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# Design and Development 10kw Solar power plant at SSCET

**Manoj. B. Ezardar[1], Rohit. S. Dhote[2], Kanchan. N. Yerme[3], Pranit. P. Madame[4], Lalit. S. Kapse[5], Ritesh. M. Kale[6], Hrishikesh.B.Gote[7]**

[1-7]Department of Electrical Engineering, Shri Sai College of Engineering and Technology (SSCET), DR. Babashaeb Ambedkar Technical University, Lonere, Raigad.

**Abstract**: This project is installed in the SSCET building which will provide an uninterrupted power through solar energy in the day hours for the requirement of load of SSCET. Existing electrical appliances viz., Indoor lights, Corridor lights, Fans, EPBX, Computers, Printers etc.
Today, PV systems have an important use in areas remote from an electricity grid where they provide power for water pumping, lighting, vaccine refrigeration, electrified livestock fencing, telecommunications and many other applications. However, with the global demand to reduce carbon -dioxide emissions, PV technology is also gaining popularity as a mainstream form of electricity generation. Photovoltaic modules provide an independent, reliable electrical power source at the point of use, making it particularly suited to remote locations. However, solar PV is increasingly being used by homes and offices to provide electricity to replace or supplement grid power, often in the form of solar PV roof tiles. The daylight needed is free, but the cost of equipment can take many years before receiving any payback. However, in remote areas where grid connection is expensive, PV can be the most cost-effective power source.

## I. INTRODUCTION

Solar energy is energy produced by sun created through a thermonuclear process and this process crates heat and electromagnetic radiations. These electromagnetic radiations have the energy that reaches the earth. As solar energy is an indirect source of energy so we need two components: one the collector and other the storage device initially. The collector will collect the radiations coming from the sun and convert it in the form of electrical energy. On the other hand we require storage unit since the radiations keeps varying throughout the day and during night hours there will be no radiations. Now let us discuss the types of collectors. These are of three types- 1) flat-plate collectors, 2) Focusing collectors, 3) Passive collectors. Most of the time we use flat- plate panel which is a combination of array of solar cells arranged in a simple plane. The output of these panels depends upon Solar PV power plant system comprises of C-Si (Crystalline Silicon)/ Thin Film Solar Modules with intelligent Inverter having MPPT technology and Anti-Islanding feature and associated power electronics, which feeds generated AC power to the Grid. Other than PV Modules and Inverter/Inverters, the system consists of Module Mounting Structures, appropriate DC and AC Cables, Array Junction Boxes (AJB) / String Combiner Boxes (SCB), AC and DC DistributionBox, Lightning Arrester, Earthing Systems, Net meter, etc. The system should be capable for exporting the generated AC power to the Grid, whenever the Grid is available with all System Protection facilities. The size of panel, intensity of radiations and the cleannessof the panel.

**PV Modules and specifications for installation:the specifications for the PV Module is detailed below:**

1. The PV modules must be PID compliant, salt, mist & ammonia resistant and should withstand weather conditions for the project life cycle.
2. The back sheet of PV module shall be minimum of three layers with outer layer (exposure to ambience) and shall be made of PVDF or PVF. The Back sheets for PV Module with 2 layered or 3 layered Polyester types or the back sheets with Polyester (PET type) at Air side material are not permitted for the empanelment; The minimumthickness of the core layers (without adhesive and inner EVA coated) must be 300 microns. The maximum allowed water vapor transmission rate shall be less than 2 g /m2
/day and shall have a Partial Discharge > / = 1500V DC
3. The front glass shall meet the following specifications:

a. The facing glass must be Tempered, PV grade with Low iron and high transmission.
b. The transmission shall be > 93 %
c. Thickness shall be min 3.2 mm

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d. Textured to trap more light
e. The glass shall have an Anti-reflective coating for the better transmission and lightabsorption.
f. Tempered glass to meet the external load conditions

4. The encapsulant used for the PV modules should be UV resistant in nature. No yellowing of the encapsulant with prolonged exposure shall occur. The sealant used for edge sealing of PV modules shall have excellent moisture ingress Protection with good electrical insulation and with good adhesion strength. Edge tapes for sealing are not allowed.

5. Anodized Aluminium module frames of sufficient thickness shall be used which are electrically & chemically compatible with the structural material used for mounting themodules having provision for earthing.
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6. UV resistant junction boxes with minimum three numbers of bypass diodes and two numbers of MC4 connectors or equivalent with appropriate length of 4 sq.mm Cu cable shall be provided. IP67 degree of protection shall be used to avoid degradation during Life. .
7. Shading correction/ bypass diode for optimizing PV out to be incorporated in each solarmodule or panel level.

8. Each PV module used in any solar power project must use a RF identification tag(RFID), which must contain the following information. The RFID can be inside or outside the module laminate but must be able to withstand harsh environmental conditions.
a) Name of the manufacturer of PV Module.
b) Name of the manufacturer of Solar cells.
c) Month and year of the manufacture (separately for solar cells and module).
d) Country of origin (separately for solar cell and module).
e) I-V curve for the module.
f) Peak Wattage, IM, VM and FF for the module.
g) Unique Serial No. and Model No. of the module.
h) Date and year of obtaining IEC PV module qualification certificate.
i) Name of the test lab issuing IEC certificate.
j) Other relevant information on traceability of solar cells and module as per ISO9000 series.

9. The following details should be provided on the module
a) Name of the manufacture.
b) Month and year of manufacture.
c) Rated Power at STC.
d) VMP, IMP, VOC, ISC.
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10. The successful bidder shall arrange an RFID reader to show the RFID details of the modules transported to sites, to the site Engineer in charge up to their satisfaction, whichis mandatory for the site acceptance test.

11. Each PV module used in any solar power project must use a RF identification tag(RFID), which must contain the following information. The RFID can be inside or outside the module laminate but must be able to withstand harsh environmental conditions.

12. The PV modules must qualify (enclose Test Reports/Certificates from IEC/NABL accredited laboratory) as per relevant IEC standard. The Performance of PV Modules at STC conditions must be tested and approved by one of the IEC/NABL Accredited Testing Laboratories.

13. PV modules used in solar power plant/ systems must be warranted for 10 years for their material, manufacturing defects, workmanship. The output peak watt capacity which should not be less than 90% at the end of 10 years and 80% at the end of 25 years

14. Original Equipment Manufacturers (OEM) Warrantee of the PV Modules shall be submitted by the successful bidder when the materials delivered at site.
15. The PV Module should be under the Indigenous / DCR (Domestic Content Requirement) category (Based on the specific requirement).

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16. The PV modules shall conform to the following standards:
IS 14286: Crystalline silicon terrestrial photovoltaic (PV) modules — designqualification and type approval.
- IEC 61215 / IEC 61646: c-Si (IEC 61215): Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval Thin Film (IEC 61646):

Design, Qualification & Type Approval
- IEC 61730-1: Photovoltaic Module safety qualification- Part 1: Requirements forconstruction
- IEC 61730-2 : Photovoltaic Module safety qualification- Part 2: Requirements fortesting
- IEC 61701 : Salt mist corrosion testing of photovoltaic modulesTech Specs of On-Grid PV Power Plants
- IEC 62716 : Test Sequences useful to determine the resistance of PV Modules toAmmonia (NH3)

17. The PV module should have IS14286 qualification certification for solar PV modules (Crystalline silicon terrestrialphotovoltaic (PV) modules — design qualification and type approval).

18. PV Module of same Make/ Model in the same series shall be considered as a single product while making thepayment.

**Specification of solar module:**

| IMAGE |  |
|---|---|
| COMPANY | WAAREE |
| MODULE CODE | WS-325 |
| MAXIMUM POWER( P MAX) | 325.0 W |
| OPEN CIRCUIT VOLTAGE( VOC) | 46.60 V |
| SHORT CIRCUIT CURRENT (ISC) | 9.20 A |
| MAXIMUM POWER VOLTAGE (VMP) | 37.80 V |
| MAXIMUM POWER CURRENT (IMP) | 8.60 A |
| MAXIMUM SYSTEM VOLTAGE | 1000 V DC |
| WEIGHT | 22.50 KG |
| DIMENSIONS | 1960*990 MM |
| APPLICATION CLASS | A |
| MAXIMUMSERIES FUSE RATING | 15 A |
| ALL VALUES MEASURED AT STC | $25^0$ C |
| WORKING TEMP OF CELL | 1000W/$m^2$ |

**POWER CONDITIONING UNIT (PCU)/ INVERTER:**

The Power Conditioning Unit shall be String Inverter with power exporting facility to the Grid. The List of Inverters under On-Grid category is attached as Annexure II-F. Howeverthe specifications for the ON-Grid Inverters are detailed below:
General Specifications:
1. All the Inverters should contain the following clear and indelible Marking Label & Warning Label as per IS16221 Part II, clause 5. The equipment shall, as a minimum, bepermanently marked with:
a. The name or trademark of the manufacturer or supplier.
b. A model number, name or other means to identify the equipment.
c. A serial number, code or other markings allowing identification of manufacturing location and the manufacturing batch or date within a three-month time period.
d. Input voltage, type of voltage (A.C. or D.C.), frequency, and maximum continuouscurrent for each input.
e. Output voltage, type of voltage (A.C. or D.C.), frequency, maximum continuous current, and for A.C. outputs, either the power or power factor for each output.

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f. The Ingress Protection (IP) rating

2. The inverter output shall be 415 VAC, 50 Hz, 3 phase or 230 VAC, 50 Hz, 1 phase. Tech Specs of On-Grid PV Power Plants.

3. The inverter shall include appropriate self-protective and self-diagnostic feature to protect itself and the PV array from damage in the event of inverter component failure or from parameters beyond the inverter's safe operating range due to internal or external causes.

4. The Technical Specification of On-Grid Inverters are summarized below:

Specifications of Inverters Parameters Detailed specification Nominal voltage 230V/415V
Voltage Band Between 80% and 110% of V nominal Nominal Frequency 50 Hz
Operating Frequency Range 47.5 to 50.5 Hz Waveform Sine wave
Harmonics AC side total harmonic current distortion < 3% Ripple DC Voltage ripple content shall be not more than 1%
Efficiency Efficiency shall be >97%

**Casing protection levels**

Degree of protection: Minimum IP-54 for internal units and IP-65 for outdoor units
Operating ambient Temp range
-10 to + 60 degree Celsius Operation
Completely automatic including wakeup, synchronization (phase locking) and shut down
MPPT MPPT range must be suitable to individual array voltages Protections
Over voltage: both input and output Over current: both input and output Over / Under grid frequency
Over temperature Short circuit Lightning
Surge voltage induced at output due to external source Islanding

**Ingress Protection**

IP 65 for Outdoor / IP 54 for Indoor DATALOGGING

A dedicated data logging system (Hardware and software) for monitoring the plant shall be provided even if the inverter has embedded data logging system. The following weather parameters are to be measured as part of the data logging system.

a) Solar Irradiance:

A Pyranometer/ Solar cell-based irradiation sensor (along with calibration certificate) shall be provided, with the sensor mounted in the plane of the array. Readout shall be integrated with data logging system: from 10kWp to less than 100kWp

Pyranometer (Class II or better) shall be provided with the sensor mounted in the place of the array. Readout shall be integrated with data logging system: for 100kWp and above.

b) Temperature: Integrated temp, sensors for measuring the module surface temp., inverter inside enclosure temp, and ambient temp to be provided complete with readouts integrated with the data logging system.

2. It is recommended that the following important parameters shall be accessible through the Data Logging Facility.

a) AC Voltage
b) AC Output current
c) Output Power
d) Energy in kWh
e) DC Input Voltage
f) DC Input Current
g) Temperatures (C)
h) Invertor Status

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2 Irradiation

2) Module temperature

• String Voltage & Current (For PV Plants from 100kWp onwards)

3. Provision for Internet monitoring and download of historical data shall be incorporated. GSM Modem/Wi Fi modem in case GSM connectivity is used or Wireless Router + modem in case Ethernet connection is being used for remote access must be provided. Performance Ratio

4. Performance Ratio (PR) is to be assessed for Grid Connected PV Plants above 25kWp. The data from the data monitoring system will be used for calculating the Performance Ratio (PR) of the power plant as per IEC 61724 and the recommended procedure is described in the below clause.

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5. The plant acceptance test period is five days long with the following minimum irradiance criteria for PR measurement.

- At least three days must have irradiance measured in the plane of the array that is greater than 600 W/sq.m for three continuous hours, and the daily total irradiance must exceed 3,000 Wh/sq.m/day.
- If there are not five days that meet these minimum irradiance criteria, the test period may be extended until five sufficient days have been recorded. There will not be any liquidated damages triggered as a result of this weather-related test delay.

7. Performance Ratio (PR) is to be assessed for Grid Connected PV Plants above 25kWp.

However, there shall be special clause in the Tender Document under different schemes of ANERT including Deposit Work, Technical Consultancy, RESO under ANERT and other programmers, either or not under the subsidy schemes of MNRE/ State Govt. or Schemes under Local Self Governments (LSGDs).

## MODULE MOUNTING STRUCTURE:

Photovoltaic arrays must be mounted on a stable, durable structure that can support the array and withstand wind, rain, and other adverse conditions. The modules will be fixed on structures with fixed arrangement.

The module mounting structures shall have adequate strength and appropriate design suitable to the locations, which can withstand the load and high wind velocities.

Stationary structures shall support PV modules at a given orientation, absorb and transfer the mechanical loads to the surface properly.

Each structure with fixed tilt should have a tilt angle as per the site conditions to take maximum insolation which will be approximately equal to the latitude of the location facing true South with a North - South orientation. The tilt angle can vary from 9 degree to 12 degree based on the location's latitude in Chandrapur. The PV module mounting structure shall have a capacity to withstand a wind velocity of 150 km/hr. unless specified for dedicated requirements.

Suitable fastening arrangement such as grouting and clamping should be provided to secure the installation against the specific wind speed. The PV array structure design shall be appropriate with a factor of safety of min 1.5. The STAAD / Equivalent structural design report must be attached along with the technical bid as Annexure II-K the materials used for structures shall be Hot dip Galvanized Mild Steel conformed to IS 2062:1992 or aluminium of suitable grade minimum alloy 6063 or better.

The minimum thickness of galvanization for hot dip Galvanized Mild Steel should be at least 80 microns as per IS 4759.

The Bolts, Nuts, fasteners, and clamps used for panel mounting shall be of Stainless Steel SS 304.

No Welding is allowed on the mounting structure.

Aluminium structures used shall be protected against rusting either by coating or Anodization Aluminium frames should be avoided for installations in coastal areas.

The structure shall be designed to withstand operating environmental conditions for a period of minimum 25 years. And shall be free from corrosion while installation.

Screw fasteners shall use existing mounting holes provided by module manufacturer. The total load of the structure (when installed with PV modules) on the terrace should be less than 60 kg/m2 .

Minimum distance between the lower level of PV Module and the ground shall be 0.6m from the ground level.

The PV Panel area shall be accessible for cleaning and for any repair work.

Sufficient gap need to be provided between the rows to avoid falling of shadow of one row on the next row. Seismic factors for the site will be considered while making the design of the foundation.

Adequate spacing shall be provided between any two modules secured on PV panel for improved wind resistance.

Installation of structure for solar PV mounting should not tamper with the water proofing of the roofs.

The Structural Drawing of the Module Mounting Structure is as per Annexure II-H

The above drawing is specific for RCC flat roofs and may vary for slope roofs. However the drawings shall be approved by concerned Technical Officer before installing the plant.

## SOLAR METER and NETMETER:

**Solar Meter:**

A separate Energy Meter called Solar Meter shall be provided at the output of PCU to record the energy generation from the Solar System. (This energy meter should not be integrated with PCU). Solar energy meter means a unidirectional meter to be installed at the delivery point of the solar energy system to measure the solar electricity generated. This Energy Meter should be tested along with the Net Meter (Import-Export Meter).

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**Net meter:**

As per Maharashtra State Electricity Regulatory Commission (Renewable Energy and Net Metering) Regulations 2020, net metering system is to be provided to the solar consumer. Net meter means the bidirectional energy meter to be installed at the interconnection point of the consumer with the network of distribution licensee

Energy meters shall be installed and maintained in accordance with the provisions of The Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006 as

Tech Specs of On-Grid PV Power Plants amended from time to time. The Contractor shall maintain the Metering System as per metering code and CEA guidelines. The defective meter shall be immediately tested and rectified/ replaced.

A solar meter and bidirectional energy meter suitable for the installed solar plant shall be supplied and installed by the contractor after testing and sealing from respective TMR Divisions of MSEB Ltd. Energy Meters must be provided with the necessary data cables if required.

The solar energy meter and net energy meter shall be of accuracy as given and CT and PT shall be utilized according to CEA metering regulations 2006 and its amendment.

## EARTHING:

The Solar PV Plant should have a dedicated earthing system. The Earthing for array and LT power shall be made as per the provisions of IS:3043-2018 “Code of practice for earthing (Second Revision),” that governs the earthing practices of a PV system and IS 732:2019 “Code of practice for electrical wiring installations (Fourth Revision)

- Earthing System shall connect all non –current carrying metal receptacles, electrical boxes, appliance frames, chassis and PV module mounting structures in one long run.

The earth strips should not be bolted. Earthing GI strips shall be interconnected by proper welding.

- The earthing conductor should be rated for 1.56 times the maximum short circuit current of the PV array. The factor 1.56 considers 25 percent as a safety factor and 25 percent as albedo factor to protect from any unaccounted external reflection onto the PV modules increasing its current
- In any case, the cross-section area or the earthing conductor for PV equipment should not be less than 6 mm2 if copper, 10 mm2 if aluminum or 70 mm2 if hot-dipped galvanized iron. For the earthing of lightning arrestor, cross-section of the earthing conductor should not be less than 16 mm2 of copper or 70 mm2 if hot-dipped galvanized iron. The complete Earthing system shall be mechanically & electrically connected to provide independent return to earth.
- Masonry enclosure with the earth pit of size not less than 400mm X 400 mm(depth) complete with cemented brick work (1:6) of minimum 150mm width duly plastered with cement mortar (inside)shall be provided. Hinged inspection covers of size not less than 300mm X 300mm with locking arrangement shall be provided . Suitable handle shall be provided on the cover by means of welding a rod on top of the cover for future maintenance.
- Minimum four (04) numbers of interconnected earth pit needs to be provided in each location. Minimum required gap shall be provided in between earth pits as per Tech Specs of On-Grid PV Power Plants.

relevant standard. Body earthing shall be provided in inverter, each panel frame, module mounting structure, kiosk and in any other item as required.

Earth pit shall be constructed as per IS: 3043-2018. Electrodes shall be embedded below permanent moisture level.. Earth pits shall be treated with salt and charcoal if average resistance of soil is more than 20-ohm meter

- Earth resistance shall not be more than 5 ohms. Earthing system must be interconnected through GI strip to arrive equipotential bonding. The size of the GI earth strip must be minimum 25mm X 6mm.
- In compliance to Rule 11& 61 Of Indian Electricity Rules,1956(as amended up to date), all non-current carrying metal parts shall be Earthing with two separate and distinct earth continuity conductors to an efficient earth electrode.
- The equipment grounding wire shall be connected to earth strip by proper fixing arrangement. Each strip shall be continued up to at least 500mm from the equipment.
- Necessary provisions shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance. For each earth pit, a necessary test point shall be provided.

Total no of Earth pits for solar plants:

i. Up to 50kWp: AC-01, DC-02, LA-01
ii. Above 50kWp: AC-02, DC-02, LA-01

## LIGHTNING PROTECTION:

The SPV power plant should be provided with lightning and over voltage protection. 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.

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The design and specification shall conform to IS/IEC 62305, "Protection against lightning" govern all lightning protection-related practices of a PV system.

| PERTICULARS | SOLAR POWER PLANT |
|---|---|
| IMAGES |  |
| CAPACITY | 10 Kw |
| UNITS | 1 UNIT |
| APPLICATIONS | SOLAR POWER BACKUP FOR COMPUTER LABAND REQUIRED LOAD OF SSCET. |
| SCOPE OF SUPPLY | SYSTEM INCLUDE SOLAR MODULE,INVERTERAND GRID CONNECTIONS |
| SOLAR PANEL WATTAGE | 325WP X 30.NO |
| POWER SAVING PM | 1500 UNITS |
| MONEY SAVED PM(EB UNIT COST @ RUPEES6.50) | RUPEES 9750/- ACCORDING TO THE EB UNITS@RS 6.50 |
| OTHER WORK INCLUDES | CIVIL WORKS ,CONDUIT MATERIALS ANDWIRING. |
| WARRANTY | 2 YEARS FOR THE SYSTEM AND 15 YEARS FORTHE SOLAR PANELS. |

## CONCLUSION:

Most of the people are not aware of non-renewable energy resources, solar energy provide us electricity because of the regional area and geographical location.

This project give us a wide understanding about benefits of solar energy, and the design and installation process for the erection of 10 kw solar power plant, this project also encourages us to move towards green energy and it also provide the testing and learning platform for students in the campus.

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