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# **PHQ Solar PV Rooftop System Technical Specifications**

## **1. SCOPE OF WORK**

Work under this section shall include the design, supply of materials, installation, commissioning, testing and delivery in perfect running conditions of the 27kwatts Rooftop Mounting Solar Power System for PHQ, in most effective and efficient manner in accordance with the entire requirements of contractual agreement to the full stratification of UNDP electrical engineer.

27Kwatts Solar Rooftop Photo Voltaic (SPV) power plant consists of SPV array, Module Mounting Structure, Power Conditioning Unit (PCU) consisting of Maximum Power Point Tracker (MPPT), Inverter, and Controls & Protections, interconnect cables, MC4 connectors, Junction boxes, Distribution boxes and switches. PV Array is mounted on a suitable structure. SPV system is with battery backup and should be designed with necessary features. Components and parts used in the SPV power plants including the PV modules, metallic structures, cables, junction box, switches, PCUs etc., should conform to the BIS or IEC or international specifications, wherever such specifications are available and applicable. The Rooftop Mounting Solar Power System installations comprise, but are not limited to the followings items:

- Solar PV modules consisting of required number of Crystalline PV cells.
- Energy Storage, Battery Backup (Battery Bank)
- Inverter, Charger Controller, Control Panel and Junction Boxes
- Roof Top Mounting Structures
- IR/UV Protected Cabling, Conduits and fittings
- Grounding, Earthing and Lightning Protection Systems
- Complete installations

The supply shall include all the equipment, accessories and other materials not enumerated in these specifications but found necessary for the completion and perfect functioning of the installations of roof top mounting solar power system for successful execution and completion of the project.

Electrical works and solar system installations shall be executed in a first-class work-manlike manner in accordance with these specifications, the drawings and notes indicated therein, the instructions of UNDP Electrical Engineer, the provisions of the Bill of Quantities delivered in place and tested to the full satisfaction of the Electrical Engineer.

## **2. Design, Survey and Planning**

The contractor should conduct a site visit before supplying the equipment to identify proper location for installation of the system. It should also include proper survey of the building including the electrical appliance and internal wiring configuration and propose any changes in design of the system if required. Also, the contractor should carry out Shadow Analysis at the site and accordingly design strings & arrays layout considering optimal usage of space, material and labor. Two sets of Engineering, electrical drawings and Installation and O&M manuals are to be supplied.

### **3. Solar PV Module Mounting Structures and Civil Works**

The civil works for the proposed Solar PV rooftop System shall include, design of the Roof Top Solar PV mounting frame structures and installation. The PV modules shall be mounted on fixed metallic structures having adequate strength and as per requirement of site to withstand the load of the modules and high wind velocities. the mounting structure should be facing south direction tilted at 34degree and Rooftop Module Mounting structure must be designed accordingly. It should be able to withstand 90 km/hr wind speed and support the installed solar PV modules, ensuring the roof remains water proof, stability and wind withstanding capacity. The Contractor must provide the technical design and drawing of the PV mounting structure.

Regarding existing building structures, the contractor need to take care of the load bearing capacity of the roof and need arrange suitable structures based on the quality of roof. The total load of the structure (when installed with PV modules) on the terrace should be less than 60 kg/m<sup>2</sup>. The array structure shall be grounded properly using maintenance free earthing kit suitable for mounting over building terrace.

### **4. DRILLING AND CUTTING**

The Contractor shall have to do all drillings and cutting of roof, walls, ceilings or other parts of the building for the complete proper installation of the mounting support structures, conduits, cables, switchboards and other parts of equipment.

Beams, girders and other principal structural members shall not be cut or drilled unless permission has been granted by the Engineer.

If such drilling and cutting is made on finished surfaces, any marring of the surface shall be made good by repair or replacement at the Contractor's expense.

### **5. ACTUAL ROUTE OF CABLES AND CONDUITS**

The location of conduits, cables, switchboards, cable trucking, etc.... is shown on the drawings approximately, therefore the actual route of cables and conduits may differ from the plans according to the details or the building construction and the conditions of execution of the installation.

The Contractor shall supply and install at his expense all secondary materials and special fittings found necessary to overcome the interference and to apply the modifications on the route of cables and conduits that are found necessary during the work to the complete satisfaction of the Engineer.

### **6. Operation and Maintenance Manual**

An Operation, Instruction and Maintenance Manual, in English and the local language, should be provided with the Solar PV standalone System, Single Line Diagram and detail of Wiring and Connection Diagrams will also be provided with the manual. Manual should also have information on structure of internal wiring and number of existing circuits connected to the

backup system. Information should be also provided on energy efficiency aspects, particularly when the system is running on backup.

## 7. TOOLS & TACKLES AND SPARES

After completion of successful installation & commissioning of the roof top solar power system, necessary tools & tackles are to be provided free of cost by the contractor for operation and maintenance purposes.

## 8. Warrantee/Guarantee

1. The Solar PV System must be warranted for power for 25 years.
  - a. The structure should be warranted for 25 years.
  - b. Inverter warranty should be 10 years.
  - c. Battery warranty must be warranted for power for 10 years.
2. PV modules used in Power Plant must be warranted for their rated output
3. The Warrantee/ Guarantee Card to be supplied with the Solar PV System must contain the details of the system supplied. The suppliers/manufacturers can provide additional information about the system.
4. During the Warrantee/ Guarantee period, **UNDP** will have all the rights to cross check the performance of Solar PV System. **UNDP** may carry out the frequent inspections of the system installed and randomly pick up its components to get them tested at any test centre. If during such tests any part is not found as per the specified technical parameters, **UNDP** will take the necessary action. The decision of **UNDP** in this regard will be final and binding to the Bidder.
5. Solar PV modules should have reduction of rated power of not more than 2% in the first year and not more than 0.7% per year from the subsequent year for the remaining 25 years.

## **Section-A: Technical Specifications**

SN	Component	Description:	Bidder Remarks
1	Solar PV Modules	<ul style="list-style-type: none"> <li>Total Size of Array must be at least 27 kW Peak for PHQ.</li> <li>Individual Solar PV Module must be 4.5KW with PV 15x300 Watt.</li> <li>The proposed Solar PV Module must comply with the latest IEC type tests. A list of IEC type tests are mentioned below.</li> </ul>	
2	Energy Storage (Battery Bank)	<ul style="list-style-type: none"> <li>Total Size of Battery Bank must be at least 144kWh for PHQ.</li> <li>Maximum allowed parallel string connection is two, it is important to be chosen the right individual battery capacity that will give suitable form the battery bank.</li> </ul>	

		<ul style="list-style-type: none"> <li>The proposed Battery must comply with the latest IEC type tests. A list of TEC type tests are mentioned below</li> </ul>	
3	Inverter	<ul style="list-style-type: none"> <li>Total Size of inverter should be not less than the size mentioned in the BOQ</li> <li>Inverter Type: Hybrid</li> <li>The proposed inverter must comply to the latest IEC type tests. A list of IEC type tests are mentioned below.</li> </ul>	
4	Mounting Structure/Frame	<ul style="list-style-type: none"> <li>MS-hot dip Galvanized support structures to be fixed on the roof of the building. The galvanization thickness should adhere to ASTM 123.</li> <li>Mounting structure must be designed such that it is installed to have solar PV array towards due south around local latitude at 34 degree with horizontal space</li> <li>The support frame structure should be able to resist at least 25 years of outdoor exposure without suffering significant damage or corrosion.</li> <li>It shall support solar PV modules at a given orientation, absorb and transfer the mechanical loads to the ground properly. The structure should withstand a windload of 90 KMPH</li> </ul>	
5	Installation materials	<ul style="list-style-type: none"> <li>As required following national/international standards</li> </ul>	
6	Earthing Protection and	<ul style="list-style-type: none"> <li>As required following NS/ IS standard</li> <li>Battery management system should be a part of the system.</li> <li>The solar PV plant structure shall be grounded properly using adequate number of earthing kits. All metal casing of the system shall be thoroughly grounded to ensure safety of the Solar PV system.</li> <li>The Solar PV system shall be provided with lightning and over voltage protection.</li> <li>The main aim in this protection shall be to reduce the over voltage to a tolerable value before it reaches the system.</li> </ul>	

		<ul style="list-style-type: none"> <li>• The system should have protection against battery overcharge and deep discharge conditions.</li> <li>• Fuses should be provided to protect against short circuit conditions.</li> <li>• Full protection against open circuit, accidental short circuit &amp; reverse polarity should be provided.</li> <li>• The earth resistance value should be less than 5 <math>\Omega</math></li> </ul>	
7	Cables and conduits	<ul style="list-style-type: none"> <li>• As required following NS/ IS standard</li> <li>• Outdoor cables must be UV protected</li> <li>• Cables must be selected to ensure voltage drop across it must not exceed 3%</li> </ul>	
8	System Voltage	<ul style="list-style-type: none"> <li>• Installing company can design the system voltage as per requirement and technical correctness. The system voltage should be compatible to solar PV module, Inverter, Charge Controller and Battery Bank</li> </ul>	
9	Wiring Restructuring	<ul style="list-style-type: none"> <li>• The existing wiring to be checked and ensure that circuit for outlets are separated.</li> <li>• Circuit for heavy high consumption electrical appliance such boiler, air conditioners must be separated.</li> <li>• In consultation with PHQ staff the circuits for essential and non-essential appliance should be speared. Load segregation of the building will be the responsibility of the contractor.</li> </ul>	

#### Certificate:

**The main equipment supplied for the project should be submitted the latest IEC Type Test certificate during implementation to the UNDP electrical engineer or to UNDP the project manager for review and approval.**

IEC Codes for Solar PV Panels	
IEC 61215	Design Qualification and Type Approval for Crystalline Silicon Terrestrial Photovoltaic (PV) Modules
IEC 61646	Design Qualification and Type Approval for Thin-Film Terrestrial Photovoltaic (PV) Modules
IEC 61701	Salt Mist Corrosion Testing of Photovoltaic (PV) Modules
IEC 61853- Part 1	Photovoltaic (PV) module performance testing and energy rating –: Irradiance and temperature performance measurements, and power rating
IEC 61730-1,2	Photovoltaic (PV) Module Safety Qualification – Part 1: Requirements for Construction, Part 2: Requirements for Testing
IEC 62804	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation (PID). IEC TS 62804-1: Part 1: Crystalline silicon (Mandatory for system voltage is more than 600 VDC and advisory for system voltage is less than 600 VDC)
IEC 62759-1	Photovoltaic (PV) modules – Transportation testing, Part 1: Transportation and shipping of module package units
IEC 62716	Photovoltaic (PV) Modules – Ammonia (NH <sub>3</sub> ) Corrosion Testing
IEC Codes for Solar PV Inverters	
IEC 62109-1, IEC 62109-2	Safety of power converters for use in photovoltaic power systems Safety compliance (Protection degree IP 65 for outdoor mounting, IP 54 for indoor mounting)
IEC/IS 61683 (For stand Alone System)	Photovoltaic Systems – Power conditioners: Procedure for Measuring Efficiency (10%, 25%, 50%, 75% & 90-100% Loading Conditions)
IEC 62891	Overall efficiency of grid-connected photovoltaic inverters:
IEC 62116/ UL 1741/ IEEE 1547	Utility-interconnected Photovoltaic Inverters - Test Procedure of Islanding Prevention Measures
IEC 60255-27	Measuring relays and protection equipment - Part 27: Product safety requirements
IEC 60068-2 (1, 2, 14, 27, 30 & 64)	Environmental Testing of PV System – Power Conditioners and Inverters
IEC 61000- 2,3,5	Electromagnetic Interference (EMI), and Electromagnetic Compatibility (EMC) testing of PV Inverters (as applicable)
IEC Codes for Fuses	
IEC 60947 (Part 1, 2 & 3), EN 50521	General safety requirements for connectors, switches, circuit breakers (AC/DC)
IEC 60269-6	Low-voltage fuses - Part 6: Supplementary requirements for fuse-links for the protection of Solar photovoltaic systems
IEC Codes for Surge Arrestors	
IEC 61643-11:2011	Low-voltage surge protective devices - Part 11: Surge protective devices connected to lowvoltage power systems - Requirements and test methods
IEC Codes for Cables	
IEC 60227, IEC 60502	General test and measuring method for PVC (Polyvinyl chloride) insulated cables (for working voltages up to and including 1100 V, and UV resistant for outdoor installation)
BS EN 50618	Electric cables for photovoltaic systems (BT(DE/NOT)258), mainly for DC cables
IEC Codes for Earthing /Lightning	
IEC 62561 Series( Part 1,2 & 7) (Chemical earthing)	IEC 62561-1 Lightning protection system components (LPSC) - Part 1: Requirements for connection components IEC 62561-2 Lightning protection system components (LPSC) - Part 2: Requirements for conductors and earth electrodes IEC 62561-7 Lightning protection system components (LPSC) - Part 7: Requirements for earthing enhancing compounds
IEC Codes for Junction Boxes	
IEC 60529	Junction boxes and solar panel terminal boxes shall be of the thermo plastic type with IP 65 protection for outdoor use, and IP 54 protection for indoor use
IEC Code for installation, testing, commissioning	
IEC 62446 - : 2016	Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 1: Grid connected systems - Documentation, commissioning tests and inspection
IEC codes for Battery	
IS 1651 & IS 13369,	Stationary lead-acid batteries – Vented types – General requirements and methods of test.
IS 15549	Stationary Valve regulated lead-acid batteries specification.
IEC 62259,	Secondary cells and batteries containing alkaline or other non-acid electrolytes-Nickel cadmium prismatic secondary single cells with partial gas recombination.
IEC 61951 –1,	Secondary cells and batteries containing alkaline or other non-acid electrolytes-Portable sealed rechargeable single cells-Part 1: Nickel cadmium.
IEC 61951 –2,	Secondary cells and batteries containing alkaline or other non-acid electrolytes-Portable sealed rechargeable single cells-Part 2: Nickel metal hydride. 70 IEC 61960, Secondary cells and batteries containing alkaline or other nonacid electrolytes-Secondary lithium cells and batteries for portable applications.

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## Technical Specifications for Hybrid Solar PV Plant, Major Equipment/Components

### 1. Solar PV Panels.

- a. PV Modules to be supplied should have a minimum declared output of 300 Wp (under standard test conditions) for monocrystalline SPV modules. Number of modules shall be worked accordingly.
- b. Modules proposed by the bidder should have been qualified with the existing IEC or other international certifications.
- c. The modules shall be warranted for at least 10 years for failures due to material defects and workmanship.
- d. PV modules used in the solar power plants must be warranted for output wattage, which should not be less than 90% at the end of the 10 years and 80% at the end of 25 years.
- e. Maximum power loss at the end of the first year of operation should not be more than 2% of the power at the start of the solar power plant.
- f. The Solar panels should have a linear degradation of power not more than 0.7% per year till the 25<sup>th</sup> year.
- g. The front surface of the module shall consist of impact resistant, low iron and high transmission toughened glass.
- h. The module frame shall be made of corrosion resistant material, which shall be electrically compatible with the structure material selected for the power plant
- i. A DC Combiner Box shall be used to combine the DC cables of the solar module arrays with DC fuse protection for the outgoing DC cable(s) to the DC Distribution Box.
- j. The cables from the array strings to the solar grid inverters shall be provided with DC fuse protection. Fuses shall have a voltage rating and current rating as required. The fuse shall have DIN rail mountable fuse holders and shall be housed in thermoplastic IP 65 enclosures with transparent covers.

### 2. Roof-Top Module Mounting Structure.

- a. The Roof Top Module Mounting Structure design shall be appropriate with a safety factor of not less than 1.5. The design calculation shall be submitted to **UNDP**.
- b. Design drawings with the material selected shall be submitted for approval of **UNDP**.
- c. The roof top module mounting structure shall be designed to allow easy replacement of any modules and easy access to the O&M staff and personal and protection.
- d. The roof top module mounting structure shall be designed for appropriate mechanical and electrical installation. It shall support the solar PV modules at an orientation of 34°, absorb and transfer the mechanical loads to the ground properly. There shall be no requirement of welding or complex machinery at site.
- e. The array structure shall withstand a maximum wind speed of 90 KMPH.

- f. Nuts and bolts, supporting structures including the roof top module mounting structures shall have to be adequately protected with anti-corrosive paints of sufficient thickness.
- g. The contractor/manufacturer shall specify installation details of the solar PV modules and the support structures with appropriate drawings.
- h. The drawings along with the detailed design shall be submitted to **UNDP** for approval before starting the erection work. The work will be carried out as per designs approved by **UNDP**.
- i. The minimum clearance between the lower edge of the PV panel and the ground level shall be 800mm. While making foundation design consideration should be given to the weight of the solar modules and a maximum wind speed of 90 KMPH. Seismic factors for the site to be considered while making the design of the foundation. The design of the array structure shall be approved by **UNDP**.
- j. Foundation drawings and design should be submitted to **UNDP** for approval before starting the work.
- k. The mounting structure shall have an adequate provision to alter the tilt of the panel at least twice in a year.
- l. The location of the water faucets is to be provided for periodic cleaning/washing of the solar PV modules and the same shall be indicated in the drawings

### **3. Junction Box**

- a. The junction boxes shall be dust free and waterproof and made of thermoplastic. The terminals will be connected to copper bus-bar arrangement of proper sizes. The junction box will have a cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables. Suitable marking shall be provided on the bus bars for easy identification and cable ferrules will be fitted at the cable termination points for identification. The connections should be compatible with MC-4 connectors.
- b. Each array junction box will have suitable reverse blocking diodes of maximum DC blocking voltage of 600V with suitable arrangement for its connection. The array junction box will have a suitable surge protection. The junction boxes shall have suitable arrangements for the following.
- c. Combine groups of modules into independent charging sub-arrays that will be wired to the controller
- d. Provide arrangement for disconnection for each of the groups.
- e. Provide test point for each sub-group for quick fault location.
- f. To provide group array isolation
- g. The current carrying rating of the junction boxes shall be suitable with adequate safety factor to inter connect the solar PV array.



#### 4. Power Conditioning Units

- a. Capacity of each PV inverter shall be as per the design
- b. The efficiency of the PV inverter shall be more than 98% at full load. The PV INVERTER shall have high overload capacity. The bidder should specify the overload capacity in the bid.
- c. The output power factor of the PV INVERTER shall be of a suitable range to supply or sink reactive power.
- d. The PV INVERTER shall have internal protection arrangement against sustained fault in the feeder line.
- e. The dimension, weight, foundation details etc. of the PV Inverter shall be clearly indicated in the detailed technical specification.
- f. The PV Inverter should be Three phase static solid state type power conditioning unit. Both the AC and DC lines shall have suitable fuses and contactors to allow safe start up and shut down of the system. Fuses used in DC circuit shall be DC rated.
- g. The PV Inverter shall have provision for input & output isolation.
- h. PV Inverter front panel shall be provided with display (LCD or equivalent) to monitor the following
  - DC power input.
  - DC input voltage.
  - DC current
  - AC output power
  - AC voltage (all the 3 phases)
  - AC Current (all the 3 phases)
- i. All the above parameter/information shall be displayed on the LCD window of the PV Inverter
- j. Nuts and bolts including metallic cubicle shall have to be adequately protected taking into consideration atmosphere and weather prevailing in the area.
- k. Operation & maintenance manual should be furnished by the contractor before dispatch of the PV Inverter.
- l. The PV Inverter must have the feature to work in tandem with other similar PV Inverter's and be able to be successively switched "ON" and "OFF" automatically based on solar radiation variations during the day. Inverters must operate in synergy and intelligently to optimize maximum generation at all times with minimum losses.
- m. The inverter should have a facility to change the priority of power from either Solar/battery/grid to grid/solar/battery.
- n. The PV Inverter shall be capable of controlling power factor dynamically.

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- o. Maximum power point tracker (MPPT) shall be integrated in the power conditioner unit to maximize energy drawn from the Solar PV array. The MPPT should be microprocessor based to minimize power losses. The details of working mechanism of MPPT shall be mentioned by the Bidder in its proposal. The MPPT unit shall confirm to IEC 62093 for design qualification.
  - p. **Sleep Mode:** Automatic sleep mode shall be provided so that unnecessary losses are minimized at night. The power conditioner must also automatically re-enter standby mode when threshold of standby mode reached.
  - q. **Stand – By Mode:** The control system shall continuously monitor the output of the solar power plant until pre-set value is exceeded & that value to be indicated.
  - r. **Basic System Operation (Full Auto Mode):** The control system shall continuously monitor the output of the solar power plant until pre-set value is exceeded & that value to be indicated.
  - s. PV INVERTER shall have provisions/features to allow interfacing with monitoring software and hardware devices.
  - t. **Protection against faults for PV Inverter**
  - u. The PV inverter shall include appropriate self-protective and self-diagnostic feature to protect itself and the PV array from damage in the event of PV Inverter component failure or from parameters beyond the PV Inverter's safe operating range due to internal or external causes. The self- protective features shall not allow signals from the PV Inverter front panel to cause the PV inverter to be operated in a manner which may be unsafe or damaging.
  - v. Faults due to malfunctioning within the PV Inverter, including commutation failure, shall be cleared by the PV Inverter protective devices. In addition, it shall have following minimum protection against various possible faults.
  - w. **Grounding Leakage Faults:** The PV Inverter shall have the required protection arrangements against grounding leakage faults.
  - x. **Over Voltage & Current:** In addition, over voltage protection shall be provided between positive and negative conductor and earth ground such as Surge Protection Devices (SPD).
  - y. **Galvanic Isolation:** The PV Inverter shall have provision for galvanic isolation with external transformer, if required.
  - z. **Anti-islanding (Protection against Islanding of grid):** The PV Inverter shall have anti islanding protection. (IEEE 1547/UL 1741/ equivalent BIS standard)
  - aa. **Unequal Phases:** The system shall tend to balance unequal phase voltage (with 3- phase systems).
  - bb. **Reactive Power:** The output power factor of the PV Inverter should be of suitable range to supply or sink reactive power. The PV Inverter shall have internal protection arrangement against any sustained fault in the feeder line and against lightning in the feeder line.

- cc. **Isolation:** The PV Inverter shall have provision for input & output isolation. Each solid-state electronic device shall have to be protected to ensure long life as well as smooth functioning of the PV Inverter.
- dd. PV Inverter shall have arrangement for adjusting DC input current and should trip against sustainable fault downstream and shall not start till the fault is rectified.
- ee. Each solid state electronic device shall have to be protected to ensure long life of the inverter as well as smooth functioning of the inverter.
- ff. All inverters/ PV Inverter s shall be three phase using static solid state components. DC lines shall have suitably rated isolators to allow safe start up and shut down of the system. Fuses & Circuit breakers used in the DC lines must be rated suitably.

## 5. Standards & Compliances

- a. PV Inverter shall confirm to the following standards and appropriately certified by the labs:
  - 1. Efficiency measurement: IEC 61683
  - 2. Environmental Testing: IEC 60068-2 or IEC 62093
  - 3. EMC, harmonics, etc.: IEC 61000 series, 6-2, 6-4 and other relevant Standards.
  - 4. Electrical safety: IEC 62109 (1&2), EN 50178 or equivalent
  - 5. Recommended practice for PV – Utility interconnections: IEEE standard 929 – 2000 or equivalent
  - 6. Protection against islanding of grid: IEEE1547/ UL1741/ IEC 62116 or equivalent
  - 7. Grid Connectivity: Relevant CEA/ CERC regulation and grid code (amended up to date) Reliability test standard: IEC 62093 or equivalent
- b. The Bidder should select the string inverter as per its own system design so as to optimize the power output.
- c. Desired Technical Specifications of PV INVERTER.
  - a. Sinusoidal current modulation with excellent dynamic response.
  - b. Compact and weather proof housing (indoor/ outdoor)
  - c. Comprehensive network management functions (including the LVRT and capability to inject reactive power to the grid)
  - d. Total Harmonic Distortion (THD) <3%
  - e. No load loss < 1% of rated power and maximum loss in sleep mode shall be less than 0.05%
  - f. Optional VAR control
  - g. Power factor Control range: 0.9 (lead – lag)
  - h. Humidity: 95% Non – Condensing
  - i. Unit wise & integrated Data logging

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- j. Dedicated Prefabs / Ethernet for networking
  - d. Inverter/ Power Condition unit must provide protection against:
    - a. Over current
    - b. Sync loss
    - c. Over temperature
    - d. DC bus over voltage
    - e. Cooling Fan failure (If provided)
    - f. Short circuit
    - g. Lightning
    - h. Earth fault
    - i. Surge voltage induced at output due to external source
    - j. Power regulation in the event of thermal overloading
    - k. Set point pre-selection for VAR control
    - l. Bus communication via -interface for integration
    - m. Remote control via telephone modem or mini web server
    - n. Integrated protection in the DC and three phase system
    - o. Insulation monitoring of the PV array with sequential fault location
  - e. Ground fault detector which is essential for large PV generators in view of appreciable discharge current with respect to ground.
  - f. Over voltage protection against atmospheric lightning discharge to the PV array is required.
  - g. The power conditioner must be entirely self-managing and stable in operation.
  - h. A self-diagnostic system check should occur on start up. Functions should include a test of key parameters on start up.
    - a. Power Factor.
    - b. Documentary Requirements & Inspection
  - i. The bill of materials associated with PV Inverter's should be clearly indicated while delivering the equipment.
  - j. The Contractor shall provide to the Employer, data sheet containing detailed technical specifications of all the inverters and PV Inverter's, Type test reports and Operation & Maintenance manual before dispatch of PV Inverter's.
  - k. The Employer or its authorized representative reserves the right to inspect the PV Inverter/ Inverters at the manufacturer's site prior to dispatch.

## 5. Cables and Wires:

Cables of appropriate size to be used in the system shall have the following characteristics:

- a. Shall meet IEC 60227/IS 694, IEC 60502/IS1554 standards Temp. Range: –10 C to +80 C. Voltage rating 660/1000V
- b. For the DC cabling, Solar cables with multi stranded copper conductors XLPE or XLPO insulated and sheathed with the voltage rating of 1000 V DC or higher UV stabilised single core flexible copper cables shall be used. Multi-core cables shall not be used.
- c. For the AC cabling, PVC or XLPE insulated and PVC sheathed single or multi-core flexible copper cables shall be used. Outdoor AC cables shall have a UV-stabilised outer sheath
- d. The total voltage drop on the cable segments from the solar PV modules to the solar grid inverter shall not exceed 1.0%.
- e. The total voltage drop on the cable segments from the solar grid inverter to the building distribution board shall not exceed 2.0%
- f. *The DC cables from the SPV module array shall run through a **UV-stabilised PVC conduit pipe** of adequate diameter with a minimum wall thickness of 1.5mm or through a High Density Poly Ethylene (HDPE) conduit. The conduits shall not run across the path way of the terrace. Flexible corrugated PVC conduits shall not be used.*
- g. Cables and wires used for the interconnection of solar PV modules shall be provided with solar PV connectors (MC4) and couplers.
- h. *All cables and conduit pipes shall be clamped to the rooftop, walls and ceilings with thermo-plastic clamps at intervals not exceeding 50 cm.*
- i. All cables shall be PVC insulated 1100V grade confirming to IEC standards and of the make approved by **UNDP**.
- j. The Wiring for modules interconnection shall be of with hard PVC conduit of approved make.
- k. Cables inside the control room shall be laid in suitable cable trays of approved make.
- l. All the wires used on the LT side shall conform to IEC standards and should be of appropriate voltage grade. Only Copper conductor wires of reputed make should be used for connection in the LT side.
- m. Cables and wires should be marked with good quality letters and number ferrules for proper identification.
- n. All cables and connectors for use 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. (Note: DC cables for outdoor installations should comply with the TUV 2PFG 1169/09.07 for service life expectancy of 25 years)
- o. Insulation: Outer sheath of cables shall be electron beam cross-linked XLPO type and black in colour. In addition, Cable drum no. / Batch no. to be embossed/ printed at every one meter. Cable Jacket should also be electron beam cross-linked XLPO, flame retardant, UV resistant and black in color.
- p. DC cables used from solar modules to array junction box shall be solar grade copper (Cu) with XLPO insulation and rated for 1.1kV only. The cables used from array junction box

to inverter shall be solar grade copper (Cu) with XLPO insulation and rated for 1.1kV only as per relevant standards. Bidder shall provide the type test report for each type of cable used before dispatch of the cable.

- q. Wires with sufficient ampere capacity and parameters shall be designed and used so that maximum voltage-drop at full power from the PV modules to inverter should be less than 1.5% (including diode voltage drop). Successful Bidder shall provide voltage drop calculations in excel sheet.
- r. Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted. If a condition arises where the laying length is greater than the drum length and in case of faults at the site actual conditions, the same may be accepted after due assessment by Employer and the joint kit shall be of reputed make and to be installed by the certified cable joiner. All wires used on the LT side shall conform to IS and should be of appropriate voltage grade. Only copper conductor wires compliant with IEC 60228, Class 5 of reputed make shall be used.
- s. Cable terminations shall be made with suitable cable lugs & sockets etc., crimped properly and passed through brass compression type cable glands at the entry & exit point of the cubicles.
- t. All cable/wires shall be provided with UV resistant printed ferrules for DC side however, for HT cables, punched/ embossed aluminium tags are required. The marking on tags shall be done with good quality letter and number ferrules of proper sizes so that the cables can be identified easily.
- u. The wiring for modules interconnection could be in the weather resistant pipe of reputed make.

#### **6. Switchboard box / DC Distribution Box (DCDB) / AC Distribution Box (ACDB) panels**

- a. Successful Bidder shall provide sufficient no. of switchboards / DCDB / ACDB wherever required.
- b. All boxes/ panels should be equipped with appropriate functionality, safety (including fuses, grounding, etc.) and protection.
- c. The terminals will be connected to bus-bar arrangement of proper sizes to be provided. The panels/ boxes will have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables.
- d. Adequate rating fuses & isolating RCD/RCCD/ ELCB should be provided.
- e. The panels/ boxes shall have suitable arrangement for the followings:
  - 1. Provide arrangement for disconnection
  - 2. Provide a test point for quick fault location
  - 3. To provide isolation
- f. The current carrying rating of the boxes/ panels shall be suitable with adequate safety factor
- g. The rating of the boxes/ panels shall be suitable with adequate safety factor to inter connect to the local/ internal grid
- h. Thermal/ heat dissipation arrangement/ Vent for safe operation.

- i. Adequate number of spare terminals
- j. The boxes/ panels shall be dust, vermin, and waterproof and made of thermoplastic/ metallic in compliance with IEC 62208, which should be sunlight/ UV resistive as well as fire retardant & must have minimum protection to IP 65(Outdoor)/ IP 20(indoor) and Protection Class II.
- k. All panels/ boxes shall be provided with adequately rated bus-bar, incoming control, outgoing control etc. as a separate compartment inside the panel to meet the requirements of the Chief Electrical Inspector General (CEIG). All live terminals and bus bars shall be shrouded. The outgoing terminals shall be suitable to receive suitable runs and size of cables required for the Inverter/Transformer rating.
- l. The boxes/ panels must be grounded properly to ensure all safety related measures for safe operation. The parts of panel, wherever applicable, must be insulated properly.
- m. All the Panels to be manufactured with sufficient space for working and must have temperature suitability up to 85°C with separate cable and bus bar alley.

## **7. GROUNDING, EARTHING AND LIGHTNING PROTECTIONS**

The system should be provided with all necessary protections like Grounding, Earthing, and Lightning protection systems as following:

### **7.1 LIGHTNING PROTECTION**

The SPV power plants shall be provided with lightning & overvoltage protection. The main aim in this protection shall be to reduce the over voltage to a tolerable value before it reaches the PV or other sub system components. The source of over voltage can be lightning, atmosphere disturbances etc. The entire space occupying the SPV array shall be suitably protected against Lightning by deploying required number of Lightning Arrestors. Lightning protection should be provided as per IEC 62305 /IS 2309 standard. The protection against induced high-voltages shall be provided by the use of metal oxide varistors (MOVs) and suitable earthing such that induced transients find an alternate route to earth.

- The source of over voltage can be lightning or other atmospheric disturbance. Main aim of over voltage protection is to reduce the over voltage to a safe level before it reaches the PV or other sub-system components as per NFC 17 – 102. Bidder to provide ESE type lightening arrester, placed at strategic locations to protect the plant from lightening and shall not cause any shadow on the solar modules.
- Necessary foundation / anchoring for holding the lightning conductor in position to be made after giving due consideration to shadow on PV array, maximum wind speed and maintenance requirement at site in future.
- The site is prone to lightning strikes and hence bidder is suggested to take utmost care while designing the lightning protection system. The Bidder shall submit the drawings, calculations and detailed specifications of the PV array lightning protection equipment to Employer for approval before installation of system.

- The lightning conductor shall be earthed through flats and connected to the grounding mats as per applicable International Standards with earth pits. Three earth pits shall be provided for each lightning arrester. 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 required as per provisions of IS.

## **7.2 SURGE PROTECTION**

Surge protection shall be provided on both the DC and the AC side of the solar system. The DC surge protection devices (SPDs) shall be installed in the DC distribution box adjacent to the solar grid inverter.

The AC SPDs shall be installed in the AC distribution box adjacent to the solar grid inverter. The SPDs earthing terminal shall be connected to earth through the above-mentioned dedicated earthing system.

## **7.3 GROUNDING/EARTHING PROTECTION**

1. (a) Each array structure of the PV yard should be grounded/ earthed properly. In addition, the lightning arrester/masts should also be earthed inside the array field. Earth Resistance shall be tested in presence of the representative of UNDP and when required after earthing by calibrated earth tester. PCU, ACDB and DCDB should also be earthed properly.
2. (b) Earth resistance shall not be more than 5 ohms. It shall be ensured that all the earthing points are bonded together to make them at the same potential.

## **8. Technical Specification for Large Scale Storage Battery.**

- a. Capacity of the battery bank should be designed in such a manner that the energy stored in the battery should cater to a loads of 100%.
- b. The Batteries should be only Sealed Maintenance Free battery.
- c. Relevant IEC Standards should be referred to during designing the battery bank. Below is list of IEC/IS specifications for the battery specification.
- d. IS 1651 & IS 13369, Stationary lead-acid batteries – Vented types – General requirements and methods of test.
- e. IS 15549, Stationary Valve regulated lead-acid batteries specification. IS 15767 (2008) / IEC 62259, Secondary cells and batteries containing alkaline or other non-acid electrolytes-Nickel cadmium prismatic secondary single cells with partial gas recombination.
- f. Depth of discharge is limited to 70%.



- g. The typical charge and discharge currents are the following: - Maximum charge current: C/10 A - Average discharge current determined by the load: C/120 A.
1. NOTE 1- Depending on the system design, the charge and the discharge current may vary in a wider range.
  2. NOTE 2- In some systems the load current must be supplied at the same time as the battery charging current

### **Period of high state of charge**

Typically, batteries will be operated at high state of charge between 80 to 100% of rated capacity unless batteries & systems are not properly sized. The system designer should choose the maximum charge voltage of the battery (as applicable to each battery technology) as a compromise allowing to recover to a maximum state of charge (SOC) as early as possible in the seasons other than the monsoon but without substantially overcharging the battery. The overcharge increases the gas production resulting in water consumption in vented cells. In valve regulated lead acid cells, the overcharge will cause a lesser increase of water consumption and battery internal temperature there by reduction in battery life. Typically, the maximum charge voltage is 2.4 V per cell for lead-acid batteries and 1.55V per cell for vented nickel-cadmium batteries (refer manufacturers recommendations). These values are applicable for the reference temperature specified by the manufacturer. For the other batteries the values shall be given by the battery manufacturers. Charge voltage compensation shall be used according to the battery manufacturer instructions if the battery operating temperature deviates significantly from the reference temperature. The expected life-time of a battery in a PV system even kept regularly at a high state of charge may be considered less than the published life of the battery used under continuous float charge.

## **9. Commissioning and Completion of the Facilities.**

As soon as installation of the Facilities has, in the opinion of the Contractor, been completed as specified in the Technical Specifications, excluding minor items not materially affecting the operation or safety of the Facilities, the Contractor shall so notify the UNDP in writing to witness the pre- commissioning of the facility.

As soon as all works in respect of Pre-commissioning are completed and, in the opinion of the Contractor, the Facilities is ready for Commissioning, the Contractor shall so notify the **UNDP** in writing. The Contractor shall commence Commissioning of the facilities.

Commissioning of the Facilities shall be completed by the Contractor as per procedures detailed in the Technical Specifications and in the presence of the electrical engineer or the representatives of the **UNDP**.

If the UNDP notifies the Contractor of any defects and/or deficiencies, the Contractor shall then correct such defects and/or deficiencies, and shall repeat the procedure.

If the **UNDP electrical engineer** is satisfied that the Facilities have reached Completion, the **UNDP electrical engineer** shall, within seven (7) days after receipt of the Contractor's repeat notice, issue a Completion Certificate stating that the Facilities have reached Completion as at the date of the Contractor's repeat notice.

If the **UNDP electrical engineer** is not so satisfied, then it shall notify the Contractor in writing of any defects and/or deficiencies within seven (7) days after receipt of the Contractor's repeat notice, and the above procedure shall be repeated.

As soon as possible after Completion, the Contractor shall complete all outstanding minor items so that the Facilities are fully in accordance with the requirements of the Contract, failing which the Employer will undertake such completion and deduct the costs thereof from any monies owing to the Contractor.

Upon Completion, commissioning and successful demonstration and submission of the test results, the contractor shall be responsible for the care and custody of the Facilities, together with the risk of loss or damage thereto, and shall thereafter take over the Facilities or the relevant part thereof for the agreed duration of operation and maintenance as stipulated and mutually agreed terms and conditions.