TECHNICAL SPECIFICATIONS
OF
HYBRID
SOLAR PV POWER PLANTS

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TECHNICAL SPECIFICATIONS OF HYBRID SOLAR POWER PLANT

1. SCOPE OF THE WORK

The scope includes guidelines and practices for the Supply, Installation, Testing and Commissioning of Hybrid rooftop/ Ground Mounted PV power plants.

All the necessary approvals from KSEBL/Electrical Inspectorate, feasibility study, necessary civil work, Mounting of Module Structures, PV Module Installation, Inverter Installation, Battery Bank DC/AC Cabling and interconnections, Installation of Lightning Arresters and Earthing System as per the standards, Net Metering, Arranging all the necessary inspections from KSEBL/Electrical Inspectorate/ ANERT District Office as part of Pre-Commissioning, if any, Commissioning of the PV Power Plant, are coming under the scope of the EPC company.

2. LOCATION

Shade free Rooftops of Residential, Public/Private Commercial/Industrial buildings, Local Self Government Buildings, State Government buildings.

3. DEFINITION

A Hybrid Solar PV power plant system comprises of C-Si (Crystalline Silicon)/ Thin Film Solar PV modules with intelligent Inverter having MPPT technology and Intentional-Islanding feature and associated power electronics, which feeds generated AC power to the Grid and islands when the Grid is not available. Other than PV Modules and Inverter/Inverters, the system consists of a Battery Bank, Module Mounting Structures, appropriate DC and AC Cables, Array Junction Boxes (AJB) / String Combiner Boxes (SCB), AC and DC Distribution Box, 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 and islands whenever the grid is not available. **The Hybrid power plants of all the capacities shall be capable of giving a battery backup of minimum one hour.**

4. SOLAR PV MODULE

The EPC Company/ Contractor shall use only the PV modules that are empanelled to the ANERT OEM empanelment. The List of PV modules under various categories (c-Si Mono/c-Si Poly/Mono PERC) are attached as Annexure II-F. However 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 minimum thickness 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 / m^2/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
    d. Textured to trap more light
    e. The glass shall have an Anti-reflective coating for the better transmission and light absorption.
    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 the modules having provision for earthing.

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 solar module 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, I_M, V_M 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 ISO 9000 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) V_{MP}, I_{MP}, V_{OC}, $I_{sc.}$

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, which is 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).**
16. The PV modules shall conform to the following standards:
    - **IS 14286**: Crystalline silicon terrestrial photovoltaic (PV) modules — design qualification 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 for construction
    - **IEC 61730-2** : Photovoltaic Module safety qualification- Part 2: Requirements for testing
    - **IEC 61701** : Salt mist corrosion testing of photovoltaic modules

- **IEC 62716 :** Test Sequences useful to determine the resistance of PV Modules to Ammonia (NH_3)

17. The PV module should have IS14286 qualification certification for solar PV modules (Crystalline silicon terrestrial photovoltaic (PV) modules — design qualification and type approval). The exemption of this certification and other details are described, as per MNRE's Gazette Notification No. S.O. 3449 €. Dated 13th July, 2018.
18. PV Module of same Make/ Model in the same series shall be considered as a single product while making the payment as per MNRE Order No. 283/54/2018-Grid Solar (ii) Dt. 06- Feb-2020.

5. 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. However the specifications for the Hybrid Inverters are detailed below:

General Specifications:

5.1 . 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, be permanently 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 continuous current 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.

f. The Ingress Protection (IP) rating

5.2 The Hybrid inverter output shall be 415 VAC, 50 Hz, 3 phase or 230 VAC, 50 Hz, 1 phase.

5.3 The Hybrid inverter should have all the technical requirements for connecting to the Grid and provision of Intentional Islanding with facility for connecting to a battery bank

5.4 The Hybrid 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.

5.5 The Hybrid Inverters from 2kW to 100kW will be empanelled.

5.6 The Technical Specification of Hybrid 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 20 / IP 21
Recommended LED indications	ON Grid ON Under/ Over voltage Overload Over temperature
Recommended LCD Display on front Panel	DC input voltage DC current AC Voltage (all 3 phases) AC current (all 3 phases) Frequency Ambient Temperature Instantaneous power Cumulative output energy Cumulative hours of operation Daily DC energy produced
Communication Interface	RS485/ RS232/Wi-Fi (with or without USB)

5.7 The Technical Specification for Interconnection are summarized below:

Sl No,	Parameters	Requirements	Reference
1	Overall conditions of service	Reference to regulations	Conditions for Supply of Electricity

2	Overall Grid Standards	Reference to regulations	Central Electricity Authority (Grid standards) Regulations 2010
3	Equipment	Applicable industry standards	IEC/EN standards
4	Safety and Supply	Reference to regulations, (General safety requirements	Central Electricity Authority (Measures of safety and electricity supply) Regulations, 2010 and subsequent amendments
5	Meters	Reference to regulations and additional conditions issued by the commission.	Central Electricity Authority (Installation & operation of meters) regulations 2006 and subsequent amendments
6	Harmonic current	Harmonic current injections from a generating station shall not exceed the limits specified in IEEE 519	IEEE 519 relevant CEA (Technical Standards for connectivity of the distributed generation resource) Regulations 2013 and subsequent amendments
7	Synchronization	Photovoltaic system must be equipped with a grid frequency synchronization device, if the system is using synchronizer inherently built in to the inverter then no separate synchronizer is required	Relevant CEA (Technical Standards for Connectivity of the distributed generation resources) regulations 2013 and subsequent amendments.
8	Voltage	The voltage-operating window should minimize nuisance tripping and should be under operating range of 80% to 110% of	

		the nominal connected voltage. Beyond the clearing time of 2 seconds, the Photovoltaic system must isolated itself from the grid	
9	Flicker	Operation of Photovoltaic system should not cause voltage flicker in excess of the limits stated in IEC 61000 or other equivalent Indian standards if any	Relevant CEA regulations 2013 and subsequent if any, (Technical standards for connectivity of the distributed generation resource)
10	Frequency	When the distribution system frequency deviates outside the specified limits (50.5 Hz on upper side and 47.5 Hz on lower side) up to 0.2 sec, the Photovoltaic systems shall automatically disconnect from grid and be in island mode.	
11	DC injection	Photovoltaic system shall not inject DC current greater than 0.5% of full rated output at the interconnection point or 1% rated inverter output current into distribution system under any operating conditions.	
12	Power Factor	While the output of the inverter is greater than	

		50%, a lagging power factor greater than 0.9 shall be maintained.	
13	Islanding and Disconnection	The photovoltaic system in the event of voltage or frequency variations must island/disconnect itself with the time stipulated as per IEC standards	
14	Overload and Overheat	The inverter should have the facility to automatically switch off in case of overload or overheat and should restart when normal conditions are restored	

5.8 The IEC Certifications of On-Grid Inverters are summarized below:

Standard	**Description**
IEC 61683	Photovoltaic systems – Power conditioners – Procedure for measuring efficiency
IEC 61727 or VDE-AR-N 4105	Photovoltaic (PV) systems- Characteristics of the utility interface
IEC/EN 62109-1	Safety of power converters for use in photovoltaic power systems – Part 1: General requirements
IEC/EN 62109-2	Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters
IEC/EN 61000-3-3/ 3-11/ 3-5	Electromagnetic compatibility (EMC) – Part 3-11; Limits; Limitation of Voltage Change, Voltage Fluctuations and Flicker in Public Low- Voltage Supply Systems; Rated Current <16A / >16A and <75A / >75A per Phase respectively

Standard	Description
IEC/EN 61000-3-2/ -3-12/ -3-4	Electromagnetic compatibility (EMC) – Part 3-12; Limits; Limits for Harmonic Currents produced by equipment connected to the public low voltage systems with Rated Current <16A / >16A and <75A / >75A per Phase respectively
*IEC/EN 61000-6-1 / 6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for residential and commercial / industrial environments
*IEC/EN 61000-6-3 / 6-4	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for residential and commercial / industrial environments
IEC 62116 /IEEE 1547 or IEEE 1547.1 / UL 1741	Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures
IEC 60068-2-1	Environmental testing – Part 2-1: Tests – Test A: Cold
IEC 60068-2-2	Environmental testing – Part 2-2: Tests – Test B: Dry heat
IEC 60068-2-14	Environmental testing – Part 2-14: Tests – Test N: Change of temperature
IEC 60068-2-30	Environmental testing – Part 2-30: Tests – Test Db:, Damp heat, cyclic (12 h + 12 h cycle)

***Recommended but not mandatory**

6. BATTERY BANK

6.1. The battery bank can be LMLA, VRLA (Smf or Gel) or Lithium Ferro Phosphate. . The EPC Company/ Contractor shall use only the Batteries that are empanelled to the ANERT OEM empanelment. The List of Batteries are attached as Annexure II-F. However the specifications for the Batteries are detailed below:

6.2. **Technical Requirements**

SlNo:	Parameters
1.	Nominal Capacity (Ah) shall be rated @C10
2.	Minimum Nominal voltage (V): 2V / Lithium ferro phosphate: 3.2V
3,	Self-discharge (less than 3% per month at 30°C)
4	A 1 hour backup of MNRE requirement is required for Hybrid Power Plant and is estimated as 1200Wh

6.3. General Specifications:

a. Test certificate submitted should qualify the minimum requirements as per above standards for capacity test, ampere-hour efficiency test, watt-hour efficiency test, self- discharge test.

b. Battery (Lead Acid LMLA/Lead Acid –VRLA or SMF/Lead Acid GEL) shall have a warrantee of minimum 5 years and Lithium Ferro Phosphate Battery shall have a warrantee of minimum 10years

c. Battery capacity is rated C/10 at 27°C

d. Original Equipment Manufacturers (OEM) Warrantee of Battery shall be submitted

6.4. STANDARDS AND CERTIFICATIONS

Major IS/IEC Certification for LMLA/VRLA / Lithium Ferro Phosphate batteries are listed below:

Standard	Description
IEC 61427	IEC 61427 – This series gives general information relating to the requirements for the secondary batteries used in photovoltaic energy systems (PVES) and to the typical methods of test used for the verification of battery performances.
IEC 60896	This part of IEC 60896 applies to all stationary lead-acid cells and Monobloc batteries of the valve regulated type for float charge applications, (i.e. permanently connected to a load and to a d.c. power supply), in a static location (i.e. not generally intended to be moved from place to place) and incorporated into stationary equipment or installed in battery rooms for use in telecom, uninterruptible power supply (UPS), utility switching, emergency power or similar applications.
IS 13369:1992	This standard specifies Ah capacities, voltage, overall dimensions, performance requirements and tests for stationary lead-acid units in Monobloc container.
IS 1651:2013	This standard specifies rated Ah capacities, overall dimensions, performance requirements and tests for Stationary Lead Acid Cells and Batteries using Tubular Positive Plates
IS 15549:2005	This standard specifies capacities and performance requirements and corresponding test methods for all types of high integrity series stationary Valve regulated lead acid batteries.
IS 16046 : 2015 / IEC 62133 : 2012**	Defines requirements and tests for the safe operation of portable sealed secondary cells and batteries containing alkaline or other non-acid electrolyte , under intended use and reasonably foreseeable misuse.
IEC 61056*	IEC 61056-1:2012 specifies the general requirements, functional characteristics and methods of test for all general-purpose lead-acid cells and batteries of the valve-regulated type

IS 16220*	IS 16220 defines the general requirements, functional characteristics and methods of test for all general-purpose lead- acid cells and batteries of the valve- regulated type.
IEC 62133-2: 2017**	IEC 62133 requirements and tests for the safe operation of portable sealed secondary lithium cells and batteries containing non-acid electrolyte, under intended use and reasonably foreseeable misuse.
IEC 62620:2014**	IEC 62620 defines marking, tests and requirements for lithium secondary cells and batteries used in industrial applications including stationary applications.

* Recommended

** Applies for Lithium ferro phosphate batteries

7. 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 datalogging system.

7.1. **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 25kWp 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.

7.2. 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

i) Irradiation

j) Module temperature

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

7.3. 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.

7.4. The data from the above data monitoring system will be used for calculating the Performance Ratio (PR) of the power plant as per IEC 61724 for plants above 25kWp.capacity Hybrid PV Plant.

Performance Ratio

7.5 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.

7.6 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.

7.7 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 programmes, either or not under the subsidy schemes of MNRE/ State Govt. or Schemes under Local Self Governments (LSGDs)

7.5.

8. 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 Kerala
- The PV module mounting structure shall have a capacity to withstand a wind velocity of 150 km/hr.
- Suitable fastening arrangement such as grouting and calming 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. No additional holes shall be drilled on module frames
- 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

9. 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).

Netmeter:

As per Kerala 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 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 KSEB 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.

Capacity	Type of operation	Class Accuracy	
		Solar Meter	Net Meter
Upto 35 kWp	LT Whole current meter 10A-60A	1.0 (LT)	1.0 (LT)
Above 35kWp below 100kWp	CT operated meter	0.5s	0.5s
100kWp and above 100kWp	CT operated meter	0.5s (LT)	0.2s (HT)

Meters shall be microprocessor based conforming IEC 60687 / IEC 6205211 / IEC 62053-22 / IS 14697 and solar energy meter or its display shall be placed adjacent to net energy meter.

Display parameters : LCD test, kWh import, kWh export, MD in kW export, MD in kW import, Date & Time, AC current and voltages and power factor (Cumulative kWh will be indicated continuously by default & other parameters through push-button). The solar energy

meters and net energy meters should be DLMS compliant and AMR compatible with RS 485 communication port for measurement of specified electrical parameters.

The solar energy meters shall be provided with two ports for communication of the measured / collected data. One port compatible with RS 485 specifications, which shall be used for remote access through suitable GPRS modem (Technical specification of GPRS modem is attached as Annexure S). The other port shall be an optical port complying with hardware specifications detailed in IEC 62056-21.

For capacity >25kWp, solar energy meter shall be with MODEM having facility of AMR and GPRS or Smart Meter.

10.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)

10.1. 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.

10.2. 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

10.3. In any case, the cross-section area or the earthing conductor for PV equipment should not be less than 6 mm^2 if copper, 10 mm^2 if aluminium or 70 mm^2 if hot-dipped galvanized iron. For the earthing of lightning arrestor, cross-section of the earthing conductor should not be less than 16 mm^2 of copper or 70 mm^2 if hot-dipped galvanized iron. The complete Earthing system shall be mechanically & electrically connected to provide independent return to earth.

10.4. 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.

10.5. 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 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

10.6. 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.

10.7. 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.

10.8. 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.

10.9. Necessary provisions shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance.

10.10. For each earth pit, a necessary test point shall be provided.

10.11. Total no of Earth pits for solar plants:

a. Up to 50kWp: AC-01, DC-02, LA-01

b. Above 50kWp: AC-02, DC-02, LA-01

The bidder shall submit the detailed specification and drawings for the Earthing arrangements as per Annexure II-H

11.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.

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

11.1. The entire space occupying SPV array shall be suitably protected against lightning by deploying required number of lightning arresters. Lightning protection should be provided as per IS/ IEC 62305.

11.2. Lightning system shall comprise of air terminations, down conductors, test links, earth electrode etc. as per approved drawings.

11.3. The protection against induced high voltages shall be provided by the use of surge protection devices (SPDs) and the earthing terminal of the SPD shall be connected to the earth through the earthing system.

11.4. The EPC Contractor / Company shall submit the drawings and detailed specifications of the PV array lightning protection equipment to Employer for approval before installation of system.

12.ARRAY JUNCTION BOX (AJB)/ STRING COMBINER BOX (SCB)

AJB shall be provided as per the design requirement of the Inverter, if required. AJB comprises of an enclosure, copper busbars, Fuses, Surge Protection Device (SPD) and Isolator. DC generated by the solar modules is transmitted through the appropriate cables from Array Yard to Control facility. AJB bus & panel shall be provided for the incoming DC supply from array yard.

AJB, if required, should be equipped with an adequate capacity indoor DC circuit breaker along with control circuit, protection relays, fuses, etc.

AJB, if required, shall have sheet from enclosure of dust and vermin proof, the bus bar / cables are to be made of copper of desired size.

The Array Junction Boxes are to be provided in the PV array for termination of connecting cables. The Array Junction Boxes shall be made of GRP/FRP/with full dust, water& vermin

proof arrangement. All wires/cables must be terminated through cable lugs. The JBs shall be such that input & output termination can be made through suitable cable glands.

12.1. Suitable markings shall be provided on the bus bar for easy identification and the cable ferrules must be fitted at the cable termination points for identification.

12.2. Copper bus bars/terminal blocks housed in the junction box with suitable termination threads conforming to IP 65 standard to prevent water entry, Single/ double compression cable glands, provision of earthing. It should be placed at a height suitable for ease of accessibility.

12.3. Each Junction Box shall have high quality Suitable capacity Metal Oxide Varistors (MOVs)/ SPDs. The Surge Protective Device shall be of Type 2 as per IEC 60364-5-53

12.4. The junction Boxes shall have suitable arrangement for the followings (typical):- Combine groups of modules into independent charging sub-arrays that will be wired into the controller. The Junction Boxes shall have arrangements for disconnection for each groups and attest point for sub-group for fault location. AJB/SCB shall be wired with optical fibre cables for enabling data collection for PV Plants from 100kWp onwards.

12.5. The current carrying ratings of the string combiner box/ junction box shall be suitable with adequate safety factor, to inter connect the Solar PV array.

12.6. All fuses shall have DIN rail mountable fuse holders and shall be housed in thermoplastic IP65 enclosures with transparent covers.

12.7. Fuse for both positive and negative inputs of each strings, Isolator of MCB, SPD of type 2 shall be provided.

12.8. The surge arresters shall be type 2 (with reference to IEC 61643-1) rated at a continuous operating voltage of at least 125 percentage of the open-circuit voltage of the PV string, and a flash current of more than 5A.

12.9. Not more than two strings can be connected in parallel to a single input of SCB/AJB. One spare input terminal along with connector shall be provided for each SCB/AJB.

12.10. Every SCB/AJB input shall be provided with fuses on both positive and negative side.

12.11. DC switch disconnector of suitable rating shall be provided at AJB/SCB output to disconnect both positive and negative side simultaneously.

13.AC DISTRIBUTION BOARD

AC Distribution Board (ACDB) shall control the AC power from inverter and should have necessary surge arrestors.

An ACDB panel shall be provided in between PCU and Utility grid. It shall have MCB/MCCB/ACB or circuit breaker of suitable rating for connection and disconnection of PCU from grid.

13.1. The connection between ACDB and Utility grid shall be of standard cable/ Conductor with suitable termination. It shall have provision to measure grid voltage, current and power.

13.2. The incomer shall be selected at required rating. The ACDB enclosure shall be of good protection and suitable for mounting on the trenches / on wall.

13.3. All the 415 V AC or 230 V AC devices/equipment like bus support insulators, circuit breakers, SFU isolators (if applicable), SPD, etc. mounted inside the switch gear shall be suitable for continuous operation

13.4. Switches/ circuit breakers/ connectors meeting general requirements and safety measurements as per IS 60947 Part I, II, III and IEC 60947 part I, II and III.

13.5. Junction boxes, enclosures, panels for inverters/ Controllers shall meet IP 54 (for outdoor)/ IP 65 (for indoor) as per IEC 529.

14.AC/DC CABLING

Cabling is required for wiring from AC output of inverter/PCU to the Grid Interconnection point. It includes the DC cabling from Solar Array to AJB and from AJB to inverter input.

14.1. All cables of appropriate size to be used in the system shall have the following characteristic:

a. Shall conform to IEC 60227 / IS 694 & IEC 60502 / IS 1554 standards.
b. Temperature Range: -10 degree Celsius to +80 degree Celsius
c. Voltage rating: 660/1000V
d. Excellent resistance to heat, cold, water, oil, abrasion, UV radiation
e. Flexible

14.2. Sizes of cables between any array interconnections, array to junction boxes, junction boxes to inverter etc. shall be so selected to keep the voltage drop (power loss) of the entire solar system to the minimum (2%).

14.3. The length exceeding 25m of AC cable from Inverter to the ACDB and to the Grid Connection point shall be borne by the customer.

14.4. For the DC cabling, XLPE or XLPO insulated and sheathed, UV stabilized single core flexible copper cables shall be used; Multi-core cables shall not be used.

14.5. For the AC cabling, PVC or XLPE insulated and PVC sheathed single or, multi-core flexible copper cables shall be used. However, for above 25kWp systems, XLPE insulated Aluminium cable of suitable area of cross section can be used in the AC side subject to a minimum area of cross section of 10 sq.mm. Outdoor AC cables shall have a UV -stabilized outer sheath IS/IEC 69947.

14.6. All LT XLPE cables shall conform to IS:7098 part I&II.

14.7. The total voltage drop on the cable segments from the solar PV modules to the solar grid inverter shall not exceed 2.0%

14.8. The total voltage drop on the cable segments from the solar grid inverter to the building distribution board shall not exceed 2.0%

14.9. The DC cables from the SPV module array shall run through a UV-stabilized PVC conduit pipe of adequate diameter with a minimum wall thickness of 1.5mm

14.10. Cables and wires used for the interconnection of solar PV modules shall be provided with solar PV connectors (MC4) and couplers

14.11. All cables and conduit pipes shall be clamped to the rooftop, walls and ceilings with thermo-plastic clamps at intervals not exceeding 50cm; the minimum DC cables size shall be 4.0mm^2 copper; the minimum AC cable size shall be 4.0mm^2 copper. In three phase systems, the size of the neutral wire size shall be equal to the size of the phase wires.

14.12. Cable Marking: All cable/wires are to be marked in proper manner by good quality ferule or by other means so that the cable can be easily identified. The following colour code shall be used for cable wires

a. DC positive: red (the outer PVC sheath can be black with a red line marking
b. DC negative: black
c. AC single phase: Phase: red; Neutral: black
d. AC three phase: phases: red, yellow, blue; neutral: black
e. Earth wires: green

14.13. Cables and conduits that have to pass through walls or ceilings shall be taken through PVC pipe sleeve.

14.14. Cable conductors shall be terminated with tinned copper end ferrules to prevent fraying and breaking of individual wire strands. The termination of the DC and AC cables at the Solar Grid Inverter shall be done as per instructions of the manufacturer, which in most cases will include the use of special connectors.

14.15. All cables and connectors used for installation of solar field must be of solar grade which can withstand harsh environment conditions including high temperatures, UV radiation, rain, humidity, dirt, salt, burial and attack by moss and microbes' for 25 years and voltages as per latest IEC standards. DC cables used from solar modules to array junction box shall solar grade copper (Cu) with XLPO insulation and rated for 1.1 kV as per relevant standards only.

14.16. Bending radii for cables shall be as per manufactures recommendations and IS: 1255.

14.17. For laying/termination of cables latest BIS/IEC Codes/ standards shall be followed.

15.CIVIL WORKS

Existing shade-free roof-top space shall be used to install Solar PV array. While installing solar power pants on rooftops, the physical condition of the rooftop, chances of shading, chances water level rise in the rooftop during raining due improper drainage in the roof-top should be taken in to consideration.

15.1. PV array shall be installed in the terrace space free from any obstruction and/or shadow and to minimize effects of shadows due to adjacent PV panel rows.

15.2. PV array shall be oriented in the south direction in order to maximize annual energy yield of the plant.

15.3. The solar PV array must be installed on the rooftop in such a way that there is sufficient space on the rooftop for maintenance etc.

15.4. There should not be any damage what so ever to the rooftop due to setting up of the solar power plant so that on a later day there is leakage of rainwater, etc. from the rooftop.

15.5. Some civil works are inevitable for erecting the footings for the module mounting structure as discussed in Module Mounting Structure section. The roof top may be given a suitable grading plaster with suitable leak proof compound so as to render the

roof entirely leak proof.

15.6. Ample clearance shall be provided in the layout of the inverter and DC/AC distribution boxes for adequate cooling and ease of maintenance.

15.7. While cabling the array, care must be taken such that no loose cables lie on the rooftops.

15.8. The roof top should look clean and tidy after installation of the array.

15.9. Neatness, tidiness and aesthetics must be observed while installing the systems.

15.10. RCC Works - All RCC works shall be as per IS 456 and the materials used viz. Cement reinforcement, steel etc. shall be as per relevant IS standards. Reinforcement shall be high strength TMT Fe 415 or Fe 500 conforming to IS: 1786-1985.

15.11. Brick Works (If any) - All brick works shall be using 1st class bricks of approved quality as per IS 3102.

15.12. Plastering - Plastering in cement mortar 1:5, 1:6 and 1:3 shall be applied to all.

15.13. Display of mandatory items- Single Line Diagram and layout diagram of modules and interconnection at installation site shall be provided near the inverter for greater than 10 kWp systems.

15.14. For painting on concrete, masonry and plastered surface IS:2395 shall be followed. For distempering IS 427 shall be followed referred. For synthetic enamel painting IS 428 shall be followed. For cement painting IS 5410 shall be followed.

15.15. All Civil works required for the installation of the PV Plant and other civil and electrical work in evacuation infrastructure, wherever necessary, shall be within the scope of the bidder

15.16. The layout of Inverter accommodation shall be designed to enable adequate heat dissipation and availability. Mount within the existing infrastructure available in consultation with the Site in charge. String Inverters may be installed with Canopy type structure over it to protect it from frequent monsoon and weather changes.

16. CONNECTIVITY

The output of the Solar Power Conditioning Unit has to be connected to the Main ACDB in the building

Plant Capacity	Connecting voltage
Up to 5 kWp	240V-single phase or 415V-three phase at the option of the consumer

Above 5kWp and up to 100 kWp	415V – three phase or higher at the option of the consumer.

17.GENARAL PROCEDURES FOR PROJECTS

The following procedures are required regarding the installation of Grid Connected PV Plants under ANERT.

17.1. There are different schemes by ANERT governed by respective guidelines of different programmes initiated by ANERT from time to time. The programmes may or may not have financial support or subsidy support from either State Government or Central Ministry (MNRE).

17.2. Also there will be specific provisions of procurement, installation, commissioning, inspection, warrantee and operation & maintenance of PV Plants procured through online portal of ANERT (buymysun.com) and the details are given in Annexure II-I.

17.3. The documentation, inspection, Commissioning Tests shall confirm to IEC 62446-1:2016 and its amendments

17.4. Projects under Deposit Works Scheme, Technical Consultancy Scheme, RESCO projects tendered by ANERT or any other specific programme implemented by ANERT will be governed by the guidelines of that particular scheme. Only Empanelled EPC companies of ANERT can participate in the tenders coming under the above schemes/programmes. They can also participate in the tenders by Local Self Governments for the installation & commissioning of Solar Power Plants. However, all the PV power plants (On-Grid/Off-Grid/Hybrid) installed by the EPC contractors shall be as per the technical specifications of this Empanelment Document.

18. PERMISSION AND PROCEDURES FOR THE CONNECTIVITY GRID CONNECTED SOLAR POWER PLANTS PUBLISHED BY KSEB Ltd.

18.1. The procedures for Grid Connectivity of the PV Plants for capacities from 1kWp to 1MWp is as per the KSEBL Circular No. CE(REES)/Escot/AEE6/Solar-General/16-17/766(1) Dt. 09-09-2016 and its Amendments.

18.2. The beneficiary shall obtain a feasibility certificate by submitting an application form along with the documents and a fee of Rs 1000/- as per the Annexure-1 form of KSEBL order.

18.3. The Feasibility certificate has a validity of one month.

18.4. For LT feeder 75% of the transformer capacity will be permitted for connecting the Grid tied PV power plant whereas it is 80% for the 11kV feeder as per KSERC (Renewable Energy and Net Metering) Regulations, 2020 Dt. 07-02-2020.

18.5. Within the period of one month, application of the registration of installed PV power plant should be submitted for which the section office, KSEBL has to appeal for any further clarification within 3 working days.

18.6. After submitting all the documents and clarification required by KSEBL , the applicant has to a pay Registration fee of Rs 1000/- per kW to KSEBL (Eg: If the plant size is 3.65kW then it will be considered as 4kW and the applicant has to pay a sum of Rs 4000/-) to acquire a SPIN (Solar Plant Identification Number). For example, 5501-00001 where 5501 is the section office code for the locality and 00001 is the solar plant number.

18.7. The PV power plant has to be installed within 6 months from the date of registration. The Assistant Engineer can approve for an extension the term of registration to another 6 months upon the request of applicant, if found necessary.

18.8. If the applicant withdraws the registration without any valid reason, the amount will not be reimbursed.

18.9. 80% of the amount of fee of solar PV plant registration will be refunded by KSEBL if the applicant has installed the PV plant within the term of 6 months from the date of registration.

18.10. Request for the cancellation of Registration by the applicant will be verified by the Assistant Engineer, KSEBL and a decision will be taken on this by division Executive Engineer, KSEBL and 80% of the amount shall be reimbursement based upon the recommendation of Assistant Engineer.

18.11. The application for testing of the installed PV power plant has to be submitted at the Electrical Section office. For plant capacities above 10kWp the application must be submitted along with Energization Certificate from Electrical Inspectorate and for the plant capacities below 10kWp the application must be submitted along with a Completion Report of a Certified Electrical Contractor. The minimum qualification for carrying out the installation work of a PV Plant shall be a B-Class contractor licensee and depending upon the capacity of installation, eligible contractors can carryout the work. (Circular no. B2-13958/2017/CEI Dtd 24.07.2018. No fees shall be remitted for pre commissioning or routine tests.

18.12. The officials from Electrical Inspectorate and KSEBL will visit the site on the schedule day within 10 days from the date of application with prior notice to the beneficiary.

18.13. The test will be carried out for parameters like:

a. Anti-Islanding

b. Harmonics Current Injection

c. Direct Current Injection and Flicker

18.14. Test Certificate for Solar Plant Installation as per annexure 9 of KSEBL order will be issued by the Assistant Engineer, once the PV plants is successfully performing as per the standards

18.15. Agreement for Connecting Solar Energy System as per Annexure 10 of KSEBL order shall be signed between KSEBL and the applicant as per the Annexure 11 (KSEBL order) in which the capacity of the net meter should be mentioned.

18.16. Then a Net meter and a Solar meter shall be installed for the plant within 7 days which shall be either bought by the applicant or rented by the KSEBL. The tariff of rent will be as per Annexure 12 of the KSEBL order. The applicant shall submit Test Certificates from NABL or KSEBL test labs for the Net meter and Solar meter purchased.

18.17. The import and export will be calculated based upon the Net meter installed at the site of the consumer for which the reading will be taken on every month from the Net meter and Solar meter.

19. WARRANTY AND COMPREHENSIVE MAINTENANCE CONTRACT

19.1. 5 years system warranty should be provided by the EPC contractor for the equipment and the components installed.

19.2. The successful bidder should submit the copies of the Warrantee Certificates for the on-site warrantee provided by the OEM for the important components like PV Modules, Inverters, Junction Boxes etc.

19.3. The Warrantee/CMC Modalities is between the Customer and the EPC Company

20. OPERATION MANUAL

An Operation, Instruction and Maintenance Manual, should be provided with the system. The following minimum details must be provided in the manual:

- About solar power plant – its components and expected performance.
- DO's and DON'T's
- Cleaning of Solar PV Modules in regular intervals
- Clear instructions on regular maintenance and troubleshooting of solar power plant
- AS built Drawings for the Installation
- OEM Warrantee Certificates of Inverters, PV Modules, Batteries etc.
- Specification of PV Plant
- Data Sheets of major equipment like PV Module, Inverter etc.
- Name and address of the E.P.C Contractor and the contract person in case of non-functionality of the solar power plant.

21.BILL OF MATERIALS

Once Empanelled and when a project is awarded the EPC Contractor should provide the bill of material mentioning the quantity of each of the item consisting in the system, for the projects they are undertaking.

The format for the Bill of Materials is given below:

Sl. No.	Item	Make (if any)	Model & Individual Capacity (If any)	Quantity (Nos)	Rating/Capacity
1.	PV Module				
2.	PCU/Inverter				
3.	DC Cables				
4.	AC Cables				
5.	AJB/SCB				
6.	Module Mounting Structure (MMS)				
7.	ACDB				
8.	Lightning Arrester				
9.	Earthing System Details and No. of Earth pits				
10.	Data Acquisition System				

22.SITE INSPECTION

Once Empanelled and when a project is awarded the EPC Contractor should visit site / sites for the checking the feasibility before proceeding.

23.DRAWINGS AND DOCUMENTS

Once Empanelled and when a project is awarded the EPC contractor must submit drawings/documents required by statutory authorities and obtain the approval before the installation.

i) Schematic drawing showing the PV panels, Power conditioning Unit(s)/Inverter, Array Junction Boxes (AJBs)/String Combiner Boxes (SJB), AC and DC Distribution Box, Net meters, MSB etc.

ii) Layout of solar PV Array

iii) Single Line Diagram (SLD) with specification of all components.

iv) Design document for Module Mounting Structure (MMS) including certificate showing wind speed withstanding capacity of the structure (STAAD/Equivalent).

v) Module Mounting Structure (MMS) drawing along with foundation details for the structure.

vi) Sizes and specification of cables for PV Module interconnections, PV Array to Array Junction Boxes, Array Junction Boxes to Inverter, Inverter to ACDB/ Grid Connection point etc. shall be furnished.

The EPC contractor shall submit a PVsyst report for PV power plants from 25kWp and above. All PV plant design should contain the following details which should be approved by the concerned officer before installation.

i) Design of string including the number of PV modules in series and number strings

ii) AC Protection (Circuit Breaker, Switches, Fuses, SPD)

iii) DC Protection (Switches, Fuses, SPD)

iv) AJB / SCB details

v) DC Cable size and length from point to point

vi) AC Cable size and length from point to point

vii) Earthing system details and number of pits

viii) Lightning protection details/specification

ix) PV Syst Simulation Report for above 25kWp

Director
ANERT

AGENCY FOR NON-CONVENTIONAL ENERGY & RURAL TECHNOLOGY
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