Detailed Project Report

for

200 MW Solar Project by Mahindra Susten Private Limited at

KHARI CHARNAN VILLAGE, TEHSIL-KOLAYAT, DISTRICT BIKANER

May 2020

Mahindra Susten Private Limited

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Contents

1 OVERVIEW OF GLOBAL RENEWABLE ENERGY SCENARIO

Renewable energy is one of the cleanest sources of energy options with almost no pollution or carbon emissions and has the potential to significantly reduce reliance on coal and other fossil fuels. By expanding renewable energy, world can improve air quality, reduce global warming emissions, create new industries and jobs, and move towards cleaner, safer and affordable energy future.

The quest for energy independence, economic growth and environmental sustainability increasingly suggests the importance of renewable energy sources across the globe. Renewables are seen not only as sources of energy, but also tools to address many other pressing needs, including improving energy security and access, reducing health and environmental impacts associated with fossil and nuclear energy and mitigating greenhouse gas emissions.

With increasing energy consumption, there is growing risk of depleting hydrocarbon energy sources and the associated climate change concerns. To overcome these challenges, the major world economies have begun to focus on increasing the energy supply through renewable and clean energy sources such as solar, wind, hydro, geothermal and biomass. In addition, they have been undertaking measures such as energy efficiency, storage and monitoring to regulate the energy demand. With technological improvements and government aided incentives, the use of solar energy in electricity generation and heating applications has been on the rise.

The year 2017 was another record-breaking one for renewable energy, characterised by the largest ever increase in renewable power capacity, falling costs, increases in investment and advances in enabling technologies. Many developments during the year impacted the deployment of renewable energy, including the lowest-ever bids for renewable power in tenders throughout the world, a significant increase in attention to electrification of transport, increasing digitalisation, jurisdictions pledging to become coal-free, new policies and partnerships on carbon pricing, and new initiatives and goals set by groups of governments at all levels. Increasingly, sub-national governments are becoming leaders in renewable energy and energy efficiency initiatives. At the same time, many developing and emerging countries are expanding their deployment of and investment in renewables and related infrastructure. The private sector is also increasingly playing a role in driving the deployment of renewable energy through its procurement and investment decisions.

As of 2016, renewable energy accounted for an estimated 18.2% of global total final energy consumption, with modern renewables representing 10.4%. The number of countries with renewable energy targets and support policies increased again in 2017, and several jurisdictions made their existing targets more ambitious.

Strong growth continued in the renewable power sector, while other renewable sectors grew very slowly. Solar photovoltaic (PV) capacity installations were remarkable – nearly double those of wind power (in second place) – adding more net capacity than coal, natural gas and nuclear power combined.

In the transport sector, the use of biofuels is still held back by sustainability debates, policy uncertainty and slow technological progress in advanced fuels, such as for aviation. Similarly, renewable heating and coolingi continues to lag behind. Both sectors receive much less attention from policy makers than does renewable power generation. However, lack of policy attention does not reflect relative importance, as heating and cooling account for 48% of final energy use, transport for 32% and electricity for 20%.

The interconnection of power, heating and cooling, and transport in order to integrate higher shares of renewable energy gained increased attention during the year, in particular the electrification of both heating and transport.

2 INDIA POWER SECTOR SCENARIO & FORECAST

2.1 INTRODUCTION

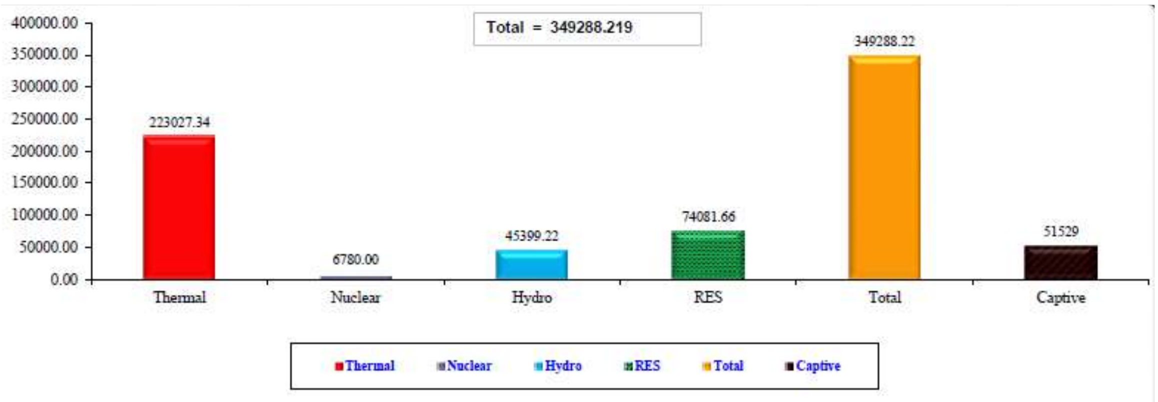
Power or electricity is one of the most critical components of infrastructure affecting economic growth and well-being of nations. The existence and development of adequate infrastructure is essential for sustained growth of the Indian economy.

The Indian power sector is one of the most diversified in the world. Sources for power generation range from conventional ones such as coal, lignite, natural gas, oil, hydro and nuclear power to other viable non-conventional sources such as wind, solar, and agriculture and domestic waste. The demand for electricity in the country has been growing at a rapid rate and is expected to grow further in the years to come. In order to meet the increasing requirement of electricity, massive addition to the installed generating capacity in the country is required.

2.2 MARKET SIZE

The Indian power sector is undergoing a significant change that is redefining the industry outlook. Sustained economic growth continues to drive power demand in India. The Government of India's focus to attain 'Power for All' has accelerated capacity addition in the country. At the same time, the competitive intensity is increasing on both market side as well as supply side (fuel, logistics, finances and manpower). The total installed generation capacity stands at 349.29 GW as on 31st January 2019.

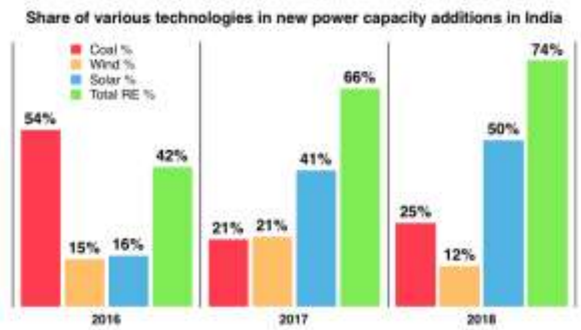
Total Installed Capacity: (As on 31.12.2018):



Source - http://www.cea.nic.in/

India added a total (net) of 17.6 gigawatts power generation capacity in 2018, a record percentage (74%) of that capacity was based on renewable energy technologies — primarily solar power. The huge capacity coming online from renewable energy sector has made 2018 the greenest year in terms of new capacity addition so far.

Of the 17.6 gigawatts of total capacity added last year, 4.1 gigawatts came from fossil fuel-based technologies (various forms of coal and natural gas), around 435 megawatts were contributed by large hydro, and 13.1 gigawatts came from renewable energy technologies. Hydro power projects with installed capacity over 25 megawatts are not classified as renewable energy projects. Solar power projects with total capacity of 8.9 gigawatts and wind energy projects of 2.2 gigawatts were commissioned last year.



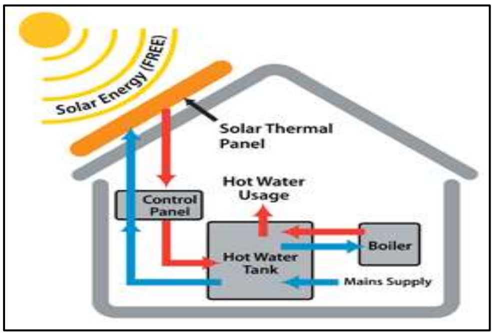
The Government has set the ambitious target of generating 100 GW of solar power by the year 2021-22 under the National Solar Mission. It is envisaged to generate 60 GW ground mounted grid-connected solar power and 40 GW through roof-top grid interactive solar power to fulfill the 100 GW of solar power.

3 SOLAR PV TECHNOLOGIES

3.1 SOLAR TECHNOLOGIES

3.1.1 Solar Thermal

Solar Thermal technology is employed for collecting & converting the sun energy to heat energy for application such as water & air heating, cooking & drying, steam generation, distillation, etc. A solar thermal device consists of a solar energy collector (the absorber), a heating or heat transferring medium, and a heat storage or heat tank. Solar thermal technology employs an elaborate use of a black body, good heat conducting materials, insulation and reflectors. Solar geyser, solar concentrators, solar cookers, solar still are some example of devices based on solar thermal technology.

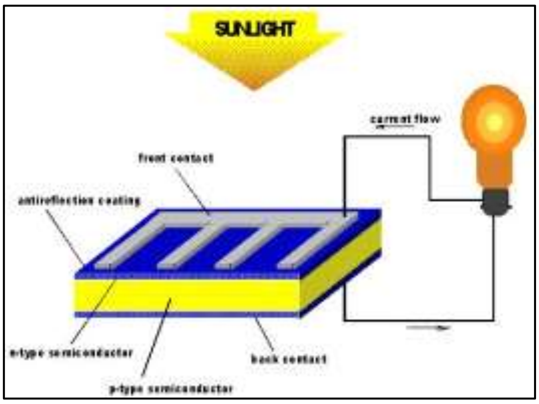


3.1.2 Solar Passive for Buildings

In Solar Passive, the solar energy can be put into use by incorporating appropriate designs in buildings to maximize utilization of solar energy for various purposes such as lighting, seasonal air conditioning, water & space heating/cooling and thereby reduce external energy inputs.

3.1.3 Solar Photovoltaic (SPV)

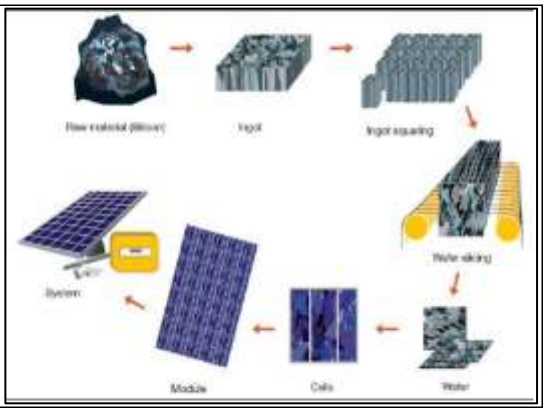
- Photovoltaic (PV) is the technical word for solar panels that create electricity. Photovoltaic material, most commonly utilizing highly-purified silicon, converts sunlight directly into electricity.
- When sunlight strikes the material, electrons are dislodged, creating an electrical current which can be captured and harnessed. The photovoltaic materials can be several individual solar cells or a single thin layer, which make up a larger solar panel.



- Over the past three decades SPV technology has shown impressive growth towards technological and economic maturity. The major SPV technologies based on materials used are (i) Crystalline Silicon Technology (ii) Thin-film Technology.

3.1.4 Crystalline Technology

- Crystalline silicon technology as on today has a share of 70% vs. 30% share of thin-film technology. Since thin-film technology is rapidly developing, the market share of crystalline technology is expected to reduce to 65% whereas the share of thin-film technology to rise to 35%.
- There are two types of crystalline silicon cells are used in the industry, mono-crystalline and multi-crystalline.
- In both mono- and multi-crystalline Si, a semiconductor junction is formed by diffusing phosphorus (an n-type dopant) into the top surface of an already boron doped (p-type) Si wafer. Screen-printed contacts are formed on the top and bottom of the cell, with the top contact pattern specially designed to allow maximum light to enter the Si material and minimize electrical (resistive) losses in the cell.



- Most efficient solar cells are produced using mono-crystalline Si with laser grooved, buried grid contacts for maximum light absorption and current collection. Some variants of c-Si technologies are also being tried by the industry. One of them is to grow ribbons of silicon from a silicon melt, either as a plain two-dimensional strip or as a hollow octagonal structure and laser cutting into strips.
- Another is to melt silicon powder on a cheap conducting substrate. Main advantage of these is the elimination of kerf loss that prevails in other crystalline technologies they have limitations by way of lower growth/pulling rates and poorer uniformity of surface evenness and scalability.
- Each c-Si cell typically generates about 0.5 V. Usually 36 cells are soldered together in series to generate voltage levels that can charge a standard 12 V battery. The cells are hermetically sealed with glass on the front side and plastic materials at the back to produce highly reliable, weather resistant c-Si Modules with performance guarantees in excess of 25 years.

3.1.5 Salient Features of Crystalline Silicon Technology

- Efficiency levels in the range of 12.0% to 16%.
- Has been extensively used and proven for over 25 years.
- Lower quantity of cables and structures, resulting in lower cost of balance of system (BOS) per MWp.
- Requirement of land in the range of 4-5 acres per MW for fix tilted structures.
- Higher cost per MW due to linkage and availability of silicon.
- Drop in performance level and efficiencies at temperatures exceeding above 35°C.
- Drop in performance level and efficiencies in the conditions of diffused radiation & dusty environment

3.1.6 Thin-film Technology

- The high cost of crystalline silicon wafers (they make up 40-50% of the cost of a finished module) has led the industry to look at cheaper materials to make solar cells. The selected materials are all strong light absorbers and only need to be about 1 micron thick, so materials costs are significantly reduced
- Amorphous silicon thin-film solar cell is the earliest device developed in this area. Other types of thin-film cells that followed are Cadmium Telluride (CdTe) and Copper Indium Gallium Di-selenide (CIGS) solar cells. New developments in this field include ‘Micro morph’ cells (a combination of amorphous and microcrystalline silicon materials) that has yielded higher efficiencies and has better stability features
- The semiconductor junctions are formed in a different way, either as a p-i-n device structure in amorphous silicon, or as a hetero-junction. A transparent conducting oxide layer (such as tin oxide) forms the front electrical contact of the cell, and a metal layer forms the rear contact.
- The technology that is most successful in achieving low manufacturing costs in the long run is likely to be the one that can deliver the highest stable efficiencies (in the region of 15%+) with the highest process yields.
- The emerging thin-film technologies are starting to make significant in-roads in to grid-connect markets, particularly in Germany.

3.1.7 Salient Features of Thin-film Technology

- Efficiency levels in the range of 6.0% to 11.5%.
- Latest technology; which has been developed in last ten years & is one of the fastest developing technologies in the world.

- Lower drop in performance level and efficiency at temperatures exceeding above 35°C, resulting in better performance at higher temperatures.
- Lesser drop in performance level and efficiency in conditions of diffused radiation & dusty environment, resulting in better performance in dusty atmosphere.
- Combination of all above factors leads to lower overall system cost per MW

3.2 MARKET SHARE OF TECHNOLOGIES

Over the last decade, PV technology has shown the potential to become a major source of power generation for the world – with robust and continuous growth even during times of financial and economic crisis. That growth is expected to continue in the years ahead as worldwide awareness of the advantages of PV increases.

The major players operating in the global solar PV industry include Shunfeng, Sun Power, First Solar, Solar Frontier, Canadian Solar, Solo Power, Chint Group, Yingli, Hanwha, JA Solar, Risen Energy, CSUN, Sharp, Rene Sola, Kyocera Solar, Hanergy, HT-SAAE, Eging PV, Jinko Solar, REC Group, Solar world, Trina Solar, NSP, BYD, and Hareonsolar.

4 PROJECT PROPONENTS

4.1 MAHINDRA SUSTEN PRIVATE LTD (MSPL) – OWNER & EPC CONTRACTOR

Mahindra Susten Private Limited (formally known as Mahindra EPC Private Limited) is a wholly owned subsidiary of Mahindra Holding Limited (MHL) which in turn is a wholly owned subsidiary of Mahindra & Mahindra Ltd. Mahindra Susten has had the distinction to complete a number of projects both Off-Grid and On-Grid. Currently Mahindra Susten has executed ~1300 MW of projects, and has ~1900 MW of projects under various stages of execution.

Key Highlights

- ✓ Established as a leading Solar EPC player in India
- ✓ Proven Technology record with highest performing plants in India
- ✓ Efficient and dedicated team of 200+ Engineers and Technology Experts
- ✓ Experience in handling varied technologies, be it Rooftop or Ground Mounted, Off-grid or On Grid

Capability

MSPL is fully supported by Mahindra Group to effectively render EPC services which involves long terms warrantees and association with the customers. Some of the key value proposition expectations of the Power Plant Developer from EPC Company are as under:

- ✓ Capability to handle large and complex project responsibilities
- ✓ Integrated services to Engineer, procure, fabricate, construct, and install / operate
- ✓ Project Management Techniques to mitigate potential risks during the project and ensure

completion within stipulated cost and time.

- ✓ the financial strength necessary to guarantee successful project execution and completion.
- ✓ MSPL is best positioned to offer these value propositions through its team and collaborations with world's leading players in solar power plant space

4.2 ABOUT MAHINDRA & MAHINDRA GROUP

The Mahindra Group operates in the key industries that drive economic growth, enjoying a leadership position in tractors, utility vehicles, and information technology & vacation ownership. Mahindra has a presence in the automotive industry, agribusiness, aerospace, components, consulting services, defense, energy, financial services, industrial equipment, logistics, real estate, retail, steel and two wheelers.

A USD 20.7 billion multinational group based in India, Mahindra employs more than 240,000 people in over 100 countries.

5 PROJECT DETAILS

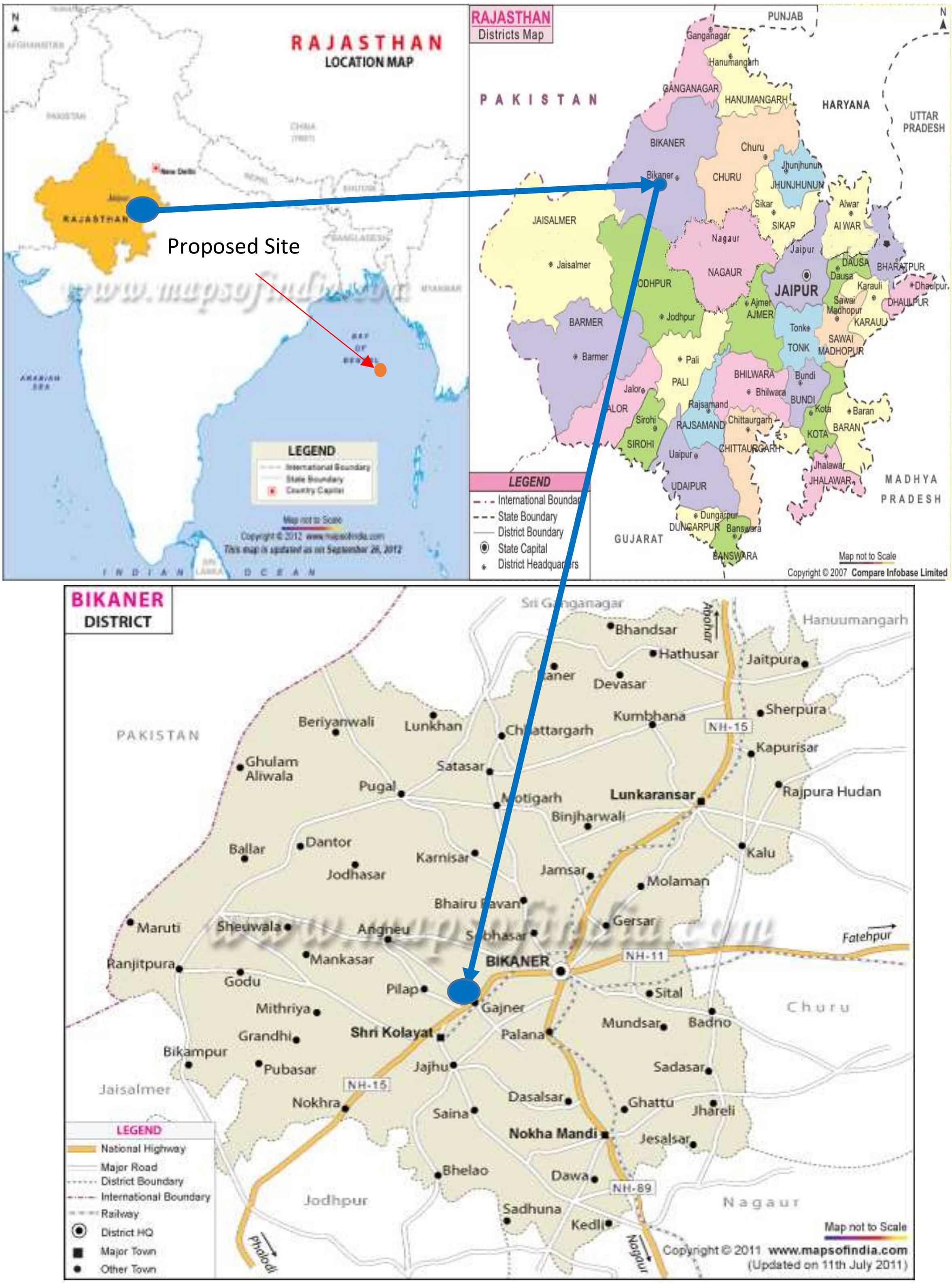
5.1 SALIENT FEATURES OF THE PROJECT

- Around 800-900 Acres of land at Khari Charnan Village, Kolayat Tehsil, Bikaner District, Rajasthan has been identified for the Project and currently land acquisition is in progress.
- Proposed site is ~40 Km from Bikaner & situated about 5 Km inside from NH-15. Nearest Airport is Bikaner which is 40 Km from Site.
- Project site is receiving solar irradiance of about 5.5 - 5.8 kWh/m^2/day and suitable for Solar PV Power Plant Installation. Below picture shows the distribution of solar irradiance on different places in India.
- A Power Purchase Agreement (PPA) for the Project has been signed with Solar Energy Corporation of India (SECI).
- The plant would be setup using Tier-1 modules. This is based on a proven technology successfully developed for commercial implementation and has been delivering reliable power generation around the world for some years now.

Accessibility to proposed location of Project

Particulars	Name	Distance from Project Site (km)
District	Bikaner	40 KM
Nearest Town	Bikaner	40 KM
Nearest Airport	Bikaner	40 KM

Location Map



Land:

a) The Identified land is mostly in nature of barren agricultural land. Entire land shall be acquired by MSPL by way of Sale deeds in name of MSPL.

b) Trenching shall be very comfortable, augers can be used for Piling

c) Excellent for tracker installation.

Water:

a) For construction purpose, Water shall be procured using tankers for nearby water resources. For operation & maintenance purpose, ground water shall be used.
b) Dry cleaning methods using automatic cleaning robots shall also be explored to reduce water requierments.

Site Approach:

a) Good road connectivity is there for project site.
b) Initially, site shall be secured by temporary fencing and at the time of project execution, concrete boundary wall shall be constructed.

5.2 PROJECT INFORMATION SUMMARY

The synopsis of the project general and technical information is detailed below:

Project Allotment

SN	Head	Description & Remarks
1	Allotment	Allotted by Solar Energy Corporation of India (SECI) under a tariff based competitive bidding
2	Allocated Capacity	200 MW_{AC}
3	PPA Rate	Year 1 - Year 25: INR 2.50/ unit
4	Tenure of PPA	25 years
5	PPA Off taker	Solar Energy Corporation of India (SECI), Rajasthan Discoms have entered into back-to-back Power Sale Agreement with SEIC for purchase of power generated from this Project.
6	Evacuation Level	220 kV level (Transmission Line) for inter-connection with the 220 kV Gajner (RVPN) Substation

5.3 TECHNICAL COMPONENTS

5.3.1 Solar PV modules

Solar PV Modules with Mono / Poly crystalline / thin-film technology (CdTe) Technology shall be sourced from Tier-1 suppliers such as Solar Frontier, Trina Solar, Jinco, First Solar, Canadian Solar etc. The Modules shall be tested & certified by an independent testing laboratory that is accredited with ISO Guide 25. The Module type will be qualified as per IEC 61730 or IEC 61646 and CE mark or UL 1703 and ULC1703 under latest amendment.

5.3.2 Combiner box

In the junction boxes, individual module strings are bundled and safely routed to the inverter. The junction boxes will have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables. These junction boxes are enclosed in IP-65 rated poly-carbonate housing, making it ideal for long-term use in PV systems. In addition, the direct connection between the strings and the spring clamp connectors ensures a durable and safe installation.

5.3.3 Cables & Connectors

Solar cables are extremely robust and resist high mechanical load and abrasion. High temperature resistance and excellent weatherproofing characteristics provide a long service life to the cables used in large scale projects. Connectors with high current capacity and easy mode of assembly are to be used for connecting power cables.

5.3.4 Module Mounting Structure

- Photovoltaic arrays are mounted on a stable, durable structure that can support the array and withstand wind, rain, hail and other adverse conditions. Sometimes, this mounting structure is designed to track the sun. However, stationary structures are usually used with flat plate systems. It shall support SPV modules at a given orientation, absorb and transfer the mechanical loads to the ground properly.
- These structures tilt the PV array at a seasonal optimum tilt angle determined by the latitude of the site, the requirements of the load and the availability of sunlight. Among the choices for stationary mounting structures, rack mounting may be the most versatile. It can be constructed fairly easily and installed on the ground.

5.3.5 Inverters

- To convert DC solar power to AC and for linkage with the grid, special grid interactive inverters will have to be installed along with interfacing, protection and control mechanisms to operate in parallel with the grid. These will be housed in an indoor arrangement as they are IP54 rated inverters. Rated capacity of Inverter is 1100 KW (AC) having 1000V nominal DC input voltage and 405V output with 50Hz.

5.3.6 Transformer:

- Transformers shall meet IEC 76(1-5), ISO 2026 standards.
- The output of 2 inverters is connected to one transformer. There will be 21 transformers of 2.2MVA to step-up the output voltage of inverter from 405 V to 11kV.
- There will be 2 nos of Power Transformer of 25MVA to step up from 11kV to 132kV.

5.3.7 Lightning & Over Voltage Protection

Lightning Protection for Array Yard

- The SPV power plant should be provided with Lightning and over voltage protection. The main aim of over voltage protection is to reduce the over voltage to a tolerable level before it reaches the PV or other sub-system components.
- The source of over voltage can be lightning or other atmospheric disturbance. The lightning conductors shall be made as per applicable Indian Standards in order to protect the entire array yard from lightning stroke.
- Necessary concrete foundation for holding the lightning conductor in position will be made after giving due consideration to maximum wind speed and maintenance requirement at site in future.
- Each lightning conductor shall be fitted with individual earth pit as per required standards including accessories, and providing masonry enclosure with cast iron cover plate having locking arrangement, watering pipe using charcoal or coke and salt as per required provisions of IS. Shall ensure adequate lightning protection to provide an

acceptable degree of protection as per IS for the array yard. If necessary, more numbers of lightning conductors may be provided.

Lightning Protection for Compact Solar Substation

- The compact solar sub-station is to be protected from lightning strikes with lightning conductor as per requirements of IS Standards

5.3.8 LT Power Interfacing Panel

- The panel shall have adequate inputs to take in from individual PCUs and adequate outputs to individual transformers.
- The panel shall be floor mounted type. All the measuring instruments such as voltmeter, ammeter, frequency meter, electronic energy meter (for measuring the deliverable units for sale), selector switches and mimic front panel will be present.

5.3.9 Earthing System

LT Side

- The earthing for array and LT power system shall be as required as per provisions of IS. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance. Each array structure of the SPV yard shall be grounded properly.
- The array structures are to be connected to earth pits as per IS standards. The earthing for the power plant equipment shall be made as per provisions of IS. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance.
- The complete earthing system shall be mechanically and electrically connected to provide independent return to earth. All three phase equipment shall have two distinct earth connections. An earth-bus shall be provided inside the control room. For each earth pit, necessary Test Point shall have to be provided.
- In compliance to Rule 33 and 61 of Indian Electricity Rules, 1956 (as amended up to date), all non-current carrying metal parts shall be earthed with two separate and distinct earth continuity conductors to an efficient earth electrode.

HT Side

- All HT side equipment's and parts shall be earthed as required as per provisions of IS.

5.3.10 Protective Relays

- The SPV system and the associated power evacuation system shall be protected as per Indian Standards. Over Current Relays, Reverse Power Relays and Earth Fault Relays are the minimum requirements.

5.3.11 Grid Interface

- The Inverter output voltages are 405 V which needs to be stepped up to 220 kV in order to evacuate the power at grid operating voltage. This stepping-up of voltage is done in two steps with two different transformers.
- It is important that the SPV power plant is designed to operate satisfactorily in parallel with the grid under extremely high voltage and frequency fluctuation conditions, so as to export the maximum possible units to the grid.
- It is also extremely important to safeguard the system during major disturbances like tripping/ pulling-out of big generating stations and sudden overloading during falling of

portion of the grid loads on the power plant unit in island mode, under fault/ feeder tripping conditions.

- Typically, there are few conditions that must be met before synchronization of two AC sources of supply can take place these are:
  - Must have equal line voltage (within a prescribed window which is mostly ± 10%)
  - Equal frequency levels (± 1.5 cycles)
  - Same phase sequence and phase angles
  - Similar waveforms
  - The power generated has to be stepped up to required voltage level as per nearest substation and fed to nearest grid substation.

5.4 POWER EVACUATION SYSTEM & GRID INTERACTION

- The generated power will be evacuated to at 220 kV level to 220 Gajner (RVPN) Substation at around 10 KM aerial distance from project site.
- Substation has sufficient space for bay extension and interconnection. Interconnection approval has been received.

5.4.1 Suitability of Power Plant Unit to Operate in Parallel with Grid

- It is important that the SPV power plant is designed to operate satisfactorily in parallel with the grid under extremely high voltage and frequency fluctuation conditions, so as to export the maximum possible units to the grid.
- It is also extremely important to safeguard the system during major disturbances, like tripping/pulling-out of big generating stations and sudden overloading during falling of portion of the grid loads on the power plant unit in island mode, under fault/feeder tripping conditions.
- Typically, there are few conditions that must be met before synchronization of two AC sources of supply can take place these are:
- Must have equal line voltage (within a prescribed window of ± 10%)
- Frequency limit Max: 50.2 Hz, Min: 49.5 Hz.
- Same phase sequence and phase angles
- Similar waveforms

5.4.2 System

- The solar PV power generated will be converted to 405 V AC using PCU, and then it will be stepped up to 33kV level & then 220kV
- Protection, metering & control panels for the switchyard and grid feeder will be accommodated in the plant's switchyard.

5.4.3 Transformer

- The quantity and capacity of 0.405/33Kv, 33/220 kV stepped up MVA transformers will depend upon the electrical system specification and the total no. of solar compact sub-stations.
- The transformer conforming to applicable standards will be complete with the fitting and accessories like conservator, MOG, breather, Buchholz relay with contacts for alarm and trip, pressure relief devices, thermometer pockets, OTI & WTI, valves, earthing terminals cooling accessories, bi-directional flanged rollers with locking and bolting device for mounting on rails, air release devices, inspection cover, off load tap changer (OLTC), marshaling box, etc.

5.4.4 Circuit Breakers

- Circuit breakers of suitable type shall be provided in SPV plant switchyard/ solar station as well as in grid sub-station for the plant feeder. The circuit breaker and accessories will be in general conforming to IEC standards.
- The circuit breaker will be totally re-strike-free under all duty conditions and will be capable of breaking magnetizing current of transformer and capacitive current of unloaded overhead lines without causing over voltages of abnormal magnitudes.
- The circuit breakers will be suitable for use in the switchgear under the operating conditions.
- Closing coil will be suitable for operation at all values of voltages between 85% and 110% of the rated voltage. Shunt trip will operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage.

5.4.5 Lightning Arrestors

- Lightning arrestors of adequate capacity will be provided for transformer/ switchyard equipment protection and on terminating ends of the transmission lines.
- The lightning arrestor will be heavy duty station class type, discharge class III, conforming to IEC specification.
- Arrestors will be complete with Insulating base, self-contained discharge counters and suitable mille-ammeters.

5.4.6 Isolators and Insulators

- Isolators complete with earth switch (wherever necessary), galvanized steel base provided with holes, solid core type post insulators with adequate creep age distance, blades made up of non-rusting material, operating mechanism (gang operated, manual/motor charging mechanism).
- They will be of centre-post rotating horizontal double break type and consist of 3 poles.
- Solid core type post insulators of adequate creepage distances (suitable for very high pollution category) will be provided for insulation and support in switchyard at plant DISCOM substation side.

5.4.7 Instrument Transformers

- The instrument transformers and accessories will conform to applicable standards.
- Instrument transformers will be mounted on suitable kV class, sealed porcelain bushings suitable for outdoor service and upright mounting on steel structures. Instrument transformers will be hermetically sealed units with in-built provision to dissipate any excessive pressure build up.
- Current transformers will be of ring type with suitable construction at the bottom for bringing out secondary terminals

5.4.8 Safety Earthing System

- A safety earthing system consisting of a buried GI flat conductor earthing grid will be provided for the switchyard. The earthing system will be formed to limit the grid resistance to below 1 ohm. In the switchyard area, the touch potential and step potential will be limited to the safe values.
- The buried earthing grid will be connected to earthing electrodes buried underground. Neutral point of transformer, non-current carrying parts of equipment, lightning arrestors, fence, etc., will be earthed rigidly.
- The following factors will be considered for earthing system design:

- Magnitude of fault current
- Duration of fault

5.4.9 Lightning Protection System

- Switchyard equipment will be shielded against direct lightning strikes by providing spikes/ shield wires.
- The spikes/ wires shall be formed to shield all substation equipment with an angle of shield of 30 Deg / 45 Deg.

5.4.10 Safety Regulations

Statutory regulations on safety measures shall be strictly followed. Safety appliances, viz. fire extinguishers, sand buckets, earth rods, gloves, rubber mats, danger sign boards, safety regulation charts, etc. shall be procured and installed as per safety norms.
Oil collection pits and soak pits for the transformers shall also be constructed. All cables in switchyard shall be neatly laid/ dressed and shall be barricaded inside trenches along the length with fire proof bricks

5.5 ESTIMATION OF POWER GENERATION

Modules are normally warranted for 90% for first 10 years and 80% up to 25 years. Average degradation is 0.8% per year. With experience of crystalline modules, probability calculation done considering yearly degradation of 0.7%

Probability of exceedance is considered from the point of bankability. These parameters have been arrived based on the experience and standard thumb rule and this consideration is based on a normal distribution of the expected yields.

The estimated specific generation of solar power from the Project will be 1659 kWh/kWp/year considering fixed tilt structures. Detailed PVSyst report for sample project size of 200 MW is depicted below.

PVSYST V6.71	Mahindra Susten Pvt.Ltd (India)	04/06/18	Page 3/4

Grid-Connected System: Main results

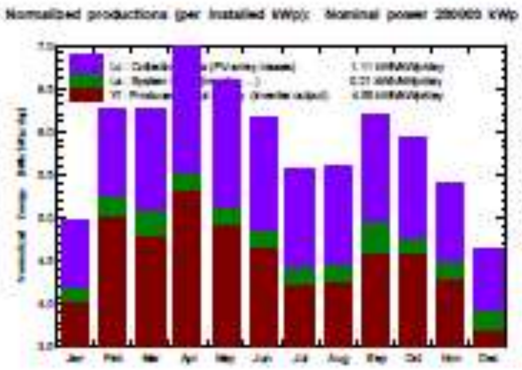
Project : **Rajasthan 200MW**

Simulation variant : **FT ABB 2.0 CS3U 330 SolarGIS R1.2**

Simulation for the 1st year of operation

Main system parameters	System type	**Unlimited sheds**		
PV Field Orientation	Sheds disposition, tilt	20°	azimuth	0°
PV modules	Model	CS3U-335P 1500V	Pnom	335 Wp
PV Array	Nb. of modules	835830	Pnom total	**280003 kWp**
Inverter	Model	PVS980-58-2000kVA-K	Pnom	2000 kW ac
Inverter pack	Nb. of units	100.0	Pnom total	**200000 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**484844 MWh/year**	Specific prod.	1659 kWh/kWp/year
	Performance Ratio PR	77.49 %		



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Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	115.7	39.03	15.16	153.5	144.5	38530	35008	0.815
February	141.1	36.15	20.23	175.4	166.5	41333	39613	0.807
March	173.3	65.14	25.40	193.7	182.7	44186	41831	0.771
April	201.5	69.45	30.92	209.1	197.0	46871	44720	0.764
May	209.7	92.76	35.07	203.8	190.7	44625	42918	0.752
June	195.0	96.42	34.16	185.0	172.0	40705	39157	0.756
July	180.0	99.01	32.60	172.5	160.3	38425	36958	0.765
August	172.5	94.24	31.24	172.9	161.0	38753	37248	0.769
September	171.3	70.91	30.79	188.0	175.0	41788	38741	0.744
October	154.5	54.65	29.15	182.9	173.5	41549	39898	0.775
November	125.3	39.76	23.01	161.9	153.3	37601	36247	0.799
December	107.7	39.76	19.04	143.8	135.4	34201	32310	0.803
Year	1948.0	797.28	27.35	2141.8	2011.8	496457	484844	0.775

Legends:			
GlobHor	Horizontal global irradiation	GlobEff	Effective Global, corr. for IAM and shadings
DiffHor	Horizontal diffuse irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	PR	Performance Ratio

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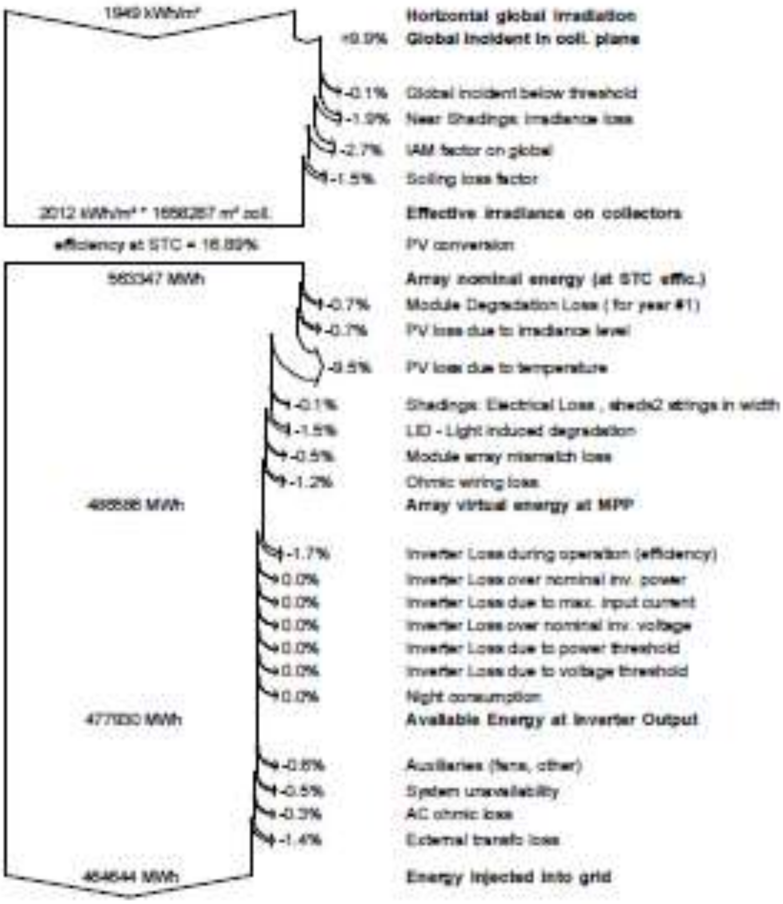
Grid-Connected System: Loss diagram

Project :	**Rajasthan 200MW**
Simulation variant :	**FT ABB 2.0 CS3U 330 SolarGIS R1.2**
	Simulation for the 1st year of operation

Main system parameters	System type	**Unlimited sheds**		
PV Field Orientation	Sheds disposition, tilt	20°	azimuth	0°
PV modules	Model	CS3U-335P 1500V	Pnom	335 Wp
PV Array	Nb. of modules	835830	Pnom total	**280003 kWp**
Inverter	Model	PVS980-58-2000kVA-K	Pnom	2000 kW ac
Inverter pack	Nb. of units	100.0	Pnom total	**200000 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



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However, with application of trackers shall significantly increase the specific generation of solar power from the Project; which is currently under design optimization stage.

5.6 ESTIMATED ENERGY LOSSES

Also losses in a PV system which eventually becomes a part of generation analysis are listed below:

a) **Module Mismatch Losses:** On account of manufacturing tolerances that yields PV modules with slightly different current-voltage characteristics. Mismatch losses are significant in PV arrays because the solar module with the lowest output determines the output of the entire PV array.

b) **IAM Loss:** The incidence effect (the designated term is IAM, for "Incidence Angle Modifier") corresponds to the decrease of the irradiance really reaching the PV cells' surface, with respect to irradiance under normal incidence, due to reflections increasing with the incidence angle.

c) **DC Wiring:** Accounts for resistive losses in the wiring between modules and the wiring connecting the PV array to the inverter.

d) **Soiling:** Soiling of solar panels occurs as a result of accumulation of dust or other foreign matter on the surface that prevent solar radiation from reaching the surface of the PV cells. Since it causes shading of the cells, the dust reduces the available power from a module. The losses are generally kept below 2% and MSPL has an O&M practices to ensure regular cleaning of modules using reference strings to minimize losses due to soiling.

e) **Inverter efficiency:** Inverter efficiency is measured by the conversion ratio of the DC voltage to AC. In addition, Inverters are less efficient when used at the low end of their maximum power.

f) **Temperature:** Output of modules is affected by the ambient temperature at the site. Temperature coefficients are measured in order to represent the change in power output with different temperatures. Typical values of temperature coefficient for various module technologies are as follows:

- γ (Pmpp) typical values for crystalline modules is -0.4 to 0.45%/K
- γ (Pmpp) typical values for amorphous modules is -0.2 to 0.23%/K
- γ (Pmpp) typical values for CdTe modules is -0.24 to 0.25%/K

g) **Shading losses:** These are mainly due to

- Physical layout
- Row Spacing
- Tilt/Azimuth
- Location (solar position)
- Array height

h) **Transformer losses:** These are daytime energy losses that occur in medium-voltage transformers.

i) **Transmission line Losses (AC wiring loss):** These are losses when energy is transmitted through the transmission line to the interconnection point at the grid

j) **Unavailability**

- Losses due to the time when the system is off because of maintenance or inverter or utility outage.
- The energy generation in solar PV power project is subject to various factors and losses in the system as shown in the PVSyst report graph above.

5.7 PROPOSED PROJECT CONFIGURATION

Parameter	Description
Project Capacity	200 MWac
Technology	Poly crystalline / Thin film / Mono crystalline
Modules	From Tier – 1 suppliers such as Trina, Solar Frontier, First Solar, Canadian Solar, longi etc
Inverters	750 kW to 5000 kW for reputed suppliers such a TMEIC, SMA, TBEA, ABB etc
Structures	Fixed / Tracker

6 SUMMARY:

a. Site is suitable for setting up the Solar PV Project, since the irradiation level is good in the range of 5.35 kWh/m²/day on horizontal plane.
b. No obstacles or shadow at site.
c. No air pollution observed near proposed project location
d. Site has clear approach to main road
e. No chances of flooding at site.

N.B: DPR is indicative.

Mahindra Susten Private Limited

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