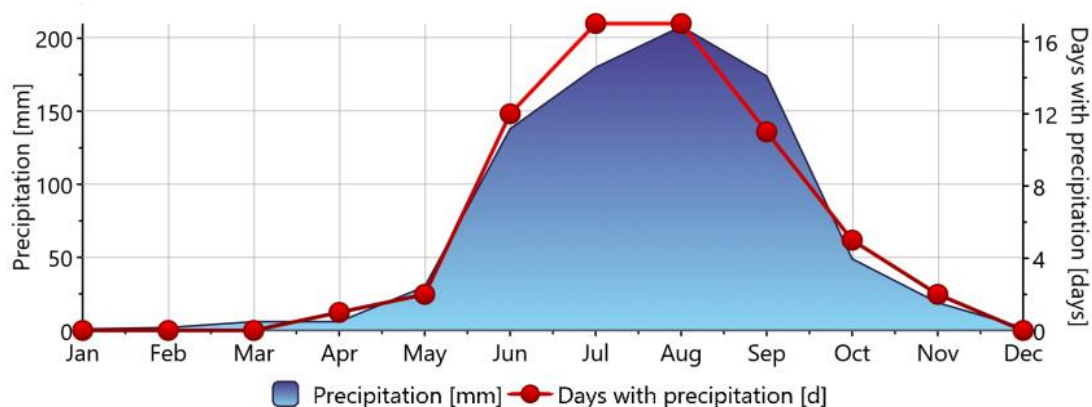
Months	Average Monthly Temperature (°C)
Annual Average	26.4

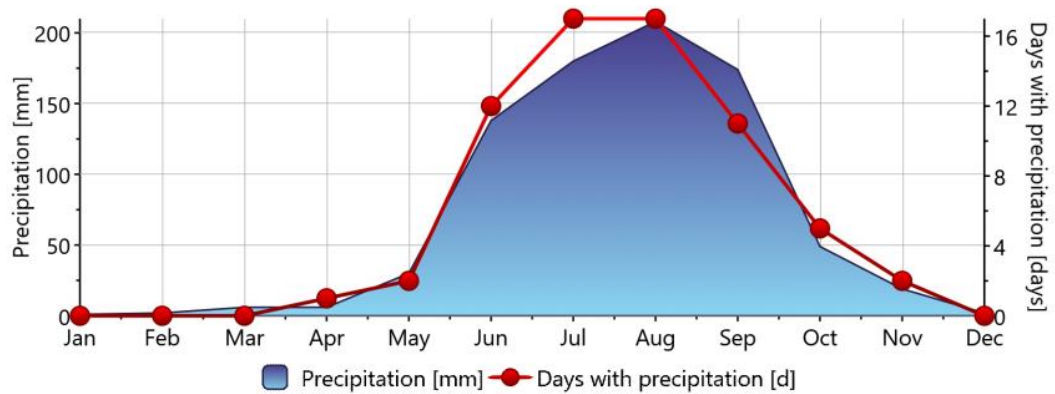
Table 6-10: SolarGIS Temperature Data for 50MW<sub>AC</sub> Site (1999 – 2018)

Months	Average Monthly Temperature (°C)
January	22.2
February	25.1
March	29.2
April	32.8
May	33.9
June	29.9
July	26.5
August	25.1
September	25.4
October	24.4
November	22.4
December	21.1
Annual Average	26.5

### 6.1.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.3 as illustrated in figure below. These figures show that the identified site is situated in a region that has marginal rainfall.

Figure 6-5 Meteonorm Predicted Precipitation for the 30MW<sub>AC</sub> site



**Figure 6-6 Meteorological Predicted Precipitation for the 50MW<sub>AC</sub> site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

Frequency of module cleaning depends on the rainfall frequency and the prevalence of dust and pollution in the local vicinity. Typical cleaning techniques include water cleaning, dry brushes or vehicle-based mechanical cleaning.

The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 1.5% has been considered by considering cleaning frequency of twice a month. However, a monthly cleaning schedule is understood to be maintained in the O&M scope of work and conditions at site are understood to be monitored to determine the exact frequency and cleaning strategy during operations.



## 7 Annual Energy yields

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 7.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in below.

**Table 7-1: Description of Energy Yield Losses**

Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.



Loss	Description
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 30MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 7.2 Annual Energy Yields

SgurrEnergy has computed the annual energy yields for the 30MW<sub>AC</sub> and 50MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

**Table 7-2: Plant parameters for the 30MW<sub>AC</sub> Solar PV Plant**

Parameter	Description
Modules	JA Solar 325 W <sub>p</sub> , (JAM60S08-325) JA Solar 330 W <sub>p</sub> (JAM60S08-330) Canadian solar 325 W <sub>p</sub> (CS3K-325MS)
Inverters	ABB Central Inverters – 2.0MW <sub>AC</sub> (PVS980-58-2000kVA-K)
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	39.4



**Table 7-3: Plant parameters for the 50MW<sub>AC</sub> Solar PV Plant**

Parameter	Description
Modules	Canadian solar 320 W <sub>p</sub> (CS1K-320MS 1500V) Canadian solar 325 W <sub>p</sub> (CS3K-325MS 1500V) Astronergy 325 W <sub>p</sub> (CHSM6612P/HV-325)
Inverters	ABB Central Inverters – 2.0MW <sub>AC</sub> (PVS980-58-2000kVA-K)
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	64.63

### 7.2.1 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 30MW<sub>AC</sub> and 50MW<sub>AC</sub> solar PV Plant with JA Solar and Canadian solar PV modules and ABB central inverters. Table 7-4 summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.

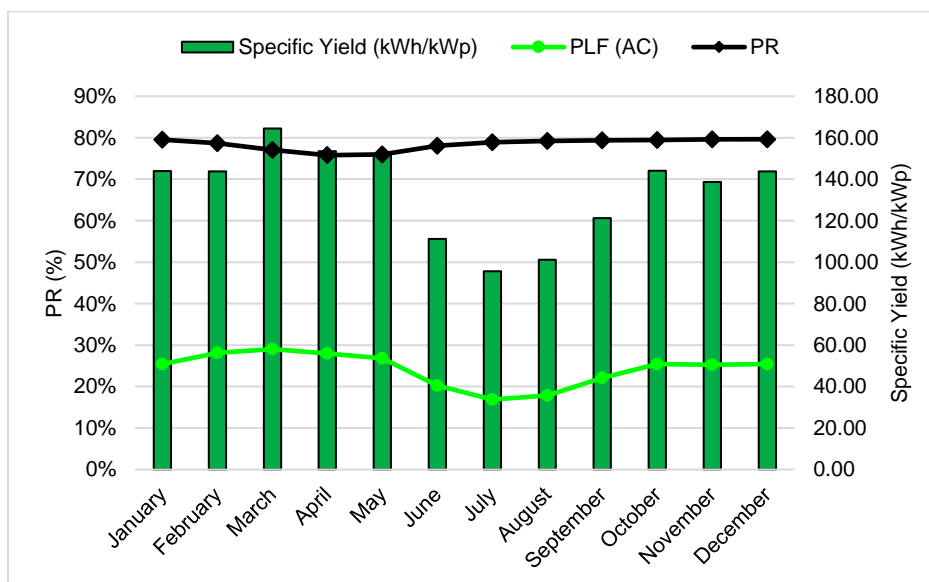
**Table 7-4: Energy Yield for the 30MW<sub>AC</sub> and 50MW<sub>AC</sub> Solar PV Plant**

Parameters	Description-30MW <sub>AC</sub>	Description-50MW <sub>AC</sub>
PV Module Technology	Monocrystalline – PERC	Monocrystalline – PERC, Polycrystalline
DC Capacity (MW <sub>p</sub> )	39.4	64.63
AC Capacity (MVA)	30.0	50.0
Contracted Capacity (MW)	30.0	50.0
P <sub>NOM</sub> Ratio	1.31	1.29
Tilt (°)	16	16
Pitch (m)	5	6
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1,950.10	1948.1
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	2059.4	2058
Transposition Factor	1.06	1.06
<b>Losses</b>		
Horizon Shading	0.00%	0.00%
Incident Irradiation Below Threshold	0.00%	0.00%
Near Shading	2.10%	1.93%
Incident Angle	2.27%	2.29%
Soiling	1.50%	1.50%
Low Irradiance	0.48%	0.84%
Module Temperature	8.00%	8.49%
Electrical Shadings	0.15%	0.16%
Module Quality	0.00%	0.00%
First year Degradation	1.50%	1.50%



Parameters	Description-30MW <sub>AC</sub>	Description-50MW <sub>AC</sub>
Module Mismatch	1.00%	1.00%
DC Ohmic	1.07%	1.07%
Inverter Performance	1.75%	1.76%
Availability	1.00%	1.00%
AC Ohmic	0.56%	0.56%
Transformer (LV/MV)	1.08%	1.08%
Transformer (MV/HV)	-	-
Transmission Line	0.41%	0.46%
Auxiliary Consumption	0.60%	0.60%
Curtailment		
<b>Total Annual Loss Factor</b>	<b>0.783</b>	<b>0.777</b>
<b>Third Year P50 Energy Yield (MWh/annum)</b>	<b>62,919.13</b>	<b>1,02,278.79</b>
<b>Third Year Specific Yield (kWh/kW<sub>p</sub>)</b>	<b>1596.93</b>	<b>1582.52</b>
<b>Third Year CUF on AC Installed Capacity</b>	<b>23.94%</b>	<b>23.35%</b>
<b>Third Year CUF on Contracted Capacity</b>	<b>23.94%</b>	<b>23.35%</b>
<b>Third Year CUF on DC Installed Capacity</b>	<b>18.22%</b>	<b>18.06%</b>
<b>Third Year Performance Ratio</b>	<b>77.54%</b>	<b>76.89%</b>

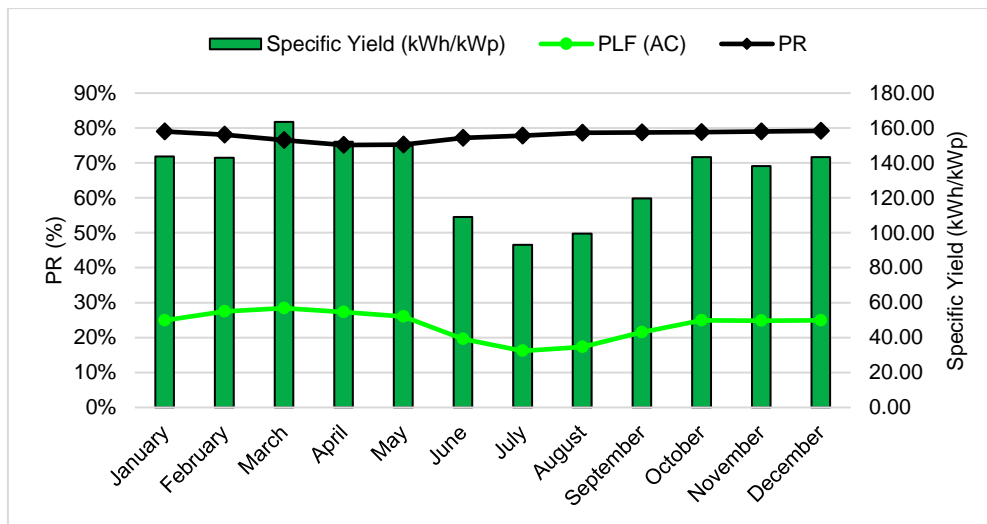
Graphical representation of the monthly generation, performance ratio and CUF for 30 MW<sub>AC</sub> and 50MW<sub>AC</sub> evaluated is illustrated graphically in figure below.



**Figure 7-1: Monthly Energy Yield for 30MW<sub>AC</sub>**







**Figure 7-2: Monthly Energy Yield for 50MW<sub>AC</sub>**

### 7.2.2 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 7.2.2.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

#### 7.2.2.2 Inter – Annual Variation in the Solar Resource

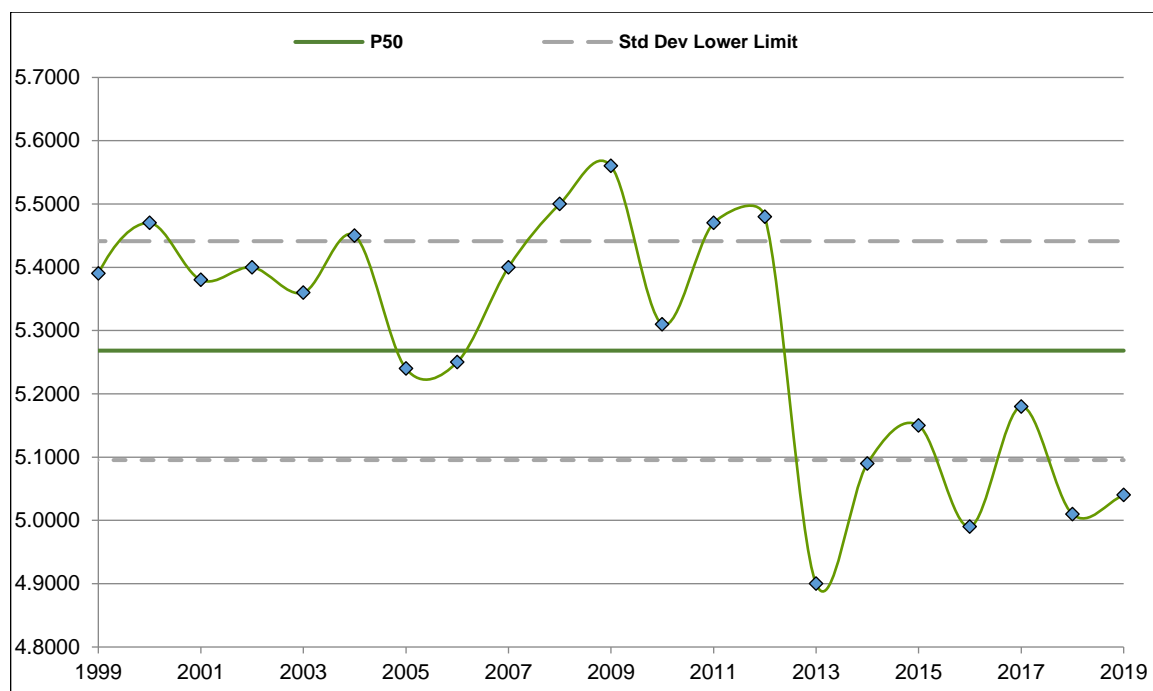
Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.

The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database for the proposed site location which is used to estimate the standard deviation of variation in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 7-5.

**Table 7-5: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	3.28





**Figure 7-3: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in Figure 7-3.

SgurrEnergy uses a coefficient of variation of 3.28% to quantify the inter-annual variation in the solar resource.

#### 7.2.2.3 Modelling Uncertainty

The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

#### 7.2.2.4 Total Uncertainty (P75, P90 and P99 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.

**Table 7-6: Life Cycle P50, P75 and P90 Generation Prediction for 30 MW<sub>AC</sub>**

Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>12</sup> (MWh/annum)	P90 Generation Prediction <sup>13</sup> (MWh/annum)
3	62,919.13	60,258.76	57,864.35
4	62,604.53	59,957.47	57,575.03
5	62,291.51	59,657.68	57,287.15
6	61,980.05	59,359.39	57,000.72
7	61,670.15	59,062.60	56,715.71

<sup>12</sup> The P75 values have been calculated over 10-year averages

<sup>13</sup> The P90 values have been calculated over 10-year averages



Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>12</sup> (MWh/annum)	P90 Generation Prediction <sup>13</sup> (MWh/annum)
8	61,361.80	58,767.28	56,432.13
9	61,054.99	58,473.45	56,149.97
<b>10</b>	<b>60,749.72</b>	<b>58,181.08</b>	<b>55,869.22</b>
11	60,445.97	57,890.17	55,589.88
12	60,143.74	57,600.72	55,311.93
13	59,843.02	57,312.72	55,035.37
14	59,543.81	57,026.16	54,760.19
15	59,246.09	56,741.03	54,486.39
16	58,949.86	56,457.32	54,213.96
17	58,655.11	56,175.03	53,942.89
18	58,361.83	55,894.16	53,673.17
19	58,070.02	55,614.69	53,404.81
<b>20</b>	<b>57,779.67</b>	<b>55,336.61</b>	<b>53,137.78</b>
21	57,490.78	55,059.93	52,872.10
22	57,203.32	54,784.63	52,607.74
23	56,917.30	54,510.71	52,344.70
24	56,632.72	54,238.15	52,082.97
<b>25</b>	<b>56,349.55</b>	<b>53,966.96</b>	<b>51,822.56</b>

Table 7-7: Life Cycle P50, P75 and P90 Generation Prediction for 50 MW<sub>AC</sub>Table 7-8: Life Cycle P50, P75 and P90 Generation Prediction for 50 MW<sub>AC</sub>

Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>14</sup> (MWh/annum)	P90 Generation Prediction <sup>15</sup> (MWh/annum)
3	1,02,278.79	97,954.20	94,061.94
4	1,01,767.39	97,464.43	93,591.63
5	1,01,258.56	96,977.11	93,123.67
6	1,00,752.26	96,492.22	92,658.05
7	1,00,248.50	96,009.76	92,194.76
8	99,747.26	95,529.71	91,733.79
9	99,248.52	95,052.06	91,275.12
<b>10</b>	<b>98,752.28</b>	<b>94,576.80</b>	<b>90,818.74</b>
11	98,258.52	94,103.92	90,364.65

<sup>14</sup> The P75 values have been calculated over 10-year averages<sup>15</sup> The P90 values have been calculated over 10-year averages

Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>14</sup> (MWh/annum)	P90 Generation Prediction <sup>15</sup> (MWh/annum)
12	97,767.23	93,633.40	89,912.83
13	97,278.39	93,165.23	89,463.26
14	96,792.00	92,699.41	89,015.95
15	96,308.04	92,235.91	88,570.87
16	95,826.50	91,774.73	88,128.01
17	95,347.37	91,315.86	87,687.37
18	94,870.63	90,859.28	87,248.94
19	94,396.28	90,404.98	86,812.69
<b>20</b>	<b>93,924.29</b>	<b>89,952.96</b>	<b>86,378.63</b>
21	93,454.67	89,503.19	85,946.74
22	92,987.40	89,055.68	85,517.00
23	92,522.46	88,610.40	85,089.42
24	92,059.85	88,167.35	84,663.97
<b>25</b>	<b>91,599.55</b>	<b>87,726.51</b>	<b>84,240.65</b>



## 8 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 0.6% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) and henceforth. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Owner, SgurrEnergy understands that the SEPEPL solar PV plant was commissioned in two phases. The 50MW capacity of the solar PV plant was commissioned on 8<sup>th</sup> April 2018 and subsequently the remaining 30MW solar PV plant was commissioned on 22<sup>nd</sup> April 2018. SgurrEnergy was provided with plant and grid availability records from May 2018 to March 2021<sup>16</sup> for the solar PV plant. However, the irradiation measurement records were provided from September 2018 to March 2021.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from September 2018 to March 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Owner.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

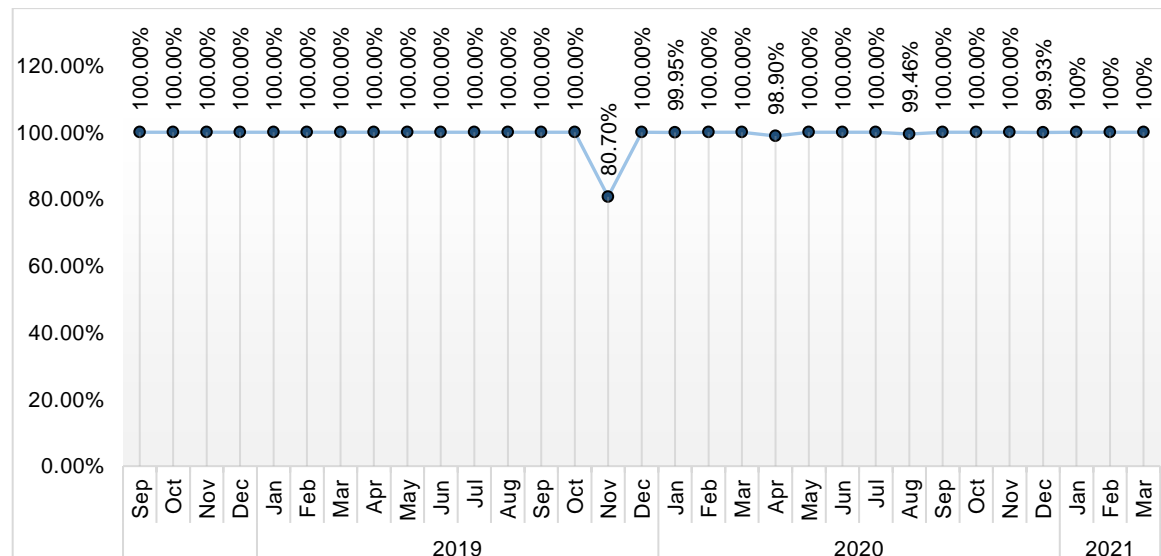
The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Owners control.

The monthly records of the grid availability from September 2018 to March 2021 have been graphically illustrated in Figure 8-1 below.

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<sup>16</sup> SgurrEnergy was provided with both the plant and grid availability records until March 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.





**Figure 8-1: Grid Availability**

From the above illustration, SgurrEnergy notes that the unavailability loss experienced due to grid anomalies are minimal over the operational period and are within expected range. However, for the month of November 2019 the unavailability due to grid was significantly high when compared to other months. The downtime due to grid unavailability was comparatively less severe during the remaining months for which the grid availability was noted to be exceeding 98.9%.

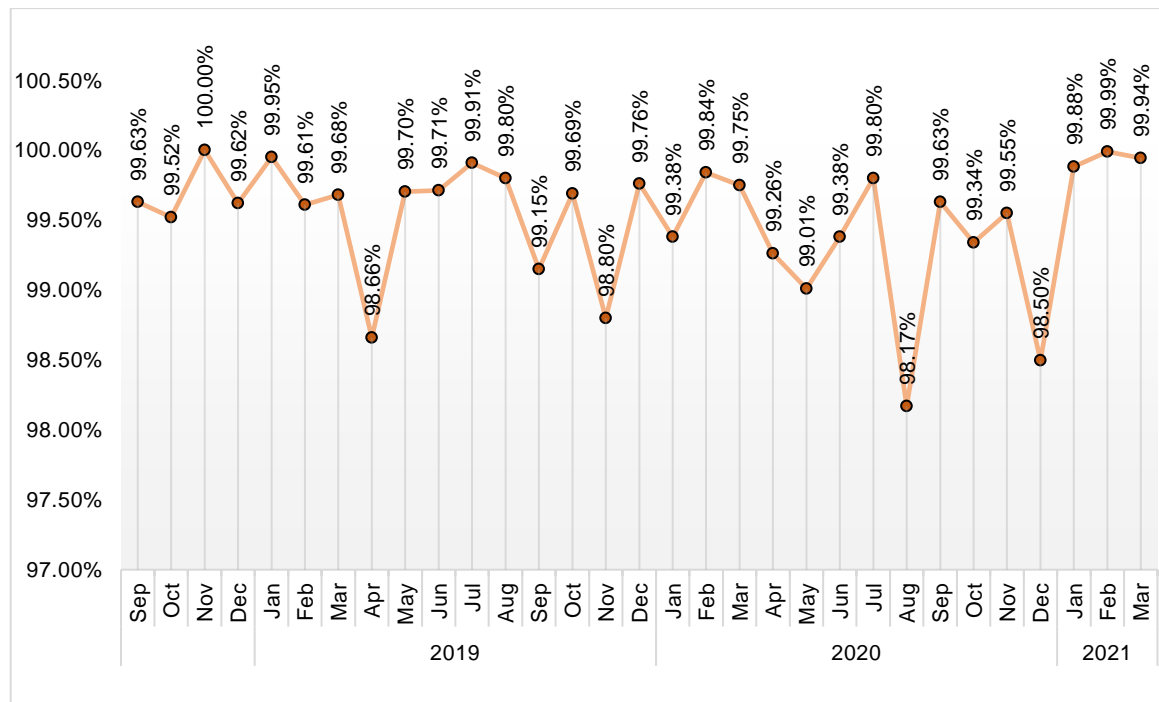
Overall, the average grid availability experienced on site for the operational period was calculated to be 99.32%

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the SEPEPL solar PV plant is graphically illustrated below in Figure 8-2.





**Figure 8-2: Plant Availability**

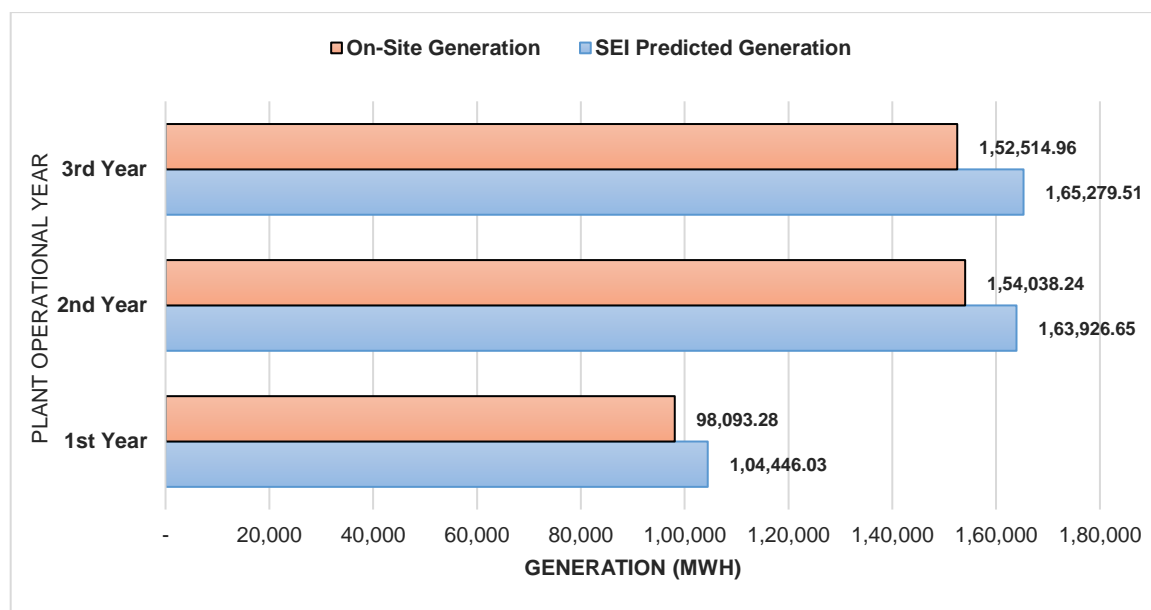
Based on the above illustrations, SgurrEnergy notes the plant availability for the SEPEPL solar PV plant is notably inconsistent for all the months ranging between 98.17% to 100%. The average plant availability is noted to be 99.50% which is considered to be within expected range.

## 1.2 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Client. To make the operational energy yield predictions more representative, SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Client. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Client.

The yearly comparison of the generation data is illustrated below in Figure 8-3.





**Figure 8-3: Generation Comparison**

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 8-1

**Table 8-1: PV Plant Performance – SEPEPL 80MW**

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>17</sup> (%)
Sep 2018 -Mar 2019	1,04,446.03	98,093.28	-6.08%
Apr 2019 -Mar 2020	1,63,926.65	1,54,038.24	-6.03%
Apr 2020 –Mar 2021	1,65,279.51	1,52,514.96	-7.72%
<b>Cumulative Period</b>	<b>4,33,652.18</b>	<b>4,04,646.48</b>	<b>-6.69%</b>

Based on the above comparison, SgurrEnergy notes that the PV plant is generating lower than the expected yield. However, SgurrEnergy considers that such variations in the energy yield can be attributed to lower irradiation level experienced on the Project site. The irradiation levels significantly impact the actual generation from the PV plant as the system losses may vary significantly due to slight change in the irradiation.

In order to understand the deviation in the irradiation pattern, SgurrEnergy has compared the monthly incident irradiation data provided by the Client with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation. The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 8-4.

**Table 8-2: Irradiation Comparison– SEPEPL 80MW**

PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>18</sup> (%)
Sep 2018 -Mar 2019	1,267.35	1,227.86	-3.12%
Apr 2019 -Mar 2020	2,058.70	1,896.15	-7.90%
Apr 2020 -Mar 2021	2,058.70	1,924.43	-6.52%

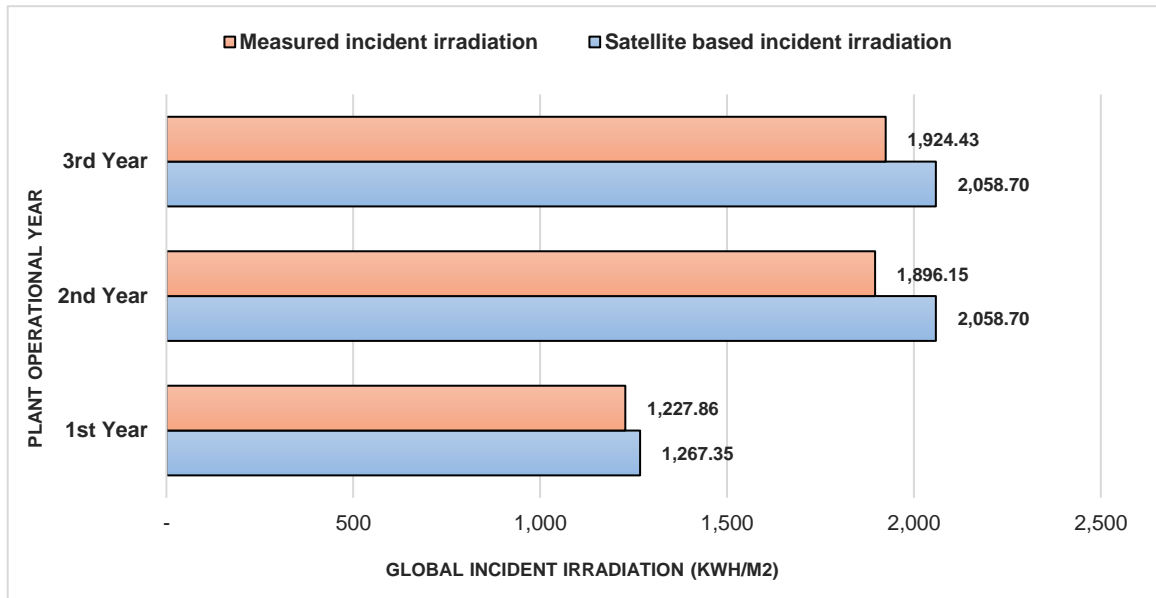
<sup>17</sup> Positive values indicate higher generation, while negative values indicate lower generation

<sup>18</sup> Positive values indicate higher irradiation, while negative values indicate lower irradiation





PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>18</sup> (%)
Cumulative Period	5,384.75	5,048.44	-6.25%



**Figure 8-4: Irradiation Comparison**

Based on the above illustration, it is observed that the overall recorded generation is approximately 6.69% lower than the generation predicted on site. Correspondingly, it has also been observed that the recorded irradiation is approximately 6.25% lower than the predicted irradiation.

Based on the comparative analysis, the drop-in generation can be attributed to the drop-in irradiation for the period of evaluation (September –18 to March –21).



## 9 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar PV plants as having a lifetime of 25-40 years<sup>19</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>20</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the PV plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement.

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<sup>19</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>20</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>



Virescent Infrastructure

13MW(AC) SSEGPL Solar PV Plant  
Sindicatum Solar Energy Gujarat Private Limited  
Technical Assessment Report

July 2021



**Report Details**

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**Amendment Records**

Revision Number	Date	Purpose of Revision	Summary of Amendments
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B2	28 June 2021	Minor Updates	-
B3	2 July 2021	Minor Updates	-
B4	6 July 2021	Minor Updates	-
B5	15 July 2021	Minor Updates	-

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## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 13MW<sub>AC</sub> SSEGPL plant. The summary of the technical assessment is captured in the below table.

**Table 1-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	Review presented in Section 2
2	PV Module	<p>According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of First Solar, assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.</p> <p>Further, the warranty document was not provided for review, based on review of datasheet provided, it is noted that First solar provides a limited product warranty of 5 years. SgurrEnergy considers five-year product warranty provided by First Solar to be lower than the industry standard of 10-years and suggests getting clarity from the manufacturer regarding the warranty offered for the modules utilized for the project.</p> <p>SgurrEnergy is unable to comment on warranty terms and conditions and suggests getting clarity from the manufacturer regarding the warranty offered for the PV modules. Regarding the certifications, the complete set of certifications of the installed modules was not made available for SgurrEnergy's review. Since the solar PV plant is already operational, SgurrEnergy raises no major concern regarding the unavailability of IEC certifications.</p>
3	Inverter	<p>SgurrEnergy has conducted review of the Power-one's PVI-500.0-TL-CN -500kVA central inverter. The central inverter make have the required certification for use in solar PV plants. The technical characteristics of the inverters are in-line with the industry standard. Referring the warranty document available in public domain, SgurrEnergy understands that Power-one offer a product warrant of 66 months, which is in line with the current industry standards.</p> <p>In conclusion, Power-one (ABB) can be considered as established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters. SgurrEnergy raises no major concern in the utilization of Power-one inverters for the project.</p>
4	Inverter and Power Transformer	<p>The inverter transformers (1250kVA) and power transformer (6.25MVA and 10/12.5MVA) used within the project are manufactured by Areva T&amp;D. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.</p>



Sr. No.	Parameter	Comment														
5	String Sizing	The V <sub>OC</sub> does not exceed the inverter input voltage for the site, and therefore, SgurrEnergy considers the number of modules in series to be acceptable for the PV Project.														
6	Resource Assessment	For resource analysis, SgurrEnergy has compared various satellite datasets. For the satellite databases, SEI has compared Meteonorm 7.3, NASA, SWERA and SolarGIS data to find the most suitable solar resource for long-term energy yield prediction. Owing to low uncertainty and high resolution, SEI considers SolarGIS dataset to be the most representative satellite database among all the satellite databases for long-term energy yield assessment.														
7	Operational Analysis and Generation Comparison	Review presented in Section 8														
8	Allied Components and Systems	Review presented in Section 4														
9	Energy Yield Assessment	<div>Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for ninth year of plant operation for the 13 MW<sub>AC</sub> PV plant.</div> <table><tr><td>Global Horizontal Irradiation (kWh/m2)</td><td>2006.60</td></tr><tr><td>Global Inclined Irradiation (kWh/m²)</td><td>2196.32</td></tr><tr><td>First Year P50 Energy Yield (MWh/annum)</td><td>26,543.854</td></tr><tr><td>Ninth Year P50 Energy Yield (MWh/annum)</td><td>24,493.20</td></tr><tr><td>Ninth Specific Yield (kWh/kW<sub>p</sub>)</td><td>1629.72</td></tr><tr><td>Ninth Performance Ratio (PR)</td><td>74.20%</td></tr><tr><td>Ninth PLF on Contracted Capacity (13MW<sub>AC</sub>)</td><td>21.51%</td></tr></table>	Global Horizontal Irradiation (kWh/m2)	2006.60	Global Inclined Irradiation (kWh/m²)	2196.32	First Year P50 Energy Yield (MWh/annum)	26,543.854	Ninth Year P50 Energy Yield (MWh/annum)	24,493.20	Ninth Specific Yield (kWh/kW <sub>p</sub> )	1629.72	Ninth Performance Ratio (PR)	74.20%	Ninth PLF on Contracted Capacity (13MW <sub>AC</sub> )	21.51%
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Ninth Specific Yield (kWh/kW <sub>p</sub> )	1629.72															
Ninth Performance Ratio (PR)	74.20%															
Ninth PLF on Contracted Capacity (13MW <sub>AC</sub> )	21.51%															



## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
m	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon



MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation



## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 68MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of four projects, as presented within Table 1-1.

**Table 1-1: Project Key Summary**

Project Name	SSEPL – 5MW <sub>AC</sub>	SSEGPL – 13MW <sub>AC</sub>	PLG – 20MW <sub>AC</sub>	USUPL – 30MW <sub>AC</sub>
<b>Site Location</b>	26.52°N, 72.85E, Tiware, Jodhpur, Rajasthan, India	23.9128°N, 71.2183°E, Santalpur, Patan, Gujarat, India	23.9°N, 71.5°E, Dahisar, Patan, Gujarat, India	25°18'52.79"N, 79°25'2.49"E, Devgaon, Mahoba, Uttar Pradesh, India
<b>Owner</b>	Sindicatum Solar Energy Private Limited (SSEPL)	Sindicatum Solar Energy Gujarat Private Limited (SSEGPL)	PLG Photovoltaic Private Limited (PPPL)	Universal Saur Urja Private Limited (USUPL)
<b>DC / AC Capacity</b>	5.745MW <sub>P</sub> / 5MW <sub>AC</sub>	15MW <sub>P</sub> / 13MW <sub>AC</sub>	20MW <sub>P</sub> / 20MW <sub>AC</sub>	36.98MW <sub>P</sub> / 30MW <sub>AC</sub>

This report presents the evaluation of the 13MW<sub>AC</sub> solar PV plant developed by Sindicatum Solar Energy Gujarat Private Limited (SSEPL). The Solar PV plant under evaluation is located in Santalpur village, Patan district in Gujarat state. The purpose of this report is to provide a technical appraisal of PV plant under evaluation.

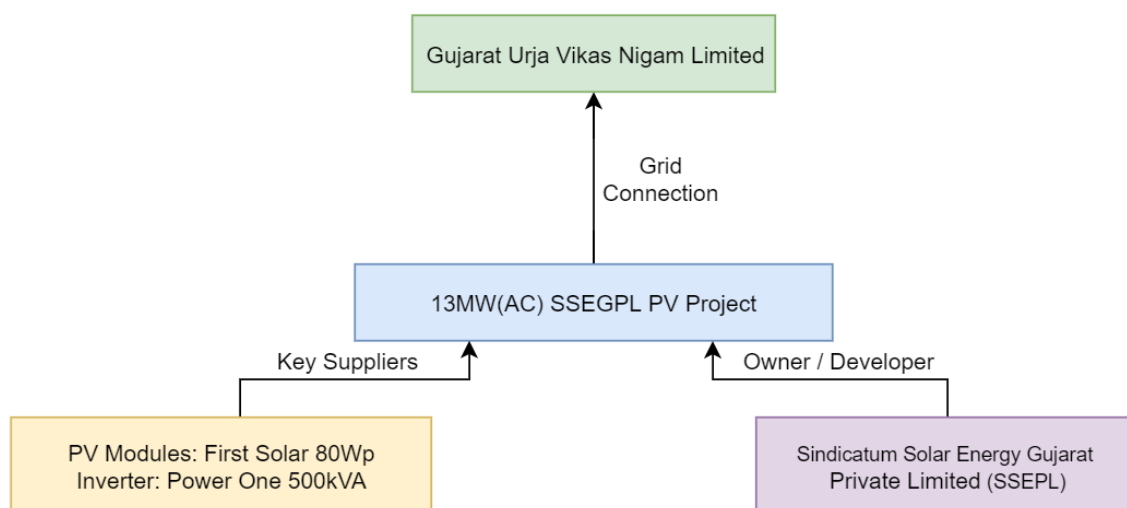
The report focuses on the following key parameters:

- System Design.
- Major Components.
- Engineering Design.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Plant Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project and is based on information made available by the Client through online data room. The main Project characteristic is summarised in Table 1-2.

Figure 1-1 illustrates the project structure indicating key project participants for the 5MW<sub>AC</sub> solar PV plant.





**Figure 1-1: Project Structure for 13MW<sub>AC</sub> Solar PV Plant**

**Table 1-2: Project Key Summary**

Project Information	
<b>Project Name</b>	13MW <sub>AC</sub> SSEGPL solar PV plant
<b>Location</b>	Santalpur, Patan, Gujarat
<b>Developer</b>	Sindicatum Solar Energy Private Limited
<b>DC/ AC capacity</b>	13MW <sub>AC</sub> PV Plant – 15MW <sub>P</sub> / 13MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: First Solar Inverters: Power One
<b>MMS Configuration</b>	Fixed Tilt: 22°, Azimuth: 0°
<b>Commissioning Status</b>	Commissioning for 4MW <sub>P</sub> was achieved on 4 March 2012, 6MW <sub>P</sub> was achieved on 31 March 2012, 4.92MW <sub>P</sub> was achieved on 12 April 2012 and 0.08MW <sub>P</sub> was commissioned on 31 October 2021.



## 2 13MW<sub>AC</sub> Solar PV Plant Overview

The project site lies around the coordinates 23.9128°N, 71.2183°E. Satellite imageries of 13MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1. The Owner has leased approximately 78.52 acres of land from the government for the project. The Project site is located near the *Santalpur* village, in *Patan* district of Gujarat.

Project is contracted for generating 13MW<sub>AC</sub> power; SEI therefore interprets 13MW<sub>AC</sub> as the maximum AC installed capacity for the solar PV plant.



**Figure 2-1: Satellite image of 13MW<sub>AC</sub> plant**

### 2.1 13MW<sub>AC</sub> Project Summary

Solar PV plant is modular in nature; therefore, SSEGPL 13MW<sub>AC</sub> solar PV plants is implemented by adopting modularity in designs. 2MW<sub>AC</sub> and 1 MW<sub>AC</sub> are the typical inverter stations considered for implementing SSEGPL 13MW<sub>AC</sub> solar PV plant.

Table 2-1 presents the summary of 13MW<sub>AC</sub> PV plant.

**Table 2-1: Summary of 13MW<sub>AC</sub> Plant Configurations**

General	
PV Module Technology	Cd-Te Thin Film
Inverter Technology	Central Inverters
Installed DC Peak Capacity (MW <sub>p</sub> )	15.00
Installed AC Capacity (MW)	13.00



General	
Mounting Type	Fixed Tilt
Tilt Angle (°)	22°
Pitch (m)	6.8
PV Modules	
PV Module Manufacturer	First Solar
Model	FS-280
Wattage (W <sub>p</sub> )	80W <sub>p</sub>
Number of Modules per String	10
Inverter	
Inverter Manufacturer / Model	Power One / PVI-Central-500
Inverter Nominal AC Output	500kW
Number of Inverters	26
Mounting Structure	
Mounting Structure Details (rows × columns)	6 × 10
Orientation of Modules	Landscape

The 13MW<sub>AC</sub> plant is implemented with a total of seven (7) inverter stations of capacity 2MW<sub>AC</sub> and 1MW<sub>AC</sub>. The 2MW<sub>AC</sub> stations comprise of two (2) three winding transformers to accommodate 4 × 500kVA inverters, taking the individual inverter station size to 4MW<sub>AC</sub>. While The 2MW<sub>AC</sub> stations comprise of one (1) three winding transformer to accommodate 2 × 500kVA inverters, taking the individual inverter station size to 1MW<sub>AC</sub>. Inverter station is comprised of a physical block connecting 2.3MW<sub>p</sub> and 1.15MW<sub>p</sub> of installed photovoltaic array. The output of the inverter stations are connected to transformers of 12.5MVA and 6.3MVA for stepping up the voltage to 33kV.





### 3 Review of Major plant components

SgurrEnergy has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions.

#### 3.1 PV modules – First Solar

SgurrEnergy has conducted a technical review of the supplier and module specification with regards to their suitability for their use in the Projects under evaluation.

##### 3.1.1 Company Profile

First Solar Inc. is a USA based (Tempe, Arizona) producer of Cadmium Telluride (CdTe) thin-film modules and has more than 6,400<sup>1</sup> employees worldwide with manufacturing facilities in the USA, Malaysia, and Vietnam. Formed in 1999 the company launched production of commercial products in 2002 and was the first company to integrate thin film solar module technology into high-volume, low-cost production.

According to information available on public domain, First Solar is committed to providing a commercially attractive recycling solution for PV power plant and module owners to help them meet their module end-of-life (EOL) obligation simply, cost-effectively and responsibly.

First Solar has received the following certifications at all of its manufacturing facilities; ISO 14001:2015 environmental management systems certification, ISO 9001:2015 quality management systems certification, and ISO 45001:2018 certification for Occupational Health and Safety Management Systems.

First Solar thin film modules are used in ground-mounted and commercial rooftop applications ranging from a few kilowatts to tens of megawatts in size.

##### 3.1.2 Experience and track record

First Solar modules have global solar PV installed capacity of 633.7GW. First Solar modules have more than 1.8GW PV modules have installed capacity and nearly 150MW capacity is under operation in India<sup>2</sup>. Figure 3-1 illustrates the installed capacity of first-solar modules in India.

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<sup>1</sup>[http://www.firstsolar.com/-/media/First-Solar/Documents/Corporate-Collaterals/FS\\_Corporate\\_Factsheet.ashx](http://www.firstsolar.com/-/media/First-Solar/Documents/Corporate-Collaterals/FS_Corporate_Factsheet.ashx)

<sup>2</sup> <https://www.firstsolar.com/en-IN/PV-Plants/Project-Development>





**Figure 3-1: First-solar modules installed in India.**

Few of the commissioned solar power plants using First Solar modules are listed in Table 3-1

**Table 3-1: Track record of First Solar Modules**

Sr. No.	Project	Location	Capacity (MW)	Installation Year
1	Hindupur Solar Park	Andhra Pradesh India	40.0	2016
2	Kodangal Solar Park	Telangana State India	10.0	2016
3	Mahabubnagar Solar Park	Telangana State India	10.0	2015
4	Polepally Solar Park	Telangana State India	25.0	-
5	Karoor Solar Park	Telangana State India	15.0	2016
6	Marikal Solar Parks	Telangana State India	10.0	2015
7	Hindupur Solar Park	Andhra Pradesh, India	40.0	2016



Sr. No.	Project	Location	Capacity (MW)	Installation Year
8	Topaz Solar farm	USA	550.0	-
9	Agua Caliente	USA	290.0	-
10	Copper Mountain 1	USA	48.0	-
11	Greenough River	Australia	10.0	-
12	Phalodi	Rajasthan, India	50.0	-
13	Dewa Solar plant	UAE	13.0	-

SgurrEnergy considers First solar to have an acceptable track record in delivering PV modules to PV projects worldwide.

### 3.1.3 Main Technical Characteristics

First Solar FS-280 modules of 80W<sub>P</sub> capacity have been used for the Project. The shortlisted modules have a temperature coefficient (P<sub>max</sub>) of -0.25%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy's expectation for thin film. The technical characteristics of FS-280 are presented in the Table 3-2

**Table 3-2: First Solar PV Module Technical Characteristics**

Specifications	FS-280; 80W <sub>P</sub>
Technology	Thin Film
Nominal power (P <sub>MPP</sub> )	80W <sub>P</sub>
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	71.2V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	1.1A
Open circuit voltage (V <sub>OC</sub> )	91.5V
Short circuit current (I <sub>SC</sub> )	1.2A
Maximum System Voltage	1,000V
Dimensions (length × breadth × width) (mm)	1200 × 600 × 6.8mm
Module area (m <sup>2</sup> )	0.72m <sup>2</sup>
Weight (kg)	12
Temperature coefficient at P <sub>MAX</sub>	-0.25%/°C
Maximum reverse current	3.5A
Product warranty	5 years
Power output guarantee	25 years
<i>Module technical characteristics are given at STC (1,000W/m<sup>2</sup> irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet)</i>	

Overall, the module characteristics can be considered to be in line with market standard.

### NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>3</sup> characteristics of selected FS-280; 80W<sub>P</sub> modules is given in Table 3-3 relate to more realistic operating conditions compared to

<sup>3</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C



STC. It is impacted by the module materials used as well as the packing density of module materials. The NOCT for the module is 45°C. This is comparable with other manufacturers and demonstrates the module is effective at heat dissipation.

**Table 3-3: PV Module NOCT Characteristics – First Solar Modules**

Model	FS-280
Maximum Power ( $P_{MAX}$ )	60W <sub>P</sub>
Maximum Power Voltage ( $V_{MP}$ )	66.8V
Maximum Power Current ( $I_{MP}$ )	0.9A
Open Circuit Voltage ( $V_{OC}$ )	85.1V
Short circuit current ( $I_{SC}$ )	1.0A

### 3.1.4 Certification of Modules

The modules are manufactured in an automated facility certified to ISO9001, ISO14001 and OHSAS18001. SgurrEnergy has summarised the certification obtained for the module as below in Table 3-4.

**Table 3-4: Certification for PV Module**

Sr. No.	Certification	Description
1	IEC 61646	Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval
2	IEC 61730 (Edition 1/2)	PV module safety qualifications

It is common for PV modules to hold the design, performance and safety certifications based on IEC prescribed testing methods. However, complete set of certifications of the installed modules was not made available for SgurrEnergy's review. Since the solar PV plant is operational, SgurrEnergy does not raise any major concern regarding the unavailability of IEC certificates.

### 3.1.5 Warranty

The warranty document is essentially required to understand the terms and conditions and also the warranted power performance values. Although the Client has not provided the warranty documents for review, however, referring to the datasheet provided, SgurrEnergy understands that the specified modules are provided with two forms of warranty: a 5-year Limited Product Warranty and a 25-year Limited Power Output Warranty. Both warranties are described in the sections below.

### 3.1.6 Product Warranty

First solar provides a limited product warranty of 5 years. During this period the modules shall be free from defects in materials and workmanship under normal use, installation, operation and service for a period of ten years.

SgurrEnergy considers five-year product warranty provided by First Solar to be lower than the industry standard of 10-years and suggests getting clarity from the manufacturer regarding the warranty offered for the modules utilized for the project.

### 3.1.7 Linear Power-Output Warranty



First solar warrants that the modules will not experience a power loss of greater than 10% during the first ten (10) years and 20% during twenty-five (25) years subject to the terms and conditions mentioned in the warranty document.

Since the warranty document was not provided for review, SgurrEnergy is unable to comment on warranty terms and conditions and suggests getting clarity from the manufacturer regarding the warranty offered for the PV modules.

### 3.2 Inverters- Power-one

The Developer has utilized PVI-Central- 500.0-TL capacity central inverter for the project under evaluation.

#### 3.2.1 Company background

Founded in Chatsworth, California, in 1972 as an AC/DC power supplies manufacturer, Power-one was incorporated in late 1970s and shifted its headquarters to Camarillo. Power-one was one of the leading providers of renewable energy and energy-efficient power conversion and power management solutions and a leading designer and manufacturer of photovoltaic inverters, in the late 1990s.

The company provided services in sales, manufacturing, and R&D across Asia, Europe, and the Americas. In addition to its manufacturing units in Dominican Republic and Mexico, the company also had research and development centre in Limerick, Ireland.<sup>4</sup> In 2013, Power-one had over 40-years of experience of providing services for variety of industries including renewable energy, servers, storage and networking, industrial and network power systems, etc. In 2012, Power-one employed nearly 3,300 people, mainly in China, Italy, the USA and Slovakia and generated USD120million in earnings.

However, due to poor business conditions at the start of the 21<sup>st</sup> century, the company suffered significant losses. On April 22, 2013, the ABB acquired Power-one's solar inverter business.

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, ABB is one of the largest engineering companies as well as one of the largest conglomerates in the world. ABB has operations in around 100 countries, with approximately 147,000 employees<sup>5</sup>. Company reported global revenue of around \$34,312 million for 2017.<sup>6</sup>

On July 9, 2019, the Italian company FIMER acquired ABB's solar inverter business. The takeover of ABB's solar inverter business included 800 employees in 26 countries as well as two manufacturing plants, in Italy and in India, and a R&D facility in Finland.

FIMER was founded in 1942, headquartered in Vimercate, Italy, has been actively working in inverter technology since 1983. As of 2020, the company employs more than 1,100 employees across its three manufacturing facilities and three R&D centres across the globe. As a result of acquisition of ABB's PV inverter line, FIMER ranked the fifth-largest PV inverter globally in 2019.

#### 3.2.2 Track Record

Table 3-5 lists the state-wise installed capacity of Power-one (ABB) inverters in India. However, it is to be noted that the table below doesn't not comprise of the installed capacities till date.

<sup>4</sup> <https://www.encyclopedia.com/books/politics-and-business-magazines/power-one-inc>

<sup>5</sup> <https://new.abb.com/news/detail/26838/abb-to-exit-solar-inverter-business>

<sup>6</sup> <https://new.abb.com/investorrelations/company-profile/facts-figures>



**Table 3-5: Power-one (ABB) Inverter Track Record**

Location	Capacity (MW)
Punjab	227
Haryana	62
Uttar Pradesh	106
Bihar	225
Rajasthan	371
Madhya Pradesh	271
Chhattisgarh	28
Odisha	20
Andhra Pradesh	647
Maharashtra	261
Tamil Nadu	747
Karnataka	305
Kerala	50

### 3.2.3 Technical Characteristics

Power-one PVI-500.0-TL-CN inverter has been selected for technical feasibility of the Project.

The PVI-500.0-TL-CN -500kVA Series of central inverters designed ideal for large PV Power Plants. These inverters are designed to operate with DC inputs up to 1,000 V. PVI-500.0-TL-CN -500kVA inverter is designed for outdoor use with an IP20 ingress protection class. They perform optimally at ambient air temperatures between -20°C to 55°C and relative humidity in the range of 0% to 95% with maximum noise level of less than 62dBA.

The PVI-500.0-TL-CN -500kVA inverter has peak efficiency of 98.5% and a European efficiency of 98.2%.

The main technical characteristics of these inverters are illustrated in Table 3-6.

**Table 3-6: Power-one inverter specifications**

ABB Central Inverter Specifications	
Inverter	PVI-500.0-TL-CN -500kVA
Type	Central Inverter
<b>Input Data</b>	
PV voltage range, MPP (V)	475 to 900V
Maximum DC voltage (V)	1,000V
Maximum input current (A)	1,100A
<b>Output Data</b>	
Nominal AC power (kW)	500kW
Maximum AC current (A)	900A
AC voltage range (V)	272 to 352V
AC grid frequency (Hz)	50Hz±5%



<b>ABB Central Inverter Specifications</b>	
Maximum THD	< 4%
<b>Operating Performance</b>	
Maximum efficiency (%)	98.50%
Euro efficiency (%)	98.20%
<b>Power consumption</b>	
Night-time power loss (W)	<66W
Standby operation consumption (W)	<66W
<b>Other</b>	
Dimensions (W × H × D) (mm)	2280mm x 2000mm x 800mm
Weight (kg)	<1400kg
Environmental Protection Rating	IP20
Operating temperature range (°C)	-20 to +55°C
Relative humidity (%)	0% to 95%

The following protection devices are included within the inverter design:

- Anti-islanding protection
- Reverse polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection

Power-one inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components.

### 3.2.3.1 Certification

Power-one is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. Power-one inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information available in public domain, SgurrEnergy has summarized the certification of the Power-one inverter within Table 3-7.

**Table 3-7: Description of Certification of Power-one inverters**

<b>Certification</b>	<b>Description</b>
IEC 61000-6-2	Electromagnetic compatibility
IEC 62109-2:2011	Safety of Power Converters
IEC 62116:2014	Islanding prevention measures

### 3.2.3.2 Warranties





According to the warranty documents available on public domain<sup>7</sup>, the standard warranty offered by Power-one for central is for a period of 66 months from the date of invoice. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards and do not raise any concern over the use of inverter for the project.

### 3.3 Transformer- Areva Transmission & Distribution Ltd.

The solar PV plant is implemented with two level transformation. Power at low voltage from inverters is stepped up to 11kV using 1250kVA inverter transformers and further to 66kV using 10/12.5MVA and 6.25MVA Power transformers of Areva T&D make.

#### 3.3.1 Company Profile

Established in 2001 and headquartered in Paris, France, Areva S.A. was a French multinational group providing services in nuclear power and renewable energy. Areva's global renewable energies business group was formed in 2006 as an expansion of its clean energy portfolio. The group worked majorly in four business line: concentrated solar power, offshore wind power, biomass power, and hydrogen power storage and distribution.

As a part of the restructuring program following its insolvency, Areva's transmission and distribution business was jointly acquired by Alstom and Schneider Electric in November 2009. According to the agreement signed between the parties, the transmission business was acquired by Alstom and the distribution business was acquired by Schneider Electric.

Alstom is a French multinational company established in 1928 and headquartered in Saint-Ouen-sur-Seine, France. In November 2015, Alstom sold its Power generation and grid business to General Electric.

#### 3.3.2 Technical Specifications

The 1250kVA inverter transformer used in the project is outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

The 6.25MVA and 10/12.5MVA power transformer used in the project is outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that both the transformers have been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformers technical characteristics are presented in Table 3-8.

**Table 3-8: Technical Specification of Areva Transformer**

Technical Parameters	Inverter transformer	Power transformer	
	1250kVA	6.25MVA	10/12.5MVA
Rated Power	1250kVA	6.25MVA	10/ 12.5MVA
Rated HV	11kV	66kV	66kV
Rated LV	320V	11kV	11kV

<sup>7</sup> <https://www.renvu.com/site/downloads/Power-One%20Aurora%20Warranty%20Services%20Description%20for%20String%20Inverters%20for%20RENVU.pdf>





Technical Parameters	Inverter transformer	Power transformer	
	1250kVA	6.25MVA	10/12.5MVA
Tapping on HV	-5% to +5% (steps of 2.5%)	-	-
Phases	3		
Frequency	50Hz		
Vector group	Dyn11yn11	YNyn0	YNyn0
Impedance	6.25% (with IS TOL.)	-	-
Cooling Strategy	ONAN		
Oil temperature rise	50°C	-	-
Winding temperature rise	55°C	-	-
Winding material	Electrolytic Copper		

SgurrEnergy considers the overall the technical specifications of inverter transformer to be adequate for the PV projects. However, GTP (guaranteed technical particulars) have not been provided for the power transformers for SgurrEnergy's review. Since the solar PV plant is operational, SgurrEnergy does not raise any major concern in the use of Areva transformers for the project.

### 3.3.2.1 Temperature Rise Detection and Protection

Referring the general arrangement of the inverter transformer and power transformers, SgurrEnergy observed that all the transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.2.2 Warranties and Guaranties

Warranty document have not been provided for the transformers used for the Project. In the absence of the warranty documents, SgurrEnergy is unable to provide comments regarding the warranty offered and suggests the Client to obtain clarity from the manufacturer on the final offer.

## 3.4 Conclusion on Major Plant Components

### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of First Solar, assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.

Further, the warranty document was not provided for review, SgurrEnergy is unable to comment on warranty terms and conditions and suggests getting clarity from the manufacturer regarding the warranty offered for the PV modules. Regarding the certifications, the complete set of certifications of the installed modules was not made



available for SgurrEnergy's review. Since the solar PV plant is already operational, SgurrEnergy raises no major concern regarding the unavailability of IEC certifications.

## Inverters

SgurrEnergy has conducted review of the Power-one's PVI-500.0-TL-CN -500kVA central inverter. The central inverter make have the required certification for use in solar PV plants. The technical characteristics of the inverters are in-line with the industry standard. Referring the warranty document available in public domain, SgurrEnergy understands that Power-one offer a product warrant of 66 months, which is in line with the current industry standards.

In conclusion, Power-one (ABB) can be considered as established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters. SgurrEnergy raises no major concern in the utilization of Power-one inverters for the project.

## Transformers

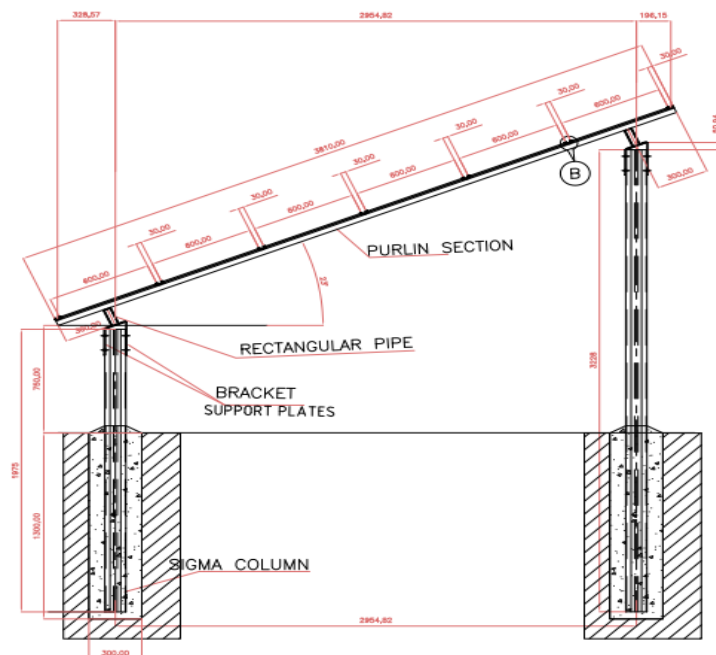
The inverter transformers (1250kVA) and power transformer (6.25MVA and 10/12.5MVA) used within the project are manufactured by Areva T&D. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.

### 3.5 Module support structures

The Array Layout provided by the Client for the 13MW(AC) SSEGPL Solar PV Plant indicates the fixed tilt module mounting structure is inclined at 23° tilt angle.

SgurrEnergy observed that the structure has been designed with three rows of modules placed in portrait orientation with 20 modules in each row. In total there are 60 modules in one mounting structure.

Figure 3-2 illustrate the module mounting structure configuration provided by the Client for the 30MW(AC) USUPL Solar PV Plant. The material used and section sizes of MMS are not available.



**Figure 3-2: Section of the module mounting structure configuration**

## 4 Allied Components and Systems

### 4.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

SgurrEnergy has reviewed the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear, and plant substation as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

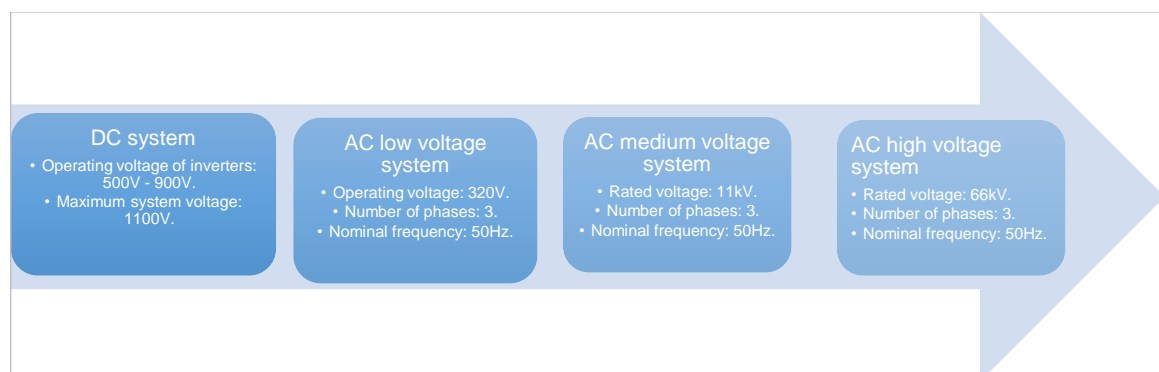
- 11kV Single Line Diagram-R3
- SLD on DC side control room - 1,2 & 3-R1
- SLD on DC side control room - 4,5 & 6-R1
- SLD on DC side control room - 7-R1

The 13MW<sub>AC</sub> solar PV Plant is designed with 80W<sub>p</sub> *First solar* make, thin film solar PV modules and 500kW *Power one* make central inverters. PV modules are interconnected to form a string of 10 modules. Such 8/9/10 strings output is connected to Array Junction Box (AJB). The 9/15/16 AJBs output is connected to string monitoring boxes. Five such string monitoring boxes are further connected to central inverters as input.

The 13MW<sub>AC</sub> solar PV plant has been configured with 26 *Power-One* make 500kW central inverters and seven inverter stations where 2/4 central inverters have been placed. Each inverter station is of 1MW<sub>AC</sub> or 2MW<sub>AC</sub> capacity contains 2/4, 500kW inverters. The two inverters output is connected to ACB (Air circuit breaker) panel. The power from ACB panel two feeders is connected to 1.25MVA, 11/0.320-0.320kV, ONAN three winding transformer for stepping up the voltage to 11kV.

The medium voltage output from one or two inverter duty transformers is connected with 11kV RMU (Ring Main Unit) panel placed at inverter station. The one or two such 11kV RMU (Ring Main Unit) panels are connected in ring philosophy and connected with respective 11kV switchgear panels. The 11kV output from main MV Switchgear panels shall be further connected to 10/12.5MVA and 6.3MVA power transformers located in 11/66kV switchyard. Power from 11/66kV switchyard is evacuated to GETCO substation via 2.2km underground transmission line. However, 11/66kV switchyard SLD and metering details are not provided to SgurrEnergy.

Figure below illustrates a power flow summary for the 5MW<sub>AC</sub> Solar PV plant.



**Figure 4-1: Power flow of 13MW<sub>AC</sub> PV plant**



## 4.2 Cabling

### 4.2.1 DC Cabling

DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. Modules are interconnected in series with 4mm<sup>2</sup> solar grade cables to form a string of 10 PV modules. Single core 4mm<sup>2</sup> multi-stranded copper PV cables connect string output to Array Junction Box (AJB). Power from AJBs is transmitted to String monitoring boxes (SMB) through 10mm<sup>2</sup> multi-stranded copper PV cables.

Power from string monitoring boxes is further transferred to the inverter using 1C, 70mm<sup>2</sup>, and 1.1kV copper XLPE cables.

### 4.2.2 AC Cabling

Three phase AC output from inverter is connected to ACB panel using 4R, 3C, 300mm<sup>2</sup> Aluminium Armoured XLPE cable. ACB panel outgoing feeders output is connected to LV winding of a 1.25MVA three-winding transformers using 4R, 3C, 300mm<sup>2</sup> Aluminium Armoured XLPE cable.

The inverter duty transformer output is connected to 11kV RMU panel located in inverter station 3C, 240mm<sup>2</sup>, 11kV Al XLPE armoured cable. The one or two such RMU panels are interconnected in ring philosophy using 3C, 240mm<sup>2</sup>, 11kV Al XLPE armoured cables.

The 11kV output from RMU panels is transmitted to 11kV switchgear panels using 3C, 240mm<sup>2</sup>, 11kV Al XLPE armoured cables.

The power from the 11kV switchgear panels is transferred to 10/12.5MVA and 6.3MVA power transformers located in 11/66kV outdoor switchyard using 3R/2R, 3C, 240mm<sup>2</sup>, 11kV Al XLPE armoured cable. Further the output power of 11/66kV Switchyard is transferred to GETCO substation over transmission line.

## 4.3 Inverter Station

The 20MW<sub>AC</sub> solar PV plant has been configured with 26 inverters and seven inverter stations. Each inverter station is of 1MW<sub>AC</sub> and 2MW<sub>AC</sub> capacity consists of two or four 500kW inverters and one or two 1.25MVA inverter duty transformer.

Each two inverters are connected to ACB (Air circuit breaker) panel. The power from ACB panel two feeders is connected to 1.25MVA, 11/0.320-0.320kV, ONAN three winding transformer for stepping up the voltage to 11kV. The inverter duty transformer steps up the voltage to 11kV for all inverter stations. Further the power from the HV side of the transformer is fed to the 11kV RMU panel through underground cable.

The 11kV RMU panel comprises of 200/1A current transformer, 630A vacuum circuit breakers, 630A load break switches and other electrical protection system. The power from inverter duty transformer is transferred to aforesaid RMU panel.

## 4.4 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed that 1.25MVA, 11kV/2x0.320kV, Dyn11yn11 three winding transformers have been used in the project. These inverter duty transformers step up the voltage to 11kV.

The two 1.25MVA inverter duty transformers output is connected to 11kV RMU panels located within inverter station. The energy from 11kV RMU panels of one or two Inverter stations is connected in ring philosophy. The combined 1/2/4MW power from one or two Inverter Stations is transmitted to 11kV switchgear panel over ring philosophy.



#### 4.5 11kV RMU Panel

The 11kV RMU panel comprises of inverter duty transformers incoming feeders, inverter station RMU panel incoming feeder and one outgoing feeder to nearest inverter station RMU panel or 11kV switchgear panel. Each RMU panel comprises of 200/1A current transformers, 630A vacuum circuit breakers, 630A load break switches, other electrical metering and protection system.

#### 4.6 11kV Main HT Panel

The 11kV main HT/switchgear panel comprises of inverter station incoming feeders and one outgoing feeder. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class, Core balance CT. All feeders have been provided with relay and metering unit. The 11kV main HT panel outgoing and incoming feeders are provided with instantaneous overcurrent and earth fault i.e. 50/50N and IDMT overcurrent & earth fault i.e. 51/51N protections. Furthermore, the incoming feeders are equipped with directional overcurrent (67) and directional earth fault (67N) protection relays. The 11kV outgoing feeder from main HT panel is provided with 0.5 class instrument transformers.

Power from 11kV switchgear panel is transmitted to 11/66kV outdoor Switchyard. Further power from 66kV Switchyard is evacuated to GETCO substation.

#### 4.7 Auxiliary Power Supply

SgurrEnergy had reviewed the electrical schematics shared for the projects to evaluate auxiliary system. One 200kVA, 11/0.433kV auxiliary transformer has been considered to cater the auxiliary loads. ACDB panels have been considered for load distribution to auxiliary loads.

#### 4.8 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are mounted within the panels as well as on individual structures.

Following the review of 11kV SLD and switchyard layout, SgurrEnergy observed that 11kV, 630A, 21kA/3sec, 1250A, 25kA/3sec VCB type circuit breaker and 66kV, 2000A, 31.5kA/3sec SF6 circuit breakers have been used in the project.

#### 4.9 Load break switch

Load break switches are used to isolate the equipment during load condition for maintenance.

Based on the review of 11kV SLD, SgurrEnergy observed 11kV, 630A load break switches switch has been used in the project.

#### 4.10 Isolators

Isolators are used to transfer load from one bus to another and also to isolate equipment for maintenance.

Based on the review of 66/11kV switchyard equipment layout, SgurrEnergy observed 72.5kV, 1250A, 31.5kA/3sec without earth switch, with one earth switch and with two earth switch type double break isolator have been used in the project.

#### 4.11 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the



values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.

The current transformers with accuracy class of 0.5/0.2S for metering and class 5P10/5P20 for protection has been used in 13MW<sub>AC</sub> solar PV plant. The potential transformers with accuracy class of 0.2/0.5 for metering and class 3P for protection has been used in the project.

#### 4.12 Surge Arrestors and Lightning Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes on the lines entering the substation. The apparatus most commonly used for this purpose is the surge arrester. Transformer is the costliest equipment in substation, and it is normal practice to install surge arrester near to the transformer. Additional surge arresters shall be provided either on bus or on various lines for protection of the equipment.

Following the review, SgurrEnergy observed that 60kV, 10kA, Class III surge arresters have been provided near Power Transformers and at incoming line. However, Switchyard SLD is not been provided to SgurrEnergy.

#### 4.13 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy will be provided at the medium voltage switchboards for each of the feeder sections. These meters will be digital with an RS 485 port for remote monitoring. These usually have an accuracy class of 0.5.

Similarly, HV side shall also be equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point shall be 0.2S. GETCO metering at 66kV has been considered at 66/11kV plant end switchyard with 0.2S class current transformers and 0.2 class potential transformers.



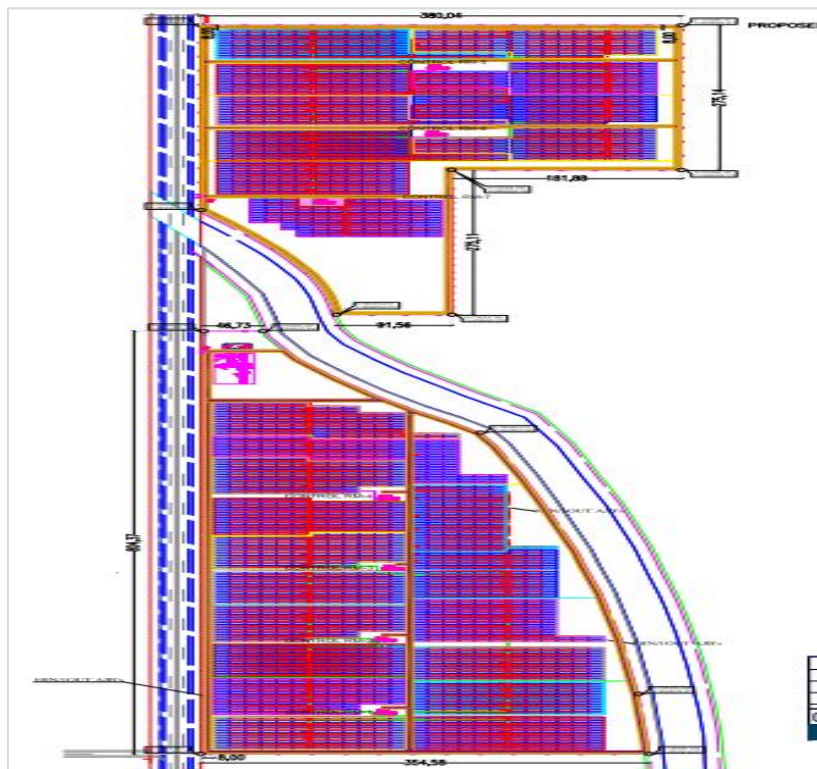


## 5 System Design Appraisal

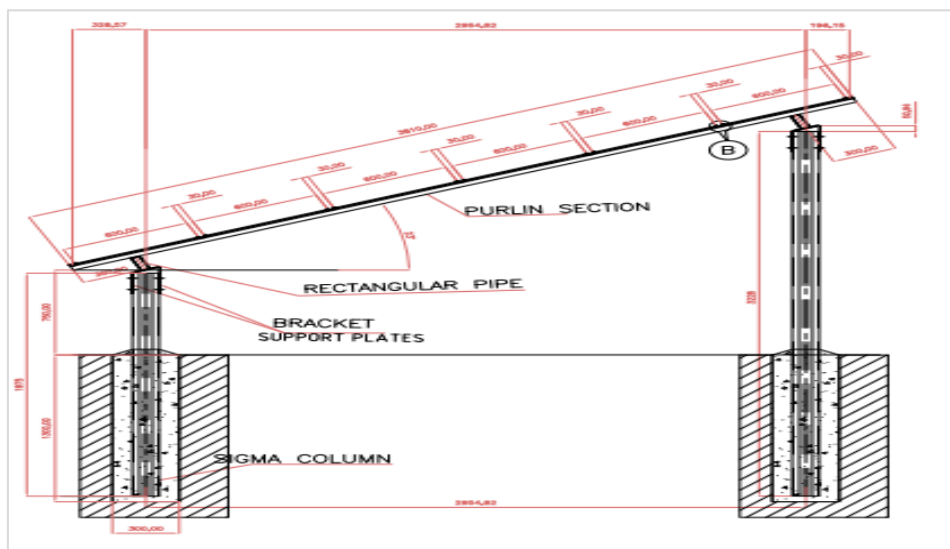
SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

## 5.1 Plant Layout Design

SgurrEnergy was provided with as built plant layout and electrical schematics. SgurrEnergy has verified the plant configuration with electrical schematics provided by the Client. The PV plant is First Solar (80W<sub>P</sub>) PV modules. The total DC installed capacity stands at 15.02MW<sub>P</sub>. The AC installed capacity stands at 13 MW<sub>AC</sub> with 26 inverters of capacity 500 kW each. Overall, 13 MW<sub>AC</sub> PV plant is illustrated below in the Figure 5-1. All the PV modules are orientated towards South.



**Figure 5-1: Plant layout of 13 MW<sub>AC</sub>**



**Figure 5-2: Side view of typical module mounting structure configuration**

The selected tilt for the 13 MW<sub>AC</sub> plant is 22°. The 13 MW<sub>AC</sub> plant is designed with a pitch of 6.80m.

10 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.16. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.

## 5.2 String Sizing

The plant layout provided by the Developer indicate Ten 80W<sub>p</sub> First Solar CdTe modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage ( $V_{OC}$ ) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum  $V_{OC}$  of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy in validating string configuration. Subsequent to calculating open circuit voltage ( $V_{OC}$  max), maximum power voltage ( $V_{mp}$  min) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 45°C and 11°C respectively for system design validation to be fair and representative for the PV plants' site.

The results of string sizing validation are presented in Table 5-1. Results indicate that  $V_{OC}$  max at the minimum ambient temperature is within the maximum system voltage of 1,000V for the selected Power One (PVI-Central-500-TL) inverters.

**Table 5-1: String Sizing for First Solar PV Modules**

Parameters	First Solar 80W <sub>p</sub>
PV module power (W <sub>p</sub> )	80
Modules per string	10
Inverters	Power one - 500 KW (PVI-Central-500-TL)
Maximum Open-circuit voltage ( $V_{OC}$ max) at minimum ambient temperature of 11°C	888V
Minimum power voltage ( $V_{mp}$ min) at maximum ambient temperature of 45°C	689V

## 5.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with First Solar and Power-one central inverter is presented in Table 5-2. SgurrEnergy has selected the highest rated First Solar module (80W<sub>p</sub>) their compatibility with Power-one inverter, as SgurrEnergy considers this to be representative for all the First Solar PV modules installed on site.





**Table 5-2: Inverter Compatibility with First Solar 80W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	First Solar FS-280 (80 W <sub>p</sub> )	
Modules per string	10	Acceptable
Strings per inverter	723	Acceptable
Maximum power, P <sub>mpp</sub> at STC (kW <sub>p</sub> )	580.00	Nominal power ratio is 1.16, this is within the inverter bus current carrying capacity.
Maximum power voltage, V <sub>mpp</sub> at STC (V)	713	Acceptable.
Maximum power current, I <sub>mpp</sub> at STC (A)	770.40	Acceptable
Open-circuit voltage, V <sub>oc</sub> at STC (V)	940	Acceptable.
Minimum MPP voltage at 45°C ambient temperature (V)	689	Acceptable: Inverter MPPT ranges 475 - 900V.
Maximum MPP voltage at 11°C ambient temperature (V)	737	Acceptable: Inverter MPPT ranges 475 - 900V.
Maximum open circuit voltage, V <sub>oc</sub> at 11°C (V)	888	Acceptable: Maximum inverter voltage 1000V.

Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.



## 6 Resource assessment

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SEI has sourced monthly horizontal plane irradiation data for the Project site from:

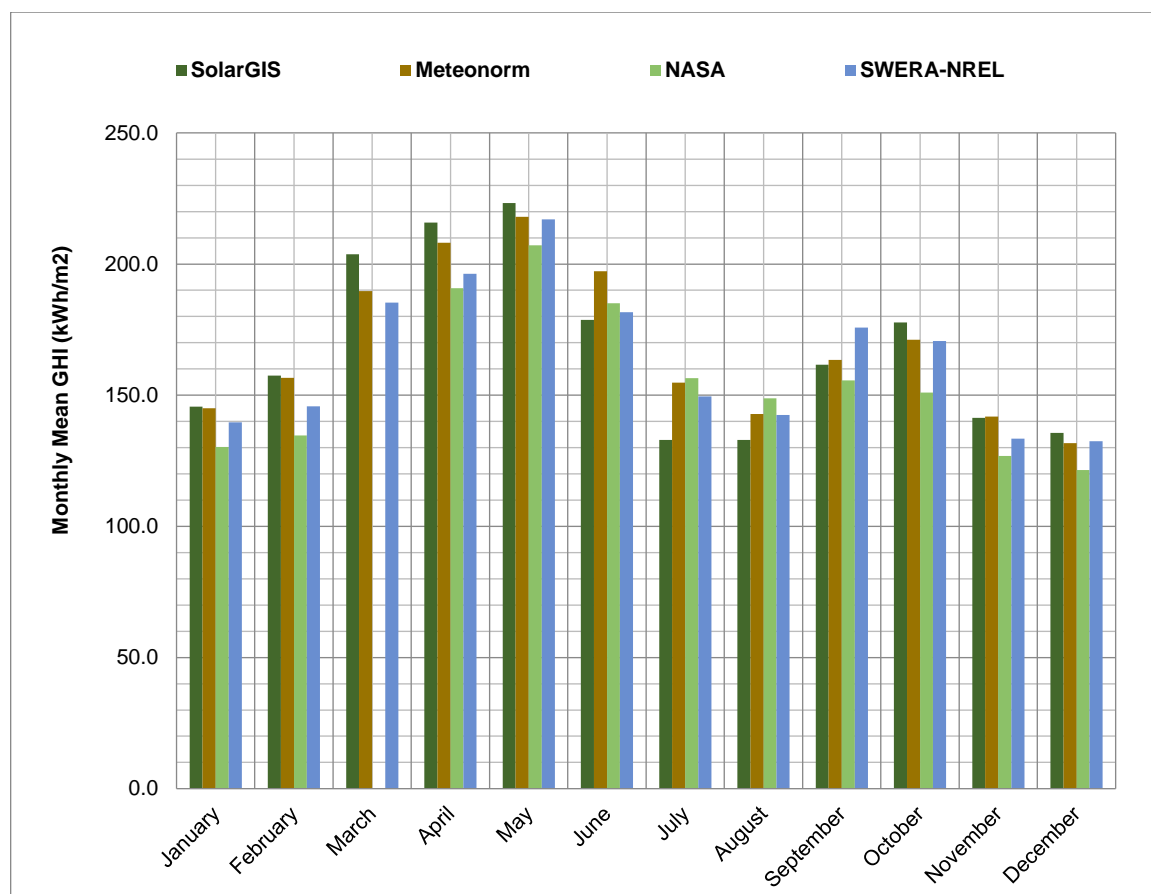
- **NASA's Surface Meteorology and Solar Energy data set**; holds satellite derived monthly data for a grid of 0.5° × 0.5° covering the globe for a thirty-four-year period (1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.



- The **METEONORM (version 7.2)** *global climatological database and synthetic weather generator*; contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **SolarGIS:** SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km x 4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by *IEA (International Energy Agency) SHC Collaboration Agreement, and EU FP6 project MESoR* in terms of bias and RMSE.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.

SEI has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS and, NREL (SWERA) data for the site. The comparison is graphically illustrated Table6-1





**Figure 6-1: Monthly Global Horizontal Irradiation**

**Table6-1: Comparison of Solar Irradiation Datasets for the site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	2,006.6
Meteonorm 7.2	14km × 14km	4.0%	2,020.4
NASA	55km × 55km	Unknown	1,708.3
NREL (SWERA)	40km × 40km	Unknown	1,970.2

The comparison of solar data for Project site location illustrated in Table6-1 indicates Meteonorm 7.2 dataset to give the highest irradiation levels. The next highest irradiation is given by SolarGIS followed by NREL (SWERA) and NASA.

The irradiation values given by Meteonorm 7.2 typically provide a combination of ground and satellite measured data. Meteonorm 7.2 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as 6.2% for the proposed site.

The NREL (SWERA) data illustrated has been obtained for a location approximately 11.86 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data.

The NASA-SSE data source provides purely satellite measured data for a grid covering 0.5° × 0.5° on the earth's surface and generally more suited for initial site selection.



The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also been compared with other data sources globally. The IEA (International Energy Agency) validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>8</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)
- Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 6%.

SEI is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 6.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 6-2 and shown graphically in Figure 6-2. Diffuse irradiation accounts for 42.42% of the total irradiation. Table 6-2 illustrates direct and diffuse daily irradiation on a horizontal plane for the proposed site. SolarGIS irradiation data is presented in Table 6-2.

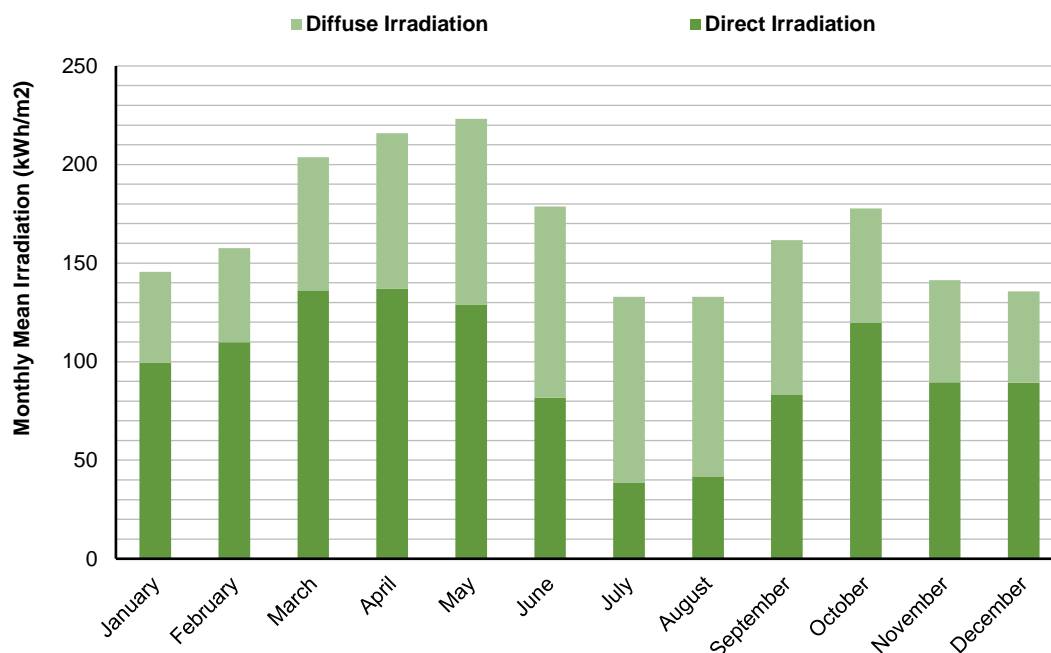
**Table 6-2: SolarGIS Irradiation Data for the Project site**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	145.6	46.2	7.3%
February	157.5	47.6	7.8%
March	203.7	67.6	10.2%
April	215.8	78.9	10.8%
May	223.2	94.2	11.1%
June	178.7	96.9	8.9%
July	132.9	94.2	6.6%
August	132.9	91.1	6.6%
September	161.6	78.3	8.1%

<sup>8</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>



Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
October	177.7	58.0	8.9%
November	141.4	51.9	7.0%
December	135.6	46.2	6.8%
<b>Annual Sum</b>	<b>2,006.6</b>	<b>851.2</b>	<b>-</b>



**Figure 6-2: Monthly Direct and Diffuse Irradiation on a horizontal plane for the project site**

## 6.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.0.17), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -6-3 represents the monthly GTI profile.

**Table -6-3: Monthly Global Tilted Irradiation Data**

Month	GTI (kWh/m <sup>2</sup> )
January	191.10
February	191.10
March	225.30
April	219.00
May	211.80
June	165.80
July	125.20



Month	GTI (kWh/m <sup>2</sup> )
August	129.90
September	170.80
October	208.70
November	178.20
December	179.30
<b>Annual Sum</b>	<b>2,196.20</b>

### 6.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 6-4 below. The average wind speed of 2.3 m/s was measured at 10m height from ground level for the proposed project site location.

**Table 6-4: Simulated Wind Speed for site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	1.5
February	1.6
March	1.9
April	2.7
May	3.8
June	3.8
July	3.5
August	3
September	2.2
October	1.3
November	1.1
December	1.3
<b>Yearly Average</b>	<b>2.3</b>

### 6.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.

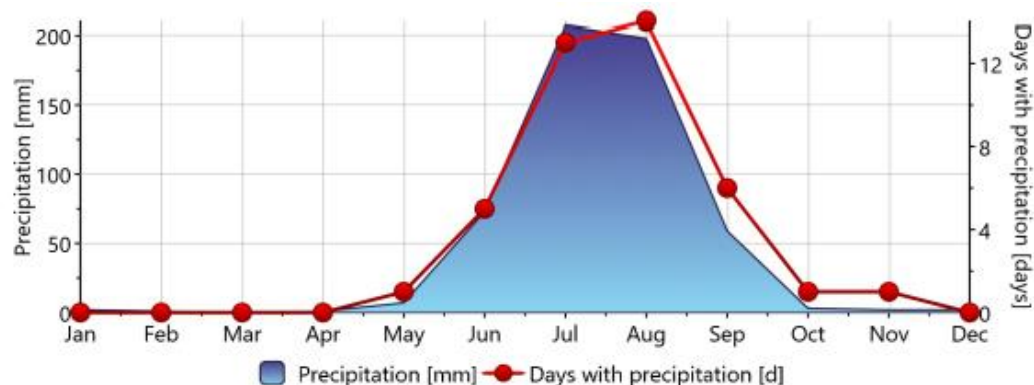


**Table 6-5: SolarGIS Temperature Data for Site (1999 – 2018)**

Months	Average Monthly Temperature (°C)
January	19.7
February	22.7
March	27.9
April	32.3
May	35.1
June	34.8
July	31.3
August	30.1
September	31.6
October	30.3
November	25.5
December	21.3
<b>Annual Average</b>	<b>28.6</b>

## 6.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.2 as illustrated in Figure 6-3. These figures show that the identified site is situated in a region that has marginal rainfall.

**Figure 6-3 Meteonorm Predicted Precipitation for the site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

Frequency of module cleaning depends on the rainfall frequency and the prevalence of dust and pollution in the local vicinity. Typical cleaning techniques include water cleaning, dry brushes or vehicle-based mechanical cleaning.

The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 1.64%<sup>9</sup> has been considered by considering cleaning frequency of twice a month.

<sup>9</sup> The soiling loss considered in simulation is 2.0% and spectral correction factor (applicable for first solar modules only) is applied to the soiling loss in PVSyst to get the corrected energy yield estimate. The soiling after applying the spectral correction factor is 1.64%.





## 7 Energy Yield Analysis

SgurrEnergy has computed the annual energy yields for the 13 MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

Parameter	Description
Modules	First Solar 80 Wp, (FS-280)
Inverters	Power-One – (PVI-Central-500-TL) 500 kW <sub>ac</sub>
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	15.0

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 7.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in Table 7-1 below.

**Table 7-1: Description of Energy Yield Losses**

Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.



Loss	Description
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 30MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 7.2 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 30MW<sub>p</sub> solar PV Plant with First Solar PV modules and Power One central inverters. Table 7-2 summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.



**Table 7-2: Energy Yield for the 13MW<sub>AC</sub> Solar PV Plant**

Parameters	Description
PV Module Technology	Thin Film
DC Capacity (MW <sub>p</sub> )	15
AC Capacity (MVA)	13
Contracted Capacity (MW)	13
P <sub>NOM</sub> Ratio	1.15
Tilt (°)	22
Pitch (m)	6.80
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	2006.60
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	2196.32
Transposition Factor	1.09
<b>Losses</b>	
Horizon Shading	0.00%
Incident Irradiation Below Threshold	0.00%
Near Shading	2.09%
Incident Angle	2.54%
Soiling	1.64%
Low Irradiance	1.97%
Module Temperature	9.61%
Electrical Shadings	0.03%
Module Quality	-2.30%
First year Degradation	0.00%
Module Mismatch	1.00%
DC Ohmic	0.78%
Inverter Performance	1.72%
Availability	1.00%
AC Ohmic	0.60%
Transformer (LV/MV)	1.02%
Transformer (MV/HV)	0.50%
Transmission Line	0.00%
Auxiliary Consumption	0.96%
Curtailment	
<b>Total Annual Loss Factor</b>	<b>0.804</b>
<b>First Year P50 Energy Yield (MWh/annum)</b>	<b>26,543.854</b>
<b>Ninth Year P50 Energy Yield (MWh/annum)</b>	<b>24,493.20</b>
<b>Ninth Year Specific Yield (kWh/kW<sub>p</sub>)</b>	<b>1629.72</b>
<b>Ninth Year CUF on AC Installed Capacity</b>	<b>21.51%</b>
<b>Ninth Year CUF on Contracted Capacity</b>	<b>21.51%</b>



Parameters	Description
Ninth Year CUF on DC Installed Capacity	18.60%
Ninth Year Performance Ratio	74.20%

Graphical representation of the monthly generation, performance ratio and CUF for 13 MW<sub>AC</sub> evaluated is illustrated graphically in the Figure 7-1.

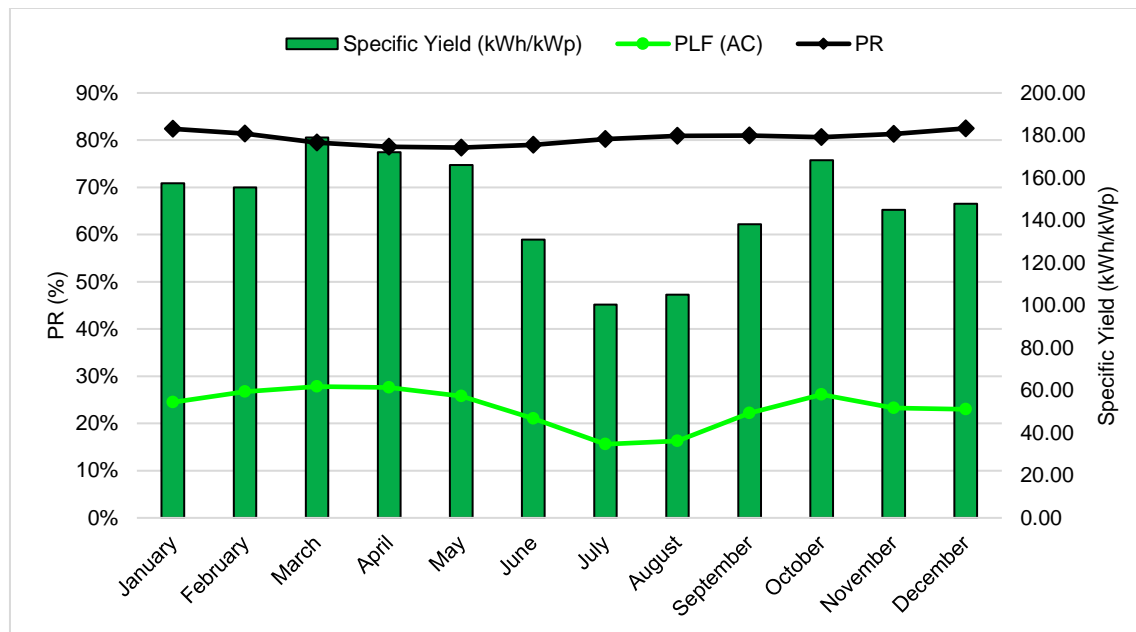


Figure 7-1: Monthly Energy Yield for 13MW<sub>AC</sub>

### 7.3 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 7.3.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

#### 7.3.2 Inter – Annual Variation in the Solar Resource

Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.

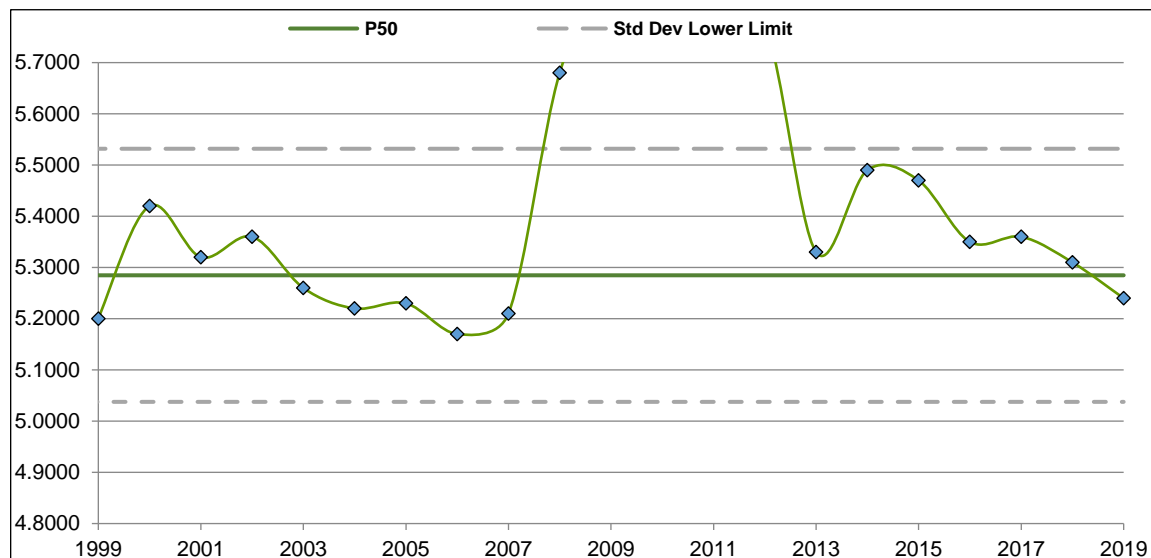
The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database for the proposed site location which is used to estimate the standard deviation of variation



in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 7-3.

**Table 7-3: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	4.68



**Figure 7-2: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in Figure 7-2.

SgurrEnergy uses a coefficient of variation of 4.68% to quantify the inter-annual variation in the solar resource.

### 7.3.3 Modelling Uncertainty

The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

### 7.3.4 Total Uncertainty (P75 and P90 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.

**Table 7-4: Life Cycle P50, P75 and P90 Generation Prediction for 13 MW<sub>AC</sub>**

<b>Year</b>	<b>Annual P50 Generation (MWh/annum)</b>	<b>P75 Generation Prediction<sup>10</sup></b>	<b>P90 Generation Prediction<sup>11</sup></b>
9	24,493.20	23,472.64	22,554.11

<sup>10</sup> The P75 values have been calculated over 10-year averages

<sup>11</sup> The P90 values have been calculated over 10-year averages



Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>10</sup>	P90 Generation Prediction <sup>11</sup>
10	24,248.27	23,237.92	22,328.57
11	24,088.23	23,084.55	22,181.20
12	23,929.25	22,932.19	22,034.81
13	23,771.31	22,780.84	21,889.38
14	23,614.42	22,630.48	21,744.91
15	23,458.57	22,481.12	21,601.39
16	23,303.74	22,332.75	21,458.82
17	23,149.94	22,185.35	21,317.19
18	22,997.15	22,038.93	21,176.50
19	22,845.37	21,893.47	21,036.73
20	22,694.59	21,748.97	20,897.89
21	22,544.80	21,605.43	20,759.97
22	22,396.01	21,462.83	20,622.95
23	22,248.19	21,321.18	20,486.84
24	22,101.36	21,180.46	20,351.62
25	21,955.49	21,040.67	20,217.30



## 8 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 1.0% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) till ten years from COD. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Owner, SgurrEnergy understands that the SSEGPL solar PV plant was commissioned in 17<sup>th</sup> April 2012. SgurrEnergy was provided with plant, grid availability and irradiation records from June 2016 to April 2021<sup>12</sup> for the solar PV plant.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from June 2016 to April 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Owner.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Owners control.

The monthly records of the grid availability from June 2016 to April 2021 have been graphically illustrated in Figure 8-1 below.

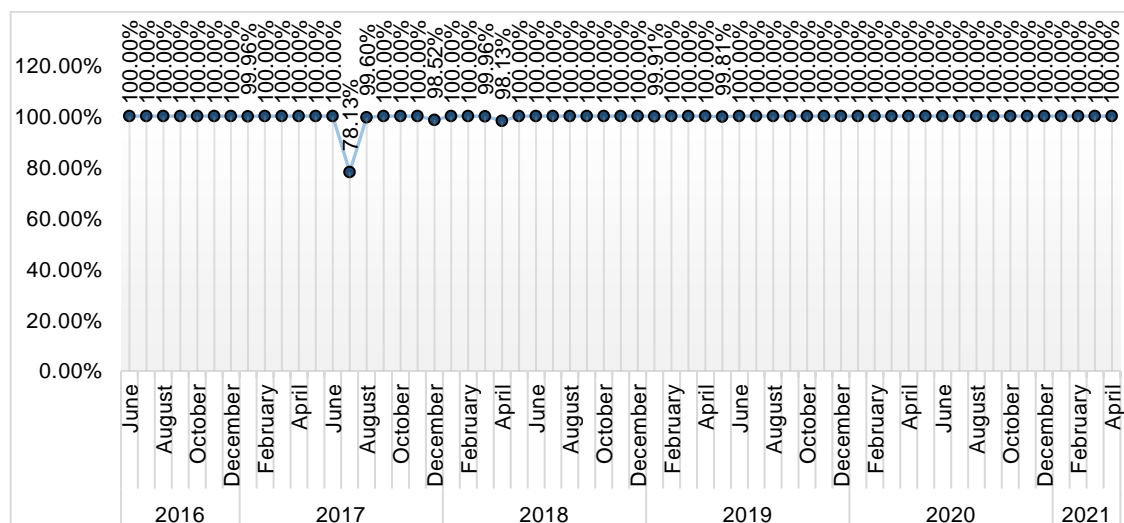


Figure 8-1: Grid Availability

<sup>12</sup> SgurrEnergy was provided with both the plant and grid availability records until April 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.



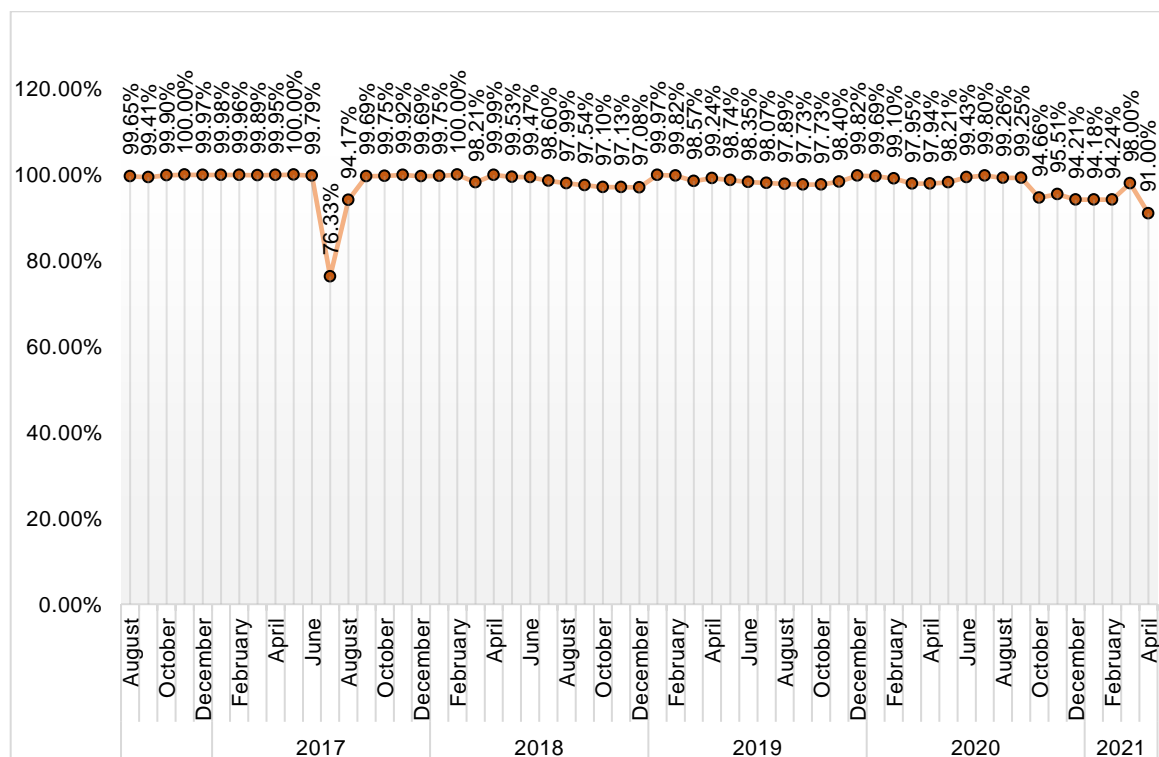
From the above illustration, SgurrEnergy notes that the unavailability loss experienced due grid anomalies are minimal over the operational period and are within expected range. However, for the month of July 2017 the unavailability due to grid was high when compared to other months. The downtime due to grid unavailability was close to 100% during the remaining months for which the grid availability was noted to be exceeding 98.52%.

Overall the average grid availability experienced on site for the operational period was calculated to be 99.56%

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the SSEGPL solar PV plant is graphically illustrated below in Figure 8-2.



**Figure 8-2: Plant Availability**

Based on the above illustrations, SgurrEnergy notes the plant availability for the SSEGPL solar PV plant is notably inconsistent for all the months ranging between 76.33% to 100%. The average plant availability is noted to be 98.06% which is considered to be within the expected range.

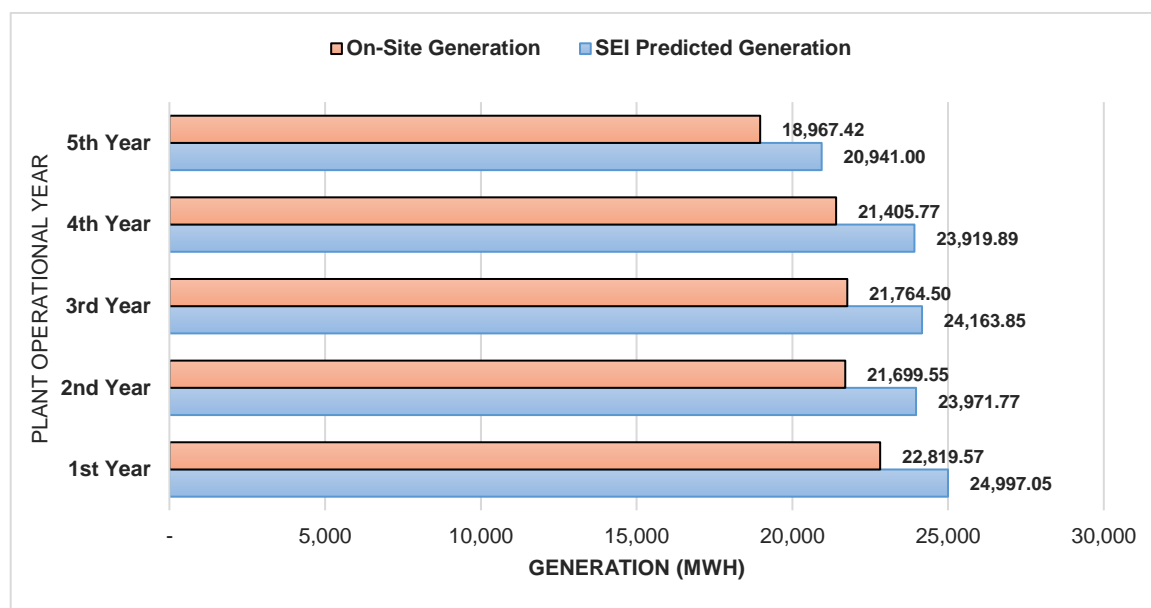
### 1.2 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Client. To make the operational energy yield predictions more representative, SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Client. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Client.





The yearly comparison of the generation data is illustrated below in Figure 8-3.



**Figure 8-3: Generation Comparison**

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 8-1

**Table 8-1: PV Plant Performance – SSEGPL**

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>13</sup> (%)
June 2016 -May 2017	24,997.05	22,819.57	-8.71%
June 2017 -May 2018	23,971.77	21,699.55	-9.48%
June 2018 -May 2019	24,163.85	21,764.50	-9.93%
June 2019 -May 2020	23,919.89	21,405.77	-10.51%
June 2020 -April 2021	20,941.00	18,967.42	-9.42%
<b>Cumulative Period</b>	<b>117,993.56</b>	<b>106,656.81</b>	<b>-9.61%</b>

Based on the above comparison, SgurrEnergy notes that the PV plant is generating lower than the expected yield. However, SgurrEnergy considers that such variations in the energy yield can be attributed to higher irradiation level experienced on the Project site. The irradiation levels significantly impact the actual generation from the PV plant as the system losses may vary significantly due to slight change in the irradiation.

In order to understand the deviation in the irradiation pattern, SgurrEnergy has compared the monthly incident irradiation data provided by the Client with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation.

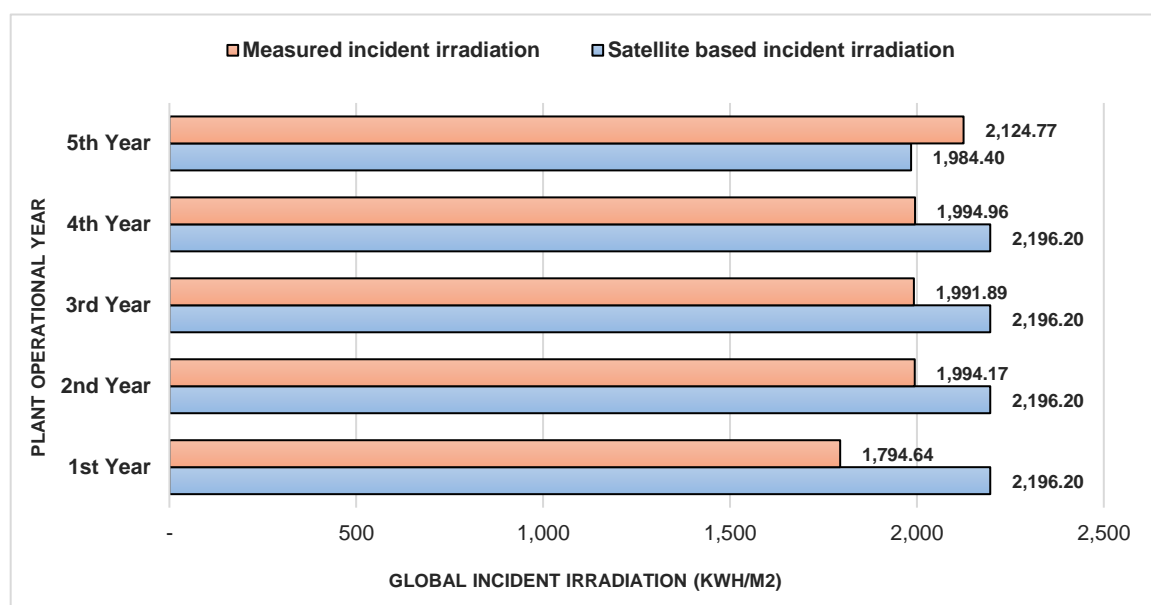
<sup>13</sup> Positive values indicate higher generation, while negative values indicate lower generation



The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 8-4.

**Table 8-2: Irradiation Comparison– SSEGPL**

PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>14</sup> (%)
June 2016 -May 2017	2196.20	2124.77	-3.25%
June 2017 -May 2018	2196.20	1994.96	-9.16%
June 2018 -May 2019	2196.20	1991.89	-9.30%
June 2019 -May 2020	2196.20	1994.17	-9.20%
June 2020 -April 2021	1984.40	1794.64	-9.56%
<b>Cumulative Period</b>	<b>10,769.20</b>	<b>9,900.43</b>	<b>-8.07%</b>



**Figure 8-4: Irradiation Comparison**

Based on the above illustration, it is observed that the overall recorded generation is approximately 9.61% lower than the generation predicted on site. It has also been observed that the recorded irradiation is approximately 8.07% lower than the predicted irradiation.

Based on the comparative analysis, the drop-in in generation can be attributed to the drop-in irradiation during the period of evaluation.

<sup>14</sup> Positive values indicate higher irradiation, while negative values indicate lower irradiation



## 9 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar pv plants as having a lifetime of 25-40 years<sup>15</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>16</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the pv plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement.

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<sup>15</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>16</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>



Virescent Infrastructure

5MW(AC) SSEPL Solar PV Plant  
Sindicatum Solar Energy Private Limited  
Technical Assessment Report

July 2021



**Report Details**

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**Amendment Records**

Revision Number	Date	Purpose of Revision	Summary of Amendments
B1	23 June 2021	Draft Issue	-
B2	28 June 2021	Minor updates	-
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B4	6 <sup>th</sup> July 2021	Minor updates	-
B5	15 <sup>th</sup> July 2021	Minor updates	-

SF/04/023

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## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 5MW<sub>AC</sub> SSEPL plant. The summary of the technical assessment is captured in the below table.

**Table 1-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	Review presented in Section 2
2	PV Module	<p>According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of First Solar, assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.</p> <p>Further, the warranty document was not provided for review, SgurrEnergy is unable to comment on warranty terms and conditions and suggests getting clarity from the manufacturer regarding the warranty offered for the PV modules. Regarding the certifications, the complete set of certifications of the installed modules was not made available for SgurrEnergy's review. Since the solar PV plant is already operational, SgurrEnergy raises no major concern regarding the unavailability of IEC certifications.</p>
3	Inverter	<p>SgurrEnergy has conducted review of the SMA's Sunny Central-630CP central inverter. Since the solar PV plant is operational, SgurrEnergy raises no major concern regarding the unavailability of the complete set of IEC certificates for SMA's Sunny Central-630CP central inverter used for the project. SMA offers a product warrant of 5 years which is in line with the current industry standards.</p> <p>In conclusion, SMA can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters. SgurrEnergy raises no major concern regarding the use of SMA inverters for the Project.</p>
4	Inverter and Auxiliary Transformer	The auxiliary transformers (100kVA) and inverter transformer (1250kVA) used within the project are manufactured by Shilchar Technologies Limited. The manufacturer has good track record of supplying transformers for solar application throughout the. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.
5	String Sizing	The V <sub>OC</sub> does not exceed the inverter input voltage for the site, and therefore, SgurrEnergy considers the number of modules in series to be acceptable for the PV Project.
6	Resource Assessment	For resource analysis, SgurrEnergy has compared various satellite datasets. For the satellite databases, SgurrEnergy has compared Meteonorm 7.3, NASA, SWERA and SolarGIS data to



Sr. No.	Parameter	Comment														
		find the most suitable solar resource for long-term energy yield prediction. Owing to low uncertainty and high resolution, SgurrEnergy considers SolarGIS dataset to be the most representative satellite database among all the satellite databases for long-term energy yield assessment.														
7	Operational Analysis and Generation Comparison	Review presented in Section 8														
8	Allied Components and Systems	<p>The 5MW<sub>AC</sub> solar PV Plant is designed with 80W<sub>P</sub> and 115W<sub>P</sub> <i>make</i> solar PV modules and 625kW SMA inverters. Modules are interconnected to form a string of 15 and 11 modules for 80W<sub>P</sub> and 115W<sub>P</sub> modules respectively. Five such strings forms a single output that feeds as a single input to the 16 input combiner boxes. Eight string combiner boxes are further connected to the inverter.</p> <p>The 5MW<sub>AC</sub> solar PV plant has been configured with 8 SMA 625kW central inverters and two inverter stations. Each inverter station is of 2.5MW<sub>AC</sub> capacity contain four inverters of 625kW capacity, which is further connected to 0.315/0.315/33kV three-winding, 1.25MVA transformer, that steps up the voltage up to 33kV for all inverter stations. The power from the HV side of the 33kV inverter transformer is transferred to 33kV HT panel.</p> <p>The output power of each 33kV HT panel is connected to 33kV main HT panel located in the main control room. Further power from main control room is fed to 33kV outdoor switchyard.</p> <p>Power from 33kV switchyard is evacuated to the substation situated at a distance of 5.5km from the project site at 33kV voltage level.</p>														
9	Energy Yield Assessment	<p>Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for third year of plant operation for the 5 MW<sub>AC</sub> PV plant.</p> <table><tr><td>Global Horizontal Irradiation (kWh/m2)</td><td>2044.20</td></tr><tr><td>Global Inclined Irradiation (kWh/m²)</td><td>2253.77</td></tr><tr><td>First Year P50 Energy Yield (MWh/annum)</td><td>10,536.692</td></tr><tr><td>Tenth Year P50 Energy Yield (MWh/annum)</td><td>9,625.45</td></tr><tr><td>Tenth Specific Yield (kWh/kW<sub>p</sub>)</td><td>1676.90</td></tr><tr><td>Tenth Performance Ratio (PR)</td><td>74.40%</td></tr><tr><td>Tenth PLF on Contracted Capacity (5MW<sub>AC</sub>)</td><td>21.80%</td></tr></table>	Global Horizontal Irradiation (kWh/m2)	2044.20	Global Inclined Irradiation (kWh/m²)	2253.77	First Year P50 Energy Yield (MWh/annum)	10,536.692	Tenth Year P50 Energy Yield (MWh/annum)	9,625.45	Tenth Specific Yield (kWh/kW <sub>p</sub> )	1676.90	Tenth Performance Ratio (PR)	74.40%	Tenth PLF on Contracted Capacity (5MW <sub>AC</sub> )	21.80%
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Tenth PLF on Contracted Capacity (5MW <sub>AC</sub> )	21.80%															



## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
m	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon



MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation



## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 68MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of four projects, as presented within Table 1-1.

**Table 1-1: Project Key Summary**

Project Name	SSEPL – 5MW <sub>AC</sub>	SSEGPL – 13MW <sub>AC</sub>	PLG – 20MW <sub>AC</sub>	USUPL – 30MW <sub>AC</sub>
<b>Site Location</b>	25.52°N, 72.85°E, Tiwari, Jodhpur, Rajasthan, India	23.9128°N, 71.2183°E, Santalpur, Patan, Gujarat, India	23.9°N, 71.5°E, Dahisar, Patan, Gujarat, India	25°18'52.79"N, 79°25'2.49"E, Devgaon, Mahoba, Uttar Pradesh, India
<b>Owner</b>	Sindicatum Solar Energy Private Limited (SSEPL)	Sindicatum Solar Energy Gujarat Private Limited (SSEGPL)	PLG Photovoltaic Private Limited (PPPL)	Universal Saur Urja Private Limited (USUPL)
<b>DC / AC Capacity</b>	5.745MW <sub>P</sub> / 5MW <sub>AC</sub>	15MW <sub>P</sub> / 13MW <sub>AC</sub>	20MW <sub>P</sub> / 20MW <sub>AC</sub>	36.98MW <sub>P</sub> / 30MW <sub>AC</sub>

This report presents the evaluation of the 5MW<sub>AC</sub> solar PV plant developed by Sindicatum Solar Energy Private Limited (SSEPL). The Solar PV plant under evaluation is located in Tiwari village, Jodhpur district in Rajasthan state. The purpose of this report is to provide a technical appraisal of PV plant under evaluation.

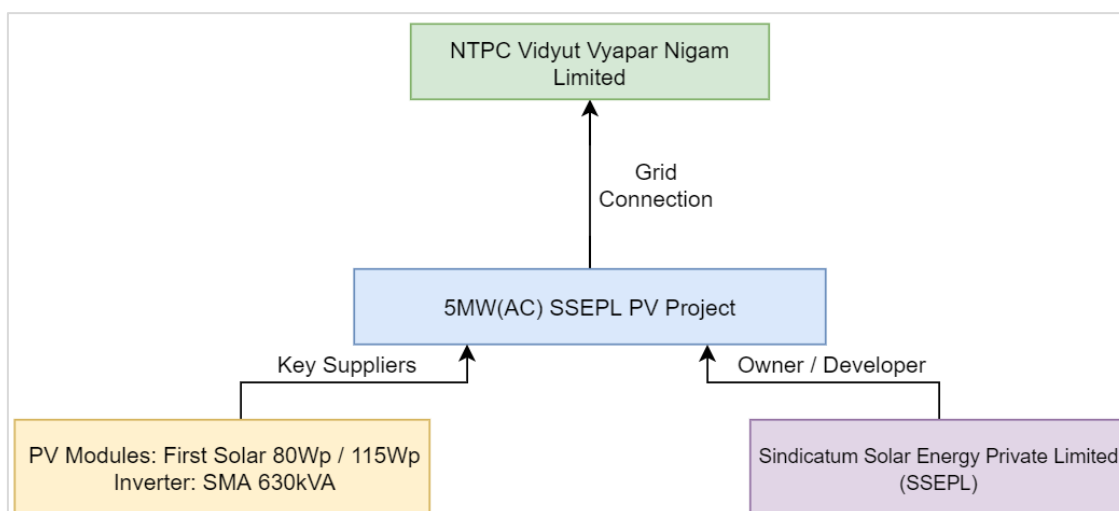
The report focuses on the following key parameters:

- System Design.
- Major Components.
- Engineering Design.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Plant Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project and is based on information made available by the Client through online data room. The main Project characteristic is summarised in Table 1-2.

Figure 1-1 illustrates the project structure indicating key project participants for the 5MW<sub>AC</sub> solar PV plant.





**Figure 1-1: Project Structure for 5MW<sub>AC</sub>Solar PV Plant**

**Table 1-2: Project Key Summary**

Project Information	
<b>Project Name</b>	5MW <sub>AC</sub> SSEPL solar PV plant
<b>Location</b>	Tiwari, Jodhpur, Rajasthan
<b>Developer</b>	Sindicatum Solar Energy Private Limited
<b>DC/ AC capacity</b>	5MW <sub>AC</sub> PV Plant – 5.745MW <sub>P</sub> / 5MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: First Solar Inverters: SMA
<b>MMS Configuration</b>	Fixed Tilt: 20°, Azimuth: 0°
<b>Commissioning Status</b>	Commissioning for 5MW <sub>AC</sub> PV Plant was achieved on 15 October 2011.





## 2 5MW<sub>AC</sub> Solar PV Plant Overview

The project site lies around the coordinates 26.52N, 72.85 E. Satellite imageries of 5MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1. The Owner has leased approximately 37.06 acres of land for the project. The Project site is located near the *Tiwari* village, in *Jodhpur* district of Rajasthan.

Project is contracted for generating 5MW<sub>AC</sub> power; SgurrEnergy therefore interprets 5MW<sub>AC</sub> as the maximum AC installed capacity for the solar PV plant.



**Figure 2-1: Satellite image of 5MW<sub>AC</sub> plant**

### 2.1 5MW<sub>AC</sub> Project Summary

Solar PV plant is modular in nature; therefore, SSEPL 5MW<sub>AC</sub> solar PV plants is implemented by adopting modularity in designs. 1.26MW<sub>AC</sub> is the typical inverter stations considered for implementing SSEPL 5MW<sub>AC</sub> solar PV plant.

Table 2-1 presents the summary of 5MW<sub>AC</sub> PV plant

**Table 2-1: Summary of 5MW<sub>AC</sub> Plant Configurations**

General	
PV Module Technology	Cd-Te Thin Film
Inverter Technology	Central Inverters
Installed DC Peak Capacity (MW <sub>p</sub> )	5.745
Installed AC Capacity (MW)	5.040
Mounting Type	Fixed Tilt
Tilt Angle (°)	20°
Pitch (m)	6.01





General	
PV Modules	
PV Module Manufacturer	First Solar
Model	FS-380, FS-4115
Wattage (W <sub>p</sub> )	80W <sub>p</sub> / 115W <sub>p</sub>
Number of Modules per String	11/15
Inverter	
Inverter Manufacturer / Model	SMA / Sunny Central 630CP
Inverter Nominal AC Output	630kW
Number of Inverters	8
Mounting Structure	
Mounting Structure Details (rows x columns)	5 x 11, 5 x 15
Orientation of Modules	Landscape

The 10MW<sub>AC</sub> plant is implemented with a total of four (4) inverter stations of capacity 1.26MW<sub>AC</sub> which comprising of three winding transformers to accommodate 2 x 630kVA inverters, taking the individual inverter station size to 1.26MW<sub>AC</sub>. Inverter station is comprising of a physical block connecting 2.4MW<sub>p</sub> of installed photovoltaic array.

The output of the 1.26MW<sub>AC</sub> inverter stations are connected to 0.400/0.400/33kV three winding transformer of 1.25MVA for stepping up the voltage to 33kV.

The medium voltage 33kV output of the inverter stations are placed in main control room (MCR), these are combined to form a solar PV plant of 5MW<sub>AC</sub>. The 33kV output is evacuated at the HT switchyard located in the plant premises.

The power generated by the SSEPL 5MW<sub>AC</sub> PV plant is fed to *Tinwari* substation located approximately 5.5km from the Project site. The point of interconnection is at the *Tinwari* substation.



### 3 Review of Major plant components

SgurrEnergy has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions. SgurrEnergy has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions.

#### 3.1 PV modules – First Solar

SgurrEnergy has conducted a technical review of the supplier and module specification with regards to their suitability for their use in the Projects under evaluation.

##### 3.1.1 Company Profile

First Solar Inc. is a USA based (Tempe, Arizona) producer of Cadmium Telluride (CdTe) thin-film modules and has more than 6,400<sup>1</sup> employees worldwide with manufacturing facilities in the USA, Malaysia, and Vietnam. Formed in 1999 the company launched production of commercial products in 2002 and was the first company to integrate thin film solar module technology into high-volume, low-cost production.

According to information available on public domain, First Solar is committed to providing a commercially attractive recycling solution for PV power plant and module owners to help them meet their module end-of-life (EOL) obligation simply, cost-effectively and responsibly.

First Solar has received the following certifications at all of its manufacturing facilities; ISO 14001:2015 environmental management systems certification, ISO 9001:2015 quality management systems certification, and ISO 45001:2018 certification for Occupational Health and Safety Management Systems.

First Solar thin film modules are used in ground-mounted and commercial rooftop applications ranging from a few kilowatts to tens of megawatts in size.

##### 3.1.2 Experience and track record

First Solar modules have global solar PV installed capacity of 633.7GW. First Solar modules have more than 1.8GW PV modules have installed capacity and nearly 150MW capacity is under operation in India<sup>2</sup>. Figure 3-1 illustrates the installed capacity of first-solar modules in India.

---

<sup>1</sup>[http://www.firstsolar.com/-/media/First-Solar/Documents/Corporate-Collaterals/FS\\_Corporate\\_Factsheet.ashx](http://www.firstsolar.com/-/media/First-Solar/Documents/Corporate-Collaterals/FS_Corporate_Factsheet.ashx)

<sup>2</sup> <https://www.firstsolar.com/en-IN/PV-Plants/Project-Development>





**Figure 3-1: First-solar modules installed in India.**

Few of the commissioned solar power plants using First Solar modules are listed in Table 3-1

**Table 3-1: Track record of First Solar Modules**

Sr. No.	Project	Location	Capacity (MW)	Installation Year
1	Hindupur Solar Park	Andhra Pradesh India	40.0	2016
2	Kodangal Solar Park	Telangana State India	10.0	2016
3	Mahabubnagar Solar Park	Telangana State India	10.0	2015
4	Polepally Solar Park	Telangana State India	25.0	-
5	Karoor Solar Park	Telangana State India	15.0	2016
6	Marikal Solar Parks	Telangana State India	10.0	2015
7	Hindupur Solar Park	Andhra Pradesh, India	40.0	2016



Sr. No.	Project	Location	Capacity (MW)	Installation Year
8	Topaz Solar farm	USA	550.0	-
9	Agua Caliente	USA	290.0	-
10	Copper Mountain 1	USA	48.0	-
11	Greenough River	Australia	10.0	-
12	Phalodi	Rajasthan, India	50.0	-
13	Dewa Solar plant	UAE	13.0	-

SgurrEnergy considers First solar to have an acceptable track record in delivering PV modules to PV projects worldwide.

### 3.1.3 Main Technical Characteristics

First Solar FS-380 and FS 4115 modules of 80W<sub>P</sub> and 115W<sub>P</sub> capacity respectively have been used for the Project. The shortlisted modules have a temperature coefficient (P<sub>max</sub>) of -0.25%/°C rise in temperature. This temperature coefficient is in line with SgurrEnergy's expectation for thin film. The technical characteristics of FS-380 and FS 115 are presented in the Table 3-2

**Table 3-2: First Solar PV Module Technical Characteristics**

Specifications	FS-380; 80W <sub>P</sub>	FS 4115-3;115W <sub>P</sub>
Technology	Thin Film	Thin Film
Nominal power (P <sub>MPP</sub> )	80W <sub>P</sub>	115W <sub>P</sub>
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	48.5	69.3
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	1.65	1.66
Open circuit voltage (V <sub>OC</sub> )	60.8	87.6
Short circuit current (I <sub>SC</sub> )	1.88	1.83
Maximum System Voltage	1,000	1,500
Dimensions (length × breadth × width) (mm)	1200 × 600 × 6.8	1200 × 600 × 6.8
Module area (m <sup>2</sup> )	1200 × 600 × 6.8	1200 × 600 × 6.8
Weight (kg)	1200 × 600 × 6.8	1200 × 600 × 6.8
Temperature coefficient at P <sub>MAX</sub>	-0.25%/°C	-0.28%/°C
Maximum reverse current	3.5A	4.0A
Product warranty	10 years	10 years
Power output guarantee	25 years	25 years
<i>Module technical characteristics are given at STC (1,000W/m<sup>2</sup> irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet)</i>		

Overall, the module characteristics can be considered to be in line with market standard.



## NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>3</sup> characteristics of selected FS-380; 80W<sub>P</sub> and FS-4115-3 ;115W<sub>P</sub> modules are given in Table 3-3 relate to more realistic operating conditions compared to STC. It is impacted by the module materials used as well as the packing density of module materials. The NOCT for the module is 45°C. This is comparable with other manufacturers and demonstrates the module is effective at heat dissipation.

**Table 3-3: PV Module NOCT Characteristics – First Solar Modules**

Model	FS-380	FS-4115
Maximum Power (P <sub>MAX</sub> )	60W <sub>P</sub>	115W <sub>P</sub>
Maximum Power Voltage (V <sub>MP</sub> )	45.5	64.9
Maximum Power Current (I <sub>MP</sub> )	1.32	1.34
Open Circuit Voltage (V <sub>OC</sub> )	56.5	82.7
Short circuit current (I <sub>SC</sub> )	1.54	1.48

### 3.1.4 Certification of Modules

The modules are manufactured in an automated facility certified to ISO9001, ISO14001 and OHSAS18001. SgurrEnergy has summarised the certification mentioned in the datasheet provided for the module as below in Table 3-4.

**Table 3-4: Certification for PV Module**

Sr. No.	Certification	Description
1	IEC 61215 (Edition 2)	Quality and design requirements
2	IEC 61646	Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval
3	IEC 61730 (Edition 1/2)	PV module safety qualifications

It is common for PV modules to hold the design, performance and safety certifications based on IEC prescribed testing methods. However, complete set of certifications of the installed modules was not made available for SgurrEnergy's review. Since the solar PV plant is already operational, SgurrEnergy raises no major concern regarding the unavailability of IEC certifications.

### 3.1.5 Warranty

The warranty document is essentially required to understand the terms and conditions and also the warranted power performance values. Although the Client has not provided the warranty documents for review, however, referring to the datasheet provided, SgurrEnergy understands that the specified modules are provided with two forms of warranty; a 10-year Limited Product Warranty and a 25-year Limited Power Output Warranty. Both warranties are described in the sections below.

<sup>3</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C



### 3.1.5.1 Product Warranty

First solar provides a limited product warranty of 10 years. During this period the modules shall be free from defects in materials and workmanship under normal use, installation, operation and service for a period of ten years.

SgurrEnergy considers ten-year product warranty provided by First Solar to be in line with the current industry standard.

### 3.1.5.2 Linear Power-Output Warranty

First solar warrants that the modules will not experience a power loss of greater than 10% during the first ten (10) years and 20% during twenty-five (25) years subject to the terms and conditions mentioned in the warranty document.

Since the warranty document was not provided for review, SgurrEnergy is unable to comment on warranty terms and conditions and suggests getting clarity from the manufacturer regarding the warranty offered for the PV modules.

## 3.2 Inverters- SMA

The Developer has utilized Sunny Central-630CP capacity central inverter for the project under evaluation.

### 3.2.1 Company background

SMA Solar Technology AG (System, Mess and Anlagentechnik) is a German solar energy equipment supplier founded in 1981 and headquartered in Niestetal, Northern Hesse, Germany. The company is one of the leading global specialists in photovoltaic system technology.

The company employs more than 3,000 people and has global presence in 18 countries. Since 2008, SMA has been listed on the Prime Standard of the Frankfurt Stock Exchange (S92). As of December 2020, the company has approximately 1,500 patents and utility models under its name. The company has more than 100GW installed PV system technology in more than 190 countries.<sup>4</sup>

SMA ranked 3<sup>rd</sup> in global solar inverter makers by increasing its market share in 2019 to 11% (as compared to 9% in 2018) generating a total revenue of €915 million.<sup>5</sup>

### 3.2.2 Track Record

Few of the noteworthy installation of SMA inverters globally are listed in Table 3-5.

**Table 3-5: Inverter Global installations**

Location	Capacity (MW)
Gannawarra Solar Farm, Australia	60.00
Kagoshima, Japan	70.00
Catalagan, Philippines	63.30
Tarlac City, Philippines	50.00
Sant Carlos City, Philippines	45.00
Kalkbut, South Africa	75.00

<sup>4</sup> <https://www.sma-india.com/>

<sup>5</sup> <https://www.pv-magazine.com/2020/02/07/sma-reduced-operating-losses-in-2019/>



Location	Capacity (MW)
Rawanda, East Africa	8.50
Kayes, Mali	50.00
Berden, UK	64.00
Niestetal, Germany	00.75
Wellingborough, UK	33.75
Antalya, Turkey	02.20
Templin, Germany	128.00
Palladam, Tamil Nadu, India	01.00
Nagaur, Rajasthan, India	40.00

### 3.2.3 Technical Characteristics

The technical specifications of SMA Sunny Central are listed in the Table 3-6. These inverters are designed to operate with DC inputs up to 1,000V. They incorporate maximum power point tracking (MPPT). The inverter is designed for outdoor use with an IP54 ingress protection class for Sunny Central-630CP inverter. It performs optimally at ambient air temperatures between -20°C to 50°C having a relative humidity of 15-95%. The technical characteristics of this inverter are illustrated in Table 3-6.

**Table 3-6: SMA Inverter Characteristics**

Inverter	Sunny Central-630CP
Type	Transformer less
<b>Input Data</b>	
PV voltage range, MPP (V)	500-820V
Maximum DC voltage (V)	1,000V
Maximum PV input current (A)	1,350A
<b>Output Data</b>	
Nominal AC power (kVA)	630kVA
Max AC current (A)	1271A
Rated output voltage (V)	315V
Normal grid frequency (Hz)	50/60Hz
Total harmonic distortion (THD)	<3%
<b>Efficiency</b>	
Maximum efficiency (%)	98.7%
Euro efficiency (%)	98.5%
<b>Dimensions and Weight</b>	
Dimensions (W x H x D) (mm)	2562 x 2279 x 956
Weight (Kg)	1800 Kg
<b>Protection and Ambient Condition</b>	
Operating temperature range (°C)	-20 to +50°C
Ingress Protection Degree	IP54





Inverter	Sunny Central-630CP
Relative humidity (%)	15 - 95%

The following protection devices are included within the inverter design:

- Input-side disconnection device
- Ground fault monitoring
- DC reverse polarity protection
- AC short circuit protection
- Motor driven load disconnect switch on DC side
- Overvoltage protection for auxiliary supply

SMA inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components.

### 3.2.4 Certification

SMA is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards. Inverter reliability is further enhanced via stringent quality control procedures. SMA inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Referring the datasheet provided by the Client, the certification of SMA inverter is enlisted in Table 3-7.

**Table 3-7: Certification details for SMA inverters**

Standard	Description of Standard	Certifying Agency
IEC 60529	Degree of protection provided by enclosure	Bureau Veritas
IEC 61000	Electromagnetic compatibility	Certificate not provided

Based on the information presented in Table 3-7, SgurrEnergy considers the certifications provided by SMA to be in-line with the industry standards. Since the plant is operational, SgurrEnergy raises no major concern regarding the unavailability of the complete set of IEC certificates.

### 3.2.5 Warranties

Referring to the extended warranty document provided by the Client for SMA inverters used for the project, SgurrEnergy understands that the inverters are under the warranty period and raises no major concern.

In case of any defect or non-conformity detected during the warranty period, resulting from a fault in workmanship or materials, the manufacturer shall replace or repair the faulty part. The SMA warranty covers any costs incurred for repair or replacement of the faulty part within the warranty period. SgurrEnergy considers the above remedial actions to be acceptable.





### 3.3 Transformers- Shilchar Technologies Limited

The solar PV plant is implemented with two level transformation. Power at low voltage from inverters is stepped up to 33kV using 1250kVA transformers of Shilchar make inverter transformers. Further, auxiliary transformers of 100kVA of Shilchar make is also utilized for the project.

#### 3.3.1.1 Company Profile

The inverter transformer used for the project are manufactured by Shilchar Technologies Limited.

Established in 1990 and headquartered in Gujrat, India, Shilchar is one of the prominent manufacturers of Power & Distribution transformers. As of April 2020, the Company has commissioned the manufacturing facility capable of manufacturing up to 50MVA, 132KV class transformer and up to 4000MVA transformers annually.

Shilchar Technologies is an ISO 90001:2015, ISO 14001:2015 and ISO 45001:2018 certified company providing services to wide range of industries across the world including utility sector to renewable energy. The Company has a dedicated marketing team to cater services required in 20 different countries in the world. Since 2011, 40% of the revenue generated by Shilchar is through export.

The Company manufactures and has type tested various 3-winding, 4-winding, and 5-winding transformer with copper and aluminium conductor. The highest rating type tested by Shilchar is 12.5MVA, 5 winding Inverter Duty Transformer (IDT). The Company has supplied nearly 4GWs of transformers for solar application throughout the world including in Philippines, Egypt, Kenya, and Chile.

#### 3.3.1.2 Technical Specifications

The 100kVA auxiliary transformer used in the project is outdoor type, three-winding (copper wound), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

The 1250kVA inverter transformer used in the project is outdoor type, three-winding (copper wound), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that both the transformers have been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformers technical characteristics are presented in Table 3-8.

**Table 3-8: Technical Specification of Shilchar Transformer**

Technical Parameters	Auxiliary transformer; 100kVA	Inverter transformer; 1250kVA
Rated Power	100kVA	1250kVA
Rated HV	33kV	33kV
Rated LV	433V	315V
Tapping on HV	-5% to +5% (steps of 2.5%)	-5% to +5% (steps of 2.5%)
Phases	3	3
Frequency	50Hz	50Hz
Vector group	Dyn11	Dyn11yn11
Impedance	3.95% (with IS TOL.)	5.24%



Technical Parameters	Auxiliary transformer; 100kVA	Inverter transformer; 1250kVA
Cooling Strategy	ONAN	ONAN
Oil temperature rise	50°C	-
Winding temperature rise	55°C	-
Winding material	Copper	-

SgurrEnergy considers the overall the technical specifications to be adequate for the PV projects and in line with the industry accepted standards.

### 3.3.1.3 Temperature Rise Detection and Protection

Inverter transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.1.4 Warranties and Guaranties

Based on the information available in public domain, SgurrEnergy understands the Shilchar transformers have been provided with a warranty of 60 months from date of dispatch. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards.

## 3.4 Conclusion on Major Plant Components

### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of First Solar, assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.

Further, the warranty document was not provided for review, SgurrEnergy is unable to comment on warranty terms and conditions and suggests getting clarity from the manufacturer regarding the warranty offered for the PV modules. Regarding the certifications, the complete set of certifications of the installed modules was not made available for SgurrEnergy's review. Since the solar PV plant is already operational, SgurrEnergy raises no major concern regarding the unavailability of IEC certifications.

### Inverters

SgurrEnergy has conducted review of the SMA's Sunny Central-630CP central inverter. Since the solar PV plant is operational, SgurrEnergy raises no major concern regarding the unavailability of the complete set of IEC certificates for SMA's Sunny Central-630CP central inverter used for the project. SMA offers a product warrant of 5 years which is in line with the current industry standards.

In conclusion, SMA can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters. SgurrEnergy raises no major concern regarding the use of SMA inverters for the Project.



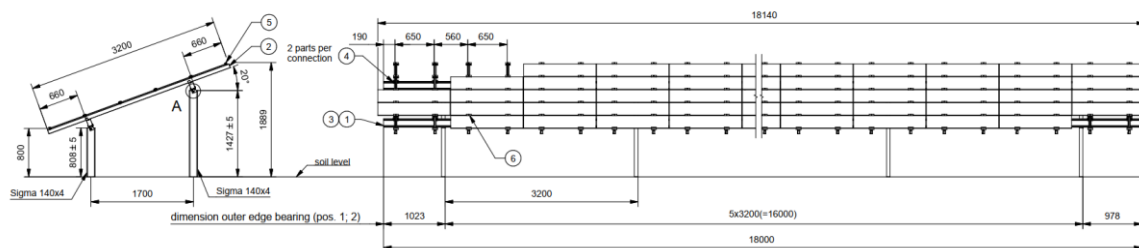
## Transformers

The auxiliary transformers (100kVA) and inverter transformer (1250kVA) used within the project are manufactured by Shilchar Technologies Limited. The manufacturer has good track record of supplying transformers for solar application throughout the. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.

### 3.5 Module Support Structures

The Array Layout provided by the Client for the 5MW<sub>AC</sub> SSELP Solar PV Plant indicates the fixed tilt module mounting structure is inclined at 20° tilt angle.

Although the as-built MMS GA drawing for the 5MW<sub>AC</sub> SSELP Solar PV Plant site has not been provided for review. Material used for MMS member, type of foundation and details provided for MMS is unavailable for review. The general arrangement is as shown in below figure.



**Figure 3-2: MMS general arrangement**



## 4 Allied Components and Systems

### 4.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

### 4.2 PV Power Transfer

SgurrEnergy has reviewed the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear, and plant substation as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

- 3b AES\_40011002 40 05\_AC SLDs\_R5(As built)-Over all SLD.
- 1z AES\_40001002 42 05\_DC SLD\_R5(As built) - INVETER STATION-1
- 1zAES\_40001002 42 05\_DC SLD\_R5(As built) - INVETER STATION-2.

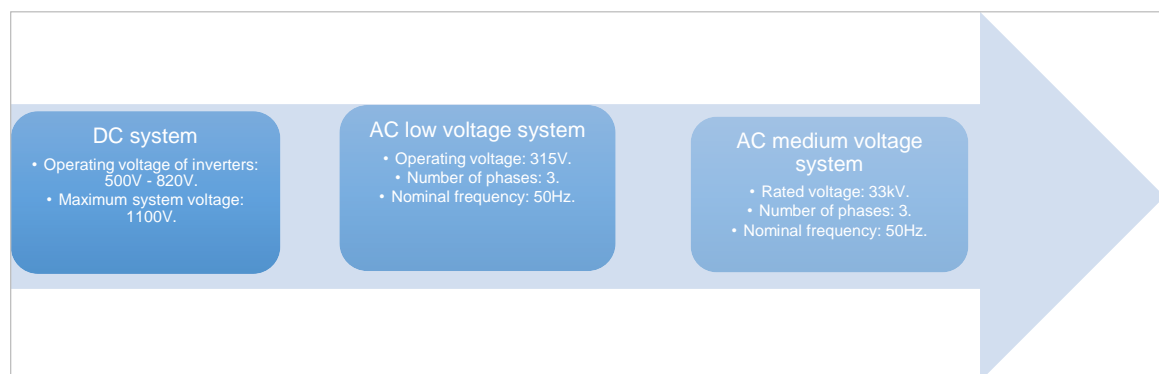
The 5MW<sub>AC</sub> solar PV Plant is designed with 80W<sub>P</sub> and 115W<sub>P</sub> make solar PV modules and 625kW SMA inverters. Modules are interconnected to form a string of 15 and 11 modules for 80W<sub>P</sub> and 115W<sub>P</sub> modules respectively. Five such strings forms a single output that feeds as a single input to the 16 input combiner boxes. Eight string combiner boxes are further connected to the inverter.

The 5MW<sub>AC</sub> solar PV plant has been configured with 8 SMA 625kW central inverters and two inverter stations. Each inverter station is of 2.5MW<sub>AC</sub> capacity contain four inverters of 625kW capacity, which is further connected to 0.315/0.315/33kV three-winding, 1.25MVA transformer, that steps up the voltage up to 33kV for all inverter stations. The power from the HV side of the 33kV inverter transformer is transferred to 33kV HT panel.

The output power of each 33kV HT panel is connected to 33kV main HT panel located in the main control room. Further power from main control room is fed to 33kV outdoor switchyard.

Power from 33kV switchyard is evacuated to the substation situated at a distance of 5.5km from the project site at 33kV voltage level. Transmission line details not provided to SgurrEnergy.

Figure below illustrates a power flow summary for the 5MW<sub>AC</sub> Solar PV plant.



**Figure 4-1: Power flow of 5MW<sub>AC</sub> PV plant**

### 4.3 Cabling

#### 4.3.1 DC Cabling



DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. Modules are interconnected in series with solar grade cables that are tied along with the module mounting structures. Modules are interconnected in daisy chain to form a string of 15 PV modules connected in series.

The 5 in 1 out cable harness has been used to pre-combine the string of PV module. Single core 6mm<sup>2</sup> multi-stranded copper PV cables connect cable harness output to String Combiner Box (SCB).

These combiner boxes are equipped with 16A fuse for each of the string connection and a disconnect switch on output side. Power from string combiner box is further transferred to the inverter using 1 runs, 1C, 120mm<sup>2</sup> cables. Detailed Cable specifications has not been provided.

#### 4.3.2 AC Cabling

Three phase AC output from inverter is connected to the LV winding of a three-winding 1.25MVA transformers, using 4 Runs/phase single core 240mm<sup>2</sup> Aluminium Armoured XLPE cable. The inverter transformers step up the voltage to 33kV.

Power is fed from the high voltage side of each transformers using 1R,3C, 95mm<sup>2</sup>, 33kV Al XLPE armoured cable to the 33kV HT panel in the 2.5MW<sub>AC</sub> inverter stations using a radial feeder arrangement.

The 33kV output from HT panel of first inverter station is transmitted to 33kV HT panel located at second Inverter Station. Output from both IDTs of second Inverter station shall be connected to the 33kV HT panel in a radial manner. Combined 5MW output from second HT Panel shall be connected to main HT panel located at Main control room using 1R,3C, 120mm<sup>2</sup>, 33kV(E) Al XLPE armoured HT cable.

The power from the Main HT panel is transferred to 33kV outdoor switchyard using 1R,3C, 120mm<sup>2</sup>, 33kV(E) Al XLPE armoured HT cable. Further the output power of 33kV Switchyard is transferred to GSS through overhead line.

#### 4.4 Inverter Station

The 5MW<sub>AC</sub> solar PV plant has been configured with 8 inverters and two inverter stations. Each inverter station is of 2.5MW<sub>AC</sub> capacity consist of four inverters of 625kW capacity.

The 2.5MW<sub>AC</sub> inverter station consists of four inverters connected to two 1250kVA three-winding transformers. Each transformer, along with allied switchgears, steps up the voltage to 33kV for all inverter stations. Further the power from the HV side of the transformer is fed to the 33kV outdoor type HT panel through radial feeder arrangement.

33kV outdoor type HT panel comprises of 30/5-5A current transformer, 33kV/110V fixed type line potential transformer, 33kV EDO TP, 630A SF6 Circuit Breaker and other electrical protection system. The power from inverter duty transformer is transferred to aforesaid MV panel.

#### 4.5 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed 1.25MVA, 33kV/2x0.3150kV, Dy11y11 three-winding transformers have been used in the project. These inverter duty transformers step up the voltage to 33kV.

The 1.25MVA inverter duty transformers output is connected to 33kV HT panels located within inverter station. The energy from 33kV HT panel of first Inverter station is connected radially at HT panel of second Inverter station. The combined 5MW power from second Inverter Station shall be connected to 33kV main HT panel located within main control room.



#### 4.6 33kV Main HT Panel

A 33kV main HT panel comprises of inverter station incoming feeders and one outgoing feeder. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class. All feeders have been provided with relay and metering unit. The 33kV main HT panel outgoing and incoming feeders are provided with instantaneous overcurrent and earth fault i.e. 50/50N and IDMT overcurrent & earth fault i.e. 51/51N protections. The 33kV outgoing feeder from main HT panel is provided with 0.2 class instrument transformers.

Power is fed from 33kV main HT panel to and 33kV outdoor Switchyard. Further power from 33kV Switchyard is transferred to GSS through overhead line.

#### 4.7 33kV Metering Yard

Revenue metering at 33kV has been considered at Kinwari GSS.

#### 4.8 Auxiliary Power Supply

SgurrEnergy had reviewed the electrical schematics shared for the projects to evaluate auxiliary system. One 100kVA 33/0.415kV Auxiliary Transformer has been considered cater the load of entire 5MW<sub>AC</sub> plant. Main ACDB panel has been considered at main control room from where tapping's for ACDBs located at Inverter stations has been provided.

#### 4.9 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are normally mounted on individual structures.

Following the review of 33kV SLD, SgurrEnergy observed 33kV, 630A, 25kA/1sec SF6 type circuit breaker has been used in the project.

#### 4.10 Isolators

Isolators are used to transfer load from one bus to another and also to isolate equipment for maintenance.

Based on the review of 33kV SLD, SgurrEnergy observed 33kV, 630A isolator without earth switch has been used in the project.

#### 4.11 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.

The current transformers with accuracy class of 0.2 for metering and class 5P for protection has been used in 5MW<sub>AC</sub> solar PV plant. The potential transformers with accuracy class of 0.2 for metering and class 3P for protection has been used in the project.

#### 4.12 Surge Arrestors and Lightning Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes on the lines entering the substation. The apparatus most commonly used for this purpose is the surge arrester. Transformer is the costliest equipment in substation, and it is normal practice to install surge arrester near to the transformer. Additional surge



arresters shall be provided either on bus or on various lines for protection of the equipment.

Following the review, SgurrEnergy observed that surge arrester has not been provided near Transformers rather only one 33kV, 10kA surge arrester has been provided in outdoor Switchyard line side.

#### 4.13 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy will be provided at the medium voltage switchboards for each of the feeder sections. These meters will be digital with an RS 485 port for remote monitoring. These usually have an accuracy class of 0.5.

Similarly, HV side shall also be equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point shall be 0.2S.





## 5 System Design Appraisal

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

### 5.1 Plant Layout Design

SgurrEnergy was provided with electrical schematics and pv syst report. Based on these documents it is noted that the PV plant has been implemented using First Solar (80W<sub>P</sub> and 115W<sub>P</sub>) PV modules. The total DC installed capacity stands at 5.8MW<sub>P</sub>. The AC installed capacity stands at 5.04MW<sub>AC</sub> with 8 inverters of capacity 630kW each.

The selected tilt for the 5.04 MW<sub>AC</sub> plant is 20°. The 5.04 MW<sub>AC</sub> plant is designed with a pitch of 6.01m.

15 and 11 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.14. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.

### 5.2 String Sizing

The plant layout provided by the Developer indicate Fifteen 80W<sub>P</sub> and Eleven 115W<sub>P</sub> First Solar CdTe modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage (V<sub>OC</sub>) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum V<sub>OC</sub> of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy in validating string configuration. Subsequent to calculating open circuit voltage (V<sub>OC</sub> max), maximum power voltage (V<sub>mp</sub> min) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 45°C and 9°C respectively for system design validation to be fair and representative for the PV plants' site.

The results of string sizing validation are presented in Table 5-1. Results indicate that V<sub>OC</sub> max at the minimum ambient temperature is within the maximum system voltage of 1,000V for the selected SMA (Sunny Central 630CP) inverters.

**Table 5-1: String Sizing for First Solar PV Modules**

Parameters	First Solar 115W <sub>P</sub>
PV module power (W <sub>P</sub> )	115
Modules per string	11
Inverters	SMA (Sunny Central 630CP)
Maximum Open-circuit voltage (V <sub>OC</sub> max) at minimum ambient temperature of 9°C	943.8V
Minimum power voltage (V <sub>mp</sub> min) at maximum ambient temperature of 45°C	718.3





### 5.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with First Solar and SMA inverter is presented in Table 5-2. SgurrEnergy has selected First Solar module (110W<sub>p</sub>) for checking compatibility with SMA inverter, as SgurrEnergy considers this to be representative for all the First Solar PV modules installed on site.

**Table 5-2: Inverter Compatibility with First Solar 110 W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>First Solar 110 W<sub>p</sub> (FS-4115)</b>	
Modules per string	15	Acceptable
Strings per inverter	420	Acceptable
Maximum power, P <sub>mpp</sub> at STC (kWp)	531	Nominal power ratio is 0.84, this is within the inverter bus current carrying capacity.
Maximum power voltage, V <sub>mpp</sub> at STC (V)	762.3	Acceptable.
Maximum power current, I <sub>mpp</sub> at STC (A)	929.6	Acceptable
Open-circuit voltage, V <sub>oc</sub> at STC (V)	963.6	Acceptable.
Minimum MPP voltage at 45°C ambient temperature (V)	718.3	Acceptable: Inverter MPPT ranges 500 - 820V.
Maximum MPP voltage at 9°C ambient temperature (V)	795.3	Acceptable: Inverter MPPT ranges 500 - 820V.
Maximum open circuit voltage, V <sub>oc</sub> at 9°C (V)	943.8	Acceptable: Maximum inverter voltage 1000V.

Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.



## 6 Resource assessment

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SEI has sourced monthly horizontal plane irradiation data for the Project site from:

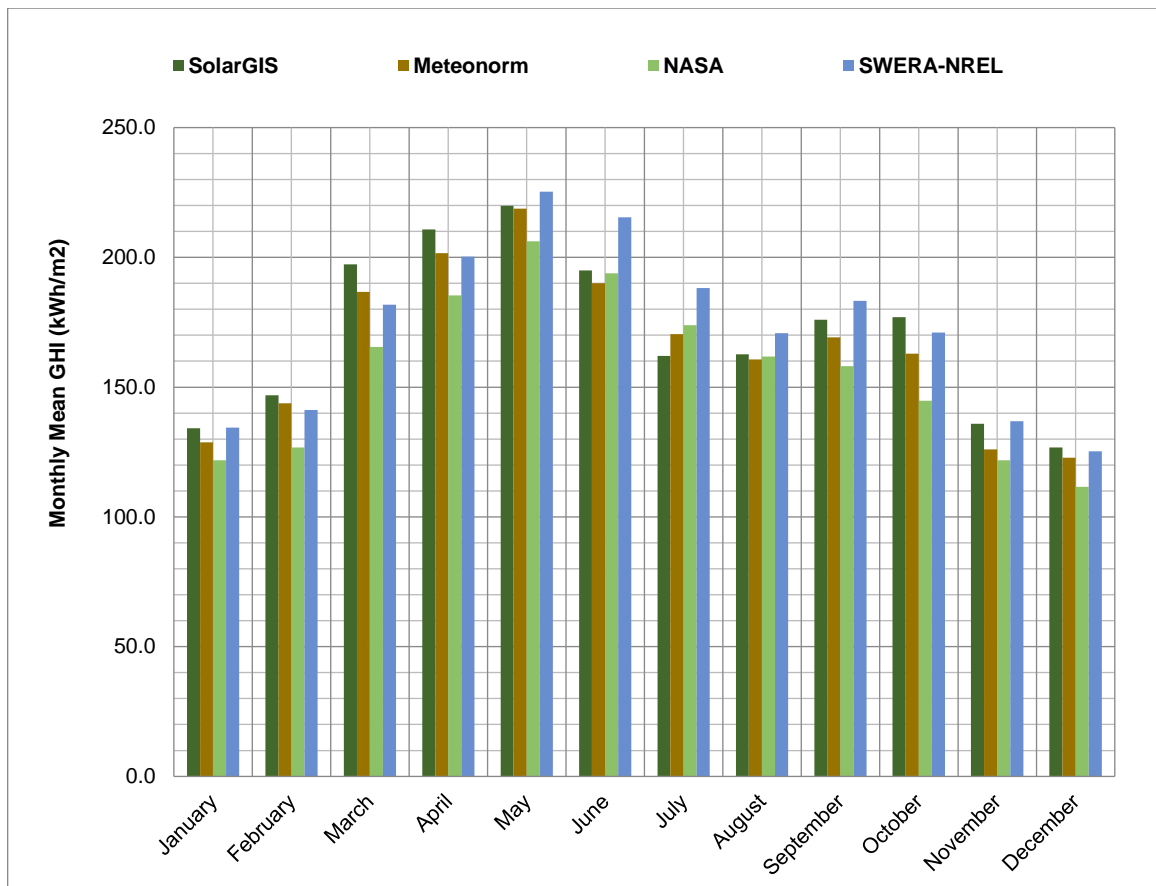
- **NASA's Surface Meteorology and Solar Energy data set**; holds satellite derived monthly data for a grid of 0.5° × 0.5° covering the globe for a thirty-four-year period (1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.



- The **METEONORM (version 7.2)** *global climatological database and synthetic weather generator*; contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **SolarGIS:** SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km × 4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by IEA (*International Energy Agency*) SHC Collaboration Agreement, and EU FP6 project MESoR in terms of bias and RMSE.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.

SEI has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS and, NREL (SWERA) data for the site. The comparison is graphically illustrated Table6-1





**Figure 6-1: Monthly Global Horizontal Irradiation**

**Table6-1: Comparison of Solar Irradiation Datasets for the site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	2044.2
Meteonorm 7.3	14km × 14km	4.0%	1981.6
NASA	55km × 55km	Unknown	1871.5
NREL (SWERA)	40km × 40km	Unknown	2073.6

The comparison of solar data for Project site location illustrated in Table6-1 indicates NREL (SWERA) dataset to give the highest irradiation levels. The next highest irradiation is given by SolarGIS followed by Meteonorm 7.2 and NASA.

The irradiation values given by Meteonorm 7.2 typically provide a combination of ground and satellite measured data. Meteonorm 7.2 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as 6.8% for the proposed site.

The NREL (SWERA) data illustrated has been obtained for a location approximately 3.54 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data.

The NASA-SSE data source provides purely satellite measured data for a grid covering 0.5° × 0.5° on the earth's surface and generally more suited for initial site selection.



The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also been compared with other data sources globally. The IEA (International Energy Agency) validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>6</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)
- Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 6%.

SEI is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 6.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 6-2 and shown graphically in Figure 6-2. Diffuse irradiation accounts for 40.52% of the total irradiation. Table 6-2 illustrates direct and diffuse daily irradiation on a horizontal plane for the proposed site. SolarGIS irradiation data is presented in Table 6-2.

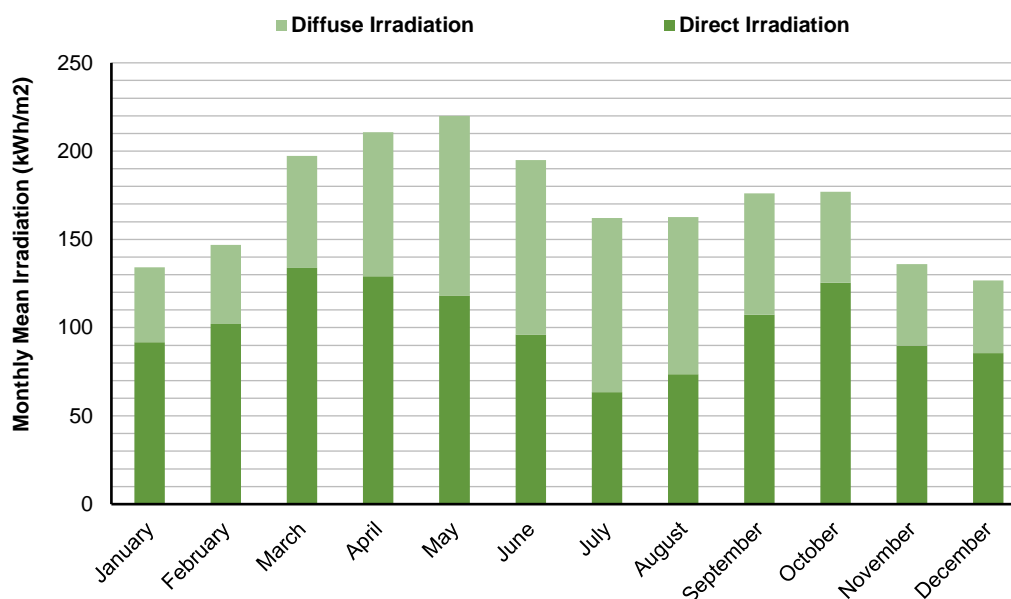
**Table 6-2: SolarGIS Irradiation Data for the Project site**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	134.2	42.5	6.6%
February	146.9	44.8	7.2%
March	197.3	63.6	9.7%
April	210.7	81.6	10.3%
May	219.9	101.7	10.8%
June	195.0	99.0	9.5%
July	162.0	98.6	7.9%
August	162.6	89.0	8.0%
September	176.0	68.7	8.6%

<sup>6</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>



Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
October	177.0	51.5	8.7%
November	135.9	46.2	6.6%
December	126.7	41.2	6.2%
<b>Annual Sum</b>	<b>2,044.2</b>	<b>828.2</b>	<b>-</b>



**Figure 6-2: Monthly Direct and Diffuse Irradiation on a horizontal plane for the project site**

## 6.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.0.17), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -6-3 represents the monthly GTI profile.

**Table -6-3: Monthly Global Tilted Irradiation Data**

Month	GTI (kWh/m <sup>2</sup> )
January	176.20
February	179.80
March	221.20
April	217.60
May	213.20
June	184.70
July	154.80



Month	GTI (kWh/m <sup>2</sup> )
August	162.10
September	190.30
October	210.00
November	173.60
December	170.10
<b>Annual Sum</b>	<b>2,253.60</b>

### 6.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 6-4 below. The average wind speed of 1.1 m/s was measured at 10 m height from ground level for the proposed project site location.

**Table 6-4: Simulated Wind Speed for site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	0.9
February	0.9
March	1
April	1.2
May	2.1
June	2
July	1.6
August	1.3
September	1
October	0.4
November	0.5
December	0.8
<b>Yearly Average</b>	<b>1.1</b>

### 6.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-



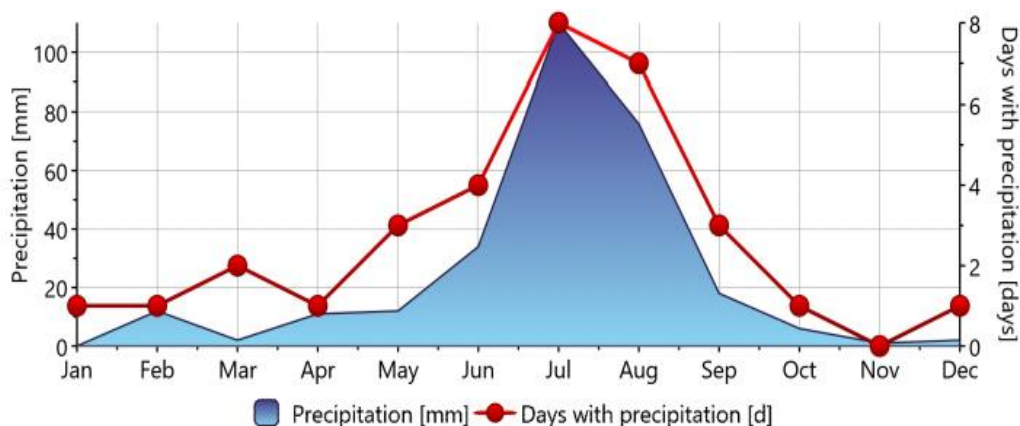
June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.

**Table 6-5: SolarGIS Temperature Data for Site (1999 – 2018)**

Months	Average Monthly Temperature (°C)
January	15.3
February	18.4
March	24.1
April	29.6
May	33.8
June	35.0
July	32.5
August	31.1
September	30.7
October	26.9
November	21.3
December	16.8
<b>Annual Average</b>	<b>26.3</b>

## 6.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.3 as illustrated in Figure 6-3. These figures show that the identified site is situated in a region that has marginal rainfall.



**Figure 6-3 Meteonorm Predicted Precipitation for the site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

Frequency of module cleaning depends on the rainfall frequency and the prevalence of dust and pollution in the local vicinity. Typical cleaning techniques include water cleaning, dry brushes or vehicle-based mechanical cleaning.





The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 2.37%<sup>7</sup> has been considered by considering cleaning frequency of twice a month.

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<sup>7</sup> The soiling loss considered in simulation is 2.0% and spectral correction factor (applicable for first solar modules only) is applied to the soiling loss in PVSyst to get the corrected energy yield estimate. The soiling after applying the spectral correction factor is 2.37%.



## 7 Energy Yield Analysis

SgurrEnergy has computed the annual energy yields for the 5 MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

Parameter	Description
Modules	First Solar 80 W <sub>p</sub> , (FS-380) First Solar 115 W <sub>p</sub> (FS-4115)
Inverters	Sunny Central Inverters – 630 KW <sub>AC</sub> (Sunny Central 630CP)
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	5.7

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 7.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in Table 7-1 below.

**Table 7-1: Description of Energy Yield Losses**



Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 30MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 7.2 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 5 MW<sub>p</sub> solar PV Plant with First solar PV modules and Sunny central inverters. Table 7-2



summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.

**Table 7-2: Energy Yield for the 5 MW<sub>AC</sub> Solar PV Plant**

Parameters	Description
PV Module Technology	Thin Film
DC Capacity (MW <sub>p</sub> )	5.7
AC Capacity (MVA)	5.0
Contracted Capacity (MW)	5.0
P <sub>NOM</sub> Ratio	1.14
Tilt (°)	20
Pitch (m)	6.01
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1957.60
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	2096.84
Transposition Factor	1.07
<b>Losses</b>	
Horizon Shading	0.00%
Incident Irradiation Below Threshold	0.00%
Near Shading	1.57%
Incident Angle	2.60%
Soiling	2.37%
Low Irradiance	0.35%
Module Temperature	6.64%
Electrical Shadings	0.02%
Module Quality	-0.90%
First year Degradation	0.00%
Module Mismatch	1.00%
DC Ohmic	0.36%
Inverter Performance	1.81%
Availability	1.00%
AC Ohmic	0.92%
Transformer (LV/MV)	1.01%
Transformer (MV/HV)	0.50%
Transmission Line	0.75%
Auxiliary Consumption	0.56%
Curtailment	
<b>Total Annual Loss Factor</b>	<b>0.814</b>
<b>First Year P50 Energy Yield (MWh/annum)</b>	<b>10,536.692</b>
<b>Tenth Year P50 Energy Yield (MWh/annum)</b>	<b>9,625.45</b>
<b>Tenth Year Specific Yield (kWh/kW<sub>p</sub>)</b>	<b>1676.90</b>



Parameters	Description
Tenth Year CUF on AC Installed Capacity	21.80%
Tenth Year CUF on Contracted Capacity	21.80%
Tenth Year CUF on DC Installed Capacity	19.14%
Tenth Year Performance Ratio	74.40%

Graphical representation of the monthly generation, performance ratio and CUF for 5MW<sub>AC</sub> evaluated is illustrated graphically in the Figure 7-1.

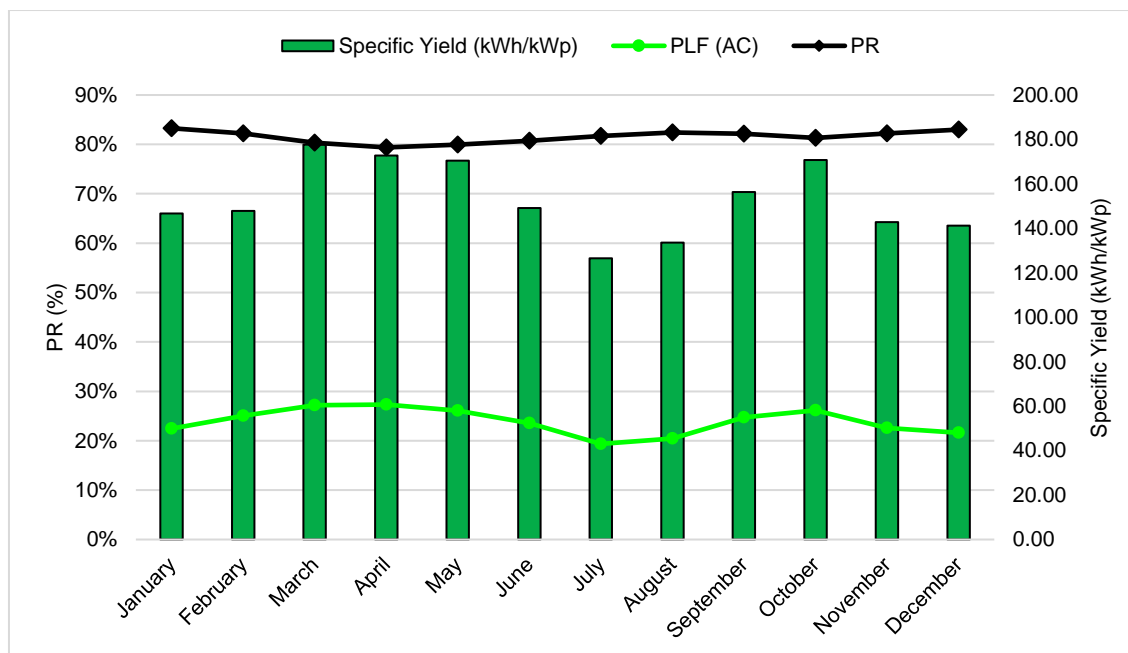


Figure 7-1: Monthly Energy Yield for 5 MW<sub>AC</sub>

### 7.3 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 7.3.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

#### 7.3.2 Inter – Annual Variation in the Solar Resource

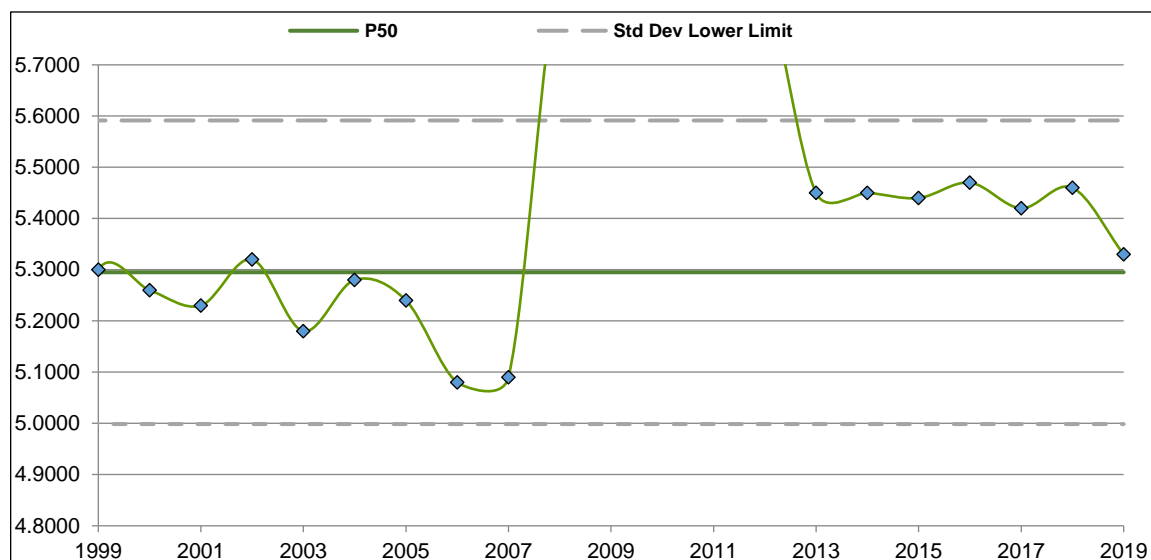
Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.



The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database for the proposed site location which is used to estimate the standard deviation of variation in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 7-3.

**Table 7-3: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	5.60



**Figure 7-2: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in Figure 7-2.

SgurrEnergy uses a coefficient of variation of 5.60 % to quantify the inter-annual variation in the solar resource.

### 7.3.3 Modelling Uncertainty

The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

### 7.3.4 Total Uncertainty (P75 and P90 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.



**Table 7-4: Life Cycle P50, P75 and P90 Generation Prediction for 5 MW<sub>AC</sub>**

<b>Year</b>	<b>Annual P50 Generation (MWh/annum)</b>	<b>P75 Generation Prediction<sup>8</sup></b>	<b>P90 Generation Prediction<sup>9</sup></b>
<b>10</b>	9,625.45	9,219.45	8,854.03
11	9,561.92	9,158.60	8,795.60
12	9,498.81	9,098.15	8,737.55
13	9,436.12	9,038.11	8,679.88
14	9,373.84	8,978.45	8,622.59
15	9,311.98	8,919.20	8,565.68
16	9,250.52	8,860.33	8,509.15
17	9,189.46	8,801.85	8,452.99
18	9,128.81	8,743.76	8,397.20
19	9,068.56	8,686.05	8,341.78
<b>20</b>	9,008.71	8,628.72	8,286.72
21	8,949.25	8,571.77	8,232.03
22	8,890.19	8,515.20	8,177.70
23	8,831.51	8,459.00	8,123.72
24	8,773.22	8,403.17	8,070.11
<b>25</b>	8,715.32	8,347.71	8,016.84

<sup>8</sup> The P75 values have been calculated over 10-year averages<sup>9</sup> The P90 values have been calculated over 10-year averages

## 8 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 1.0% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) till ten years from COD. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Owner, SgurrEnergy understands that the SSEPL solar PV plant was commissioned in 15<sup>th</sup> October 2011. SgurrEnergy was provided with plant, grid availability and irradiation records from April 2016 to April 2021<sup>10</sup> for the solar PV plant.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from April 2016 to April 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Owner.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Owners control.

The monthly records of the grid availability from April 2016 to April 2021 have been graphically illustrated in Figure 8-1 below.

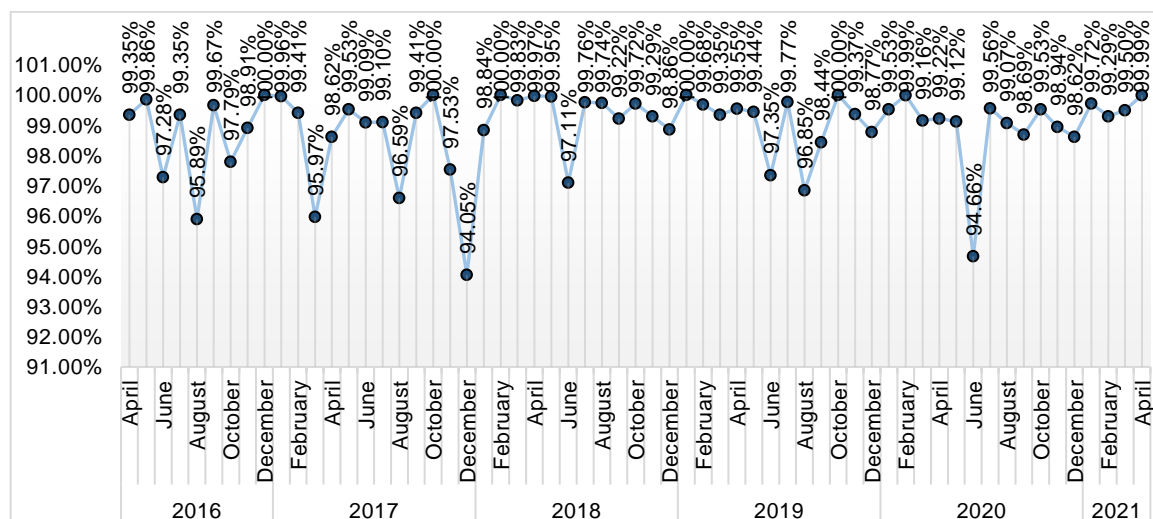


Figure 8-1: Grid Availability

<sup>10</sup> SgurrEnergy was provided with both the plant and grid availability records until April 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.





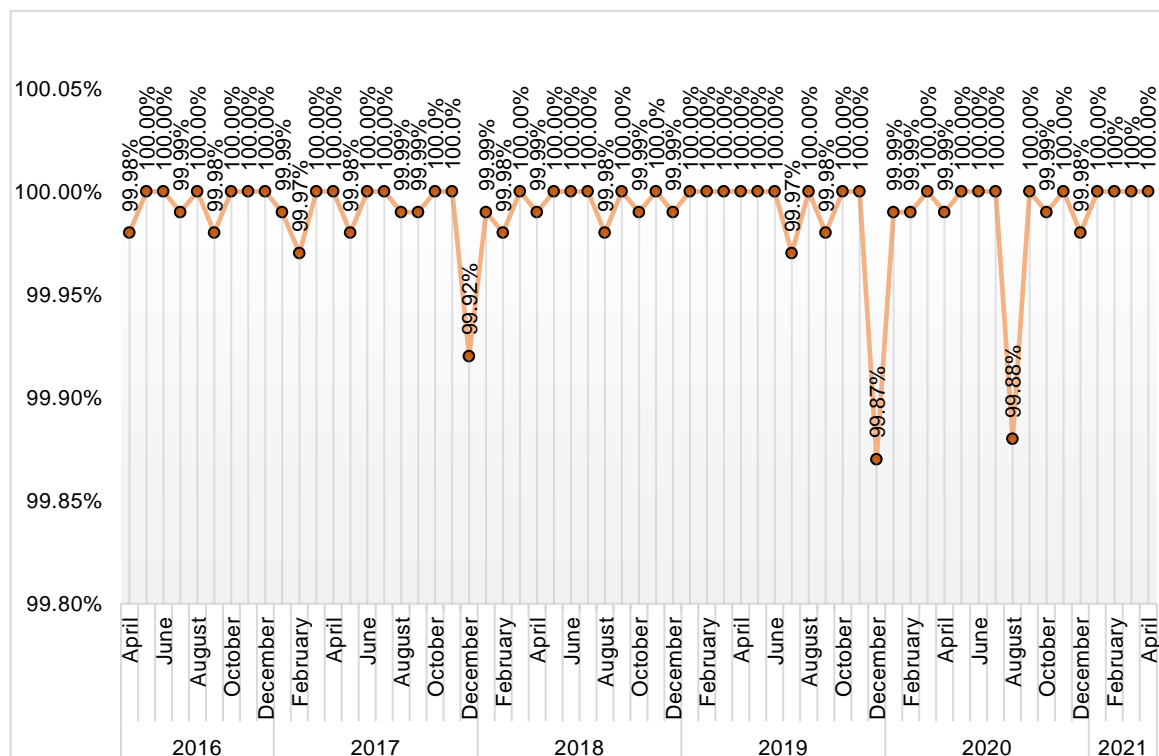
From the above illustration, SgurrEnergy notes that the unavailability loss experienced due grid anomalies are high over the operational period. For the months of August 2016, March 2017, August 2017, December 2017, June 2018, June 2019, August 2019 and June 2020 the unavailability due to grid was high when compared to other months. The downtime due to grid unavailability was above 98% during the remaining months.

Overall the average grid availability experienced on site for the operational period was calculated to be 98.90%

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the SSEPL solar PV plant is graphically illustrated below in Figure 8-2.



**Figure 8-2: Plant Availability**

Based on the above illustrations, SgurrEnergy notes the plant availability for the SSEPL solar PV plant is consistently above 99.87% for all the months ranging between 99.87% to 100%. The average plant availability is noted to be 99.99% which is considered to be well above the expected range.

### 1.2 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Client. To make the operational energy yield predictions more representative, SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Client. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Client.

The yearly comparison of the generation data is illustrated below in Figure 8-3.



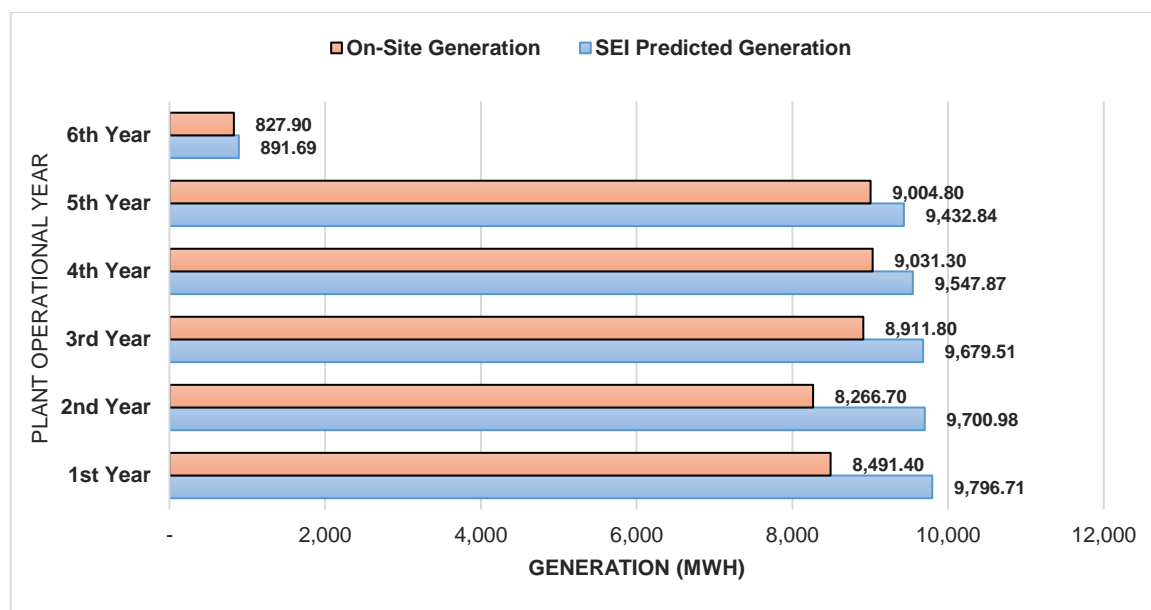


Figure 8-3: Generation Comparison

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 8-1

Table 8-1: PV Plant Performance – SSEPL

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>11</sup> (%)
April 2016 - March 2017	9,796.71	8,491.40	-13.32%
April 2017 - March 2018	9,700.98	8,266.70	-14.78%
April 2018 - March 2019	9,679.51	8,911.80	-7.93%
April 2019 - March 2020	9,547.87	9,031.30	-5.41%
April 2020 - March 2021	9,432.84	9,004.80	-4.54%
April 2021	891.69	827.90	-7.15%
<b>Cumulative Period</b>	<b>49,049.60</b>	<b>44,533.90</b>	<b>-9.21%</b>

Based on the above comparison, SgurrEnergy notes that the PV plant is generating lower than the expected yield. However, SgurrEnergy considers that such variations in the energy yield can be attributed to higher irradiation level experienced on the Project site. The irradiation levels significantly impact the actual generation from the PV plant as the system losses may vary significantly due to slight change in the irradiation.

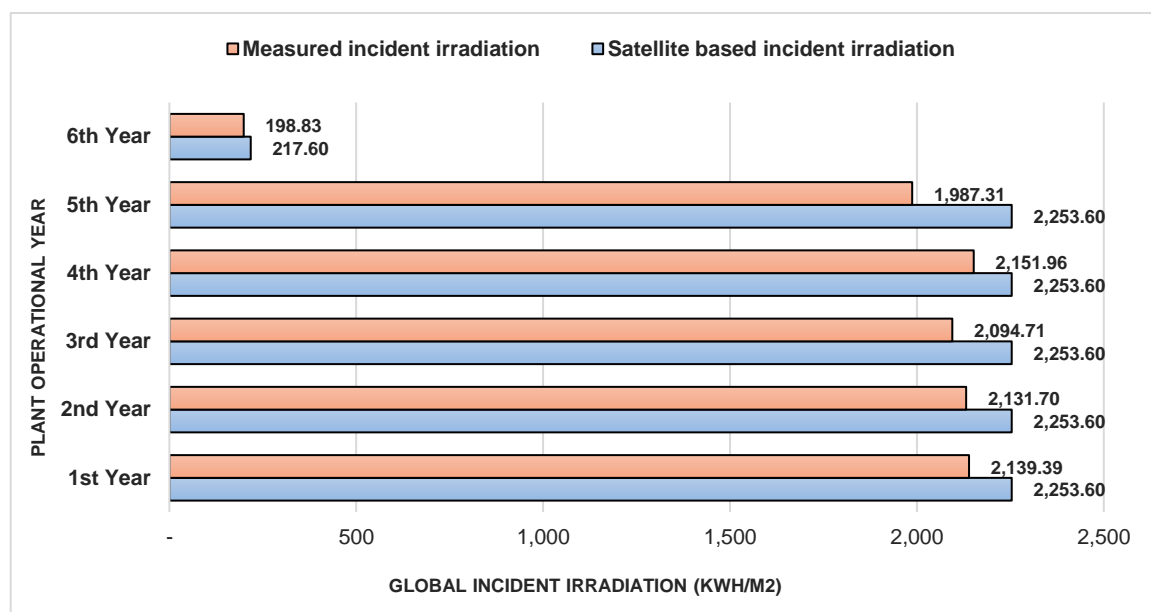
In order to understand the deviation in the irradiation pattern, SgurrEnergy has compared the monthly incident irradiation data provided by the Client with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation. The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 8-4.

<sup>11</sup> Positive values indicate higher generation, while negative values indicate lower generation



**Table 8-2: Irradiation Comparison– SSEPL**

PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>12</sup> (%)
April 2016 -March 2017	2,253.60	2,139.39	-5.07%
April 2017 - March 2018	2,253.60	2,131.70	-5.41%
April 2018 - March 2019	2,253.60	2,094.71	-7.05%
April 2019 - March 2020	2,253.60	2,151.96	-4.51%
April 2020 - March 2021	2,253.60	1,987.31	-11.82%
April 2021	217.60	198.83	-6.74
<b>Cumulative Period</b>	<b>11,485.60</b>	<b>10,703.91</b>	<b>-6.81%</b>

**Figure 8-4: Irradiation Comparison**

Based on the above illustration, it is observed that the overall recorded generation is approximately 9.21% lower than the generation predicted on site. It has also been observed that the recorded irradiation is 6.81% lower than the predicted irradiation.

Based on the comparative analysis, the drop-in generation can be attributed to the drop in irradiation during the evaluation period.

<sup>12</sup> Positive values indicate higher irradiation, while negative values indicate lower irradiation



## 9 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar pv plants as having a lifetime of 25-40 years<sup>13</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>14</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the pv plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement.

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<sup>13</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>14</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>



Virescent Infrastructure


20MW(AC) PLG Solar PV Plant  
PLG Photovoltaic Private Limited  
Technical Assessment Report

July 2021



## Report Details

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## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 20MW<sub>AC</sub> PLG Photovoltaic Private Limited (PLG). The Project is located in Patan district of Gujarat. The summary of the technical assessment is captured in the below table.

**Table 1-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	Review presented in Section 2
2	PV Module	<p>According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of Kyocera Solar, assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.</p> <p>Further, according to the warranty documents available in public domain for the module manufacturer, SgurrEnergy considers the warranty terms and conditions offered by Kyocera to be in-line with the industry standard and raises no major concern regarding the warranties offered. However, SgurrEnergy suggests getting clarity on the limited product warranty, first-year degradation and general degradation offered by the manufacturer for the PV modules used for the project.</p> <p>Referring the datasheet provided, SgurrEnergy observed that the Kyocera PV modules used for the project are IEC 61215 and IEC 61730 certified, which is in-line with the industry standard. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.</p>
3	Inverter	<p>SgurrEnergy has conducted review of the ABB's PV800-57-500kW and Power-one's PVI-500.0-TL-CN -500kVA central inverter. Both the central inverter makes have the required certification for use in solar PV plants. The technical characteristics of both the inverters are in-line with the industry standard. ABB and Power-one offer a product warrant of 63 and 66 months, respectively, which is in line with the current industry standards.</p> <p>In conclusion, ABB and Power-one can be considered as established and reputable inverter manufacturers and are known for producing good quality and high-performance inverters. SgurrEnergy raises no major concern in the utilization of ABB and Power-one inverters for the project.</p>
4	Inverter and Power Transformer	<p>The inverter transformers (1250kVA) and power transformer (12.5MVA) used within the project are manufactured by Voltamp. The manufacturers have good track record of supplying transformers for solar application throughout the world. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for</p>



Sr. No.	Parameter	Comment														
		the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.														
5	String Sizing	The V <sub>OC</sub> does not exceed the inverter input voltage for the site, and therefore, SgurrEnergy considers the number of modules in series to be acceptable for the PV Project.														
7	Resource Assessment	For resource analysis, SgurrEnergy has compared various satellite datasets. For the satellite databases, SEI has comparedMeteonorm 7.3, NASA, SWERA and SolarGIS data to find the most suitable solar resource for long-term energy yield prediction. Owing to low uncertainty and high resolution, SEI considers SolarGIS dataset to be the most representative satellite database among all the satellite databases for long-term energy yield assessment.														
8	Operational Analysis and Generation Comparison	Review presented in Section 8														
9	Allied Components and Systems	Review presented in Section 4														
10	Energy Yield Assessment	<div>Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for ninth year of plant operation for the 20MW<sub>AC</sub> PV plant.</div> <table><tr><td>Global Horizontal Irradiation (kWh/m2)</td><td>2015.00</td></tr><tr><td>Global Inclined Irradiation (kWh/m²)</td><td>2211.81</td></tr><tr><td>First Year P50 Energy Yield (MWh/annum)</td><td>32,542.19</td></tr><tr><td>Ninth Year P50 Energy Yield (MWh/annum)</td><td>31,263.05</td></tr><tr><td>Ninth Specific Yield (kWh/kW<sub>p</sub>)</td><td>1563.15</td></tr><tr><td>Ninth Performance Ratio (PR)</td><td>70.67%</td></tr><tr><td>Ninth PLF on Contracted Capacity (20 MW<sub>AC</sub>)</td><td>17.84%</td></tr></table>	Global Horizontal Irradiation (kWh/m2)	2015.00	Global Inclined Irradiation (kWh/m²)	2211.81	First Year P50 Energy Yield (MWh/annum)	32,542.19	Ninth Year P50 Energy Yield (MWh/annum)	31,263.05	Ninth Specific Yield (kWh/kW <sub>p</sub> )	1563.15	Ninth Performance Ratio (PR)	70.67%	Ninth PLF on Contracted Capacity (20 MW <sub>AC</sub> )	17.84%
Global Horizontal Irradiation (kWh/m2)	2015.00															
Global Inclined Irradiation (kWh/m²)	2211.81															
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Ninth Performance Ratio (PR)	70.67%															
Ninth PLF on Contracted Capacity (20 MW <sub>AC</sub> )	17.84%															



## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
m	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon



MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation



## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 68MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of four projects, as presented within Table 1-1.

**Table 1-1: Project Key Summary**

Project Name	SSEPL – 5MW <sub>AC</sub>	SSEGPL – 13MW <sub>AC</sub>	PLG – 20MW <sub>AC</sub>	USUPL – 30MW <sub>AC</sub>
<b>Site Location</b>	26.52N, 72.85 E, Tiware, Jodhpur, Rajasthan, India	23.9128°N, 71.2183°E, Santalpur, Patan, Gujarat, India	23.922758°N 71.523231°E, Dahisar, Patan, Gujarat, India	25°18'52.79"N, 79°25'2.49"E, Devgaon, Mahoba, Uttar Pradesh, India
<b>Owner</b>	Sindicatum Solar Energy Private Limited (SSEPL)	Sindicatum Solar Energy Gujarat Private Limited (SSEGPL)	PLG Photovoltaic Private Limited (PPPL)	Universal Saur Urja Private Limited (USUPL)
<b>DC / AC Capacity</b>	5.745MW <sub>P</sub> / 5MW <sub>AC</sub>	15MW <sub>P</sub> / 13MW <sub>AC</sub>	20MW <sub>P</sub> / 20MW <sub>AC</sub>	36.98MW <sub>P</sub> / 30MW <sub>AC</sub>

This report presents the evaluation of the 20MW<sub>AC</sub> solar PV plant developed PLG Photovoltaic Private Limited (PPPL). The Solar PV plant under evaluation is located in Dahisar village, Patan district in Gujarat state. The purpose of this report is to provide a technical appraisal of PV plant under evaluation.

The report focuses on the following key parameters:

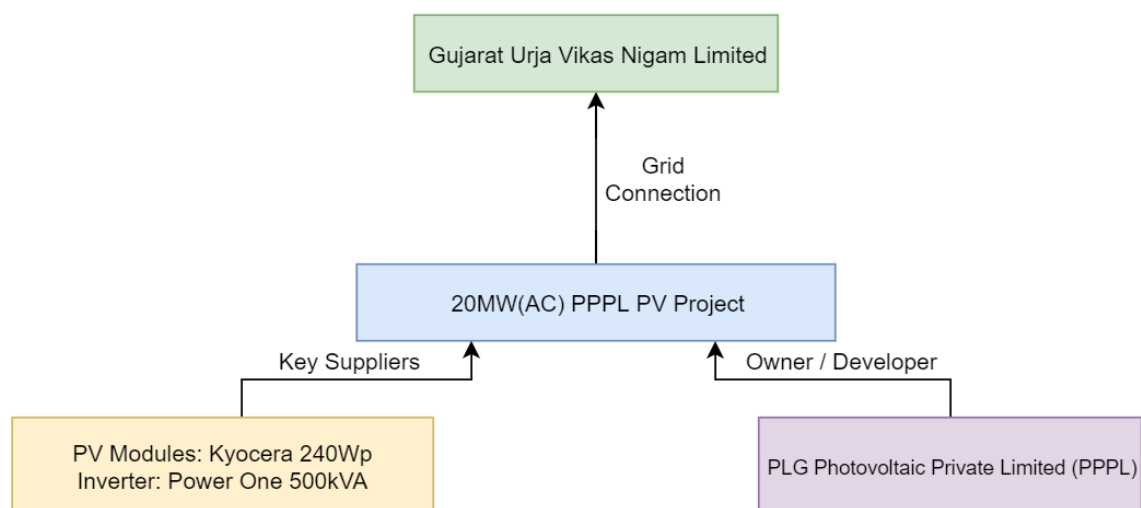
- System Design.
- Major Components.
- Engineering Design.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Plant Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project and is based on information made available by the Client through online data room. The main Project characteristic is summarised in Table 1-2.

Figure 1-1 illustrates the project structure indicating key project participants for the 5MW<sub>AC</sub> solar PV plant.







**Figure 1-1: Project Structure for 20MW<sub>AC</sub> Solar PV Plant**

**Table 1-2: Project Key Summary**

Project Information	
<b>Project Name</b>	20MW <sub>AC</sub> PPPL solar PV plant
<b>Location</b>	Dahisar, Patan, Gujarat
<b>Developer</b>	PLG Photovoltaic Private Limited (PPPL)
<b>DC/ AC capacity</b>	20MW <sub>AC</sub> PV Plant – 20MW <sub>P</sub> / 20MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: Kyocera Inverters: SMA
<b>MMS Configuration</b>	Fixed Tilt: 23°, Azimuth: 0°
<b>Commissioning Status</b>	Commissioning for 20MW <sub>AC</sub> PV Plant was achieved on 26 January 2012.



## 2 20MW<sub>AC</sub> Solar PV Plant Overview

The project site lies around the coordinates 23.922758°N and 71.523231°E. Satellite imageries of 20MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1. The Owner owns approximately 107 acres of land for the project. The Project site is located near the *Dahisar* village, in *Patan* district of Gujarat.

Project is contracted for generating 20MW<sub>AC</sub> power; SEI therefore interprets 20MW<sub>AC</sub> as the maximum AC installed capacity for the solar PV plant.



**Figure 2-1: Satellite image of 20MW<sub>AC</sub> plant**

### 2.1 20MW<sub>AC</sub> Project Summary

Solar PV plant is modular in nature; therefore, PPPL 20MW<sub>AC</sub> solar PV plants is implemented by adopting modularity in designs. 1MW<sub>AC</sub> is the typical inverter stations considered for implementing PPPL 20MW<sub>AC</sub> solar PV plant.

Table 2-1 presents the summary of 20MW<sub>AC</sub> PV plant

**Table 2-1: Summary of 20MW<sub>AC</sub> Plant Configurations**

General	
PV Module Technology	Poly-crystalline
Inverter Technology	Central Inverters
Installed DC Peak Capacity (MW <sub>p</sub> )	20.0
Installed AC Capacity (MW)	20.0
Mounting Type	Fixed Tilt



General	
Tilt Angle (°)	23°
Pitch (m)	7.2
PV Modules	
PV Module Manufacturer	Kyocera
Model	KD240GH-2PB
Wattage (W <sub>p</sub> )	240W <sub>p</sub>
Number of Modules per String	24
Inverter	
Inverter Manufacturer / Model	Power-One / PVI-500.0-TL-CN
Inverter Nominal AC Output	500kW
Number of Inverters	40
Mounting Structure	
Mounting Structure Details (rows × columns)	4 × 3
Orientation of Modules	Landscape

The 20MW<sub>AC</sub> plant is implemented with a total of twenty inverter stations of capacity 1MW<sub>AC</sub> which comprise of three winding transformers to accommodate 2 × 500kVA inverters, taking the individual inverter station size to 1MW<sub>AC</sub>. Inverter station is comprising of a physical block connecting 1MW<sub>p</sub> of installed photovoltaic array.

The output of the 1MW<sub>AC</sub> inverter stations are combined and connected to two 66/11kV for stepping up the voltage to 66kV. The 66kV output is evacuated at the HT switchyard located in the plant premises.

The power generated by the PPPL 20MW<sub>AC</sub> PV plant is fed to Gujarat Electricity Transmission Company (GETCO) substation located approximately 0.5km from the Project site. Point of interconnection and utility metering lies within the 20MW<sub>AC</sub> ZIPL PV Plant premises.



### 3 Review of Major plant components

SgurrEnergy has conducted a technical review of the supplier and module specification with regards to their suitability for their use in the Projects under evaluation.

#### 3.1.1 Company Profile

Established as Kyoto Ceramic Company Limited in 1959, Kyocera Corporation is a multinational ceramics and electronics manufacturer headquartered in Kyoto, Japan. The company manufactures industrial ceramics, solar power generating systems, telecommunications equipment, electronic components, semiconductor packages, cutting tools, etc.

With the experience of more than 40 years, Kyocera is a vertically integrated producer and supplier of solar-powered solutions providing services in both developed and developing nations across the globe.<sup>1</sup> According to a report published by GTM Researcher module reliability scorecard in June 2014, Kyocera was the only solar module manufacturer to rank as a performance leader in all six categories in independent testing by PV Evolution Labs.<sup>2</sup>

Kyocera's polycrystalline silicon solar modules were the first in the world to pass all "Long-term Sequential Tests"\* performed by TUV Rheinland Japan Ltd. Since its inception, the company has produced more than 8GW of solar power generating equipment.

Kyocera solar have three manufacturing units based in Japan and one in China along with regional offices in U.S.A., Singapore, India, Taiwan, Germany and China.

Few of the commissioned solar power plants using Kyocera modules are listed in Table 3-1.

**Table 3-1: Track record of Kyocera Modules**

Sr. No.	Project	Capacity (MW)
1	Fushimi-ku, Kyoto city	25.00
2	Yamaguchi Prefecture, Japan	21.10
3	Ichihara city, Chiba Prefecture, Japan	13.40
4	Changshu Dongyang Beverage	3.14
5	Tianjin Toyoda Gosei	2.18
6	Tianjin Qinwei industry, China	2.02
7	Tianjin Fengjin Automobile transmission	1.61
8	Alvarado Water Treatment facility, San Diego	1.20
9	Suzhou Zixiang Electronics, China	1.01
10	PPL Renewable Energy Park, Camden	0.50
11	Gatorade Distribution Facility, Tolleson	0.50
12	Integrity Building Corporation, Mesa	0.02

Kyocera is considered a Tier 1 supplier by Bloomberg (Q1, 2021). A Tier 1 supplier is defined as a module manufacturer who has *'provided products to five different projects,*

<sup>1</sup> <https://global.kyocera.com/prdct/solar/spirit/example/industrial.html>

<sup>2</sup> <https://www.solarelectricsupply.com/solar-panels/kyocera-solar-modules>



*which have been financed non-recourse by five different (non-development) banks, in the past two years’.*

Whilst the Bloomberg tiering system does not reflect on a product’s technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers Canadian solar to have a strong track record in delivering PV modules to utility-scale projects worldwide).

### 3.1.1.1 Main Technical Characteristics

The Kyocera KD240GH-2PB modules of 240W<sub>P</sub> capacity has been utilized for the project. The 24W<sub>P</sub> modules have efficiencies of 16% and power tolerance of +5/-3%. The selected series has a temperature coefficient (P<sub>max</sub>) of -1.10W/°C. This temperature coefficient is in line with SgurrEnergy’s expectation for c-Si technology. The technical characteristic of the shortlisted modules is presented in Table 3-2.

**Table 3-2: Technical specifications of KD240GH-2PB**

Specifications	KD240GH-2PB
Technology	Polycrystalline
Nominal power (P <sub>MPP</sub> )	240W
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	29.80V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	8.06A
Open circuit voltage (V <sub>OC</sub> )	36.90V
Short circuit current (I <sub>SC</sub> )	8.59A
Efficiency (%)	14.50%
Maximum System Voltage	1,000V
Power tolerance (%)	+5/-3%
Dimensions (length × breadth × width) (mm)	1662 × 990 × 46 mm
Module area (m <sup>2</sup> )	1.65m <sup>2</sup>
Weight (kg)	21.00kg
Temperature coefficient at P <sub>MAX</sub> (%/°C)	-0.46%/°C
Maximum reverse current (A)	15A
Operation temperature (°C)	-40°C to +90°C
Maximum mechanical load (N/m <sup>2</sup> )	5,400Pa
Product warranty	10 years
Power output guarantee	10/ 20 years
<i>Module technical characteristics are given at STC (1,000W/m<sup>2</sup> irradiance, 25°C module temperature, Air Mass 1.5 according to module manufacturer datasheet)</i>	

Modules have a power tolerance of +5/-3%. The module temperature coefficients are average compared with those typically seen for multi-crystalline silicon modules. The maximum system voltage is 1,000V which is standard and compatible with the Project system design. Maximum mechanical loading specifications is in line with industry norms.



## NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>3</sup> characteristics of selected KD240GH-2PB modules of 240W<sub>P</sub> capacity is given in Table 3-3 corresponding to realistic operating conditions as compared to STC. It is affected by module materials used as well as the packing density of module materials. The NOCT for the module is 45°C.

**Table 3-3: PV Module NOCT Characteristics of KD240GH-2PB**

Model	KD240GH-2PB
Maximum Power (P <sub>MAX</sub> )	172W <sub>P</sub>
Max Power Voltage (V <sub>MPP</sub> )	26.7V
Max Power Current (I <sub>MPP</sub> )	6.5A
Open Circuit Voltage (V <sub>OC</sub> )	33.7V
Short Circuit Current (I <sub>SC</sub> )	6.9A

### 3.1.1.2 Certification of Modules

General review of datasheet indicates Kyocera Solar PV modules manufactured in facilities with the following certifications:

- ISO 14001 certification for environmental management systems
- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certification mentioned in the datasheet of the modules under evaluation within Table 3-4.

**Table 3-4: Certification for PV Module- Kyocera Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification

It is common for PV modules to hold the design, performance and safety certifications based on IEC prescribed testing methods. However, complete set of certifications of the installed modules was not made available for SgurrEnergy's review. Since the solar PV plant is already operational, SgurrEnergy raises no major concern regarding the unavailability of IEC certifications.

### 3.1.1.3 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of the date of installation or 90 days from the delivery date.

### 3.1.1.4 Product Warranty

Referring the warranty document provided, SgurrEnergy understands that Kyocera has offered a limited product warranty of 2 years. During this period the modules shall be free

<sup>3</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C.





from defects in materials and workmanship that affects the performance of the module. If the PV modules fail to conform to the warranty terms, Kyocera will repair or replace the PV modules at its sole option.

Although the warranty terms are in-line with the industry standard, SgurrEnergy considers two-year product warranty offered by Kyocera to be lower than industry standard of 10-years. Hence, SgurrEnergy suggests getting clarity from the manufacturer on the product warranty period offered for the PV modules used for the Project.

#### 3.1.1.5 Linear Power-Output Warranty

According to the datasheet provided, Kyocera warrants that the nominal power output at the end of 10 years and 20 years of operation shall not be less than 90% and 80% of the minimally specified power under standard test conditions (STC), respectively. However, the power loss of in the first year of operation and degradation in each year thereafter is not mentioned in the datasheet provided. Hence, SgurrEnergy suggests getting clarity from the manufacturer on the first-year degradation and the general degradation of the PV modules used for the Project.

### 3.2 Inverters

The project has utilized ABB PVS800-57-500kW and Power one PVI-500.0-TL-CN - 500kVA central inverters for the project under evaluation.

#### 3.2.1 Company background- ASEA Brown Boveri (ABB)

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, ABB is one of the largest engineering companies as well as one of the largest conglomerates in the world. ABB has operations in around 100 countries, with approximately 147,000 employees<sup>4</sup>. Company reported global revenue of around \$34,312 million for 2017.<sup>5</sup>

The firm's shares are traded on the stock exchanges of Zurich, Stockholm, and New York. ABB is a multinational corporation headquartered in Zurich, Switzerland, operating mainly in robotics and power and automation technology.

On July 9, 2019, the Italian company FIMER acquired ABB's solar inverter business. The takeover of ABB's solar inverter business included 800 employees in 26 countries as well as two manufacturing plants, in Italy and in India, and a R&D facility in Finland.

FIMER was founded in 1942, headquartered in Vimercate, Italy, has been actively working in inverter technology since 1983. As of 2020, the company employs more than 1,100 employees across its three manufacturing facilities and three R&D centres across the globe. As a result of acquisition of ABB's PV inverter line, FIMER ranked the fifth-largest PV inverter globally in 2019.

##### 3.2.1.1 Track Record

ABB India commenced local manufacturing of solar inverters in 2012 and partnered with several customers. ABB is the solar inverter market leader in India holding approximately 24% market share in 2018. ABB has approximately 3,590MW in operation across more than 350 sites in India. ABB India manages close to 40% of the installed bases in India. As on 30 August 2017, ABB India crossed the 5GW threshold for the supply of inverters in the country.

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<sup>4</sup> <https://new.abb.com/news/detail/26838/abb-to-exit-solar-inverter-business>

<sup>5</sup> <https://new.abb.com/investorrelations/company-profile/facts-figures>



Table 3-5 lists the state-wise installed capacity of ABB inverters in India. However, it is to be noted that the table below doesn't not comprise of the installed capacities till date.

**Table 3-5: ABB Inverter Track Record**

Location	Capacity (MW)
Punjab	227
Haryana	62
Uttar Pradesh	106
Bihar	225
Rajasthan	371
Madhya Pradesh	271
Chhattisgarh	28
Odisha	20
Andhra Pradesh	647
Maharashtra	261
Tamil Nadu	747
Karnataka	305
Kerala	50

ABB India has strategically located its headquarter in Bangalore and offices in other cities Pune, Ahmedabad, Jaipur, Faridabad, Hyderabad, Tamil Nadu, and Bhopal in order to facilitate quick spare part availability and minimal response time. ABB aims to provide first response to its customers within 4 hours on weekdays and within 24 hours on weekends and holidays. ABB also provides a Turn-Around-Time of 48 and 72 hours on weekdays and weekends respectively, hence maintaining an average uptime of over 99%.

### 3.2.1.2 Technical Characteristics

ABB PV800-57-500kW inverter has been selected for technical feasibility of the Project. The technical specification of 500kW ABB inverter is listed in Table 3-6.

The PV800-57-500kW Series of central inverters designed ideal for large PV Power Plants. These inverters are designed to operate with DC inputs up to 1,100 V. PV800-57-500kW inverter is designed for outdoor use with an IP42 ingress protection class. They perform optimally at ambient air temperatures between -15°C to 50°C and relative humidity in the range of 15% to 95% with maximum noise level of less than 75dBA.

The PV800-57-500kW inverter has peak efficiency of 98.6% and a European efficiency of 98.2%.

The main technical characteristics of these inverters are illustrated in Table 3-6.

**Table 3-6: ABB inverter specifications**

ABB Central Inverter Specifications	
Inverter	PV800-57-500kW
Type	Central Inverter
<b>Input Data</b>	
PV voltage range, MPP (V)	450 to 825V
Maximum DC voltage (V)	1,100V





<b>ABB Central Inverter Specifications</b>	
Maximum input current (A)	1,145A
<b>Output Data</b>	
Nominal AC power (kW)	500kW
Maximum AC current (A)	965A
Nominal AC voltage (V)	300V
AC grid frequency (Hz)	50/60Hz
Maximum THD	< 3%
<b>Operating Performance</b>	
Maximum efficiency (%)	98.60%
Euro efficiency (%)	98.20%
<b>Power consumption</b>	
Own consumption in operation (W)	490W
Standby operation consumption (W)	65W
<b>Other</b>	
Dimensions (W × H × D) (mm)	2630mm x 2130mm x 708mm
Weight (kg)	1800kg
Environmental Protection Rating	IP42
Operating temperature range (°C)	-15 to +50°C
Relative humidity (%)	15% to 95%

The following protection devices are included within the inverter design:

- Ground fault monitoring
- Grid Monitoring
- Anti-islanding protection
- DC reverse-polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection

ABB inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components.

### 3.2.1.3 Certification

ABB is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. ABB inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information available in public domain, SgurrEnergy has summarized the certification of the ABB inverter within Table 3-7.



**Table 3-7: Description of Certification of ABB inverters**

Certification	Description
IEC 60068-2-6/29	Environmental testing of inverters to assess their ability to perform and survive under conditions such as transportation, storage, operational environments, extreme cold and heat
IEC 61683:1999	Procedure for measuring efficiency
IEC 62109-2:2011	Safety of Power Converters
IEC 62116:2014	Islanding prevention measures

### 3.2.1.4 Warranties

According to the warranty documents provided, ABB has offered the inverter warranty of 60 months from commissioning of last inverter or 63 months from the date of supply of last inverter, whichever is earlier. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards and do not raise any concern over the use of inverter for the project.

### 3.2.2 Company background- Power-one

Founded in Chatsworth, California, in 1972 as an AC/DC power supplies manufacturer, Power-one was incorporated in late 1970s and shifted its headquarters to Camarillo. Power-one was one of the leading providers of renewable energy and energy-efficient power conversion and power management solutions and a leading designer and manufacturer of photovoltaic inverters, in the late 1990s.

The company provided services in sales, manufacturing, and R&D across Asia, Europe, and the Americas. In addition to its manufacturing units in Dominican Republic and Mexico, the company also had research and development centre in Limerick, Ireland.<sup>6</sup> In 2013, Power-one had over 40-years of experience of providing services for variety of industries including renewable energy, servers, storage and networking, industrial and network power systems, etc. In 2012, Power-one employed nearly 3,300 people, mainly in China, Italy, the USA and Slovakia and generated USD120million in earnings.

However, due to poor business conditions at the start of the 21<sup>st</sup> century, the company suffered significant losses. On April 22, 2013, the ABB acquired Power-one's solar inverter business.

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, ABB is one of the largest engineering companies as well as one of the largest conglomerates in the world. ABB has operations in around 100 countries, with approximately 147,000 employees<sup>7</sup>. Company reported global revenue of around \$34,312 million for 2017.<sup>8</sup>

#### 3.2.2.1 Track Record

Table 3-5 lists the state-wise installed capacity of Power-one (ABB) inverters in India. However, it is to be noted that the table below doesn't not comprise of the installed capacities till date.

**Table 3-8: Power-one (ABB) Inverter Track Record**

<sup>6</sup> <https://www.encyclopedia.com/books/politics-and-business-magazines/power-one-inc>

<sup>7</sup> <https://new.abb.com/news/detail/26838/abb-to-exit-solar-inverter-business>

<sup>8</sup> <https://new.abb.com/investorrelations/company-profile/facts-figures>



Location	Capacity (MW)
Punjab	227
Haryana	62
Uttar Pradesh	106
Bihar	225
Rajasthan	371
Madhya Pradesh	271
Chhattisgarh	28
Odisha	20
Andhra Pradesh	647
Maharashtra	261
Tamil Nadu	747
Karnataka	305
Kerala	50

### 3.2.2.2 Technical Characteristics

Power-one PVI-500.0-TL-CN inverter has been selected for technical feasibility of the Project. The technical specification of 500kW Power One inverter is listed in Table 3-6.

The PVI-500.0-TL-CN -500kVA Series of central inverters designed ideal for large PV Power Plants. These inverters are designed to operate with DC inputs up to 1,000 V. PVI-500.0-TL-CN -500kVA inverter is designed for outdoor use with an IP20 ingress protection class. They perform optimally at ambient air temperatures between -20°C to 55°C and relative humidity in the range of 0% to 95% with maximum noise level of less than 62dBA.

The PVI-500.0-TL-CN -500kVA inverter has peak efficiency of 98.5% and a European efficiency of 98.2%.

The main technical characteristics of these inverters are illustrated in Table 3-6.

**Table 3-9: Power-one inverter specifications**

ABB Central Inverter Specifications	
Inverter	PVI-500.0-TL-CN -500kVA
Type	Central Inverter
<b>Input Data</b>	
PV voltage range, MPP (V)	475 to 900V
Maximum DC voltage (V)	1,000V
Maximum input current (A)	1,100A
<b>Output Data</b>	
Nominal AC power (kW)	500kW
Maximum AC current (A)	900A
AC voltage range (V)	272 to 352V
AC grid frequency (Hz)	50Hz±5%
Maximum THD	< 4%



<b>ABB Central Inverter Specifications</b>	
<b>Operating Performance</b>	
Maximum efficiency (%)	98.50%
Euro efficiency (%)	98.20%
<b>Power consumption</b>	
Night-time power loss (W)	<66W
Standby operation consumption (W)	<66W
<b>Other</b>	
Dimensions (W × H × D) (mm)	2280mm x 2000mm x 800mm
Weight (kg)	<1400kg
Environmental Protection Rating	IP20
Operating temperature range (°C)	-20 to +55°C
Relative humidity (%)	0% to 95%

The following protection devices are included within the inverter design:

- Anti-islanding protection
- Reverse polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection

Power-one inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components.

### 3.2.2.3 Certification

Power-one is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. Power-one inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information available in public domain, SgurrEnergy has summarized the certification of the Power-one inverter within Table 3-7.

**Table 3-10: Description of Certification of Power-one inverters**

<b>Certification</b>	<b>Description</b>
IEC 61000-6-2	Electromagnetic compatibility
IEC 62109-2:2011	Safety of Power Converters
IEC 62116:2014	Islanding prevention measures

### 3.2.2.4 Warranties



According to the warranty documents available on public domain<sup>9</sup>, the standard warranty offered by Power-one for central is for a period of 66 months from the date of invoice. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards and do not raise any concern over the use of inverter for the project.

### 3.3 Transformers- Voltamp Transformers Ltd.

The solar PV plant is implemented with two level transformation. Power at low voltage from inverters is stepped up to 11kV using 1250kVA transformers of Voltamp make inverter transformers, and further to 66kV using 12.5MVA power transformer manufactured by Voltamp.

#### 3.3.1 Company Profile

The inverter transformer used is manufactured by Voltamp Transformers limited (Voltamp).

Voltamp was founded in 1963 in Vadodara, Gujarat and now has a PAN India presence. The company initially started off by manufacturing small transformers by 1975 the largest transformer manufactured was for 132kV networks. This limit rose to 220kV class of transformers in 2008. The company employs more than 300 personnel (including 60 engineers) and has branch offices in Mumbai, New Delhi, Chennai, Bangalore, Secundrabad, Pune, Bhubaneshwar, etc.

The company has four manufacturing plants and the current manufacturing capacity totals to 13000 MVA per year. These facilities boast of manufacturing Oil filled Power and Distribution Transformers up to 160MVA, 220kV. The company got its ISO 9001 certification in 1998 and was listed on the NSE and BSE stock exchange in 2006.

Notable designs include:

- 75MVA 11/138kv GT
- 20MVA 33-22/11kV (DZ10)
- 50MVA 132-110/33kV transformer
- 6 MVA 1-ph transformer
- 15MVA 11/1.3-1.3kV (24 pulse)
- 100MVA 22kV

The company also manufacturers two types of dry transformers, i.e. resin impregnated (25KVA-5000KVA up to 11kV) and cast resin transformers (50kVA-12500kVA up to 33kV). Prominent clients include ABB, Exide, Adani, BHEL, BPCL, Suzlon etc.

#### 3.3.2 Technical Specifications

The 1250kVA rated Inverter transformers and 12.5MVA rated Power transformers, used in the project are outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 3-11.

<sup>9</sup> <https://www.renvu.com/site/downloads/Power-One%20Aurora%20Warranty%20Services%20Description%20for%20String%20Inverters%20for%20RENVU.pdf>



**Table 3-11: Technical Specification of Voltamp Transformer**

Technical Parameters	Description	
Rated Power	1250kVA	12.5MVA
Rated HV	11kV	66kV
Rated LV	2*0.625kV	11kV
Tapping on HV	+10% to -10% (steps of 2.5%)	+12.5% to -12.5% (steps of 1.5625%)
Phases	3	
Frequency	50Hz	
Vector group	Dyn11yn11	Dyn11
Impedance	4.9%	10%
Cooling Strategy	ONAN	
Oil temperature rise	50°C	
Winding temperature rise	55°C	
Winding material	Electrolytic Copper	

SgurrEnergy considers the overall the technical specification to be adequate for the PV projects and in line with the industry accepted standards.

### 3.3.3 Temperature Rise Detection and Protection

Inverter transformers and Power transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.4 Warranties and Guaranties

Based on the review of the standard warranty certificate sourced from public domain, SgurrEnergy understands the Voltamp transformers are provided with a warranty of 60 months from date of dispatch. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards.

## 3.4 Conclusion on Major Plant Components

### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of Kyocera Solar, assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.

Further, according to the warranty documents available in public domain for the module manufacturer, SgurrEnergy considers the warranty terms and conditions offered by Kyocera to be in-line with the industry standard and raises no major concern regarding the warranties offered. However, SgurrEnergy suggests getting clarity on the limited product warranty, first-year degradation and general degradation offered by the manufacturer for the PV modules used for the project.



Referring the datasheet provided, SgurrEnergy observed that the Kyocera PV modules used for the project are IEC 61215 and IEC 61730 certified, which is in-line with the industry standard. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.

## Inverters

SgurrEnergy has conducted review of the ABB's PV800-57-500kW and Power-one's PVI-500.0-TL-CN -500kVA central inverter. Both the central inverter makes have the required certification for use in solar PV plants. The technical characteristics of both the inverters are in-line with the industry standard. ABB and Power-one offer a product warrant of 63 and 66 months, respectively, which is in line with the current industry standards.

In conclusion, ABB and Power-one can be considered as established and reputable inverter manufacturers and are known for producing good quality and high-performance inverters. SgurrEnergy raises no major concern in the utilization of ABB and Power-one inverters for the project.

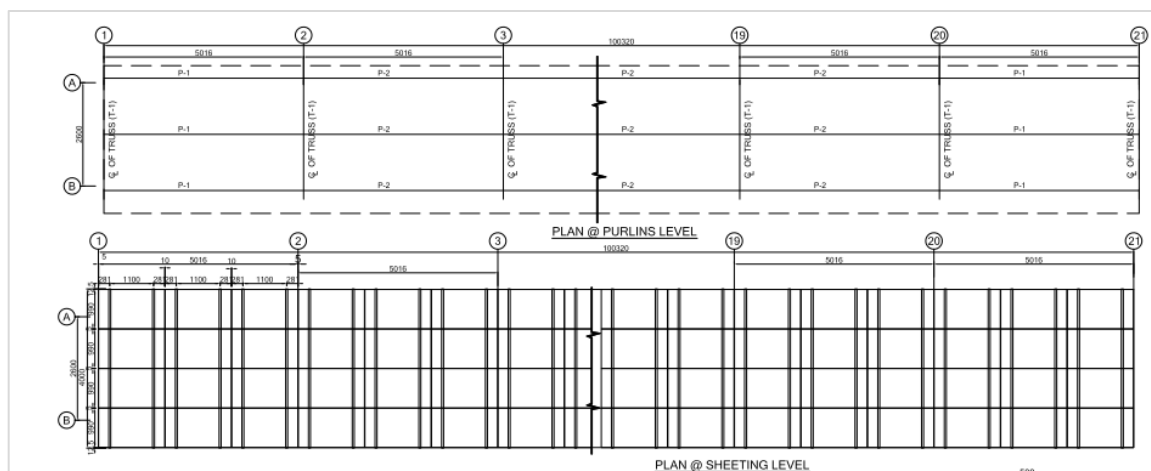
## Transformers

The inverter transformers (1250kVA) and power transformer (12.5MVA) used within the project are manufactured by Voltamp. The manufacturers have good track record of supplying transformers for solar application throughout the world. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.

### 3.5 Module support structures

The Array Layout provided by the Client for the 20MW(AC) PLG Solar PV Plant indicates the fixed tilt module mounting structure is inclined at 23° tilt angle.

Although the as-built MMS GA drawing for the 20MW<sub>AC</sub> PLG Solar PV Plant site has not been provided for review. Material used for MMS member, type of foundation and details provided for MMS is unavailable for review. The general arrangement is as shown in below figure.



**Figure 3-1: MMS General Arrangement**



## 4 Allied Components and Systems

### 4.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

### 4.2 PV Power Transfer

SgurrEnergy has gone through the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear, and plant substation as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

- AC side electrical SLD of Solar plant-R2.
- Typical DC SLD for 500kW<sub>p</sub> PV unit-R2.

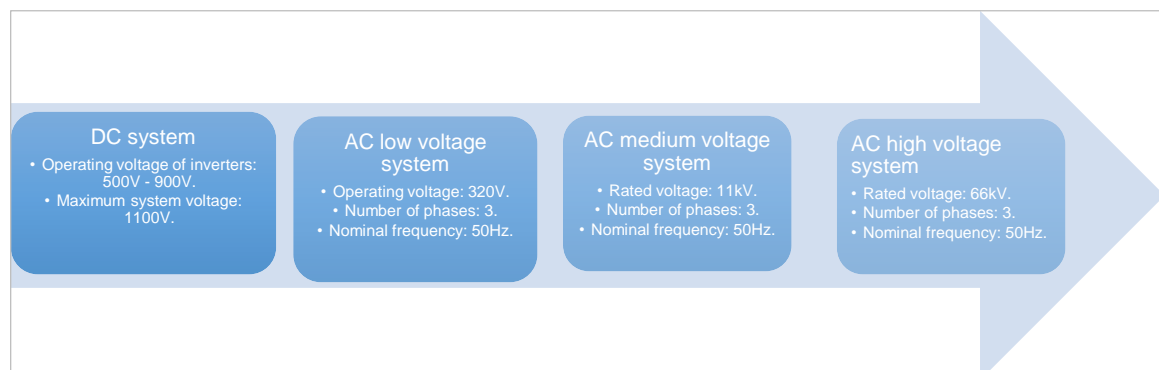
The 20MW<sub>AC</sub> solar PV Plant is designed with 240W<sub>p</sub> *Kyocera* make solar PV modules and 500kW *Power one* make central inverters. PV modules are interconnected in series to form a string of 24 modules; eight such strings are further connected to 8 input string combiner boxes as inputs. The output of seven string combiner boxes is further connected to central inverter.

The 20MW<sub>AC</sub> solar PV plant has been configured with 40 *Power one* make 500kW central inverters and 20 inverter stations. Each inverter station comprises of one three winding inverter duty transformers (IDT) to accommodate two 500kW inverters. The inverter duty transformer is connected with two Inverters, taking the individual inverter station size to 1MW<sub>AC</sub>. Inverter station comprises of a physical block connecting to 1MW<sub>p</sub> of installed photovoltaic array. The output of 500kW inverters are connected to 1.25MVA, 11/0.320-0.320kV, ONAN three winding transformer for stepping up the voltage to 11kV.

The medium voltage output from inverter duty transformer is connected with 11kV RMU (Ring Main Unit) panel placed at inverter station. The five such 11kV RMU (Ring Main Unit) panels are connected in ring philosophy and connected with 11kV switchgear panel located in control room. The 11kV output from main MV Switchgear panel shall be further connected to 11/66kV switchyard.

Power from 66kV switchyard is evacuated to the grid substation at 66kV voltage level via 0.5km overhead transmission line; however the switchyard details is not provided to SgurrEnergy.

Figure below illustrates a power flow summary for the 20MW<sub>AC</sub> Solar PV plant.



**Figure 4-1: Power flow of 20MW<sub>AC</sub> PV plant**





### 4.3 Cabling

#### 4.3.1 DC Cabling

DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. Modules are interconnected in series with 4mm<sup>2</sup> solar grade cables. PV modules are interconnected in daisy chain scheme to form a string of 24 PV modules connected in series. Single core 4mm<sup>2</sup> multi-stranded copper PV cables connect string output to String Combiner Box (SCB).

These combiner boxes are equipped with 25A fuse for each of the string connection. Power from string combiner box is further transferred to the inverter using 2C, 95mm<sup>2</sup>, 1.1kV aluminium XLPE cables.

#### 4.3.2 AC Cabling

Three phase AC output from inverter is connected to the LV winding of a 1.25MVA three-winding transformers using 3C, 300mm<sup>2</sup> Aluminium Armoured XLPE cable. The inverter transformers step up the voltage to 11kV.

The inverter duty transformer output is connected to 11kV RMU panel located in inverter station 3C, 300mm<sup>2</sup>, 11kV Al XLPE armoured cable. The five such RMU panels are interconnected in ring philosophy using 3C, 300mm<sup>2</sup>, 11kV Al XLPE armoured cables.

The 11kV output from RMU panels is transmitted to 11kV switchgear panel located in main control room using 3C, 300mm<sup>2</sup>, 11kV Al XLPE armoured cables.

The power from the Main switchgear panel is transferred to 11/66kV outdoor switchyard using 3R of 3C, 300mm<sup>2</sup>, 11kV Al XLPE armoured cable. Further the output power of 11/66kV Switchyard is transferred to GSS.

### 4.4 Inverter Station

The 20MW<sub>AC</sub> solar PV plant has been configured with 40 inverters and 20 inverter stations. Each inverter station is of 1MW<sub>AC</sub> capacity consist of two 500kW inverters and one 1.25MVA inverter duty transformer.

The 1MW<sub>AC</sub> inverter station consists of two inverters connected to 1.25MVA, 11/0.320-0.320kV, three winding transformers. The inverter duty transformer steps up the voltage to 11kV for all inverter stations. Further the power from the HV side of the transformer is fed to the 11kV RMU panel through underground cable.

The 11kV RMU panel comprises of 100/1A current transformer, 630A SF6/VCB Circuit Breaker, two 630A load break switches and other electrical protection system. The power from inverter duty transformer is transferred to aforesaid RMU panel.

### 4.5 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed that 1.25MVA, 11kV/2x0.320kV, Dyn11yn11 three winding transformers have been used in the project. These inverter duty transformers step up the voltage to 11kV.

The 1.25MVA inverter duty transformers output is connected to 11kV RMU panels located within inverter station. The energy from 11kV RMU panels of five Inverter stations is connected in ring philosophy. The combined 5MW power from five Inverter Stations is transmitted to 11kV switchgear over ring philosophy which located within main control room.



#### 4.6 11kV RMU Panel

The 11kV RMU panel comprises of inverter duty transformer incoming feeder, inverter station RMU panel incoming feeder and one outgoing feeder to nearest inverter station RMU panel or 11kV switchgear panel located in main control room. Each RMU panel comprises of 100/1A current transformer, 630A SF6/VCB Circuit Breaker, two 630A load break switches and other electrical protection system.

#### 4.7 11kV Switchgear Panel

The 11kV main switchgear panels outgoing and incoming feeders are provided with instrument transformers for protection and metering system, VCB for isolation/protection. The Class 1.0 instrument transformers for metering and class 5P10 instrument transformers for protection have been considered.

Power from 11kV switchgear panel is transmitted to 11/66kV outdoor Switchyard. Further power from 66kV Switchyard is transferred to GSS.

#### 4.8 Auxiliary Power Supply

SgurrEnergy had reviewed the electrical schematics shared for the projects to evaluate auxiliary system. One 100kVA, 11/0.430kV auxiliary transformer for control room and two, 5kVA, 320/415V auxiliary transformers have been considered to cater the auxiliary loads. ACDB panels have been considered at main control room and inverter stations.

#### 4.9 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are mounted within the panels as well as on individual structures.

Following the review of 11kV SLD, SgurrEnergy observed 11kV, 630A and 1250A, 25kA/1sec SF6/VCB type circuit breaker has been used in the project.

#### 4.10 Load break switch

Load break switches are used to isolate the equipment during load condition for maintenance.

Based on the review of 11kV SLD, SgurrEnergy observed 11kV, 630A load break switches switch has been used in the project.

#### 4.11 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.

The current transformers with accuracy class of 1.0 for metering and class 5P10 for protection has been used in 20MW<sub>AC</sub> solar PV plant.

#### 4.12 Surge Arrestors and Lightning Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes and switching surges from incoming lines. The apparatus most commonly used for this purpose is the surge arrester. Transformer is the costliest equipment in substation, and it is normal practice to install surge arrester near to the transformer. Additional surge arresters shall be provided either on bus or on various lines for protection of the equipment.



Following the review, SgurrEnergy observed that surge arrester has not been provided for 11kV system.

#### 4.13 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy will be provided at the medium voltage switchboards for each of the feeder sections. These meters will be digital with an RS 485 port for remote monitoring. These usually have an accuracy class of 0.5.

Similarly, HV side shall also be equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point shall be 0.2S. However, SgurrEnergy has not provided with 11/66kV switchyard SLD and metering details.

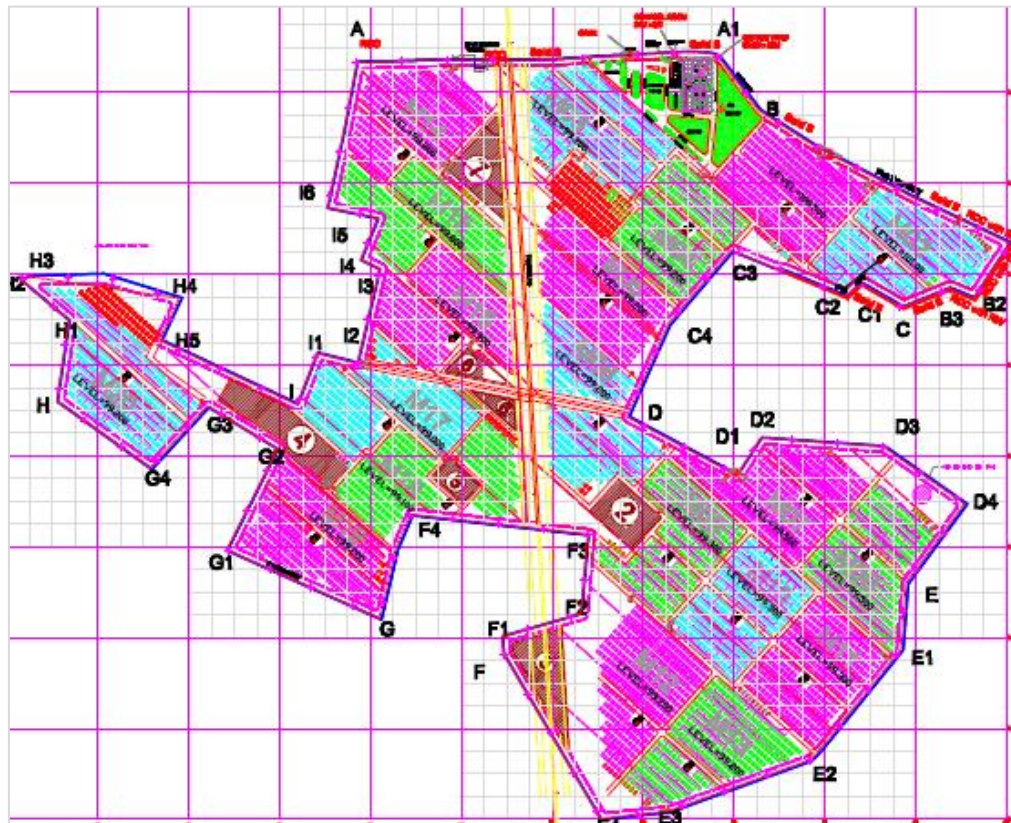


## 5 System Design Appraisal

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

### 5.1 Plant Layout Design

SgurrEnergy was provided with as built plant layout and electrical schematics. SgurrEnergy has verified the plant configuration with electrical schematics provided by the Client. The PV plant is designed with Kyocera 240W<sub>p</sub> PV modules. The total DC installed capacity stands at 20MW<sub>p</sub>. The AC installed capacity stands at 20MW<sub>AC</sub> with 40 inverters of capacity 500kW each. The 20MW<sub>AC</sub> PV plant is illustrated below in the Figure 5-1.



**Figure 5-1: Plant layout**

All the PV modules are orientated towards South. The selected tilt for the 20MW<sub>AC</sub> plant is 23°. The 20MW<sub>AC</sub> plant is designed with a pitch of 7.00m.

24 modules are connected in series to form a string. The nominal plant power ratio (DC to AC) of the Project is 1.01. Typically, PV plants are designed to have a nominal power ratio upto 1.50 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio.

### 5.2 String Sizing

The plant layout provided by the Owner indicate twenty four 240 W<sub>p</sub> polycrystalline PV modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage (V<sub>oc</sub>) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum V<sub>oc</sub> of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy



in validating string configuration. Subsequent to calculating open circuit voltage ( $V_{OC\ max}$ ), maximum power voltage ( $V_{mp\ min}$ ) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 45°C and 10°C respectively for system design validation to be fair and representative for the PV plants' site.

The results of string sizing validation are presented in Table 5-1. Results indicate that  $V_{OC\ max}$  at the minimum ambient temperature is within the maximum system voltage of 1,000V for the selected Power One 500kW inverters.

**Table 5-1: String Sizing for Kyocera PV Modules**

Parameters	Kyocera 240W <sub>p</sub>
PV module power (W <sub>p</sub> )	240
Modules per string	24
Inverters	Power One PVI 500TL
Maximum Open-circuit voltage ( $V_{OC\ max}$ ) at minimum ambient temperature of 10°C	861.6
Minimum power voltage ( $V_{mp\ min}$ ) at maximum ambient temperature of 45°C	650.4

### 5.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with Kyocera and Power One inverter are presented in Table 5-2.

**Table 5-2: Inverter Compatibility with Kyocera 240W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	<b>Kyocera 240</b>	
Modules per string	24	Acceptable
Strings per inverter	87	Acceptable
Maximum power, $P_{mpp}$ at STC (kW <sub>p</sub> )	505	Nominal power ratio is 1.01, this is within the inverter bus current carrying capacity.
Maximum power voltage, $V_{mpp}$ at STC (V)	715.2	Acceptable.
Maximum power current, $I_{mpp}$ at STC (A)	902.72	Acceptable
Open-circuit voltage, $V_{oc}$ at STC (V)	885.6	Acceptable.
Minimum MPP voltage at 45°C ambient temperature (V)	650.4	Acceptable: Inverter MPPT ranges 475 -900V.
Maximum MPP voltage at 10°C ambient temperature (V)	734.4	Acceptable: Inverter MPPT ranges 475 -900V.
Maximum open circuit voltage, $V_{oc}$ at 10°C (V)	861.6	Acceptable: Maximum inverter voltage 1000V.



Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.





## 6 Resource assessment

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SEI has sourced monthly horizontal plane irradiation data for the Project site from:

- **NASA's Surface Meteorology and Solar Energy data set**; holds satellite derived monthly data for a grid of 0.5° × 0.5° covering the globe for a thirty-four-year period (1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.

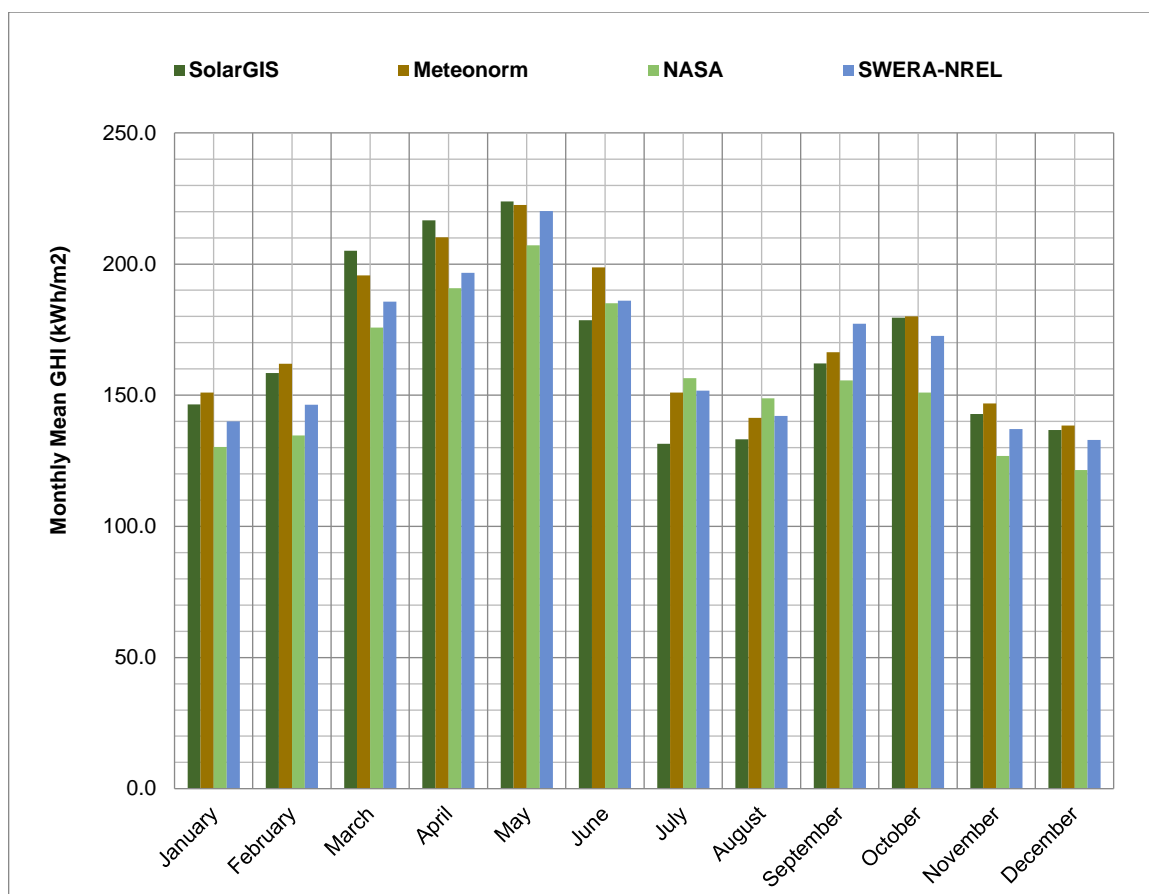


- The **METEONORM (version 7.2)** *global climatological database and synthetic weather generator*; contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **SolarGIS:** SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km × 4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by *IEA (International Energy Agency) SHC Collaboration Agreement, and EU FP6 project MESoR* in terms of bias and RMSE.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.

SEI has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS and, NREL (SWERA) data for the site. The comparison is graphically illustrated Table6-1







**Figure 6-1: Monthly Global Horizontal Irradiation**

**Table6-1: Comparison of Solar Irradiation Datasets for the site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	2,015.0
Meteonorm 7.2	14km × 14km	4.0%	2,064.1
NASA	55km × 55km	Unknown	1,864.1
NREL (SWERA)	40km × 40km	Unknown	1,988.5

The comparison of solar data for Project site location illustrated in Table6-1 indicates Meteonorm 7.2 dataset to give the highest irradiation levels. The next highest irradiation is given by SolarGIS followed by NREL (SWERA) and NASA.

The irradiation values given by Meteonorm 7.2 typically provide a combination of ground and satellite measured data. Meteonorm 7.2 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as 6.8% for the proposed site.

The NREL (SWERA) data illustrated has been obtained for a location approximately 8.76 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data.

The NASA-SSE data source provides purely satellite measured data for a grid covering 0.5° × 0.5° on the earth's surface and generally more suited for initial site selection.



The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also been compared with other data sources globally. The IEA (International Energy Agency) validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>10</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)
- Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 6%.

SEI is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 6.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 6-2 and shown graphically in Figure 6-2. Diffuse irradiation accounts for 41.31% of the total irradiation. Table 6-2 illustrates direct and diffuse daily irradiation on a horizontal plane for the proposed site. SolarGIS irradiation data is presented in Table 6-2.

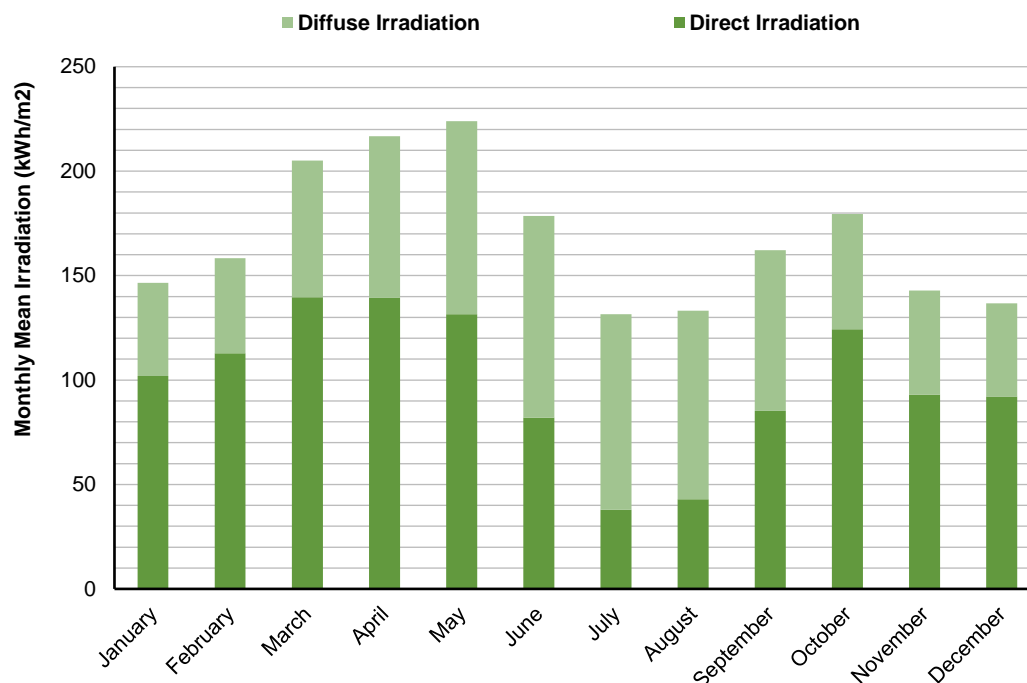
**Table 6-2: SolarGIS Irradiation Data for the Project site**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	146.5	44.6	7.3%
February	158.4	45.6	7.9%
March	205.1	65.4	10.2%
April	216.7	77.4	10.8%
May	223.9	92.4	11.1%
June	178.6	96.6	8.9%
July	131.5	93.6	6.5%
August	133.2	90.2	6.6%
September	162.1	76.8	8.0%

<sup>10</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>



Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
October	179.5	55.2	8.9%
November	142.8	49.8	7.1%
December	136.7	44.6	6.8%
<b>Annual Sum</b>	<b>2,015.0</b>	<b>832.3</b>	<b>-</b>



**Figure 6-2: Monthly Direct and Diffuse Irradiation on a horizontal plane for the project site**

## 6.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.0.17), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -6-3 represents the monthly GTI profile.

**Table -6-3: Monthly Global Tilted Irradiation Data**

Month	GTI (kWh/m <sup>2</sup> )
January	194.50
February	193.70
March	227.40
April	219.50
May	211.30
June	164.20



Month	GTI (kWh/m <sup>2</sup> )
July	123.20
August	129.60
September	171.70
October	212.20
November	181.70
December	182.80
<b>Annual Sum</b>	<b>2,211.80</b>

### 6.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 6-4 below. The average wind speed of 2.3 m/s was measured at 10m height from ground level for the proposed project site location.

**Table 6-4: Simulated Wind Speed for site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	1.7
February	1.7
March	1.9
April	2.6
May	3.7
June	3.7
July	3.4
August	2.9
September	2.2
October	1.3
November	1.2
December	1.5
<b>Yearly Average</b>	<b>2.3</b>

### 6.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.

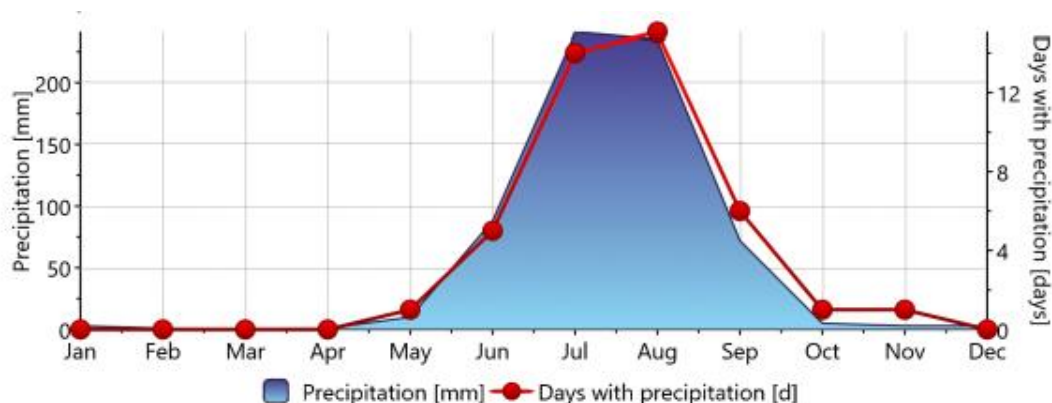


**Table 6-5: SolarGIS Temperature Data for Site (1999 – 2018)**

Months	Average Monthly Temperature (°C)
January	19.6
February	22.6
March	27.8
April	32.3
May	35.1
June	34.7
July	31.2
August	29.8
September	31.3
October	30.1
November	25.4
December	21.2
<b>Annual Average</b>	<b>28.4</b>

## 6.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.2 as illustrated in Figure 6-3. These figures show that the identified site is situated in a region that has marginal rainfall.

**Figure 6-3 Meteonorm Predicted Precipitation for the site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

Frequency of module cleaning depends on the rainfall frequency and the prevalence of dust and pollution in the local vicinity. Typical cleaning techniques include water cleaning, dry brushes or vehicle-based mechanical cleaning.

The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 2% has been considered by considering cleaning frequency of twice a month.



## 7 Energy Yield Analysis

SgurrEnergy has computed the annual energy yields for the 20MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

Parameter	Description
Modules	Kyocera Solar 240 Wp, (KD240GX-LPB)
Inverters	Power-One – PVI-Central-500-TL
Mounting System	Fixed Tilt
DC Capacity (MW <sub>p</sub> )	20

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 7.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in Table 7-1 below.

**Table 7-1: Description of Energy Yield Losses**

Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.



Loss	Description
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 30MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 7.2 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 20 MW<sub>p</sub> solar PV Plant with Kyocera Solar PV modules and Power-One central inverters. Table 7-2 summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.



**Table 7-2: Energy Yield for the 20MW<sub>AC</sub> Solar PV Plant**

Parameters	Description
PV Module Technology	polycrystalline
DC Capacity (MW <sub>p</sub> )	20.00
AC Capacity (MVA)	20.0
Contracted Capacity (MW)	20.0
P <sub>NOM</sub> Ratio	1
Tilt (°)	23
Pitch (m)	7
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	2015.00
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	2211.81
Transposition Factor	1.10
<b>Losses</b>	
Horizon Shading	0.00%
Incident Irradiation Below Threshold	0.00%
Near Shading	2.50%
Incident Angle	2.49%
Soiling	2.00%
Low Irradiance	2.09%
Module Temperature	12.16%
Electrical Shadings	0.08%
Module Quality	-0.80%
First year Degradation	2.00%
Module Mismatch	1.00%
DC Ohmic	0.79%
Inverter Performance	1.55%
Availability	1.00%
AC Ohmic	0.56%
Transformer (LV/MV)	1.03%
Transformer (MV/HV)	0.50%
Transmission Line	0.00%
Auxiliary Consumption	0.95%
Curtailment	
<b>Total Annual Loss Factor</b>	<b>0.736</b>
<b>First Year P50 Energy Yield (MWh/annum)</b>	<b>32,542.187</b>
<b>Ninth Year P50 Energy Yield (MWh/annum)</b>	<b>31,263.05</b>
<b>Ninth Year Specific Yield (kWh/kW<sub>p</sub>)</b>	<b>1563.15</b>
<b>Ninth Year CUF on AC Installed Capacity</b>	<b>17.84%</b>
<b>Ninth Year CUF on Contracted Capacity</b>	<b>17.84%</b>

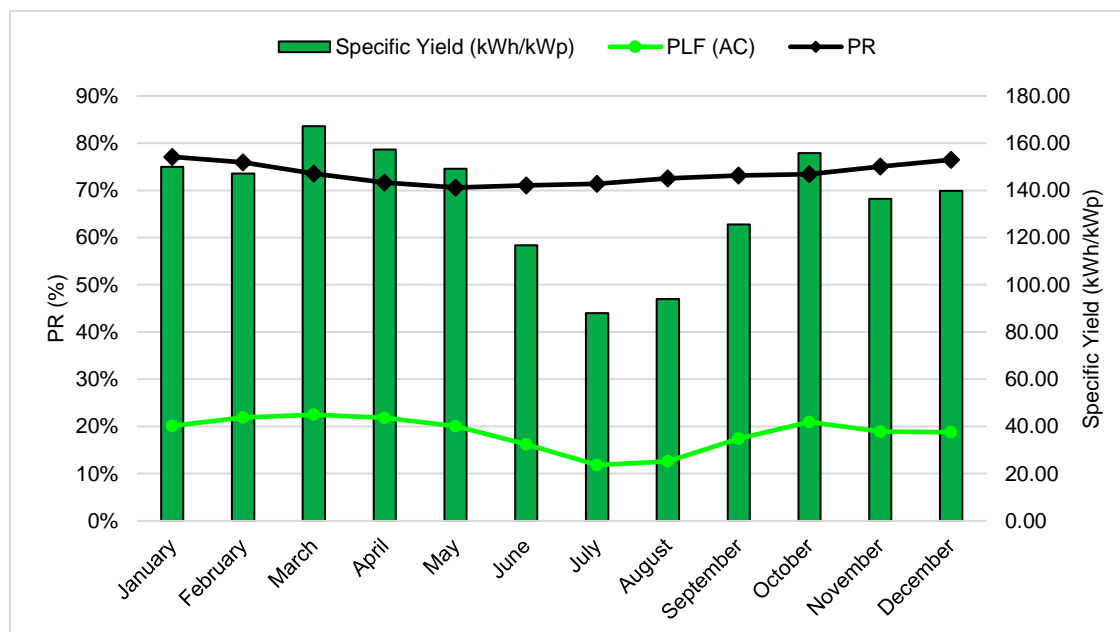




Parameters	Description
Ninth Year CUF on DC Installed Capacity	17.84%
Ninth Year Performance Ratio	70.67%

Based on the thermal loss observed in the evaluation, SgurrEnergy has validated the same from the PAN file provided. However, it is understood that the plant may not in actuality have such high operational thermal losses and the same may have been provided by the manufacturer for warranty purposes.

Graphical representation of the monthly generation, performance ratio and CUF for 20 MW<sub>AC</sub> evaluated is illustrated graphically in the Figure 7-1.



**Figure 7-1: Monthly Energy Yield for 20MW<sub>AC</sub>**

### 7.3 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 7.3.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

#### 7.3.2 Inter – Annual Variation in the Solar Resource

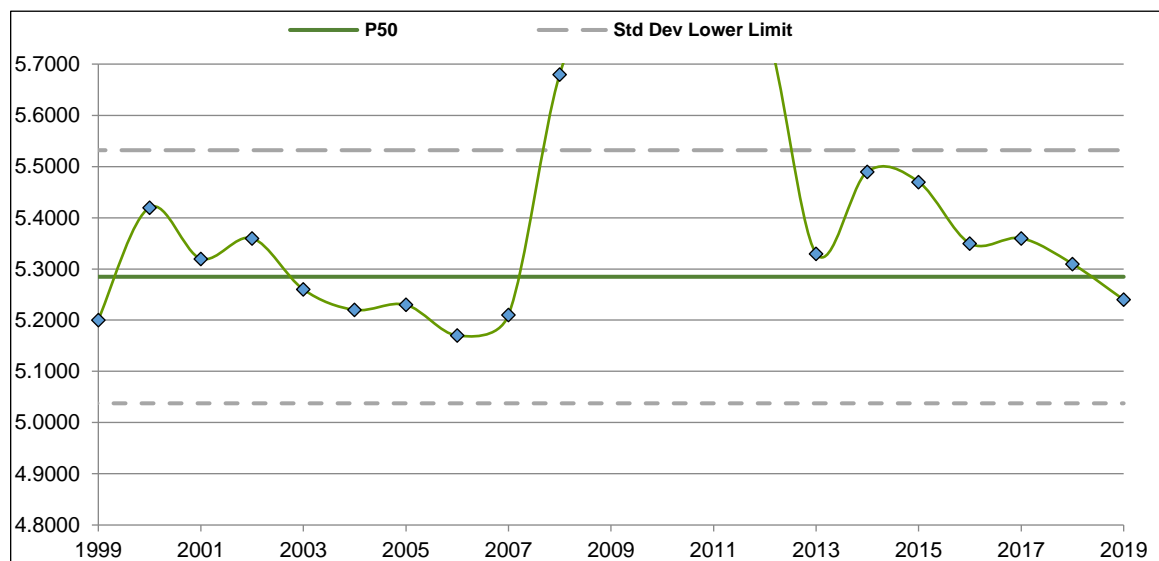


Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.

The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database for the proposed site location which is used to estimate the standard deviation of variation in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 7-3.

**Table 7-3: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	4.68



**Figure 7-2: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in Figure 7-2.

SgurrEnergy uses a coefficient of variation of 4.68% to quantify the inter-annual variation in the solar resource.

### 7.3.3 Modelling Uncertainty

The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

### 7.3.4 Total Uncertainty (P75 and P90 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.



**Table 7-4: Life Cycle P50, P75 and P90 Generation Prediction for 20 MW<sub>AC</sub>**

Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>11</sup>	P90 Generation Prediction <sup>12</sup>
9	31,263.05	29,893.85	28,661.52
10	31,106.74	29,744.38	28,518.22
11	30,951.20	29,595.66	28,375.63
12	30,796.45	29,447.68	28,233.75
13	30,642.47	29,300.44	28,092.58
14	30,489.25	29,153.94	27,952.12
15	30,336.81	29,008.17	27,812.36
16	30,185.12	28,863.13	27,673.29
17	30,034.20	28,718.81	27,534.93
18	29,884.03	28,575.22	27,397.25
19	29,734.61	28,432.34	27,260.27
20	29,585.93	28,290.18	27,123.96
21	29,438.00	28,148.73	26,988.34
22	29,290.81	28,007.99	26,853.40
23	29,144.36	27,867.95	26,719.14
24	28,998.64	27,728.61	26,585.54
25	28,853.64	27,589.96	26,452.61

<sup>11</sup> The P75 values have been calculated over 10-year averages<sup>12</sup> The P90 values have been calculated over 10-year averages

## 8 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 0.5% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) and henceforth. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Owner, SgurrEnergy understands that the PLG solar PV plant was commissioned in 23<sup>rd</sup> February 2012. SgurrEnergy was provided with plant, grid availability and irradiation records from July 2018 to April 2021<sup>13</sup> for the solar PV plant.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from July 2018 to April 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Owner.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Owners control.

The monthly records of the grid availability from July 2018 to April 2021 have been graphically illustrated in Figure 8-1 below.

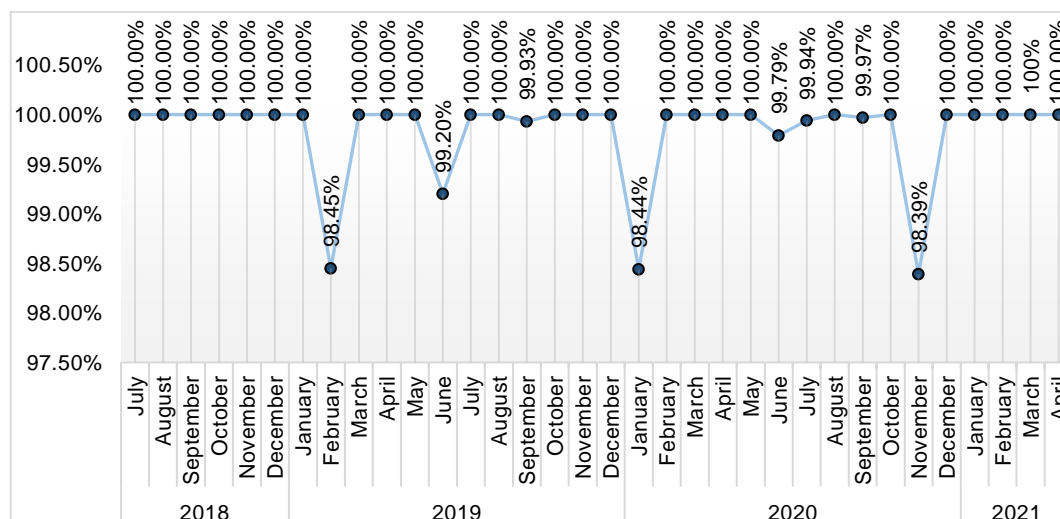


Figure 8-1: Grid Availability

<sup>13</sup> SgurrEnergy was provided with both the plant and grid availability records until April 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.



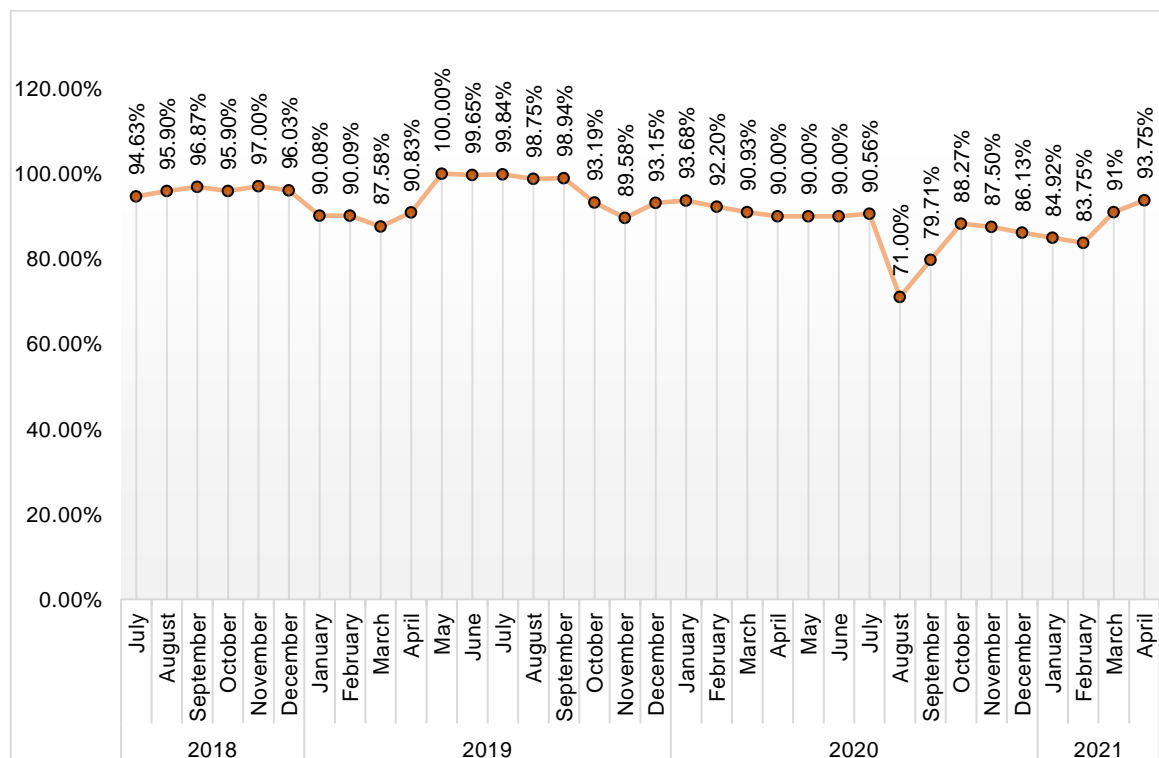
From the above illustration, SgurrEnergy notes that the unavailability loss experienced due grid anomalies are minimal over the operational period and are within expected range. However, for the month of February 2019, January 2020 and November 2020 the unavailability due to grid was slightly high when compared to other months. The downtime due to grid unavailability was close to 100% during the remaining months for which the grid availability was noted to be exceeding 99.20%.

Overall the average grid availability experienced on site for the operational period was calculated to be 99.96%

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the PLG solar PV plant is graphically illustrated below in Figure 8-2.



**Figure 8-2: Plant Availability**

Based on the above illustrations, SgurrEnergy notes the plant availability for the SEPEPL solar PV plant is notably inconsistent for all the months ranging between 71.00% to 100%. The average plant availability is noted to be 91.51% which is considered to be significantly lower than expected range.

Based on the evaluation for the availability provided, SgurrEnergy understands that the same has been carried out using time-based availability and has therefore over-estimated the losses associated with the same. SgurrEnergy has further carried out the energy yield comparison in the following section using an estimated unavailability of 1%.

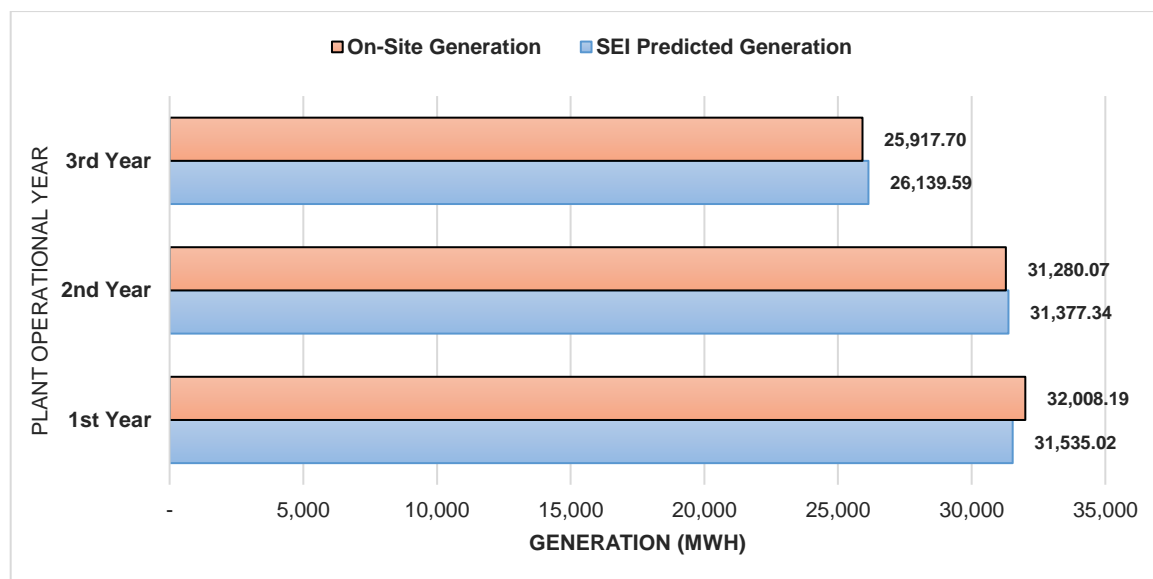
### 1.1 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Client. To make the operational energy yield predictions more representative,



SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Client. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Client.

The yearly comparison of the generation data is illustrated below in Figure 8-3.



**Figure 8-3: Generation Comparison**

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 8-1

**Table 8-1: PV Plant Performance – PLG 20MW**

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>14</sup> (%)
July 2018 -June 2019	31,535.02	32,008.19	1.50%
July 2019 -June 2020	31,377.34	31,280.07	-0.31%
June 2020 –April 2021	26,139.59	25,917.70	-0.85%
<b>Cumulative Period</b>	<b>89,051.95</b>	<b>89,205.96</b>	<b>0.17%</b>

Based on the above comparison, SgurrEnergy notes that the PV plant is generating higher than the expected yield. However, SgurrEnergy considers that such variations in the energy yield can be attributed to higher irradiation level experienced on the Project site. The irradiation levels significantly impact the actual generation from the PV plant as the system losses may vary significantly due to slight change in the irradiation.

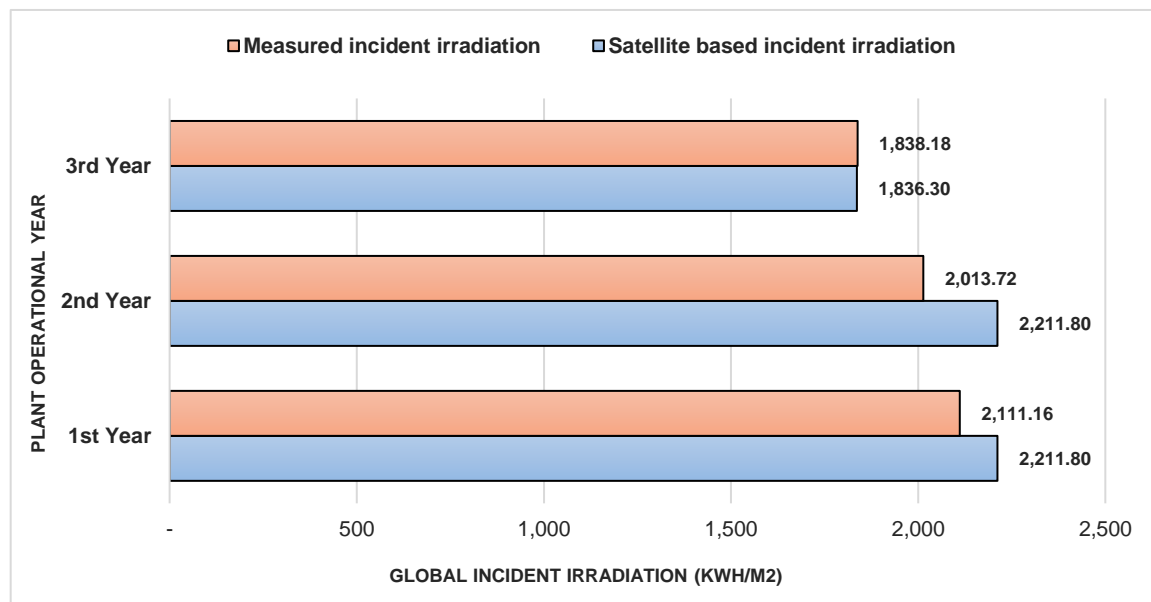
In order to understand the deviation in the irradiation pattern, SgurrEnergy has compared the monthly incident irradiation data provided by the Client with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation. The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 8-4.

<sup>14</sup> Positive values indicate higher generation, while negative values indicate lower generation



**Table 8-2: Irradiation Comparison– PLG 20MW**

PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>15</sup> (%)
July 2018 -June 2019	2,211.80	2,111.16	-4.55%
July 2019 -June 2020	2,211.80	2,013.72	-8.96%
June 2020 –April 2021	1,836.30	1,838.18	0.10%
<b>Cumulative Period</b>	<b>6,259.9</b>	<b>5,963.06</b>	<b>-4.74%</b>

**Figure 8-4: Irradiation Comparison**

Based on the above illustration, it is observed that the overall recorded generation is approximately 0.17% higher than the generation predicted on site. It has also been observed that the recorded irradiation is approximately 4.74% lower than the predicted irradiation.

Based on the comparative analysis, the increase-in generation can be attributed to the conditions experienced at the site.

<sup>15</sup> Positive values indicate higher irradiation, while negative values indicate lower irradiation



## 9 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar pv plants as having a lifetime of 25-40 years<sup>16</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>17</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the pv plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement

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<sup>16</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>17</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>





Virescent Infrastructure

30MW(AC) USUPL Solar PV Plant  
Universal Saur Urja Private Limited  
Technical Assessment Report

July 2021



## Report Details

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B3	2 July 2021	Minor Updates	-
B4	6 July 2021	Minor Updates	-
B5	15 July 2021	Minor Updates	-

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## Executive Summary

Virescent Infrastructure (the Client) backed by leading global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy has been appointed by the Client to conduct a technical appraisal of 30MW<sub>AC</sub> USUPL plant.

The summary of the technical assessment is captured in the below table.

**Table 1-1: Summary**

Sr. No.	Parameter	Comment
1	Plant Overview	Review presented in section 2
2	PV Module	<p>According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of Canadian Solar, assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.</p> <p>Further, according to the warranty documents available in public domain for the module manufacturer, SgurrEnergy considers the warranty terms and conditions offered by Canadian to be in-line with the industry standard and raises no major concern regarding the warranties offered. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.</p>
3	Inverter	<p>SgurrEnergy has conducted review of the ABB PVS800-57-1000kVA central inverter ABB PVS800-57-1000kVA central inverter has the required certification for use in solar PV plants. In-house testing of the inverter and individual components is relatively extensive during the R&amp;D phase with functional and temperature cycling testing of each manufactured inverter. ABB offers a product warrant of 5 years which is in line with the current industry standards.</p> <p>In conclusion, ABB can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters. ABB inverters have more than 3GW of installation worldwide. These inverters are quite known to the Indian market and have installed capacity of more than 1.3GW which demonstrates a good track record in the Indian solar PV market.</p>
4	Inverter and PowerTransformer	<p>The inverter transformers (2000kVA) and power transformer (15/20MVA) used within the project are manufactured by Raychem and Shilchar Technologies Limited, respectively. The manufacturers have good track record of supplying transformers for solar application throughout the. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.</p>





Sr. No.	Parameter	Comment																								
5	String Sizing	The V <sub>OC</sub> does not exceed the inverter input voltage for the site, and therefore, SgurrEnergy considers the number of modules in series to be acceptable for the PV Project.																								
6	Resource Assessment	For resource analysis, SgurrEnergy has compared various satellite datasets. For the satellite databases, SEI has compared Meteonorm 7.3, NASA, SWERA and SolarGIS data to find the most suitable solar resource for long-term energy yield prediction. Owing to low uncertainty and high resolution, SEI considers SolarGIS dataset to be the most representative satellite database among all the satellite databases for long-term energy yield assessment.																								
7	Operational Analysis and Generation Comparison	Review presented in Section 8																								
8	Allied Components and Systems	Review presented in section 4																								
9	Energy Yield Assessment	<p>Subsequent to the solar resource assessment, SEI considers SolarGIS database as the most representative for long-term energy yield predictions. The table below summarises the energy yield predictions for fifth year of plant operation for the 30MW<sub>AC</sub> PV plant.</p> <table> <tr> <th></th><th>Fix Tilt</th><th>Tracker</th></tr> <tr> <td>Global Horizontal Irradiation (kWh/m<sup>2</sup>)</td><td>1859.80</td><td>1859.80</td></tr> <tr> <td>Global Inclined Irradiation (kWh/m<sup>2</sup>)</td><td>2004.34</td><td>2186.49</td></tr> <tr> <td>First Year P50 Energy Yield (MWh/annum)</td><td colspan="2">58,115.74</td></tr> <tr> <td>Fifth Year P50 Energy Yield (MWh/annum)</td><td colspan="2">56,962.11</td></tr> <tr> <td>Fifth Specific Yield (kWh/kW<sub>p</sub>)</td><td colspan="2">1540.39</td></tr> <tr> <td>Fifth Performance Ratio (PR)</td><td colspan="2">75.91%</td></tr> <tr> <td>Fifth PLF on Contracted Capacity (30MW<sub>AC</sub>)</td><td colspan="2">21.68%</td></tr> </table>		Fix Tilt	Tracker	Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1859.80	1859.80	Global Inclined Irradiation (kWh/m <sup>2</sup> )	2004.34	2186.49	First Year P50 Energy Yield (MWh/annum)	58,115.74		Fifth Year P50 Energy Yield (MWh/annum)	56,962.11		Fifth Specific Yield (kWh/kW <sub>p</sub> )	1540.39		Fifth Performance Ratio (PR)	75.91%		Fifth PLF on Contracted Capacity (30MW <sub>AC</sub> )	21.68%	
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Fifth PLF on Contracted Capacity (30MW <sub>AC</sub> )	21.68%																									



## Glossary

A	Amp
AC	Alternating Current
a-Si	Amorphous Silicon
CdTe	Cadmium Telluride
c-Si	Crystalline Silicon
CIGS/CIS	Copper Indium (Gallium) Di-Selenide
CPV	Concentrated photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilization Factor
°C	Degrees Centigrade
°	Degrees
DC	Direct Current
E	East
GWh	Giga Watt hour
HV	High Voltage
Hz	Frequency, Hertz
IAM	Incident Angle Modifier
Isc	Short Circuit Current
IEC	International Electro technical Commission
kA	One Thousand Amps
km	One metric kilometre
kV	One thousand Volts
kVA	One thousand Volt Amps
kWp	One thousand Watts peak
kWh	One thousand Watt hours
LV	Low Voltage
m	Meters
m <sup>2</sup>	Meters squared
mm	Millimetres
mm <sup>2</sup>	Millimetres squared
m/s	Meters per second
mc-Si	Mono-crystalline Silicon



MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MTBF	Mean Time Between Failures
MV	Medium Voltage
MVA	One million Volt Amps
MW	One million Watts or Megawatt
MWp	Megawatt peak of Solar PV modules
N/m <sup>2</sup>	Newton per meter Squared
N	North
NASA	National Aeronautics and Space Administration
NEC	National Electric Codes
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
%	Percentage
pc-Si	poly-crystalline Silicon
PV	Photovoltaic
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
STC	Standard Test Conditions
SWERA	Solar and Wind Energy Resource Assessment
TUV	TÜV Rheinland Group Testing and Standards Organisation.
V	Volts
Voc	Open Circuit Voltage
VT	Voltage Transformer
W/m <sup>2</sup>	Watts per metres squared
Wp	Watt peak
XLPE insulation	Cross-Linked Polyethylene insulation



## 1 Introduction

Virescent Infrastructure (the Client) backed by global investment firm Kohlberg Kravis Roberts (KKR) in India, was established to acquire and invest in renewable energy assets in the Indian power sector.

SgurrEnergy India (SEI) has been appointed by the Client to conduct technical appraisal for the 68MW<sub>AC</sub> portfolio of Solar PV projects in India. The portfolio comprises of four projects, as presented within Table 1-1.

**Table 1-1: Project Key Summary**

Project Name	SSEPL – 5MW <sub>AC</sub>	SSEGPL – 13MW <sub>AC</sub>	PLG – 20MW <sub>AC</sub>	USUPL – 30MW <sub>AC</sub>
<b>Site Location</b>	26.52N, 72.85E, Tiwari, Jodhpur, Rajasthan, India	23.9128°N, 71.2183°E, Santalpur, Patan, Gujarat, India	23.9°N, 71.5°E, Dahisar, Patan, Gujarat, India	25°18'52.79"N, 79°25'2.49"E, Devgaon, Mahoba, Uttar Pradesh, India
<b>Owner</b>	Sindicatum Solar Energy Private Limited (SSEPL)	Sindicatum Solar Energy Gujarat Private Limited (SSEGPL)	PLG Photovoltaic Private Limited (PPPL)	Universal Saur Urja Private Limited (USUPL)
<b>DC / AC Capacity</b>	5.745MW <sub>P</sub> / 5MW <sub>AC</sub>	15MW <sub>P</sub> / 13MW <sub>AC</sub>	20MW <sub>P</sub> / 20MW <sub>AC</sub>	36.98MW <sub>P</sub> / 30MW <sub>AC</sub>

This report presents the evaluation of the 30MW<sub>AC</sub> solar PV plant developed by Universal Saur Urja Private Limited (USUPL). The Solar PV plant under evaluation is located in Devgaon village, Mahoba district in Uttar Pradesh state. The purpose of this report is to provide a technical appraisal of PV plant under evaluation.

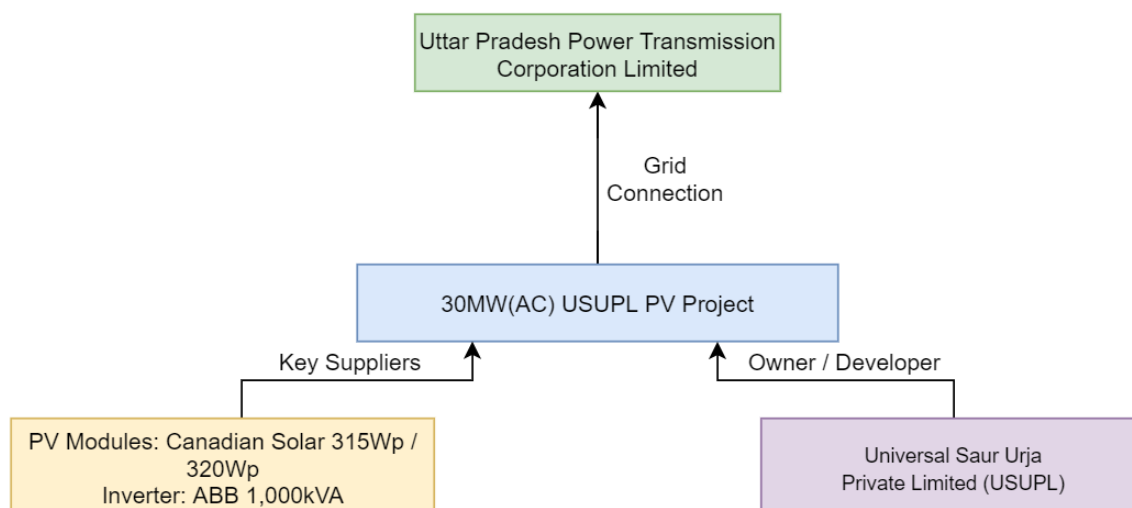
The report focuses on the following key parameters:

- System Design.
- Major Components.
- Engineering Design.
- Independent Solar Resource Assessment and Energy Yield Prediction.
- Plant Operational Analysis and Generation Comparison.
- Permits and Approvals.

This report presents independent technical appraisal of the Project and is based on information made available by the Client through online data room. The main Project characteristic is summarised in Table 1-2.

Figure 1-1 illustrates the project structure indicating key project participants for the 30MW<sub>AC</sub> solar PV plant.





**Figure 1-1: Project Structure for 30MW<sub>AC</sub> Solar PV Plant**

**Table 1-2: Project Key Summary**

Project Information	
<b>Project Name</b>	30MW <sub>AC</sub> USUPL solar PV plant
<b>Location</b>	Devgaon, Mahoba, Uttar Pradesh
<b>Developer</b>	Universal Saur Urja Private Limited (USUPL)
<b>DC/ AC capacity</b>	30MW <sub>AC</sub> PV Plant – 36.98MW <sub>P</sub> / 30MW <sub>AC</sub>
<b>Key Equipment Manufacturers</b>	PV Modules: Canadian Solar Inverters: ABB
<b>MMS Configuration</b>	Fixed Tilt: 19°, Tracker, Azimuth: 0°
<b>Commissioning Status</b>	Commissioning for 10MW <sub>AC</sub> PV Plant was achieved on 15 September 2016.



## 2 30MW<sub>AC</sub> Solar PV Plant Overview

The project site lies around the coordinates 25°18'52.79"N, 79°25'2.49"E. Satellite imageries of 30MW<sub>AC</sub> solar PV plants are illustrated below in Figure 2-1. The Owner owns approximately 142.79 acres of land for the project. The Project site is located near the *Devgaon* village, in *Mahoba* district of Uttar Pradesh.

Project is contracted for generating 30MW<sub>AC</sub> power; SEI therefore interprets 30MW<sub>AC</sub> as the maximum AC installed capacity for the solar PV plant.



**Figure 2-1: Satellite image of 30MW<sub>AC</sub> plant**

### 2.1 30MW<sub>AC</sub> Project Summary

Solar PV plant is modular in nature; therefore, USUPL 30MW<sub>AC</sub> solar PV plants is implemented by adopting modularity in designs. 4MW<sub>AC</sub> and 2MW<sub>AC</sub> is the typical inverter stations considered for implementing USUPL 30MW<sub>AC</sub> solar PV plant.

Table 2-1 presents the summary of 30MW<sub>AC</sub> PV plant

**Table 2-1: Summary of 30MW<sub>AC</sub> Plant Configurations**

General	
PV Module Technology	Poly-crystalline
Inverter Technology	Central Inverters
Installed DC Peak Capacity (MW <sub>p</sub> )	36.98
Installed AC Capacity (MW)	30.0
Mounting Type	Fixed Tilt / Tracker
Tilt Angle (°)	19° / ±45°
Pitch (m)	7.5 / 5.0
PV Modules	
PV Module Manufacturer	Canadian Solar
Model	CS6X - 315P, CS6X - 320P
Wattage (W <sub>p</sub> )	315W <sub>p</sub> / 320W <sub>p</sub>



General	
Number of Modules per String	20
Inverter	
Inverter Manufacturer / Model	ABB / PVS800-57-1000kW
Inverter Nominal AC Output	1,000kW
Number of Inverters	30

The 30MW<sub>AC</sub> plant is implemented with a total of seven (7) inverter stations of capacity 4MW<sub>AC</sub> and 2MW<sub>AC</sub>. The 4MW<sub>AC</sub> stations comprise of a five winding transformer to accommodate 4 × 1,000kVA inverters, taking the individual inverter station size to 4MW<sub>AC</sub>. While The 2MW<sub>AC</sub> station comprises of a three winding transformer to accommodate 2 × 1,000kVA inverters, taking the individual inverter station size to 1MW<sub>AC</sub>.

The output of the inverter stations are connected to two (2) two winding transformers of 15MVA for stepping up the voltage.

The power generated by the USUPL 30MW<sub>AC</sub> PV plant is fed to *Panwari* substation located approximately 12km from the Project site. The point of interconnection is at the *Tinwari* substation.





### 3 Review of Major plant components

SgurrEnergy has conducted a desktop review of the main plant components which includes a high-level review of the company, its track record, product certifications obtained, technical characteristics and warranty conditions.

#### 3.1 PV modules – Canadian

SgurrEnergy has conducted a technical review of the supplier and module specification with regards to their suitability for their use in the Projects under evaluation.

##### 3.1.1 Company Profile

Canadian Solar (NASDAQ: CSIQ) is a vertically integrated producer of ingot, wafer, solar cell and solar modules and was established in Ontario, Canada in 2001. Canadian Solar has subsidiaries in 20 countries on six continents. The company has 17 manufacturing facilities in Asia and America. Along with over 14,000 employees around the world, Canadian Solar had reported net revenue of \$3.5 Billion at the end of the fourth quarter of 2020<sup>1</sup>. The company has achieved shipment of over 52GW of solar module in more than 150 countries. Canadian Solar also has a portfolio of solar power plants in operation. Canadian Solar is currently have more than 20GW pipeline projects worldwide.

As of December 2020, the company has an ingot manufacturing capacity of 1.85GW per annum, wafer-manufacturing capacity of 5GW per annum, cell manufacturing capacity of 9.6GW per annum<sup>2</sup>.

On acquisition of Recurrent Energy, a leading utility-scale solar project developer, Canadian Solar now boasts a resulting portfolio of over 4.7GW<sup>3</sup> of solar power plants built and connected worldwide.

The company also operates three state-of-the-art research centres in Canada and China which focus on improvement of efficiency and performance of its products. These research facilities employ over 515 scientists along with engineers and technicians in order to conduct research to improve the existing technologies. The company has more than 1,500 authorized patents worldwide until March 2020.

Canadian solar modules have been shipped globally for more than 52GW capacity since 2001 and have been used in the development of ground-mounted, commercial, and residential roof-mounted applications worldwide.

Few of the commissioned solar power plants using Canadian modules are listed in Table 3-1.

**Table 3-1: Track record of Canadian Solar Modules**

Sr. No.	Project	Capacity
1	Tamil Nadu	309.0
2	Ontario, Canada	300.0

<sup>1</sup> <https://investors.canadiansolar.com/news-releases/news-release-details/canadian-solar-reports-fourth-quarter-and-full-year-2020-results#:~:text=Full%20Year%202020%20Highlights&text=9%25%20annual%20growth%20in%20net,GWh%20of%20battery%20storage%20contracts>.

<sup>2</sup> <https://www.pv-tech.org/canadian-solar-adding-significant-manufacturing-capacity-in-2021-in-attempt-to-keep-pace-with-rivals/#:~:text=In%20the%20second%20half%20of,nameplate%20capacity%20to%2010%2C000MW.&text=New%20plans%20announced%20would%20add,by%20the%20end%20of%202021>.

<sup>3</sup> <https://www.canadiansolar.com/au/wp-content/uploads/sites/2/2020/07/AU-Canadian-Solar-Company-Brochure-2020s.pdf>





Sr. No.	Project	Capacity
3	Roserock, Texax, USA	212.0
4	Garland Solar Plant, USA	272.0
5	Dubai, UAE	268.0
6	Tranquility Solar Plant, USA	257.7
7	Finley, Australia	175.0
8	Shizuishan, China	150.0
9	Brandenburg, Germany	148.0
10	Mustang, CA, USA	134.0
11	NC, USA	102.4
12	Wuhu City, Inner Mongolia, China	100.0
13	Oakey, Australia	100.0
14	Yucheng, China	100.0
15	Minas Gerais State, Brazil	82.5
16	Goyalri, India	78.0
17	Rovigo, Italy	70.0
18	Aguascalientes State, Mexico	67.0
19	Barren Ridge, NC, USA	60.0
20	Yamaguchi, Japan	56.3
21	Yangquan, China	50.0
22	Dai County, China	46.8
23	CA, USA	20.0
24	Paraguay, Maule Region, Chile	10.8
25	Thunder Bay Airport, Ontario, Canada	8.5

Canadian Solar is considered a Tier 1 supplier by Bloomberg (Q1, 2021). A Tier 1 supplier is defined as a module manufacturer who has *‘provided products to five different projects, which have been financed non-recourse by five different (non-development) banks, in the past two years.*

Whilst the Bloomberg tiering system does not reflect on a product’s technical or quality aspects, it does provide an indication of acceptability in the marketplace. SgurrEnergy considers Canadian solar to have a strong track record in delivering PV modules to utility-scale projects worldwide).

### 3.1.2 Main Technical Characteristics

The Canadian Solar CS6X-P modules of 315W<sub>P</sub> and 320W<sub>P</sub> capacities have been utilized for the project. The 315W<sub>P</sub> and 320W<sub>P</sub> modules have efficiencies of 16.42% and 16.68%, respectively and a positive power tolerance of 0~+5W. The CS6X-P series have temperature coefficient (P<sub>max</sub>) of -0.41%/°C. These temperature coefficients are in line with SgurrEnergy’s expectation for c-Si technology. Generally, the temperature coefficient of crystalline silicon modules is in the range of -0.4% rise in temperature. The technical characteristic of the shortlisted modules is presented in Table 3-2.



**Table 3-2: Technical specifications of 315W<sub>P</sub> and 320W<sub>P</sub>**

Specifications	CS6X-315P	CS6X-320P
Technology	Polycrystalline	
Nominal power (P <sub>MPP</sub> )	315W	320W
Voltage at P <sub>MAX</sub> (V <sub>MPP</sub> )	36.6V	36.8V
Current at P <sub>MAX</sub> (I <sub>MPP</sub> )	8.6A	8.7A
Open circuit voltage (V <sub>OC</sub> )	45.1V	45.3V
Short circuit current (I <sub>SC</sub> )	9.2A	9.3A
Efficiency (%)	16.4%	16.7%
Maximum System Voltage	1,000V	
Power tolerance (W)	0~+5W	
Dimensions (length × breadth × width) (mm)	1954 × 982 × 40mm	
Module area (m <sup>2</sup> )	1.9m <sup>2</sup>	
Weight (kg)	22kg	
Temperature coefficient at P <sub>MAX</sub>	-0.4%/°C	
Maximum reverse current	15A	
Maximum mechanical load	2400Pa	
Maximum snow load	5400Pa	
Product warranty	10years	
Power output guarantee	25years	

Modules have a power tolerance of 0~+5W. This is in line with the offering from other leading suppliers. The maximum system voltage is 1,000V for CS6X-P series and 1,000/1,500V for CS3U-P series which are standard and compatible with the project system design. Maximum snow and wind loading specifications are in line with industry norms.

### NOCT Characteristics

The nominal operating cell temperature (NOCT)<sup>4</sup> characteristics of selected CS6X-P modules of 315W<sub>P</sub> and 320W<sub>P</sub> capacities are given in Table 3-3 corresponding to realistic operating conditions as compared to STC. It is affected by module materials used as well as the packing density of module materials. The NOCT for the module is 42±3°C.

**Table 3-3: PV Module NOCT Characteristics of CS6X-P and CS3U-P**

Model	CS6X-315P	CS6X-320P
Maximum Power (P <sub>MAX</sub> )	228W <sub>P</sub>	232W <sub>P</sub>
Max Power Voltage (V <sub>MPP</sub> )	33.4V	33.6V
Max Power Current (I <sub>MPP</sub> )	6.8A	6.9A
Open Circuit Voltage (V <sub>OC</sub> )	41.5V	41.6V
Short Circuit Current (I <sub>SC</sub> )	7.4A	7.5A

### 3.1.3 Certification of Modules

<sup>4</sup> Irradiance = 800W/m<sup>2</sup>, Air Mass = 1.5, Ambient temperature = 45±3°C.



General review of datasheet indicates Talesun Solar PV modules manufactured in facilities with the following certifications:

- ISO 14001 certification for environmental management systems
- ISO 9001 Certification for quality management systems
- OHSAS 18001 certification for Occupational Health and Safety Management Systems

Further, SgurrEnergy has summarised the certification mentioned in the datasheet of the modules under evaluation within Table 3-4.

**Table 3-4: Certification for PV Module- Canadian Solar Modules**

Certification	Description
IEC 61215	Crystalline silicon PV modules – Design qualification and type approval
IEC 61730	PV module safety qualification
IEC 61701	Resistance to salt mist and corrosion
IEC 62716	Ammonia Corrosion Testing
UL 1703	Standard for safety for flat-plate photovoltaic modules
IEC 60068	Dust and Sand

### 3.1.4 Warranty

As is standard within the industry, the specified modules are provided with two forms of warranty; a Limited Product Warranty and a Limited Peak Power Warranty. Both warranties are described further below and start at the earlier of the date of installation or 90 days from the delivery date.

### 3.1.5 Product Warranty

Canadian Solar provides a limited product warranty of 10 years and 12 years for CS6X-P series. During this period the modules shall be free from defects in materials and workmanship that affects the performance of the module under normal application, installation, use, and service conditions as specified in Canadian Solar's standard product documentation.

SgurrEnergy considers product warranty provided by Canadian Solar to be in line with the current industry standard.

### 3.1.6 Linear Power-Output Warranty

Canadian solar warrants that the modules will not experience a power loss of greater than 2.5% in the first year of operation, and the nominal power output at that time, shall not be less than the 97.5% of the initial nominal power output; and 0.7% each year thereafter until that date which is 25 years following the warranty start date, at which the module's actual power shall not be less than 80.7% of the initial nominal power output.

For either warranties mentioned above, if defects are noted or the module's performance falls below the specified levels, Canadian solar will either repair, replace or provide additional modules to make up for the loss in power output.

## 3.2 Inverters – ASEA Brown Boveri (ABB)

The project has utilized ABB PVS800-57-1000kW central inverter for the project under evaluation.



### 3.2.1 Company background

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, ABB is one of the largest engineering companies as well as one of the largest conglomerates in the world. ABB has operations in around 100 countries, with approximately 147,000 employees<sup>5</sup>. Company reported global revenue of around \$34,312 million for 2017.<sup>6</sup>

The firm's shares are traded on the stock exchanges of Zurich, Stockholm, and New York. ABB is a multinational corporation headquartered in Zurich, Switzerland, operating mainly in robotics and power and automation technology.

On July 9, 2019 the Italian company FIMER acquired ABB's solar inverter business. The takeover of ABB's solar inverter business included 800 employees in 26 countries as well as two manufacturing plants, in Italy and in India, and a R&D facility in Finland.

FIMER was founded in 1942, headquartered in Vimercate, Italy, has been actively working in inverter technology since 1983. As of 2020, the company employs more than 1,100 employees across its three manufacturing facilities and three R&D centres across the globe. As a result of acquisition of ABB's PV inverter line, FIMER ranked the fifth-largest PV inverter globally in 2019.

### 3.2.2 Track Record

ABB India commenced local manufacturing of solar inverters in 2012 and partnered with several customers. ABB is the solar inverter market leader in India holding approximately 24% market share in 2018. ABB has approximately 3,590MW in operation across more than 350 sites in India. ABB India manages close to 40% of the installed bases in India. As on 30 August 2017, ABB India crossed the 5GW threshold for the supply of inverters in the country.

Table 3-5 lists the state-wise installed capacity of ABB inverters in India. However, it is to be noted that the table below doesn't not comprise of the installed capacities till date.

**Table 3-5: ABB Inverter Track Record**

Location	Capacity (MW)
Punjab	227
Haryana	62
Uttar Pradesh	106
Bihar	225
Rajasthan	371
Madhya Pradesh	271
Chhattisgarh	28
Odisha	20
Andhra Pradesh	647
Maharashtra	261
Tamil Nadu	747
Karnataka	305

<sup>5</sup> <https://new.abb.com/news/detail/26838/abb-to-exit-solar-inverter-business>

<sup>6</sup> <https://new.abb.com/investorrelations/company-profile/facts-figures>



Location	Capacity (MW)
Kerala	50

ABB India has strategically located its headquarter in Bangalore and offices in other cities Pune, Ahmedabad, Jaipur, Faridabad, Hyderabad, Tamil Nadu, and Bhopal in order to facilitate quick spare part availability and minimal response time. ABB aims to provide first response to its customers within 4 hours on weekdays and within 24 hours on weekends and holidays. ABB also provides a Turn-Around-Time of 48 and 72 hours on weekdays and weekends respectively, hence maintaining an average uptime of over 99%.

### 3.2.3 Technical Characteristics

ABB PVS800-57-1000kVA inverter has been selected for technical feasibility of the Project. The technical specification of 1000kW ABB inverter is listed in Table 3-6.

The PVS800-57-1000kVA Series of central inverters designed ideal for large PV Power Plants. PVS980 inverters are designed for fast and easy installation. These inverters are designed to operate with DC inputs up to 1,500 V. They incorporate maximum power point tracking (MPPT) and grid management features to meet utility requirements.

PVS800-57-1000kVA inverter is designed for outdoor use with an IP42 ingress protection class. They have closed loop cooling system based on phase transition and thermosiphon technology with water and dustproof enclosure. They perform optimally at ambient air temperatures between -15°C to 50°C and relative humidity in the range of 15% to 95% with maximum noise level of less than 75dBA.

The PVS800-57-1000kVA inverter has peak efficiency of 98.8% and a European efficiency of 98.6%.

The main technical characteristics of these inverters are illustrated in Table 3-6.

**Table 3-6: ABB inverter specifications**

ABB Central Inverter Specifications	
Inverter	ABB PVS800-57-1000kVA
Type	Central Inverter
<b>Input Data</b>	
PV voltage range, MPP (V)	600 to 850V
Maximum DC voltage (V)	1100V
Maximum input current (A)	1710A
<b>Output Data</b>	
Nominal AC power (kW)	1000kW
Maximum AC current (A)	1445A
Nominal AC voltage(V)	400V
AC grid frequency (Hz)	50Hz-5%+3%
Maximum THD	< 3%
<b>Operating Performance</b>	
Maximum efficiency (%)	98.80%
Euro efficiency (%)	98.60%
<b>Power consumption</b>	



<b>ABB Central Inverter Specifications</b>	
Own consumption in operation(W)	650W
Standby operation consumption (W)	65W
<b>Other</b>	
Dimensions (W × H × D) (mm)	3630mm x 2130mm x 708mm
Weight (kg)	2320kg
Environmental Protection Rating	IP42
Operating temperature range (°C)	-15 to+50°C
Relative humidity (%)	15% to 95%

The following protection devices are included within the inverter design:

- Ground fault monitoring
- Grid Monitoring
- Anti-islanding protection
- DC reverse-polarity protection
- AC and DC short circuit and over current protection
- AC and DC over voltage and temperature protection

ABB inverters comprise of suitable protection devices in place on both the DC and AC side to protect the PV system and inverter components.

### 3.2.4 Certification

ABB is certified to the internationally recognised standard for management systems and according to ISO 9001 that they conform to the latest quality standards.

Inverter reliability is further enhanced via stringent quality control procedures. ABB inverter manufacturing facilities operate with the following certifications:

- ISO 9001:2015 Quality Certificate
- ISO 14001:2015 Environmental Certificate
- OHSAS 18001 Health and Safety Management System

Based on information available in public domain, SgurrEnergy has summarized the certification of the ABB inverter within Table 3-7.

**Table 3-7: Description of Certification of ABB inverters**

<b>Certification</b>	<b>Description</b>
IEC 60068-2-6/29	Environmental testing of inverters to assess their ability to perform and survive under conditions such as transportation, storage, operational environments, extreme cold and heat
IEC 61683:1999	Procedure for measuring efficiency
IEC 62109-2:2011	Safety of Power Converters
IEC 62116:2014	Islanding prevention measures

### 3.2.5 Warranties

According to the warranty documents provided, ABB has offered the inverter warranty of 60 months from commissioning of last inverter or 63 months from the date of supply of last



inverter, whichever is earlier. SgurrEnergy considers the warranty offered by the manufacturer to be in line with industry standards and do not raise any concern over the use of inverter for the project.

### 3.3 Transformers

The solar PV plant is implemented with two level transformation. Power at low voltage from inverters is stepped up to 11kV using 2000kVA transformers of Raychem make inverter transformers, and further to 132kV using 15/20MVA power transformer manufactured by Schneider Electric.

#### 3.3.1 Inverter Transformer- Raychem RPG Private Limited

##### 3.3.1.1 Company Profile

Raychem RPG Private Limited incorporated in 1989 is a joint venture between TE connectivity –USA and RPG Enterprises, India. TE connectivity provides global solutions in Network, Transportation, Consumers and Industrial since last 50 years with \$12.2B sales for the financial year 2016. RPG enterprise is a leading group in India with turnover of US\$ 3.5 Billion. The group has diversified business sectors such as Automotive Tyres, Infrastructure, IT and Specialty including Pharmaceuticals, Power Ancillaries & Plantations. Headquartered in Mumbai, Raychem RPG has sales offices in Thane, New Delhi, Chennai, Bangalore, Hyderabad, and Kolkata. They have state of art manufacturing facilities in Maharashtra and Gujarat with capacity to manufacture transformer up to 45MVA, 132kV class. The company has the following transformer product segments:

- Dry Transformer
  - Cast resin Transformer up to 20MVA,33kV.
  - Vacuum Pressure Impregnated up to 10MVA,33kV.
- Special Transformers
  - Scott T transformers up to 5MVA,33kV
  - Dry type transformers up to 10MVA, 11kV
  - Oil Filled transformer up to 20MVA; 33kV.
  - Furnace transformer-up to 30MVA, 33kV
- Oil Filled transformer up to 20MVA; 132kV.

Transformer manufacturing unit has ISO 9001:2015, ISO 14001-2015 and OHSAS 18001-2007 and is equipped with state-of-the-art manufacturing and testing facilities to meet IEC, ANSI, IEEE, IS, BIS and other international standards.

Raychem has supplied its product to Indian customers like State Electricity Boards and Power Utilities such as Reliance Energy Ltd., Tata Power, NDPL, CESC and leading Industries such as Tata Motors, Bajaj Auto, Volkswagen, Hindustan Unilever, Tata Steel, JSPL, Force Marshall, Siemens and many more. The company has a cumulative track record of supplying transformers equating to 2,302.37MVA for solar PV plants in India.

##### 3.3.1.2 Technical Specifications

Inverters Transformers utilized in the project are outdoor type, five-winding transformers of capacity 2000kVA.

The transformers hold Class A insulation and are oil immersed with ONAN type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.





SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The technical characteristics of the inverter transformers utilized for the project are presented in Table 3-8

**Table 3-8: Technical Specification of Raychem Transformer**

Technical Parameters	Description
Rated Power	2,000kVA
Rated HV	11kV
Rated LV	0.38 - 0.38 - 0.8 - 0.8kV
Tapping on HV	+5% to -5% (steps of 2.5%)
Phases	3
Frequency	50Hz
Vector group	Dy11y11
Impedance	6.25% (Sub, to IS Tol.)
Cooling Strategy	ONAN
Oil temperature rise	50°C
Winding temperature rise	55°C
Winding material	Electrolytic Copper

### 3.3.1.3 Temperature Rise Detection and Protection

Inverter transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.1.4 Warranties and Guaranties

SgurrEnergy is unable to comment on warranty/guaranty of Raychem transformer, since SgurrEnergy has not been provided with the warranty certificate. Hence, SgurrEnergy suggests seeking clarity from the Developer.

### 3.3.2 Power Transformer- Schneider Electric

Schneider Electric is a French multinational corporation, headquartered in Rueil-Malmaison, France, specializing in Schneider Electric equipment. The company began in 1836 as Schneider & Cie working mainly in iron, steel, and armaments. From 1981-1997, Schneider Electric focused mainly on electricity through strategic acquisitions.

With more than 180 years of experience, the company launched a brand strategy called “Life Is On” in 2015 which has a dedicated business unit for solar<sup>7</sup>. The Solar Business of Schneider Electric is focused on designing and developing products and solutions for commercial scale and residential & off-grid systems. Schneider Electric employs more than 137,000 employees in over 100 countries.

<sup>7</sup> <https://solar.schneider-electric.com/>





As of December,2018, Schneider Electric generated a revenue of €26 billion. The company devotes around 5% of the total revenue generated to Research & Development.<sup>8</sup> Schneider Electric is a Fortune Global 500 company, publicly traded on the Euronext Exchange. The company was also included in the World's 100 most ethical companies by the Ethisphere Institute in February,2019.<sup>9</sup>

### 3.3.2.1 Technical Specifications

The 15/20MVA Power transformers used in the project are outdoor type, three-winding (copper wounded), Class A insulation class, oil immersed with ONAN/ONAF type of cooling with detachable radiators. These transformers have been designed suitable for operations with a pulsed inverter.

SgurrEnergy is satisfied that the transformer has been designed to adhere local and country specific grid codes and relevant IS codes (IS-2026). The transformer technical characteristics are presented in Table 3-9.

**Table 3-9: Technical Specification of Schneider Electric Transformer**

Technical Parameters	Description
Rated Power	15/20MVA (ONAN / ONAF)
Rated HV	132kV
Rated LV	11kV
Tapping on HV	-5% to +15% (steps of 1.25%)
Phases	3
Frequency	50Hz
Vector group	YNyn0
Cooling Strategy	ONAN / ONAF
Oil temperature rise	50°C
Winding temperature rise	55°C
Winding material	Electrolytic grade Copper

### 3.3.2.2 Temperature Rise Detection and Protection

The 15/20MVA Power transformers have been provided with standard temperature sensing systems. These comprise of an analogue oil temperature indicating (OTI) unit and winding temperature indicating (WTI) unit. Both the units have been adequately provided with alarm/trip contacts and wired to relay units located at HT panel.

The transformers are adequately provided with the Buchholz Relay that essentially serves as a critical protective device in case of excessive gas pressure released in the event of higher transformer loadings and faults.

### 3.3.3 Warranties and Guaranties

SgurrEnergy is unable to comment on warranty/guaranty of Schneider Electric transformer, since SgurrEnergy has not been provided with the warranty certificate. Hence, SgurrEnergy suggests seeking clarity from the Developer.

<sup>8</sup> <https://solar.schneider-electric.com/company/about-us/>

<sup>9</sup> <https://annualreport.se.com/>



### 3.4 Conclusion on Major Plant Components

#### PV Modules

According to the information available in public domain and the information provided by the Client, SgurrEnergy has conducted a desktop review of Canadian Solar, assessing the companies overview, track records, module technical characteristics, industry certifications and warranty conditions. SgurrEnergy considers the modules to have technical characteristics in line with the industry standard.

Further, according to the warranty documents available in public domain for the module manufacturer, SgurrEnergy considers the warranty terms and conditions offered by Canadian to be in-line with the industry standard and raises no major concern regarding the warranties offered. Regarding the certifications, SgurrEnergy considers the PV modules to have adequate design, performance and safety certifications based on IEC's prescribed testing methods. In conclusion, SgurrEnergy does not raise any major concerns about the modules used in the project.

#### Inverters

SgurrEnergy has conducted review of the ABB PVS800-57-1000kVA central inverter ABB PVS800-57-1000kVA central inverter has the required certification for use in solar PV plants. In-house testing of the inverter and individual components is relatively extensive during the R&D phase with functional and temperature cycling testing of each manufactured inverter. ABB offers a product warrant of 5 years which is in line with the current industry standards.

In conclusion, ABB can be considered as an established and reputable inverter manufacturer and is known for producing good quality and high-performance inverters. ABB inverters have more than 3GW of installation worldwide. These inverters are quite known to the Indian market and have installed capacity of more than 1.3GW which demonstrates a good track record in the Indian solar PV market.

#### Transformers

The inverter transformers (2000kVA) and power transformer (15/20MVA) used within the project are manufactured by Raychem and Shilchar Technologies Limited, respectively. The manufacturers have good track record of supplying transformers for solar application throughout the. SgurrEnergy has reviewed the transformer based on the information available and considers the transformers utilized for the Project to have technical characteristics in line with industry standards and raises no concerns over its use in the project.

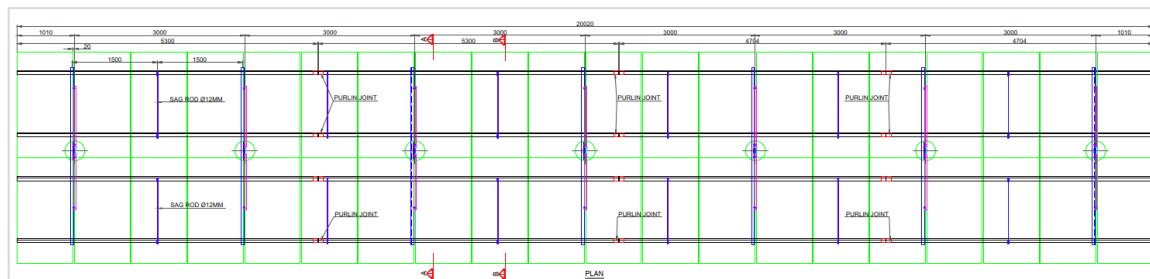
### 3.5 Module support structures

The Array Layout provided by the Client for the 30MW(AC) USUPL Solar PV Plant indicates the fixed tilt module mounting structure is inclined at 19° tilt angle.

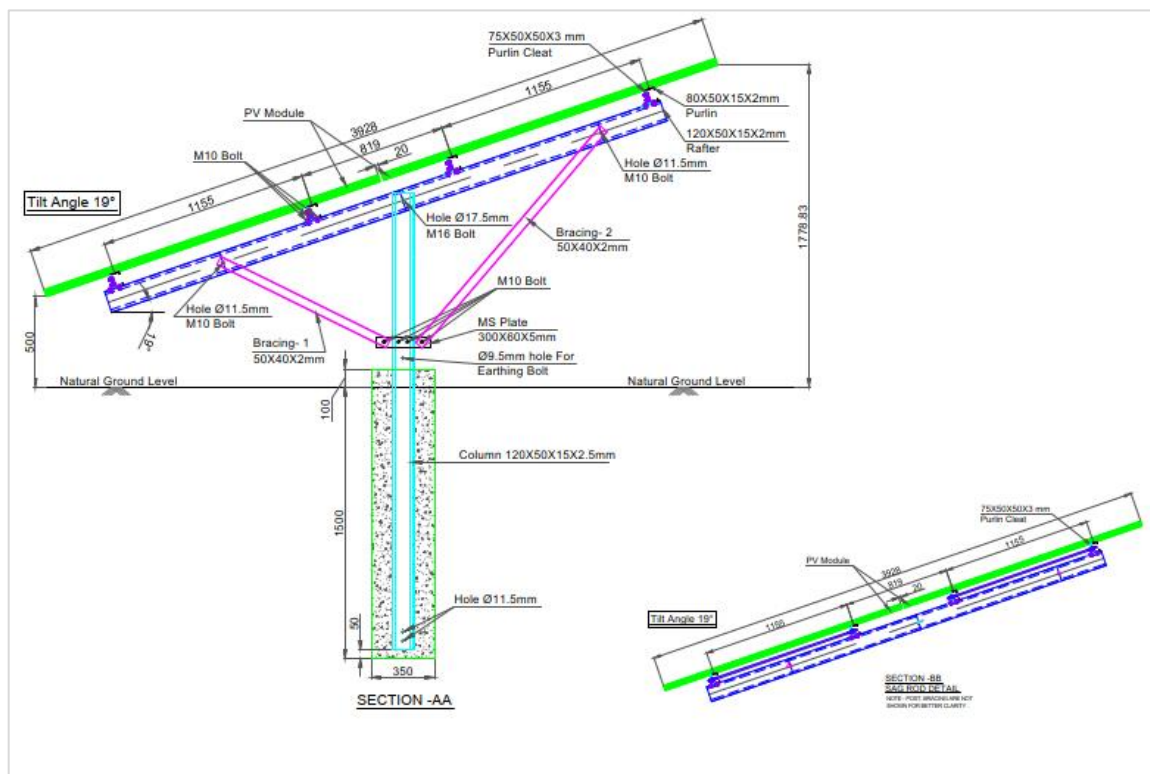
SgurrEnergy observed that the structure has been designed with two rows of modules placed in portrait orientation with 20 modules in each row. In total there are 40 modules in one mounting structure.

Figure 3-1 and Figure 3-2 illustrate the module mounting structure configuration provided by the Client for the 30MW(AC) USUPL Solar PV Plant.





**Figure 3-1: Two in portrait module mounting structure with 20 modules in each row**



**Figure 3-2: Section of the module mounting structure configuration**

## 4 Allied Components and Systems

### 4.1 Civil Structures

Based on the review of Plant layout, SgurrEnergy observed that the inverter stations are placed at centre of each block module to minimise cable losses.

### 4.2 PV Power Transfer

SgurrEnergy has reviewed the electrical schematic provided by the Client. The electrical schematic describes the overall connection of the PV modules, inverters, transformers, switchgear, and plant substation as well as providing the ratings of all the components.

SgurrEnergy has been provided with the following electrical schematic for the Project.

- 132kV Single Line Diagram dated 23/12/2015
- MCR key SLD (DC), ICR-2 to ICR-8 key SLD (DC) – R1

The 30MW<sub>AC</sub> solar PV Plant is designed with 315W<sub>P</sub>/320W<sub>P</sub> Canadian solar PV modules and 1000kW ABB inverters. PV modules are interconnected in series to form a string of 20 modules. Such two strings are paralleled with the help of Y-connector and the output of such 10/11/12 Y-connectors feeds as inputs to 12 input monitoring boxes. Eight string monitoring boxes are further connected to the inverter.

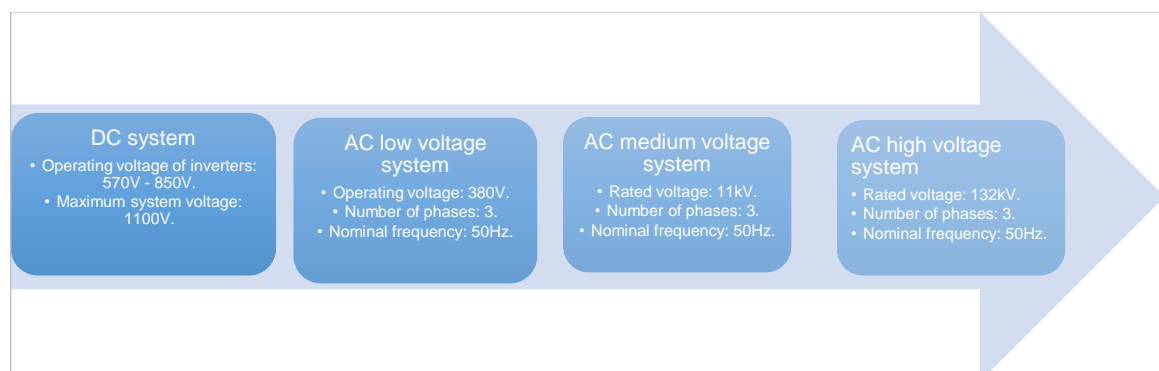
The 30MW<sub>AC</sub> solar PV plant has been configured with thirty ABB 1000kW central inverters and eight inverter stations. SgurrEnergy observed out of eight inverter station, seven inverter stations is of 4MW<sub>AC</sub> capacity and other one is of 2MW<sub>AC</sub> capacity.

Each 4MW<sub>AC</sub> capacity inverter station consists of four 1000kW inverters connected to 4MVA, 11/4x0.380kV five winding transformer while the inverter station of 2MW<sub>AC</sub> capacity consists of two inverters, which are connected to 2MVA, 11/2x0.380kV three winding transformer. The voltage is stepped up to 11kV for all inverter stations by 4MVA and 2MVA transformers.

The medium voltage output from seven inverter duty transformers is connected with 11kV ICOG (Incoming and outgoing) panel placed at inverter station. The power output from seven ICOG panels and one 2MVA transformer is radially connected to 11kV HT switchboard panel located in CMCS room. The 11kV output from switchboard panel is connected to 2x15/20MVA, 11/132kV power transformers located in switchyard.

The power from 11/132kV plant end substation is transferred to *Panwari S/S bay, UPPTCL, Switchyard* through 5km 132kV transmission line.

Figure below illustrates a power flow summary for the 30MW<sub>AC</sub> Solar PV plant.



**Figure 4-1: Power flow of 20MW<sub>AC</sub> PV plant**



### 4.3 Cabling

#### 4.3.1 DC Cabling

DC cabling comprises of PV module leads, string cables connecting the PV module strings to combiner box and main DC cables connecting the combiner box to the inverter fuse and then to the inverter. PV modules are interconnected in series with 6mm<sup>2</sup> solar grade cables.

The Y connectors shall be further connected to the 12 input String Monitoring Box using 6mm<sup>2</sup> solar grade cables. The string monitoring box output is connected to inverters by using single runs of single core 300mm<sup>2</sup> Aluminium XLPE cables. The inverter DC inputs are equipped with 315A fuses for overcurrent protection.

#### 4.3.2 AC Cabling

Three phase AC output from inverter is connected to the LV windings of 4MVA, 2MVA inverter duty transformers respectively, using multiple run single core 300mm<sup>2</sup> Aluminium Armoured XLPE cable. The inverter transformers step up the voltage to 11kV.

Power is fed from the high voltage side of each transformers using 1R, 3C, 300mm<sup>2</sup>, 11kV Al XLPE armoured cable to the 11kV ICOG panel in the inverter stations using a radial feeder arrangement.

Power from each inverter station ICOG panel is transmitted to 11kV main HT switchboard panel located within CMCS room using 1R, 3C, 185mm<sup>2</sup>, 11kV Al XLPE armoured HT cables.

The power from the Main HT switchboard panel is transferred to 2x15/20MVA, 11/132kV, power transformers. Cable details are mentioned in SLD, however as the submitted SLD is not clearly visible. Further the output power of 11/132kV plant end switchyard is transmitted to UPPTCL switchyard, Panwari.

### 4.4 Inverter Station

The 30MW<sub>AC</sub> solar PV plant has been configured with 30 inverters and eight inverter stations. out of eight inverter station, seven inverter stations is of 4MW<sub>AC</sub> capacity and other one is of 2MW<sub>AC</sub> capacity.

Each 4MW<sub>AC</sub> inverter station consists of four inverters connected to a 4000kVA five winding transformers, while each 2MW<sub>AC</sub> inverter station consists of two inverters connected to a 2000kVA three winding transformer. Each transformer, along with allied switchgears, steps up the voltage to 11kV for all inverter stations. Further the power from the HV side of the transformer is fed to the 11kV ICOG panel through radial feeder arrangement.

11kV ICOG panel comprises of current transformer, fixed type line potential transformer, 11kV Vacuum Circuit Breaker and other electrical protection system. The ratings of equipment are not clearly visible in SLD submitted.

### 4.5 LV/MV Transformers

SgurrEnergy has reviewed the SLD and observed that 4MVA, 11kV/4x0.380kV, Dy11y11 five winding transformer and 2MVA, 11kV/2x0.380kV, Dy11y11 three winding transformer have been used in this project. These inverter duty transformers step up the voltage to 11kV.

The inverter transformers output is connected to 11kV ICOG panels located within inverter station. The energy from all the inverter stations is radially combined at main HT switchboard panel located in CMCS room.



#### 4.6 11kV ICOG Panel

The 11kV ICOG panel comprises of inverter duty transformer incoming feeder with metering and protection current transformer, potential transformer, circuit breaker and other electrical protection system. The ratings of equipment are not clearly visible in SLD submitted.

#### 4.7 11kV HT Switchboard Panel

The 11kV main HT switchboard panel comprises of inverter station incoming feeders, two outgoing feeders. Each feeder comprises of dedicated VCB, instrument transformer with metering and protection class. All feeders have been provided with relay and metering unit. All feeders are provided with instantaneous and IDMT (50/51) O/C relay instantaneous and IDMT (50N/51N) E/F relay protections.

Power from 11kV HT switchboard panel is transmitted to 2x15/20MVA, 11/132kV power transformers located in switchyard.

#### 4.8 11kV/132kV Switchyard

The 11kV HT switchboard panel outgoing feeders are connected to respective 15/20MVA, ONAN/ONAF, YNyn0, 132/11kV, power transformers located in 132/11kV plant end switchyard.

The 132/11kV switchyard is equipped with SF<sub>6</sub> circuit breaker, isolators, surge arrestors and current transformers for both line and transformer feeders. The 0.2S class current transformers and 0.2 class potential transformers for tariff metering considered.

#### 4.9 Auxiliary Power Supply

Auxiliary system single line diagram has not been provided to SgurrEnergy. However, based on information received, SgurrEnergy understand that one 150kVA, 380/415kV auxiliary transformer is considered with inverter room ACDB for auxiliary loads.

#### 4.10 Circuit Breakers

Circuit breaker is a mechanical switching device capable of making, carrying and breaking currents under normal and abnormal circuit conditions. The circuit breakers are three poles type with electrically and mechanically operated trip-free with anti-pumping facility suitable for remote electrical closing and tripping. The circuit breakers are normally mounted on individual structures.

The ratings of circuit breakers are not clearly visible in SLD submitted.

#### 4.11 Isolators

Isolators are used to transfer load from one bus to another and also to isolate equipment for maintenance.

The ratings of isolators are not clearly visible in SLD submitted

#### 4.12 Instrument Transformers

Current transformers (CT) and voltage/potential transformers (VT) are known to be as instrument transformers. Instrument transformers are devices used to transform the values of current and voltage in the primary system to values suitable for the measuring instruments, meters, protective relays, etc.

The current transformer of Class 0.2S and potential transformer of Class 0.2 is seems to be considered for tariff metering in 11/132kV switchyard.



#### 4.13 Surge Arrestors and Lightning Arresters

The substation equipment has to be protected against travelling waves due to lightning strokes and switching surges from incoming lines. The apparatus most commonly used for this purpose is the surge arrester. Transformer is the costliest equipment in substation, and it is normal practice to install surge arrester near to the transformer. Additional surge arresters shall be provided either on bus or on various lines for protection of the equipment.

Following the review of SLD, SgurrEnergy observed that surge arrester have been considered for transformer and line feeders of 11/132kV switchyard. The ratings of surge arresters are not clearly visible in SLD submitted

#### 4.14 Metering

In addition to the metering and monitoring arrangement in inverters, monitoring of voltage, current and energy will be provided at the medium voltage switchboards for each of the feeder sections. These meters will be digital with an RS 485 port for remote monitoring. These usually have an accuracy class of 0.5.

Similarly, HV side shall also be equipped with voltage, current, power and energy meters in order to correlate the energy generation and losses. Class of meters at the evacuation point shall be 0.2S. The current transformer of Class 0.2S and potential transformer of Class 0.2 is seems to be considered for tariff metering in 11/132kV switchyard.



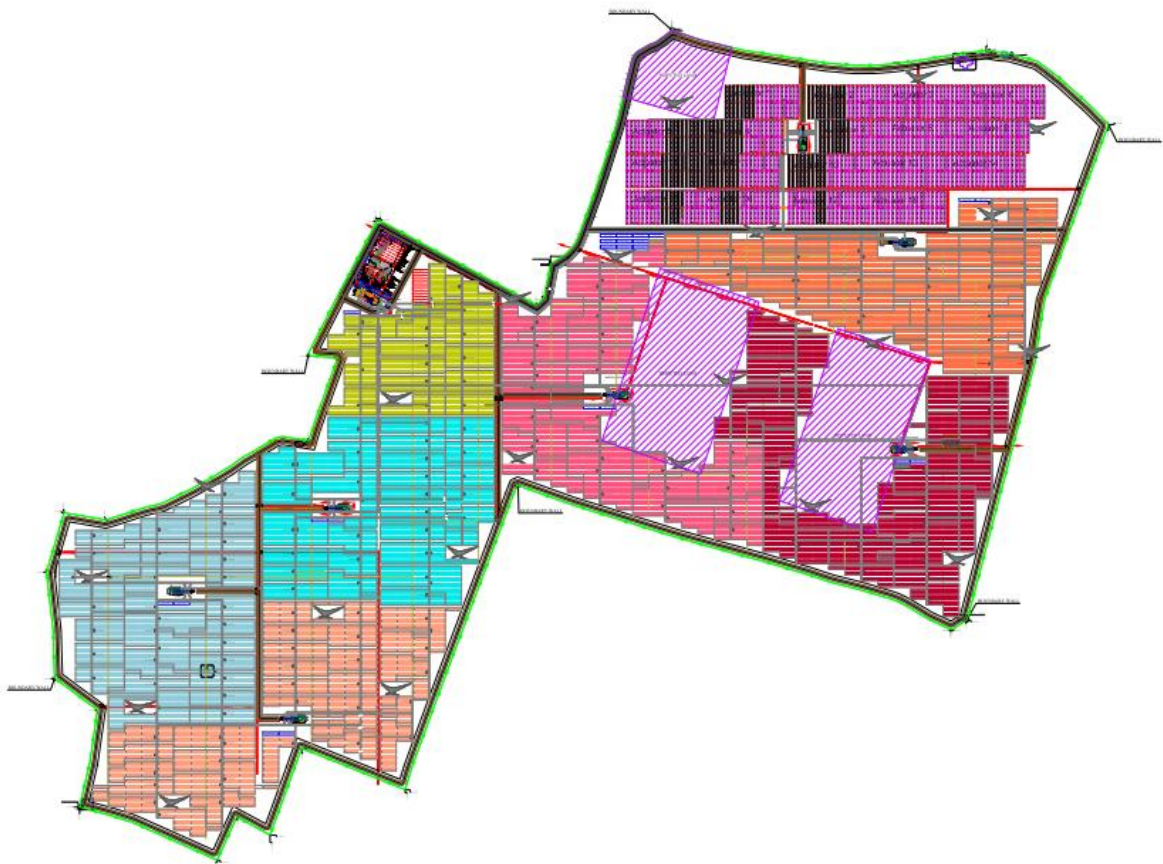


## 5 System Design Appraisal

SgurrEnergy has performed a detailed analysis to evaluate the string sizing and compatibility of the inverters with PV modules used for the Project. The following sections discuss the results obtained from the analysis.

### 5.1 Plant Layout Design

SgurrEnergy was provided with as built plant layout and electrical schematics. SgurrEnergy has verified the plant configuration with electrical schematics provided by the Client. The PV plant is implemented with Canadian Solar (315W<sub>P</sub> and 320W<sub>P</sub>) PV modules. The total DC installed capacity stands at 36.98 MW<sub>P</sub> out of which 30.76MW<sub>P</sub> has been implemented with fixed tilt configuration and remaining 4.28MW<sub>P</sub> has been implemented with trackers. The AC installed capacity stands at 30 MW<sub>AC</sub> with 30 inverters of capacity 1000 kW each. Overall 30 MW<sub>AC</sub> PV plant is illustrated below in the Figure 5-1.



**Figure 5-1: Plant layout of 30 MW<sub>AC</sub>**

The selected tilt for the 30 MW<sub>AC</sub> plant is 19° for Fix tilt and the tracers are deployed with North South axis. The 30 MW<sub>AC</sub> plant is designed with a pitch of 7.5m for Fix tilt and 5 m for Trackers

The nominal plant power ratio (DC to AC) of the Project is 1.17. Typically, PV plants are designed to have a nominal power ratio upto 1.45 in India; a higher ratio leads to greater overload losses during peak irradiance conditions. However, PV module temperature losses are substantial at the high ambient temperatures corresponding to the higher nominal power ratio. 20 modules are connected in series to form a string.





## 5.2 String Sizing

The plant layout provided by the Developer indicate Ten 320 W<sub>p</sub> Canadian Solar modules to be connected in series to form a string for the plant.

As the string voltage is dependent on temperature and irradiation, open circuit voltage ( $V_{OC}$ ) of the string must be corrected using the temperature co-efficient for the PV modules. Therefore, it becomes necessary to ensure that the maximum voltage input (i.e. the maximum  $V_{OC}$  of string at minimum temperature) to inverter does not exceed the inverter maximum operating D.C voltage and hence is a critical value considered by SgurrEnergy in validating string configuration. Subsequent to calculating open circuit voltage ( $V_{OC}$  max), maximum power voltage ( $V_{mp}$  min) is calculated to ensure that it is within the maximum power point (MPP) range of the implemented inverters.

SgurrEnergy considers the maximum and minimum ambient temperature of 47°C and 4°C respectively for system design validation to be fair and representative for the PV plants' site.

The results of string sizing validation are presented in Table 5-1. Results indicate that  $V_{OC}$  max at the minimum ambient temperature is within the maximum system voltage of 1,000V for the selected ABB 1000 KVA (PVS800-57-1000kW-C) inverters.

**Table 5-1: String Sizing for Canadian Solar PV Modules**

Parameters	Canadian Solar 320Wp
PV module power (W <sub>p</sub> )	320
Modules per string	20
Inverters	ABB 1000 KVA (PVS800-57-1000kW-C)
Maximum Open-circuit voltage ( $V_{OC}$ max) at minimum ambient temperature of 4°C	844 V
Minimum power voltage ( $V_{mp}$ min) at maximum ambient temperature of 47°C	660V

## 5.3 Inverter Compatibility

SgurrEnergy performed a detailed analysis on plant sizing to assess the compatibility of inverters with the PV modules used in the projects. The electrical design compatibility summary with Canadian Solar and ABB central inverter is presented in Table 5-2. SgurrEnergy has selected the highest rated Canadian Solar module (320W<sub>p</sub>) their compatibility with ABB inverter, as SgurrEnergy considers this to be representative for all the Canadian Solar PV modules installed on site.

**Table 5-2: Inverter Compatibility with Canadian Solar 320W<sub>p</sub> Modules**

Parameters	Inverter Compatibility	
PV module	Canadian Solar (CS6X - 320P) 320 Wp	
Modules per string	20	Acceptable
Strings per inverter	187	Acceptable
Maximum power, P <sub>mpp</sub> at STC (kW <sub>p</sub> )	1,190.00	Nominal power ratio is 1.19, this is within the inverter bus current carrying capacity.



Parameters	Inverter Compatibility	
Maximum power voltage, V <sub>mpp</sub> at STC (V)	736	Acceptable.
Maximum power current, I <sub>mpp</sub> at STC (A)	834.24	Acceptable
Open-circuit voltage, V <sub>oc</sub> at STC (V)	906	Acceptable.
Minimum MPP voltage at 47°C ambient temperature (V)	660	Acceptable: Inverter MPPT ranges 450 - 825V.
Maximum MPP voltage at 4°C ambient temperature (V)	734	Acceptable: Inverter MPPT ranges 450 - 825V.
Maximum open circuit voltage, V <sub>oc</sub> at 4°C (V)	844	Acceptable: Maximum inverter voltage 1000V.

Overall, SgurrEnergy does not raise any concerns regarding the string sizing and inverter compatibility.



## 6 Resource assessment

The accuracy of any solar energy yield prediction is heavily dependent on the accuracy of the solar resource dataset used. Solar irradiation data is currently not being measured at the location of the proposed power plant and it is therefore necessary to use alternative data sources to obtain estimates of the irradiation figures for the site.

The solar resource of a location may be defined by values of the global horizontal irradiation, direct normal irradiation and diffuse horizontal irradiation. These parameters are described below.

**Global Horizontal Irradiation (GHI)** - The global horizontal irradiation is the total solar energy received on a unit area of horizontal surface. It includes energy received from the sun in a direct beam and energy that is received from radiation scattered off the atmosphere arriving from all directions of the sky (diffuse irradiation). The units of GHI are given in kWh/m<sup>2</sup>. Values are often provided for a period of a day, a month or a year.

**Diffuse Horizontal Irradiation (DHI)** - The diffuse horizontal irradiation is the energy received from radiation scattered off the atmosphere arriving from all directions of the sky on a unit area of horizontal surface. It is measured in kWh/m<sup>2</sup> and values are strongly dependent on weather conditions and the clearness of the air.

**Direct Normal Irradiation (DNI)** - The direct normal irradiation is the total solar energy received on a unit area of surface *directly facing the sun at all times*. The units of DNI are kWh/m<sup>2</sup>. The direct normal irradiation is of particular interest for solar installations that track the sun and to concentrating solar technologies as only radiation coming directly from the sun may be focussed by a lens or mirror.

For modelling of solar PV plants, GHI and DHI are required for calculating the estimated energy yield. In the northern hemisphere, tilting the modules at an angle towards the south increases the total annual global irradiation that is received on the module plane compared to the horizontal plane. This is quantified by the global tilted irradiation. The optimal tilt angle varies primarily with latitude and also depends on local weather patterns, ground conditions and plant layout configurations.

Tilted modules also benefit from irradiation reflected from the ground which is dependent on the ground reflectance, or albedo. Albedo and global tilted irradiation are described below.

**Global Tilted Irradiation (GTI)** – The global tilted irradiation is the total solar energy received on a unit area of a tilted surface. It includes direct and diffuse irradiation along with ground reflected irradiation. The units of GTI are kWh/m<sup>2</sup>. A transposition model is used for translating horizontal irradiation to tilted irradiation within PV modelling software.

**Albedo** – The ground albedo or reflectance affects the irradiation on a plane when it is tilted from horizontal and increases the GTI. The albedo is highly site and weather dependent, with typical grass coverings giving an albedo of approximately 0.2 and fresh snow giving an albedo of approximately 0.8, meaning that 20% and 80% respectively of the irradiation is reflected back into the atmosphere.

### Comparison of Resource Data

There are a variety of possible solar irradiation data sources that may be accessed. The datasets either make use of ground-based measurements at well-controlled meteorological stations or use processed satellite imagery. A minimum of 10 years of data is recommended to allow for the expected variability of resource data between years. SEI has sourced monthly horizontal plane irradiation data for the Project site from:

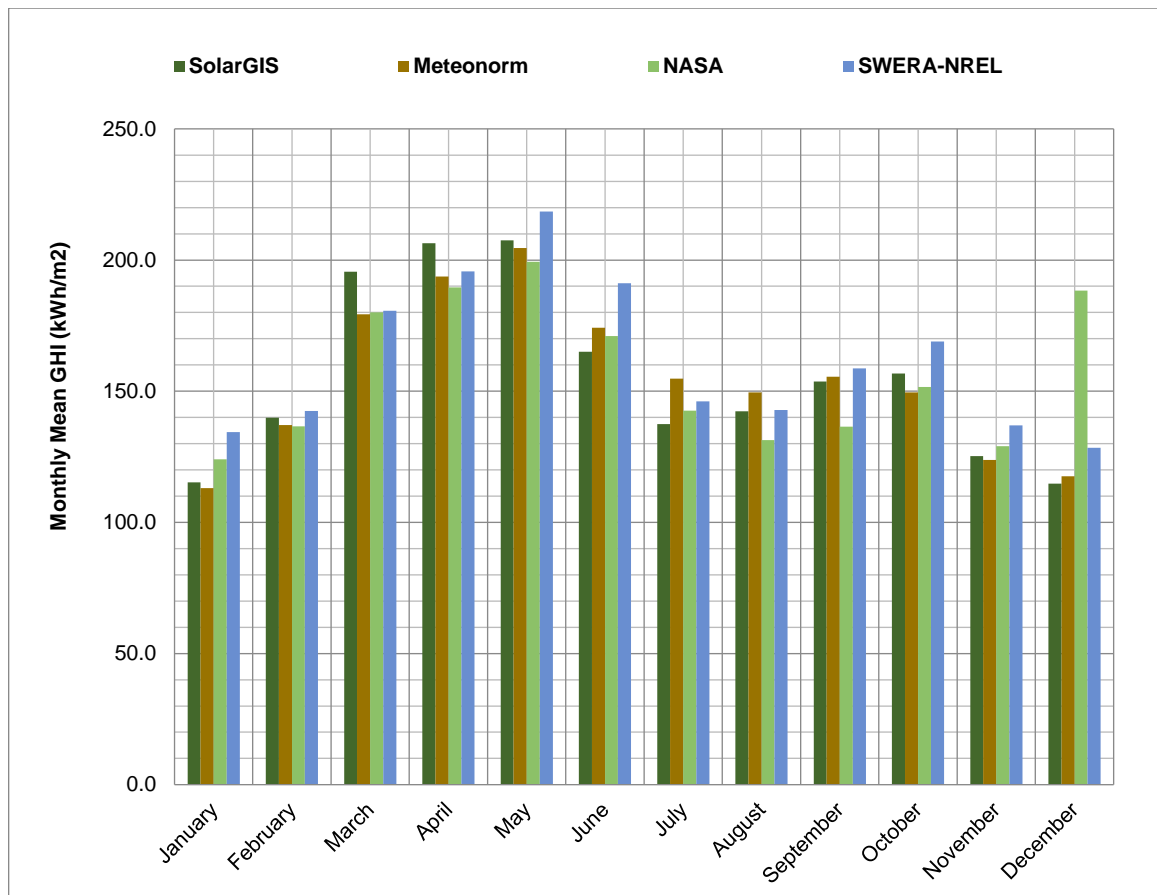
- **NASA's Surface Meteorology and Solar Energy data set**; holds satellite derived monthly data for a grid of 0.5° × 0.5° covering the globe for a thirty-four-year period (1984-2017). The data are suitable for pre-feasibility studies of solar energy projects.



- The **METEONORM (version 7.3)** *global climatological database and synthetic weather generator*; contains a database of ground station measurements of irradiation and temperature. Where a site is over 11km from the nearest measurement station it outputs climatologic averages estimated using interpolation algorithms. Where no radiation measurement station is within 300km from the site, satellite information is used. If the site is between 50 and 300km from a measurement station a mixture of ground and satellite information is used. The accuracy of irradiation figures close to measurement stations are within a few percent. Uncertainty increases with distance between the site and the measurement station, especially in hilly and mountainous terrain.
- **SolarGIS:** SolarGIS is developed and operated by GeoModel a solar company maintaining databases of climate data to support solar energy projects and systems. Database is derived from Meteosat and Geostationary Operational Environmental Satellite system (GOES) satellite data and atmospheric parameters (aerosol and water vapour) using high performance algorithms. SolarGIS regional coverage includes Europe, Africa, Asia and parts of South America and Australia. The spatial resolution of primary parameters for European region is approximately 4km x 4km with a temporal resolution of between 15 minutes to 3 hours. SolarGIS radiation models use multispectral channels and multi-dimensional statistical treatment of ground albedo, daily values of aerosol and water vapour. SolarGIS models is validated by *IEA (International Energy Agency) SHC Collaboration Agreement, and EU FP6 project MESoR* in terms of bias and RMSE.
- **Solar and Wind Energy Resource Assessment (SWERA) / National Renewable Energy Laboratory (NREL)** data was developed from NREL's Climatological Solar Radiation (CSR) Model using primary data from geostationary satellites. The satellites provide information on the reflection of the earth-atmosphere system and the surface and atmospheric temperature which is useful in determining cloud cover. Model outputs are verified with ground-based data to ensure quality of the measurements.

SEI has compared the irradiation datasets given by NASA - SSE, Meteonorm 7, SolarGIS and, NREL (SWERA) data for the site. The comparison is graphically illustrated Table6-1





**Figure 6-1: Monthly Global Horizontal Irradiation**

**Table6-1: Comparison of Solar Irradiation Datasets for the site**

Data source	Satellite Resolution	Uncertainty	GHI (kWh/m <sup>2</sup> /annual)
SolarGIS	4km × 4km	3.9%	1859.8
Meteonorm 7.3	14km × 14km	4.0%	1852.752
NASA	55km × 55km	Unknown	1880.1
NREL (SWERA)	40km × 40km	Unknown	1944.867

The comparison of solar data for Project site location illustrated in Table6-1 indicates NREL (SWERA) dataset to give the highest irradiation levels. The next highest irradiation is given by NASA followed by SolarGIS and Meteonorm 7.2.

The irradiation values given by Meteonorm 7.2 typically provide a combination of ground and satellite measured data. Meteonorm 7.2 has interpolated the data using satellite data for the proposed site. Uncertainty of satellite data is obtained as 5.2% for the proposed site.

The NREL (SWERA) data illustrated has been obtained for a location approximately 18.62 km away from the proposed site. SgurrEnergy performed iteration on an extensive list of NREL (SWERA) datasets to obtain appropriate coordinates that lie within the Indian boundaries. The results give only irradiation data without temperature and wind data.

The NASA-SSE data source provides purely satellite measured data for a grid covering  $0.5^\circ \times 0.5^\circ$  on the earth's surface and generally more suited for initial site selection.



The SolarGIS dataset has been compared with good quality ground measurements for more than 200 sites. The resulted mean bias for GHI is 0%. SolarGIS data base has also been compared with other data sources globally. The IEA (International Energy Agency) validation study conducted by University of Geneva in 2011 has resulted in SolarGIS to be the best performing database among five satellite databases. Similar IEA validation study was repeated in 2013 by University of Geneva which again resulted in SolarGIS to be the best performing database among six satellite databases. Validation study in 2013 was conducted using 18 validation sites in Europe and Mediterranean regions. Furthermore, SolarGIS has conducted its own validation for six Indian locations<sup>10</sup> with the following bias in GHI;

- Pantnagar (Uttarakhand)
- Kanpur (Uttar Pradesh)
- Mysore (Karnataka)
- Warangal (Telangana)
- Jaipur (Rajasthan)
- Ranchi (Jharkhand)

Comparative analysis of all the data sets available, indicate SolarGIS has been validated for India. Furthermore, SolarGIS dataset is based on the most recent long-term average that is from 1999 – 2015, while Meteonorm dataset is based on the time-period of 1991 - 2010. The uncertainty of SolarGIS is 3.9% while that of Meteonorm is 6%.

SEI is therefore of the opinion that SolarGIS dataset may be considered reasonable and a representative data source for conducting an energy yield assessment for the project location.

### 6.1 Global, Direct and Diffuse Irradiation on a Horizontal Plane

Horizontal plane irradiation data based on long-term monthly averages are presented in Table 6-2 and shown graphically in Figure 6-2. Diffuse irradiation accounts for 49.07% of the total irradiation. Table 6-2 illustrates direct and diffuse daily irradiation on a horizontal plane for the proposed site. SolarGIS irradiation data is presented in Table 6-2.

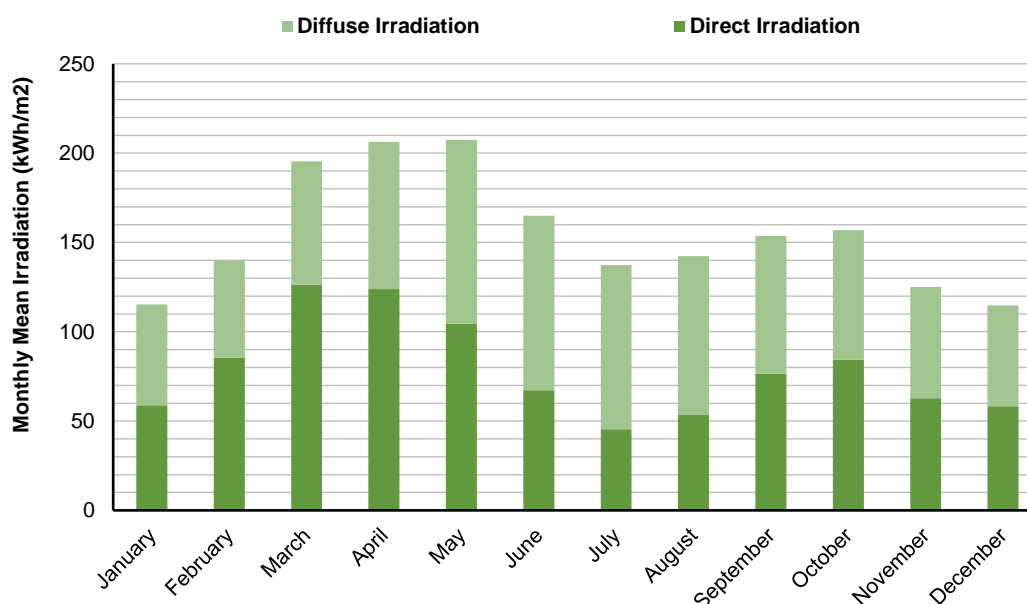
**Table 6-2: SolarGIS Irradiation Data for the Project site**

Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
January	115.3	56.4	6.2%
February	139.9	54.3	7.5%
March	195.5	69.1	10.5%
April	206.4	82.5	11.1%
May	207.5	102.9	11.2%
June	165.0	97.8	8.9%
July	137.4	92.1	7.4%
August	142.4	89.0	7.7%
September	153.7	77.1	8.3%

<sup>10</sup> <https://solargis.com/docs/accuracy-and-comparisons/overview/>



Month	Monthly GHI (kWh/m <sup>2</sup> )	Monthly Diffuse (kWh/m <sup>2</sup> )	Proportion of GHI to Annual
October	156.8	72.5	8.4%
November	125.2	62.4	6.7%
December	114.7	56.4	6.2%
<b>Annual Sum</b>	<b>1,859.8</b>	<b>912.6</b>	<b>-</b>



**Figure 6-2: Monthly Direct and Diffuse Irradiation on a horizontal plane for the project site**

## 6.2 Global Tilted Irradiation

Industry standard PV modelling software PVsyst (v.7.0.17), was used. An albedo of 0.2 was assumed based on the ground surface covering within and around the PV array. Table -6-3 represents the monthly GTI profile.

**Table -6-3: Monthly Global Tilted Irradiation Data**

Month	GTI (kWh/m <sup>2</sup> ) (Fix Tilt)	GTI (kWh/m <sup>2</sup> ) (Tracker)
January	141.8	175.70
February	166.7	207.40
March	216.7	253.60
April	211.9	217.70
May	201.3	183.40
June	156.6	137.30
July	131.2	117.60
August	141.1	135.60
September	162.6	178.00



Month	GTI (kWh/m <sup>2</sup> ) (Fix Tilt)	GTI (kWh/m <sup>2</sup> ) (Tracker)
October	178.7	210.80
November	151.8	187.50
December	144.1	181.80
<b>Annual Sum</b>	2004.3	2186.50

### 6.3 Climate

For wind speed analysis, data sourced from Meteonorm dataset was used and has been tabulated in Table 6-4 below. The average wind speed of 0.8 m/s was measured at 10m height from ground level for the proposed project site location.

**Table 6-4: Simulated Wind Speed for site**

Month	Average Wind Speed (m/s) – Meteonorm Data
January	0.5
February	0.7
March	0.8
April	0.9
May	1.3
June	1.3
July	1.2
August	1.1
September	0.8
October	0.4
November	0.3
December	0.4
<b>Yearly Average</b>	0.8

### 6.4 Temperature

Temperature data has been sourced from the SolarGIS database. A typical operating temperature range for PV modules is -40°C to +85°C. Inverter operating ranges are more bounded to temperature, typically -20°C to +45°C, with the electronic equipment in the inverter degrading quicker in high temperature environments. Thus, considering the temperature range at selected site, the modules and inverters should be able to operate normally.

The effect of temperature on module performance and the corresponding plant performance may be quite significant. Typically, a reduction in efficiency of 0.40 – 0.45%/°C is noted for crystalline modules and 0.25 -0.30%/°C for thin film modules for increase in temperatures above 25°C. Therefore, during the summer months (February-June) temperature losses may be significantly high as module temperatures typically go beyond 50°C.



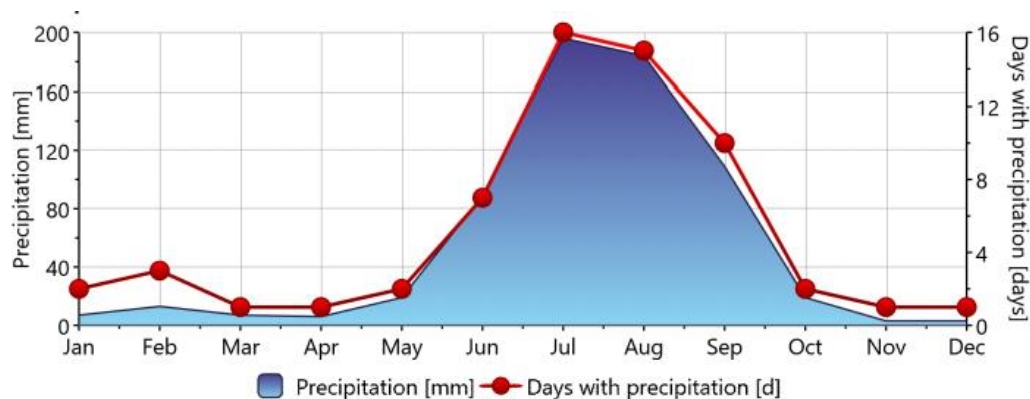


**Table 6-5: SolarGIS Temperature Data for Site (1999 – 2018)**

Months	Average Monthly Temperature (°C)
January	14.8
February	18.7
March	24.7
April	30.7
May	34.9
June	35.0
July	30.8
August	28.9
September	28.2
October	25.8
November	20.4
December	15.8
<b>Annual Average</b>	<b>25.8</b>

## 6.5 Precipitation

The rainfall figures have been simulated using Meteonorm 7.2 as illustrated in Figure 6-3. These figures show that the identified site is situated in a region that has marginal rainfall.

**Figure 6-3 Meteonorm Predicted Precipitation for the site**

PV modules are soiled by particulates of dust, dirt and bird droppings. Soiling of modules has a high impact on the energy yield thereby leading to a loss up to 3% in non-arid regions. Therefore, the modules need to be cleaned for avoiding the loss due to soiling.

Frequency of module cleaning depends on the rainfall frequency and the prevalence of dust and pollution in the local vicinity. Typical cleaning techniques include water cleaning, dry brushes or vehicle-based mechanical cleaning.

The frequency of module cleaning is primarily dependent on the amount of soiling experienced on the site. Soiling loss of 2% has been considered by considering cleaning frequency of twice a month.



## 7 Energy Yield Analysis

SgurrEnergy has computed the annual energy yields for the 30MW<sub>AC</sub> Solar PV Plant using basic designs and indicative layout. Energy yields for all the PV technology configurations under evaluation is further elaborated in the following section.

Parameter	Description
Modules	Canadian Solar 320 W <sub>p</sub> , (CS6X - 320P) Canadian Solar 315 W <sub>p</sub> (CS6X - 315P)
Inverters	ABB Central Inverters – 1.0MW <sub>AC</sub> (PVS800-57-1000kW-C)
Mounting System	Fixed Tilt, Tracker
DC Capacity (MW <sub>p</sub> )	36.98

For energy yields SgurrEnergy has:

- 1) Sourced average monthly horizontal irradiation, wind speed and temperature data with the other sources which included satellite image derived data. These data have been assessed for use in the energy yield simulation software.
- 2) Following the assessment, SgurrEnergy has selected site specific data sourced from SolarGIS to arrive at representative energy yield estimates.
- 3) Calculated the global incident radiation on the tilted plane, taking into account shading.
- 4) Applying downtime losses, AC ohmic losses, and module degradation losses to obtain energy yields that reflect twenty-five-year plant life.

Using statistical analysis of resource data for inter-annual variability to derive appropriate levels of uncertainty in the energy yield prediction, steps 2 and 3 are facilitated using industry standard photovoltaic simulation software which simulates the energy yield using hourly time steps. The software takes as input detailed specifications of:

- The solar PV modules.
- The inverter.
- Mounting system.
- Electrical configuration including number of modules in series and parallel.

### 7.1 Correction and Losses

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modelling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid. The losses may be described as a yield loss factor. They are calculated within the PV modelling software and calculated from the cable dimensions. Others are nominal figures applied from knowledge of performance of similar PV plants. The losses are broadly summarised in Table 7-1 below.

**Table 7-1: Description of Energy Yield Losses**

Loss	Description
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.



Loss	Description
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temperature	The characteristics of a PV module are determined at standard temperature conditions of 25°C. For every °C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wiring Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise to ohmic losses ( $I^2R$ ).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
MPP Tracking	The inverters are constantly seeking the maximum power point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.
AC Losses	This includes ohmic losses from inverter to evacuation point.
Downtime	Downtime is a period when the plant does not generate due to failure. The downtime periods will depend on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.
Grid Availability and Disruption	The ability of a PV power plant to export power is dependent on the availability of the distribution or transmission network. Unless detailed information is available, this loss is typically based on an assumption that the local grid will not be operational for a given number of hours/days in any one year, and that it will occur during periods of average production.
Power Curtailment Losses	Curtailment loss is attributed to the utility limiting the power intake at the contracted AC capacity of the PV Plant; thus, the excess energy generated beyond the limit of 30MW <sub>AC</sub> at the metering level shall not be accounted
Degradation	The performance of a PV module decreases with time.

## 7.2 P50 Energy Yield Predictions

This section presents the SgurrEnergy's independent energy yield prediction for the 30MW<sub>p</sub> solar PV Plant with Canadian solar PV modules and ABB central inverters. Table 7-2 summarises the solar PV power plant, the available resource, the losses and the predicted P50 yields.

**Table 7-2: Energy Yield for the 30MW<sub>AC</sub> Solar PV Plant**

Parameters	Description	
	Fix Tilt	Tracker
PV Module Technology	Polycrystalline	



Parameters	Description	
	Fix Tilt	Tracker
DC Capacity (MW <sub>p</sub> )	31.95	5.02
AC Capacity (MVA)	26	4
P <sub>NOM</sub> Ratio	1.22	1.25
Cumulative DC Capacity (MW <sub>p</sub> )	36.97	
Cumulative AC Capacity (MVA)	30.0	
Contracted Capacity (MW)	30.0	
Cumulative P <sub>NOM</sub> Ratio	1.23	
Tilt (°)	19	-
Pitch (m)	7.5	5
Annual Global Horizontal Irradiation (kWh/m <sup>2</sup> )	1859.80	
Global Irradiation Incident on Collector Plane (kWh/m <sup>2</sup> )	2004.34	2186.49
Transposition Factor	1.08	1.18
<b>Losses</b>		
Horizon Shading	0.00%	0.00%
Incident Irradiation Below Threshold	0.00%	0.00%
Near Shading	1.7%	1.5%
Incident Angle	2.8%	2.1%
Soiling	2.0%	2.0%
Low Irradiance	0.2%	0.2%
Module Temperature	9.2%	9.8%
Electrical Shadings	0.0%	0.0%
Module Quality	0.00%	0.00%
First year Degradation	2.00%	2.00%
Module Mismatch	1.00%	1.00%
DC Ohmic	0.7%	0.8%
Inverter Performance	1.6%	1.7%
Availability	1.00%	1.00%
AC Ohmic	0.5%	0.6%
Transformer (LV/MV)	1.00%	1.00%
Transformer (MV/HV)	0.5%	0.5%
Transmission Line	0.0%	0.0%
Auxiliary Consumption	0.75%	0.75%
Curtailment		
<b>Total Annual Loss Factor</b>	<b>0.775</b>	<b>0.774</b>



Parameters	Description	
	Fix Tilt	Tracker
First Year P50 Energy Yield (MWh/annum)	49,611.98	8,503.76
Fifth Year P50 Energy Yield (MWh/annum)	48,627.15	8,334.96
Fifth Year Specific Yield (kWh/kW <sub>p</sub> )	1,521.93	1,657.74
Fifth Year CUF on AC Installed Capacity	21.35%	23.79%
Fifth Year CUF on Contracted Capacity	21.35%	23.79%
Fifth Year CUF on DC Installed Capacity	17.37%	18.92%
Fifth Year Performance Ratio	75.93%	75.82%
<b>Cumulative</b>		
First Year P50 Energy Yield (MWh/annum)	58,115.74	
Fifth Year P50 Energy Yield (MWh/annum)	56,962.11	
Fifth Year Specific Yield (kWh/kW <sub>p</sub> )	1540.39	
Fifth Year CUF on AC Installed Capacity	21.68%	
Fifth Year CUF on Contracted Capacity	21.68%	
Fifth Year CUF on DC Installed Capacity	17.58%	
Fifth Year Performance Ratio	75.916%	

Graphical representation of the monthly generation, performance ratio and CUF for 30 MW<sub>AC</sub> evaluated is illustrated graphically in the Figure 7-1.1 (Fix Tilt , 26 MW<sub>AC</sub>) &Figure 7-1.2 (Tracker , 26 MW<sub>AC</sub>) .

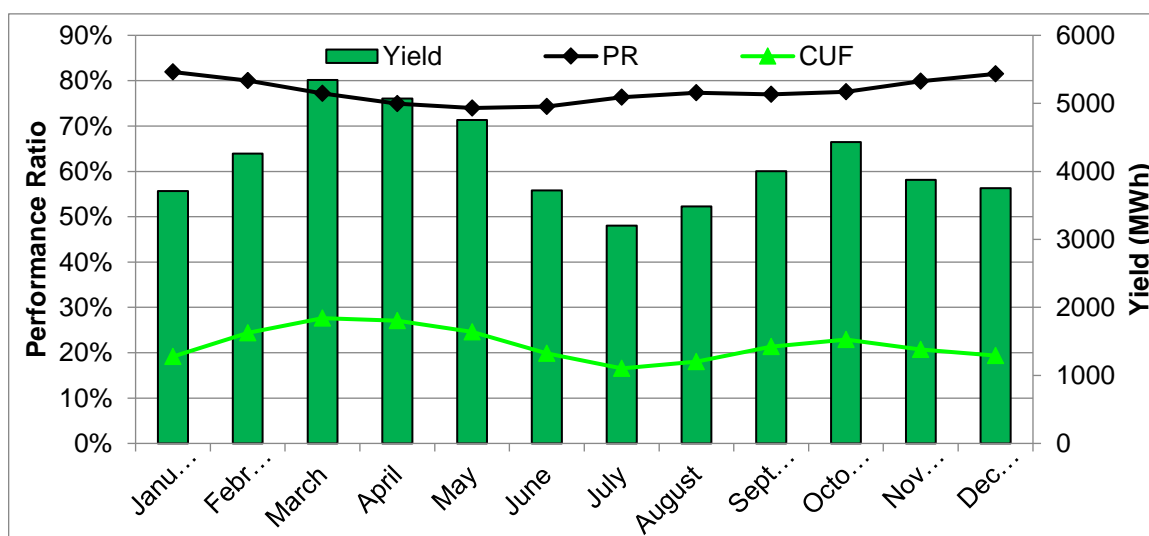


Figure 7-1.1: Monthly Energy Yield for Fix Tilt 26 MW<sub>AC</sub>



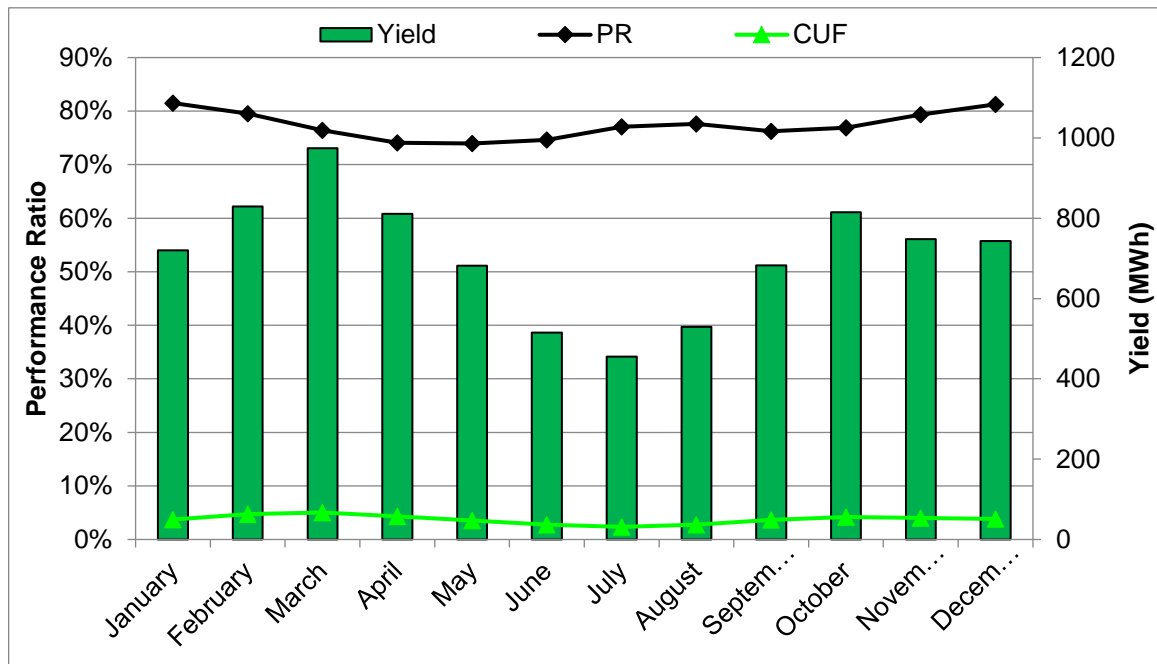


Figure 7-2.2 : Monthly Energy Yield for Tracker 4 MW<sub>AC</sub>

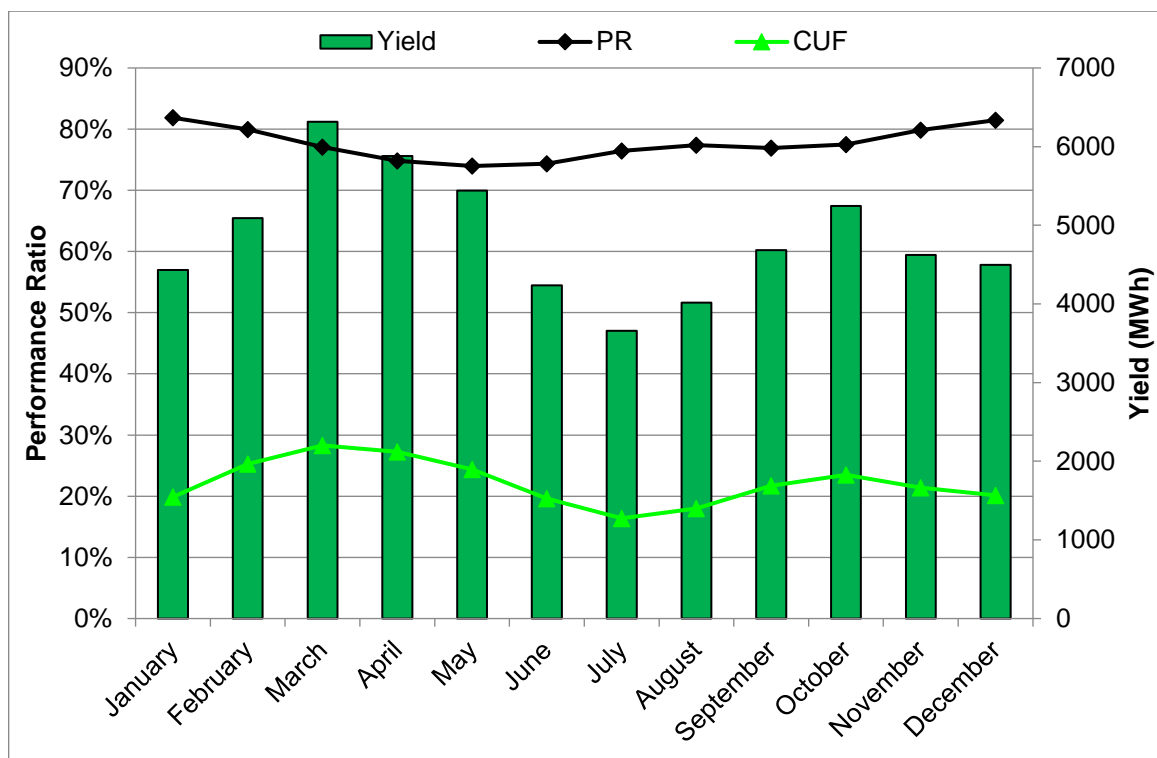


Figure 7-3.3 : Monthly Energy Yield for Tracker 30 MW<sub>AC</sub>



### 7.3 Yield Uncertainty

The uncertainty in energy yield predictions is difficult to quantify as it is a function of many independent factors. The discussion below represents simplification of the estimated uncertainty which is believed to be the best approach given the uncertainty in the resource data.

#### 7.3.1 Solar Resource Measurement Uncertainty

Energy yield prediction is based on SolarGIS database, a satellite data which is derived from Meteosat Indian Ocean Data Coverage (Meteosat IODC) and atmospheric parameters using high performance algorithms set by SolarGIS method.

The resource data for 16+ years (1999-2015) has been obtained from the SolarGIS climatological database. SolarGIS recommends an uncertainty of 3.9%.

The uncertainty in transposing the global horizontal irradiation to global tilted irradiation is dependent on the accuracy of the initial data and the characteristics of the specific location. Based on the SgurrEnergy's experience, the uncertainty associated with the transposition model is 1.5%.

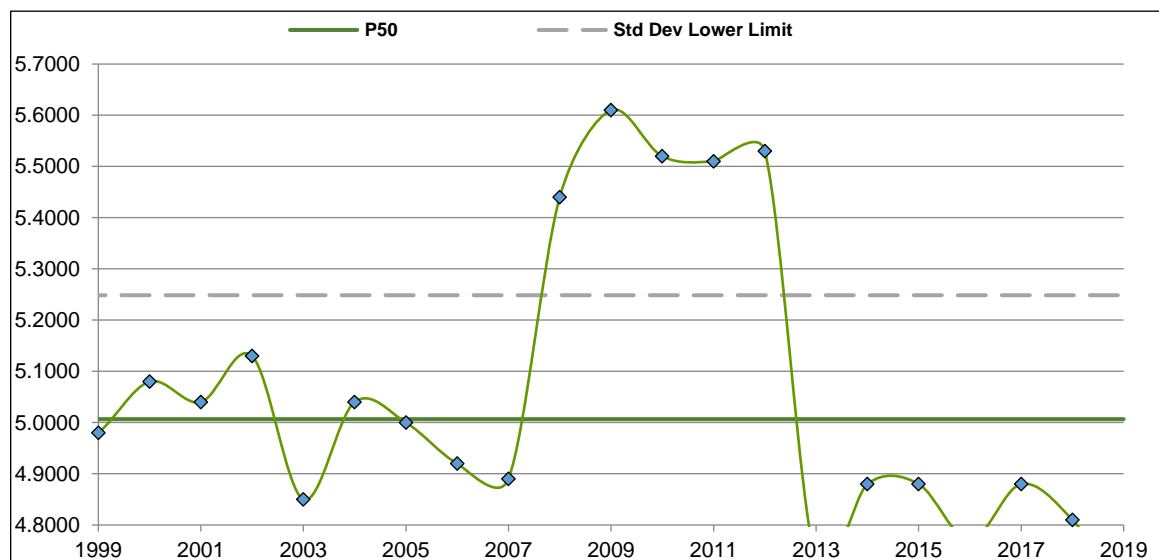
#### 7.3.2 Inter – Annual Variation in the Solar Resource

Mean global daily irradiation on a horizontal plane varies on an annual basis. This means that the plant owner does not know what energy yield to expect in any given year but can have a good idea of the expected yield in the long term.

The likely variation can be quantified based on analysis of variation in long-term irradiation data in the vicinity of site. SgurrEnergy has sourced 35 year's data from NASA database for the proposed site location which is used to estimate the standard deviation of variation in irradiation. SgurrEnergy has analysed this dataset and computed the coefficient of variation (standard deviation divided by the mean) as shown in Table 7-3.

**Table 7-3: Summary of Figures for Inter-Annual Variation in Resource**

<b>Number of Years of Data</b>	35
<b>Coefficient of Variation</b>	4.83



**Figure 7-4: Inter-Annual Variability of GHI**

Graphical illustration of inter annual variation is presented in Figure 7-4.

SgurrEnergy uses a coefficient of variation of 4.83% to quantify the inter-annual variation in the solar resource.

#### 7.3.3 Modelling Uncertainty



The modelling uncertainty is a combination of the various uncertainties for each loss factor assessed in the modelling process. Efforts to validate the photovoltaic simulation software used data from seven grid connected systems in Europe. These indicated that the accuracy of the results of the simulation is in the order of 2 to 3%.

#### 7.3.4 Total Uncertainty (P75 and, P90 Energy Yield Predictions)

Combining the uncertainties in energy yield and inter-annual variation in the solar resource, the P50, P75 and P90 confidence interval are presented for each PV plant configuration in the table below.

**Table 7-4: Life Cycle P50, P75 and P90 Generation Prediction for 30 MW<sub>AC</sub>**

Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>11</sup>	P90 Generation Prediction <sup>12</sup>
5	56,962.11	54,729.27	52,719.65
6	56,677.30	54,455.63	52,456.05
7	56,393.92	54,183.35	52,193.77
8	56,111.95	53,912.43	51,932.80
9	55,831.39	53,642.87	51,673.14
<b>10</b>	<b>55,552.23</b>	<b>53,374.66</b>	<b>51,414.77</b>
11	55,274.47	53,107.78	51,157.70
12	54,998.10	52,842.24	50,901.91
13	54,723.11	52,578.03	50,647.40
14	54,449.49	52,315.14	50,394.16
15	54,177.24	52,053.57	50,142.19
16	53,906.36	51,793.30	49,891.48
17	53,636.83	51,534.33	49,642.02
18	53,368.64	51,276.66	49,393.81
19	53,101.80	51,020.28	49,146.84
<b>20</b>	<b>52,836.29</b>	<b>50,765.18</b>	<b>48,901.11</b>
21	52,572.11	50,511.35	48,656.61

<sup>11</sup> The P75 values have been calculated over 10-year averages

<sup>12</sup> The P90 values have been calculated over 10-year averages





Year	Annual P50 Generation (MWh/annum)	P75 Generation Prediction <sup>11</sup>	P90 Generation Prediction <sup>12</sup>
22	52,309.25	50,258.79	48,413.32
23	52,047.70	50,007.50	48,171.26
24	51,787.46	49,757.46	47,930.40
25	51,528.53	49,508.68	47,690.75



## 8 Operational Analysis and Generation Comparison

To assess the operational performance of the plant, SgurrEnergy has comparatively evaluated the monthly energy yield predicted using satellite-based weather data with the plant generation SCADA values. A factor of 0.5% degradation has been considered for values after a duration of 1 year from COD (Commercial Operational Date) and henceforth. The variation has been evaluated with respect to the difference between the two generation figures.

Based on the information provided by the Owner, SgurrEnergy understands that the USUPL solar PV plant was commissioned in 15<sup>th</sup> September 2016. SgurrEnergy was provided with plant and grid availability records from April 2017 to April 2021<sup>13</sup> for the solar PV plant. The irradiation records were provided from January 2017 to April 2021.

SgurrEnergy has thus carried out the generation comparison for the PV project for the period from April 2017 to April 2021, henceforth referred to as 'operational period'. SgurrEnergy compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Owner.

SgurrEnergy also observed that the monthly availability figures were provided for the operational period of the solar PV plant. These availability figures were captured within the monthly energy yield predictions assessed for the site in question and were accounted for representative comparison. The average availability based on the provided data has also been specified below.

Based on the availability records provided, SgurrEnergy has analysed the trend in the plant availability and grid availability for each month as presented in the following sections.

### 1.1.1 Grid Availability

The ability of a PV power plant to export power is dependent on the availability of the grid transmission network and the utility grid substation. Grid unavailability is solely due to the breakdown events associated with the grid substation and substation maintenance, which is beyond the Owners control.

The monthly records of the grid availability from April 2017 to April 2021 have been graphically illustrated in Figure 8-1 below.

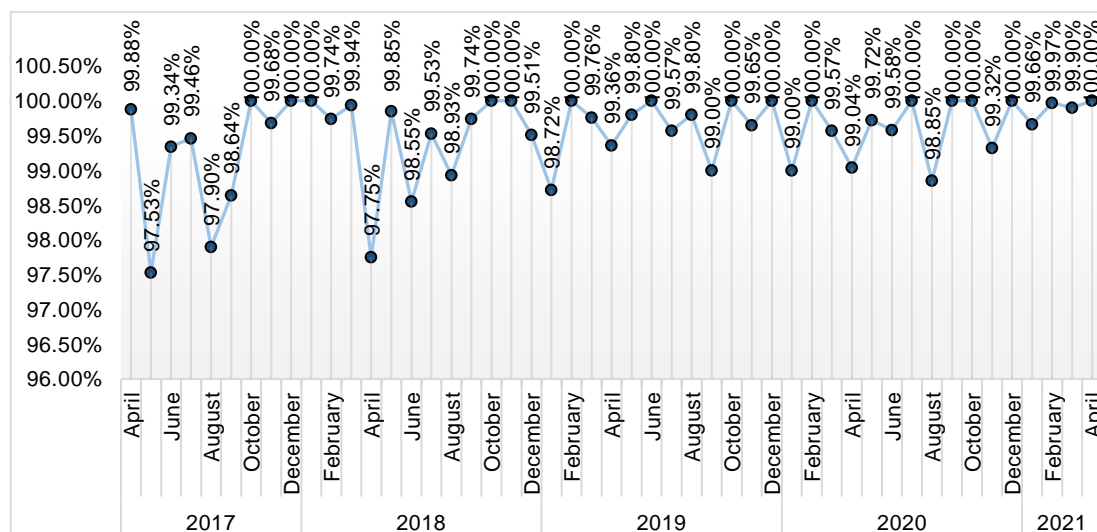


Figure 8-1: Grid Availability

<sup>13</sup> SgurrEnergy was provided with both the plant and grid availability records until April 2021 and hence the analysis conducted in the sections below has been done to incorporate the available data.



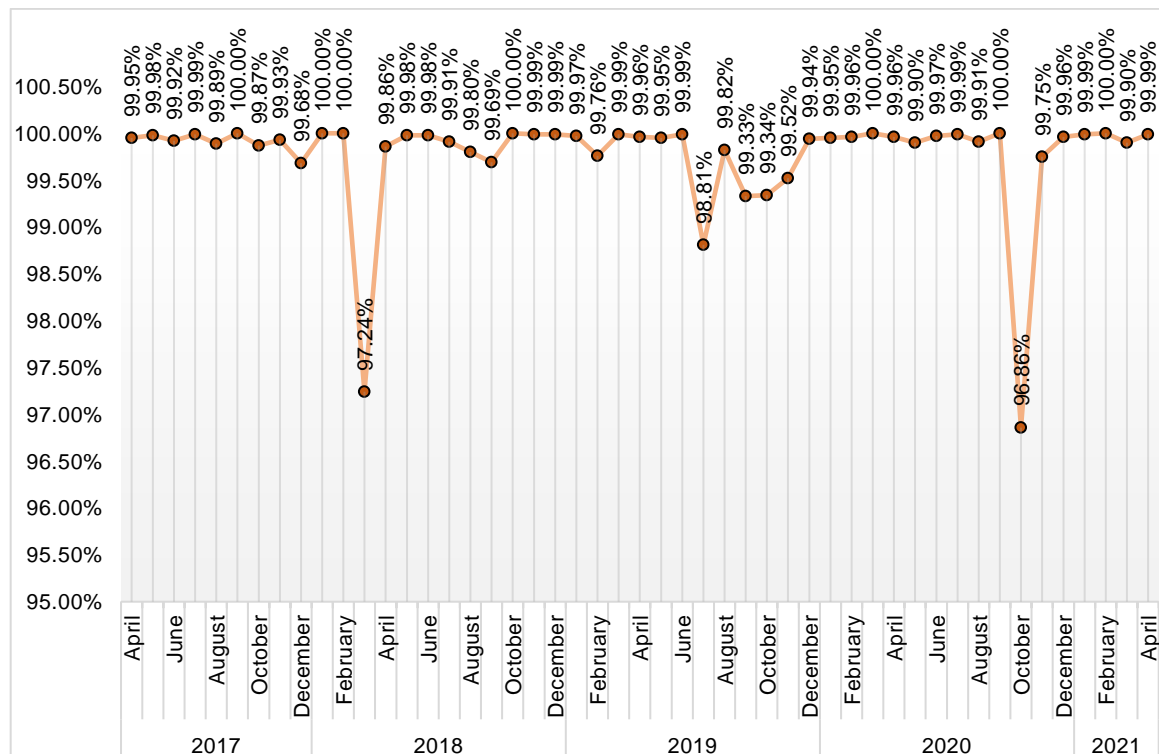
From the above illustration, SgurrEnergy notes that the unavailability loss experienced due grid anomalies are high over the operational period. For the months of May 2017, August 2017 and April 2018 unavailability due to grid was high when compared to other months. The downtime due to grid unavailability was above 98.55% during the remaining months.

Overall, the average grid availability experienced on site for the operational period was calculated to be 99.52%

### 1.1.2 Plant Availability

Plant downtime is a period when the plant does not generate due to failure of equipment in plant until the injection point. The plant downtime period depends on the quality of the plant components, design, environmental conditions, diagnostic response time and the repair response time.

Plant availability of the USUPL solar PV plant is graphically illustrated below in Figure 8-2.



**Figure 8-2: Plant Availability**

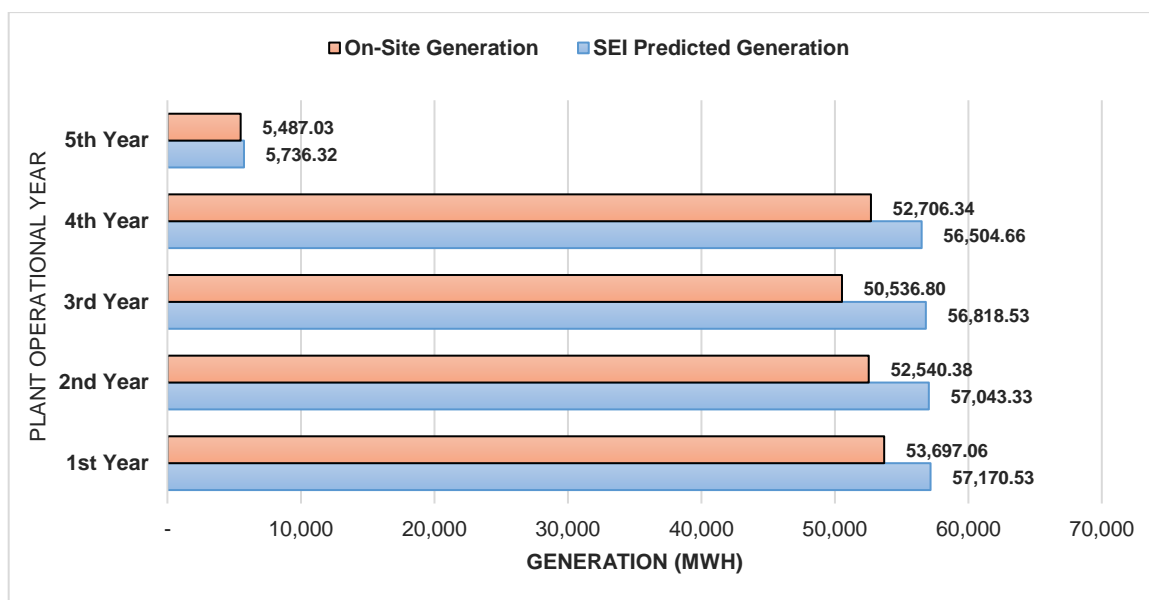
Based on the above illustrations, SgurrEnergy notes the plant availability for the USUPL solar PV plant is consistently above 98.81% for all the months ranging between 98.81% to 100% except for the months of March 2018 and October 2020 where the plant availability was 97.24% and 96.86% respectively. The average plant availability is noted to be 99.76% which is considered to be well above the expected range.

### 1.2 Energy Yield Comparison

SgurrEnergy has compared its operational energy yield predictions with the onsite generation figures recorded at the energy meter on a monthly level data provided by the Client. To make the operational energy yield predictions more representative, SgurrEnergy has applied the monthly losses due plant and grid unavailability provided by the Client. These predictions are in turn compared with the actual performance of that plant, which are the generation figures shared by the Client.

The yearly comparison of the generation data is illustrated below in Figure 8-3.





**Figure 8-3: Generation Comparison**

The variation of the performance of the PV plant for the period of evaluation has been tabulated below in Table 8-1

**Table 8-1: PV Plant Performance – USUPL**

PV Plant Operation Period	Predicted Generation (MWh)	Recorded Generation (MWh)	Performance Percentage <sup>14</sup> (%)
April 2017 -March 2018	57,170.53	53,697.06	-6.08%
April 2018 - March 2019	57,043.33	52,540.38	-7.89%
April 2019 - March 2020	56,818.53	50,536.80	-11.06%
April 2020 - March 2021	56,504.66	52,706.34	-6.72%
April 2021	5,736.32	5,487.03	-4.35%
<b>Cumulative Period</b>	<b>233,273.38</b>	<b>214,967.61</b>	<b>-7.85%</b>

Based on the above comparison, SgurrEnergy notes that the PV plant is generating lower than the expected yield. However, SgurrEnergy considers that such variations in the energy yield can be attributed to higher irradiation level experienced on the Project site. The irradiation levels significantly impact the actual generation from the PV plant as the system losses may vary significantly due to slight change in the irradiation.

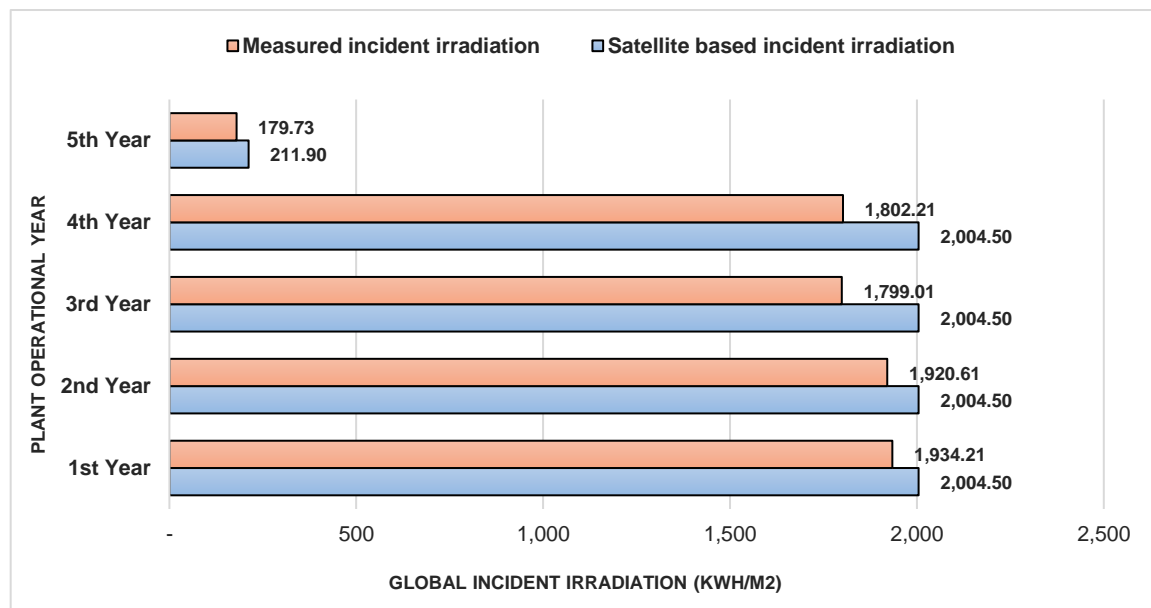
In order to understand the deviation in the irradiation pattern, SgurrEnergy has compared the monthly incident irradiation data provided by the Client with the monthly incident irradiation predicted using satellite-based meteorological data for the period of evaluation. The result of the comparison is presented in the table below and the same is graphically illustrated in the Figure 8-4.

<sup>14</sup> Positive values indicate higher generation, while negative values indicate lower generation



**Table 8-2: Irradiation Comparison– USUPL**

PV Plant Operation Period	Predicted Irradiation (MWh)	Recorded Irradiation (MWh)	Performance Percentage <sup>15</sup> (%)
April 2017 -March 2018	2,004.50	1,934.21	-3.51%
April 2018 - March 2019	2,004.50	1,920.61	-4.19%
April 2019 - March 2020	2,004.50	1,799.01	-10.25%
April 2020 - March 2021	2,004.50	1,802.21	-10.09%
April 2021	211.90	179.73	-15.18%
<b>Cumulative Period</b>	<b>8,229.90</b>	<b>7,635.77</b>	<b>-7.22%</b>

**Figure 8-4: Irradiation Comparison**

Based on the above illustration, it is observed that the overall recorded generation is approximately 7.85% lower than the generation predicted on site. It has also been observed that the recorded irradiation is 7.22% lower than the predicted irradiation.

Based on the comparative analysis, the drop-in generation can be attributed to the drop in irradiation.

<sup>15</sup> Positive values indicate higher irradiation, while negative values indicate lower irradiation



## 9 Solar Plant Life beyond 25 years

The traditional life of a solar plant is 25 years, which is based primarily on solar panel warranty period. The National Renewable Energy Laboratory (NREL) in the U.S however lists solar pv plants as having a lifetime of 25-40 years<sup>16</sup>. Most modules are expected to see a degradation rate of 0.7% for the 25 years and hence the expected power output at the end of 25 years is around 80% of the rated power. However, research from NREL<sup>17</sup> shows that the median degradation rates of panels are around 0.5% and power output after the 25 year term could be higher than the power output guaranteed by the module manufacturer. Hence the possibility of the module producing electricity beyond 25 years with a year on year degradation is not farfetched, however whether these degradation rates will be in a linear pattern or in an unpredictable pattern is yet discovered and hence evaluating the generation/ performance of the plant and life of the plant beyond 25 years becomes risky. The life of the plant also depends on the quality of the other components such as inverters, cables, transformers used. Over the twenty five year plant life, these component will need to be serviced and repaired, as the warranty period for all of these components are less than 10 years. The repair and service of these equipment can continue beyond 25 years and the component may be fit for use for another ten years, however the risk of equipment failure increases year on year. The life of the plant also depends on the operations and maintenance activities carried out during the plant lifecycle and hence carrying out O&M activities diligently during the lifetime of the plant can increase the life of the plant beyond 25 years.

Overall, the pv plant is expected to function beyond plant life of 25 years, however the risk associated with the plant operation increases as the panel warranties would have expired, degradation rates beyond 25 years are unknown and other components used in the plant would also need additional repair/replacement.

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<sup>16</sup> <https://www.nrel.gov/analysis/tech-footprint.html>

<sup>17</sup> <https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html>

