Sr. No.	Activities	Supplier/ EPC	Purchaser/ HPCL
9	MMS Earthing	S	
10	Inverter Body/Dedicated Earthing	S	
11	ESE Lighting Arrester Earthing	S	
12	Complete DC Yard Earthing	S	
13	ESE Lightening Arrester	S	
14	Cable termination and jointing kits (Indoor/Outdoor)	S	
15	Cable Tray along with Support structure/HDPE Pipe/Hume Pipe/Conduits for cable laying wherever required	S	
16	Connection accessories – lugs, ferrules, glands etc.	S	
17	Module Mounting Structures (Fix/ Seasonal Tilt structure) with associated accessories and Hardware fasteners	S	
18	Associated civil foundations for MMS	S	
	AC Part		
1	Supply of Power Conditioning Units (String Inverters)	S	
2	Unloading at site, storage, inter carting, shipping on desired location from storage yard, Security and Installation of Inverter	S	
3	LV Power Cable between Inverter and ACCB/LV Panel/ Inverter Transformer	S	
4	Cable Tray along with Support structure/HDPE Pipe/Hume Pipe/Conduits for cable laying wherever required	S	
5	Relay	S	
6	AC Earthing as per Design requirement	S	
7	Lightning Arresters of suitable ratings and arrangements of complete solar plant	S	

Sr. No.	Activities	Supplier/ EPC	Purchaser/ HPCL
8	Surge Protection devices and Fuses	S	
9	Rubber Mats for specific kV ratings	S	
10	Termination at HPCL SS end	S	
11	Termination of DC and AC cable along with termination kit, suitable lugs	S	
D	**Civil Works**		
1	All civil works related to MMS structure	S	
2	MMS Foundation as per design concept	S	
3	Lighting Arrester Foundation	S	
4	Inverter Mounting Structure & Foundation	S	
5	Earthing pits, Earth pit chambers with covers and earthing arrangement	S	
6	Soil Excavation and disposing, LV Cable Laying and back filling (inside the Plant boundary)	S	
7	Cross over of different types of cables, Road crossing with hume Pipe	S	
8	Foundation and Civil Work for Inverter	S	
9	Cable trench and associate civil work as per design requirement	S	
D	**General Scope**		
1	Plant Design and Layout	S	
2	Loading & Unloading of equipment's of Bidders scope of work	S	
3	Hiring Crane/Hydra for installation of equipment	S	
4	Shifting and movement of materials inside the plant	S	
5	Danger sign plates, anti-climbing, bird protection etc.	S	

Sr. No.	Activities	Supplier/ EPC	Purchaser/ HPCL
6	Responsibility of damaging materials while installation/ testing or commissioning	S	
7	Clearing of scrap after completion of work	S	
8	All labor and supervisors' safety precautions	S	
9	Spares as per List provided	S	

I. TECHNICAL SPECIFICATIONS:

1.1 PHOTOVOLTAIC MODULES:

a. The Contractor shall employ solar PV module of Crystalline-Si (Poly) solar technology only. The Contractor shall provide detail Technical Data Sheets, Certifications of Standard Testing Conditions (STC: defined as Standard Testing Condition with air mass AM1.5, irradiance 1000W/m^2, and cell temperature 25°C) as per the latest edition of IEC 61215 and as tested by IEC / MNRE recognized test laboratory. The Bidder shall also specify the minimum guaranteed energy output of solar PV module as per the Site Condition in the Bid.

b. The PV modules to be employed shall be of minimum 72-cell configuration with rated power of **module ≥ 300Wp** as certified for solar PV module power performance test as prescribed by latest edition of IEC 61215 and as tested by IEC / MNRE recognized test laboratory. The maximum tolerance in the rated power of solar PV module shall have maximum tolerance of +3%. **No negative tolerance** in the rated capacity of solar PV module is allowed.

c. All modules shall be certified IEC 61215 2nd Ed. (Design qualification and type approval for Crystalline Si modules), IEC 61730 (PV module safety qualification testing @ 1000 V DC or higher).

d. Minimum certified module efficiency shall be minimum 16% for crystalline.

e. All photovoltaic modules should carry a performance warranty of >90% during the first 10 years, and >80% during the next 15 years. Further, module shall have minimum performance warranty of > 97% during the first year of installation.

f. The module mismatch losses for modules connected to an inverter should be less than 1%.

g. SPV module shall have module safety class-II and should be highly reliable, light weight and must have a service life of more than 25 years.

h. The SPV module shall be made up of high transitivity glass & front surface shall give high encapsulation gain and the module shall consists of impact resistance, low

iron and high transmission toughened glass.

i. The module frame shall be made of corrosion resistant material, which shall be electrically compatible with the structural material used for mounting the modules. The SPV modules shall have suitable encapsulation and sealing arrangements to protect the silicon cells from environment. The encapsulation arrangement shall ensure complete moisture proofing for the entire life of solar modules.

j. The module frame should have been made of Aluminium or corrosion resistant material, which shall be electrolytic ally compatible with the structural material used for mounting the modules with sufficient no. of grounding/installation.

k. All materials used for manufacturing solar PV module shall have a proven history of reliability and stable operation in external applications. It shall perform satisfactorily in relative humidity up to 95% with temperature between -40°C to +85°C and shall withstand adverse climatic conditions, such as high speed wind, blow with dust, sand particles, saline climatic / soil conditions and for wind 180 km/hr on the surface of the panel.

l. Modules shall compulsorily bear following information in the form of ID encapsulated with solar cell in the manner so as not to cast shadow on the active area and to be clearly visible from the top.

m. HPCL or its authorized representative reserves the right to inspect the modules at the manufacturer's site prior to dispatch.

n. The Bidder is advised to check and ensure the availability of modules prior to submitting the Tender Document

o. The Contractor would be required to maintain accessibility to the list of module IDs along with the parametric data for each module as below:

Table 5-1 Information to be displayed on solar PV module

Sr.	Particulars
1	Name of the manufacturer of the PV module and RFID code
2	Name of the manufacturer of solar cells

3	Month & year of the manufacture (separate for solar cells and modules)
4	Country of origin (separately for solar cells and module)
5	I-V curve for the module at standard test condition (1000 w/m^2 , AM 1.5, 25^oC
6	Wattage, Imp, Vmp, Isc, Voc, temperature co-efficient of power and FF for the module
7	Unique Serial No. and Model No. of the module
8	Date and year of obtaining IEC PV module qualification certificate
9	Name of the test lab issuing IEC certificate
10	Other relevant information on traceability of solar cells and module as per ISO 9001 and ISO 14001

1.2 JUNCTION BOX / COMBINER BOX

a. The Contractor shall provide sufficient no. of Array Junction Boxes / PV combiner boxes / DCDBs.

b. All switch boards shall be provided with adequately rated copper bus-bar, incoming control, outgoing control etc. as a separate compartment inside the panel to meet the requirements of the Discom, Chief Electrical Inspector of Government (CEIG), GEDA, MNRE, STU. 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 rating.

c. The degree of protection for following equipment shall be IP 65.

d. All junction/ combiner boxes including the module junction box, string junction box, array junction box and main junction box should be equipped with appropriate functionality, safety (including fuses, grounding, etc.), string monitoring capabilities, and protection.

e. Each Array Junction Box shall have suitable Reverse Blocking Diodes of maximum DC blocking voltage of 1000 V with suitable arrangement for its connecting. The Array Junction Box shall also have suitable surge protection device. In addition, over

voltage protection shall be provided between positive and negative conductor and earth ground such as Surge Protection Device (SPD) or on-load DC disconnectors with shoes. All incoming & outgoing cables must be terminated with Brass Gland for Cu Cables & Steel Gland for Al Cables. All Glands must be of Double Compression type for Outdoor duty & Single Compression type for Indoor duty. The rating of the Junction Boxes shall be suitable with adequate safety factor to inter connect the Solar PV array.

f. The Junction Boxes shall have suitable arrangement for the followings

- Combine groups of modules into independent charging sub-arrays that will be wired into the controller.
- Provide arrangement for disconnection for each of the groups.
- Provide a test point for each sub-group for quick fault location.
- To provide group array isolation

g. The junction boxes shall be dust, vermin, and waterproof and made of thermoplastic in compliance with IEC 62208, which should be sunlight/ UV resistive as well as fire retardant & must have minimum protection to IP 65(Outdoor and Protection Class II.

h. The terminals will be connected to copper bus-bar arrangement of proper sizes to be provided. The junction boxes will have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables.

i. The current carrying rating of the Junction Boxes shall be rated with standard safety factor to interconnect the Solar PV array.

j. Suitable markings shall be provided on the bus-bars for easy identification and cable ferrules will be fitted at the cable termination points for identification.

k. Adequate capacity solar DC fuses & isolating miniature circuit breakers / MCCB should be provided if required. The Junction Box must have space for the maintenance and spare Install Capacity for future integration. For SJB with upto 25 inputs 2 inputs shall be kept in spare, for SJB with more than 25 inputs, 3 inputs shall be kept in spare

l. Detailed junction box specifications and data sheet shall be provided in the Technical Bid document.

m. Other Sub systems and components used in the SPV power plants (Cables,connectors, Junction Boxes, Surge Protection devices, etc.) must also confirm to the relevant international /national standards for electrical safety besides that for quality required for ensuring expected service life and weather resistance. It is recommended that the interim, the cables of 600-1800 Volts DC for outdoor installations should comply with the draft EN 50618 or Equivalent to other Indian / American / European Standard for service life expectancy of 25 years.

1.3 INVERTER AND POWER CONDITIONING UNIT (PCU):

Parameter	**Specification**
Type of Inverter	String
Rated AC power	As per design
Maximum input voltage	1000V/1500V
Rated AC output voltage	415V+/- 10% ,3 Phase
Tolerance on rated AC output voltage	+/-10%
Rated frequency	50 Hz
Operating frequency range	47.5 Hz to 52 Hz
Power factor control range	0.85 lag to 0.85 lead
European efficiency	Minimum 98%
Maximum loss in Sleep Mode	0.05% of rated AC power
Total Harmonic Distortion	Less than 3% at 100% load
Degree of protection	IP65

a. The rated/ name plate AC capacity of the Inverter shall be AC power output of the Inverter at 50°C.

b. The PCU output shall always follow the grid in terms of voltage and frequency. The operating voltage and frequency range of the inverter shall be sufficient enough to

accommodate the allowable grid voltage and frequency variations.

c. The Contractor has to provide sufficient information to the satisfaction of HPCL before placing the final order for PCUs/Inverters. Power Conditioning Unit (PCU) shall consist of an electronic inverter with latest technology available in the market along with associated control.

d. All PCUs should consist of associated control, protection and data logging devices and remote monitoring hardware, software for string level monitoring.

e. No. of inverters to be supplied shall be worked out by contractor based on DC rating of inverter, Pnom ratio (Pnominal array/ Pnominal inverter) shall ber as per optimum desing to deliver higher output.

f. The Bidder shall guarantee average annual power loss due to non-threshold condition to be less than 0.1% and shall support the claim with necessary document / data / graphs in the Bid.

g. Inverters shall be capable of operating at varying power factor preferably in between 0.85 lag to 0.85 lead and shall be able to inject or absorb reactive power.

h. Inverters shall operate at ambient temperature of 50°C without deration.

i. The up-time of Inverters should be of 99% in a year, in case of failing to achieve this due to failure of any component of inverter the Contractor shall either replace the inverter or the component at his own cost.

j. All inverters shall be tested for IEEE 519 &IEC 62116 standard.

k. DC input terminals must be in enough numbers so as each terminal is connected to dedicated single input. Two DC inputs cannot be connected on the single input DC terminal of the inverter. If adequate number of input are not available in the selected inverter by the Contractor then a weather proof DC junction box with copper busbar, protection devices such as fuse, DC disconnects may be incorporated in to design.

l. The PCU shall be tropicalized and design shall be compatible with conditions prevailing at site. Provision of exhaust fan with proper ducting for cooling of PCU's should be incorporated in the PCU's, keeping in mind the extreme climatic condition of the site.

m. The inverters shall have minimum protection to IP 65(Outdoor) and Protection Class II.

n. Nuts & bolts and the PCU enclosure shall have to be adequately protected taking into consideration the atmosphere and weather prevailing in the area.

o. (Grid Connectivity) Relevant CERC/GERC/GETCO/GoG regulations and grid code as amended and revised from time to time shall be complied.The system shall incorporate a uni-directional inverter and should be designed to supply the AC power to the grid at load end. The power-conditioning unit shall adjust the voltage & frequency levels to suit the Grid.

p. All three phases shall be supervised with respect to rise/fall in programmable threshold values of frequency.

q. The inverter output shall always follow the grid in terms of voltage and frequency. This shall be achieved by sensing the grid voltage and phase and feeding this information to the feedback loop of the inverter. Thus control variable then controls the output voltage and frequency of the inverter, so that inverter is always synchronized with the grid.

r. This should be capable of synchronize maximum within 2 Minutes.

s. The PCU shall be capable of controlling power factor dynamically.

t. 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 and make of MPPT shall be mentioned by the Bidder in the Bid. The MPPT must have provision for constant voltage operation. The MPPT unit shall confirm to IEC 62093 for design qualification.

u. The system shall automatically “wake up” in the morning and begin to export power provided there is sufficient solar energy and the grid voltage and frequency is in range.

v. 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.

w. 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.

x. 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.

y. The PCU shall include appropriate self-protective and self-diagnostic feature to protect itself and the PV array from damage in the event of PCU component failure or from parameters beyond the PCU's safe operating range due to internal or external causes. The self-protective features shall not allow signals from the PCU front panel to cause the PCU to be operated in a manner which may be unsafe or damaging. Faults due to malfunctioning within the PCU, including commutation failure, shall be cleared by the PCU protective devices. In addition, it shall have following minimum protection against various possible faults

z. Earth Leakage Faults: The PCU shall have the required protection arrangements against earth leakage faults and –Ve DC directional protection

aa. 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).

bb. PCU shall have arrangement for adjusting DC input current and should trip against sustainable fault downstream and shall not start till the fault is rectified.

cc. Anti-islanding (Protection against Islanding of grid): The PCU shall have anti islanding protection. (IEEE 1547/UL 1741/ equivalent BIS standard).

dd. Unequal Phases: The system shall tend to balance unequal phase voltage.

ee. The inverter should have an inbuilt cooling fan.

ff. Reactive Power: The output power factor of the PCU should be of suitable range to supply or sink reactive power. The PCU shall have internal protection arrangement against any sustained fault in the feeder line and against lightning in the feeder line.

gg. Isolation: The PCU 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 PCU.

hh. All inverters/ PCUs 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. Circuit breakers used in the DC lines must be rated suitably.

ii. Sinusoidal current modulation with excellent dynamic response.

jj. Compact and weather proof housing.

kk. No load loss < 1% of rated power and maximum loss in sleep mode shall be less than 0.05%.

ll. PCU shall have protection against over current, sync loss, over temperature, DC bus over voltage, cooling fan failure (if provided), short circuit, lightening, earth fault, surge voltage induced at output due to external source, power regulation in the event of thermal overloading.

mm. The power conditioner must be entirely self-managing and stable in operation. A self- diagnostic system check should occur on start up. Functions should include a test of key parameters on start up.

nn. Over voltage protection against atmospheric lightning discharge to the PV array is required.

oo. The power conditioner must be entirely self-managing and stable in operation. A self- diagnostic system check should occur on start up. Functions should include a test of key parameters on start up.

pp. Documentary Requirements & Inspection.

- The bill of materials associated with PCUs should be clearly indicated while delivering the equipment.
- The Contractor shall provide to HPCL data sheet containing detailed technical specifications of all the inverters and PCUs. Operation & Maintenance manual should be furnished by the Bidder before dispatch of PCUs.

<u>Note:</u> The Company or its authorized representative reserves the right to inspect the PCUs/ Inverters at the manufacturer's site prior to dispatch.

1.4 CABLES AND WIRES:

a. All cables and connectors for use for installation of solar field must be of solar grade which can withstand harsh environment conditions for 25 years and voltages as per latest IEC standards. (Note: IEC standards for DC cables for PV systems is under development, the cables of 600- 1800 volts DC for outdoor installations should comply with the draft EN 50618 for service life expectancy of 25 years and alternate American / European / Indian Standards are accepted with detail report.)

b. Wires with sufficient 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). PV Modules should be connected with USE-2/RHW-2 cables array to junction box conductors and junction box to photovoltaic disconnector with the THHN/THWN-2 sunlight resistant with 90ºC wet rated insulation cable. Due consideration shall be made for the de-rating of the cables with respect to the laying pattern in buried trenches / on cable trays, while sizing the cables. The Contractor shall provide voltage drop calculations in excel sheet.

c. Irrespective of utilization voltage and current rating all type of power cables shall be minimum of 1100 V grade PVC insulated conforming to IS 1554 / IS 694/IEC 60502 for working voltage less than 150 V control cable shall be of minimum 500 V grade, the control and power cable has to be laid separately. All LT XLPE cables shall confirm to IS: 7098 Part I & II.

d. The cables shall be adequately insulated for the voltage required and shall be suitably color coded for the required service. Bending radius for cables shall be as per manufacturer's recommendations and IS: 1255.

e. Packing and marking shall be as per clause No. 18 of IS 7098 (part I)/1988 amended up to date.

f. Cables inside the electrical /telecom room shall be laid in Galvanized Cable Trays mounted on mild steel supports duly painted, in constructed trenches with RCC raft

and brick sidewalls and provided with removable RCC covers.

g. 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.

h. All cable/wires shall be provided with Punched Aluminium tags only. 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.

i. The Interconnecting Wires and connectors of the Solar Modules should be routed through Rigid PVC/ HD Pipes of suitable diameter only. The open end of the pipes should be filled with Silicone gel to avoid any ingression of water, insects, rodents etc.

j. Cable end terminations and joint kits shall comply with the latest version of the relevant IS standard.

k. The cable ends shall be terminated with adequate size copper lugs and sockets etc, single/double compression cable glands. Cable glands shall be of robust construction capable of clamping cable and cable armor (for armored cables) firmly without injury to insulation. The metallic glands shall be earthed at two locations. Suitable lock type crimping lugs shall be used for cable end terminations. Where cables are raising from ground, suitable PVC pipe guarding shall be provided for cable raising with sealing of the guarding PVC pipe including a suitable clamp.

Table 5-3 Relevant Codes & Standards for Cable

Sr.	Item	Relevant IS	Relevant IEC
1	Conductors of Insulated Cables	IS: 8130 – 1984	**IEC: 228**
2	Impulse tests on cables and their accessories		**IEC: 230**
3	Test methods for insulations and sheaths of electric cables and chords.		**IEC: 540**

4	Test on cable over a sheath which has special protective functions and are applied by extrusion.	**IEC: 229**
5	Calculations of continuous current rating of cables (100% load factor).	**IEC: 287**
6	PVC insulation & sheath of electrical cables.	IS: 5831 – 1984
7	Mild steel wires, formed wires and tapes for armouring of cables.	IS: 3975
8	Methods of test for cables.	IS: 10810
9	Common test methods for insulating and sheathing materials of electric cables.	**IEC: 811**

2 TECHNICAL SPECIFICATION OF LT CABLES:

a. General Constructional Features

The medium voltage cables shall be supplied, laid, connected, tested and commissioned in accordance with the drawings, specifications, relevant Indian Standards specifications, manufacturer's instructions. The cables shall be delivered at site in original drums with manufacturer's name, size, and type, clearly written on the drums.

- Material:

Medium voltage cable shall be XLPE insulated. PVC sheathed, aluminium or copper conductor, armoured conforming to IS: 7098 Part I.

- Type:

The cables shall be circular, multi core, annealed copper or aluminium conductor, XLPE insulated and PVC sheathed, armoured.

- Conductor:

Uncoated, annealed copper, of high conductivity up to 4 mm² size, the conductor shall be solid and above 4 mm², conductors shall be concentrically stranded as per IEC:228. Allowable solid Cu. Conductor up to 4 mm² for power wiring. All control wiring must be through Flexible Cu. Conductor.

- Insulation:XLPE rated 90° c. extruded insulation.
- Core Identification:

Two core	:	Red and Black
Three core	:	Red, Yellow and Blue
Four core	:	Red, Yellow, Blue and Black
Single core	:	Green cable with Yellow strips for earthing

Black shall always be used for neutral.

- Assembly:

Two, three or four insulated conductors shall be laid up, filled with non-hygroscopic material and covered with an additional layer of thermoplastic material.

- Armour: Galvanised steel flat strip / round wires applied helically in single layers complete with covering the assembly of cores.

For AC cable Armour of non magnetic 1.4 mm dia round wire

For DC cable Armour of 4 mm wide 0.8 mm thick strip

- Sheath:

The cable shall be rated extruded for XLPE 90 deg.c. Inner sheath shall be extruded type and shall be compatible with the insulation provided for the cables.

Outer sheath shall be of an extruded type layer of suitable PVC material compatible with the specified ambient temp 50 deg. C and operating temperature of cables. The sheath shall be resistant to water, ultraviolet radiation, fungus, termite and rodent attacks. The colour of outer sheath shall be black. Sequential length marking required at every 1.0 meter interval on outer sheath shall be available. The contractor has to furnish resistance / reactance / capacitances of the cable in the technical datasheet.

- Rating:

Up to and including 1100 Volts.

1.5 CLAMPS AND CONNECTORS:

a. The bus-support clamps, spacers, T-connectors and various equipment

connectors shall be supplied as per the enclosed drawings. The material to be used for these items shall be generally as per the Table 5-4.

b. The materials shall be of the best workmanship, and all the sharp edges and corners shall be rounded off. The thickness of tinning, wherever applicable, shall be not less than 10 microns. The minimum thickness of pads made of copper shall be 10 mm and those made out of Aluminium/Aluminium Alloy, shall be 12 mm, unless otherwise indicated in the specifications.

c. All the clamps and connectors shall be designed to carry a continuous current not less than 125% of the rated current of the conductor (twin/single as the case may be)/equipment terminal to which these are to be connected. Temperature rise of the connector under the above condition shall not be more than 50% of the temperature of the main conductor/equipment terminal.

Table 5-4 Clamps & Connectors

Sr.	Application	Material
1.	Bolted type connection	
2.	For connection to ACSR/AAAC/ Aluminum Terminal	Aluminum Alloy conforming to designate A6 as per IS 617
3.	For connection to copper terminals, with crimping facility to connect ACSR/AAAC jumper	Electrolytic grade copper, forged and tinned
4.	Crimping type connection	
5.	For connection to ACSR/AAAC jumper	Electrolytic grade aluminum

d. All the fasteners (i.e. nut-bolts, washers, check-nuts, etc.) used in the clamps and connectors shall be of non-magnetic stainless steel. The straight

bolts shall be fully threaded, and the U-bolts shall be threaded up to 30 mm from the ends. For connectors made out of Aluminium/Aluminium Alloy, the bolts shall be of 12 mm diameter, and for copper connectors the bolts shall be of 10 mm diameter.

e. The clamps and connectors meant for ACSR and AAAC (525 sq.mm) shall have the same crimping dimensions. It shall be possible to use the same clamp/connector for ACSR or AAAC, as would be required, without any modification/change at site.

f. The length of bolt shall be chosen such that after fully tightening the nut and check- nut, minimum 5 (five) threads of the bolt shall project outside the nut/check-nut.

g. As an alternative to the various types of clamps and connectors detailed under 2.0 above, the Contractors may offer connectors of Power Fired Wedge Pressure Technology (PFWPT). However, the same needs to be specified in the Bid.

h. Connectors of PFWPT type shall meet the general requirements for various connections/joints as indicated in the relevant drawings.

i. PFWPT type connectors shall comprise of:

- Tapered `C' - shaped spring member
- Wedge for connecting solid/stranded conductor, along with handle, suitable for connection between:
  - Aluminium & Aluminium
  - Copper & Copper
  - Aluminium & Copper
  - Aluminium & Al. Alloy
  - Copper & Al. Alloy
  - Al. Alloy & Al. Alloy

j. Components of the PFWPT type connectors shall be made of Aluminium

Alloy suitably heat-treated to ensure that the required Mechanical & Electrical parameters are in line with ANS 1 specification no. C 119.4-1991. The connectors shall have

k. `self-cleaning' capability during application. The connector shall ensure stable and low contact resistance under varying load conditions and the thermal cycling effects.

l. The special tools and tackles required for installation of the PFWPT type connectors shall be identified in the offer. One set of these bolts and tackles shall be included in the scope of supply.

m. The Contractor shall furnish the following information in their bill of material:

n. Availability of the PGWT connectors indigenously.

o. Unit rate of each item

p. Not-withstanding anything stated above, the final decision regarding acceptance of the type of clamps and connectors (conventional/PFWPT type) shall rest with HPCL .

1.6 LIGHTENING PROTECTION FOR PV ARRAY:

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 tolerable level before it reaches the PV or other sub-system components as per IEC 62305, IS: 2309 – 1989 (Reaffirmed – 2005), Edition 3.1 (2006-01).

a. 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.

b. The lightning conductor shall be earthed through flats and connected to the earth mats as per applicable Indian Standards with earth pits. Minimum Two earth pits shall be provided for each lightening arrestor. Each lightning conductor shall be fitted with individual earth pit in parallel as per required Standards including

accessories, and providing masonry/ precast enclosure with cast iron cover plate having locking arrangement, watering pipe using charcoal or coke and salt as required as per provisions of IS 3043 & Earth Resistance of Lightening System must be less than one (1) Ohm.

c. If necessary more numbers of lightning conductors may be provided. The Contractor is also free to provide Franklin rod / Early Streamer type of lightning arrestors on the MMS structure designed in such a way not to cast shadow on the next raw of solar PV modules. The Contractor to submit necessary calculations based upon rolling sphere method for the Lightening protection system.

d. The Contractor shall submit the drawings and detailed specifications of the PV array lightning protection equipment to HPCL for approval before installation of system.

1.7 PROTECTIVE RELAYS:

a. The Solar PV system and the associated power evacuation system interconnections should be protected as per IEC 61727 Ed.2, norms. Over current relays, reverse power relays, differential protection relays, Transformer Protection and earth fault relays have to be essentially provided. All relay should be numerical type.

b. Detailed Design calculations shall be provided on fault power computations and the philosophy of protective relaying with respect to short circuit kA calculations. The Company/Electricity Authority shall approve design, drawing and model of protection relay.

1.8 LIGHTENING ARRESTOR

a. Type and Rating

Lightning arrestor shall be station class, heavy duty, non-linear resistance type with rating as per design . The arrestor shall have adequate thermal discharge capacity for severe switching surges, long duration surges and multiple strokes.

b. Constructional Features

- The arrestor shall be single pole and hermetically sealed off. It shall be of robust construction with excellent electrical and mechanical characteristics.
- Insulators must be non-hygroscopic and shall be wet process porcelain, brown

glazed and free from imperfection. All metal parts and hardware shall be hot dip galvanized.

- Cree page distance shall correspond to heavily polluted atmosphere. Grading ring in required shall be provided to maintain voltage gradient within permissible limit.
- The arrestor shall be provided with pressure relief device if applicable to prevent shattering of approach in case excessive gas pressures build up.

c. Accessories

- Lightning arrestor shall be furnished complete with insulating base, surge counter and anchoring hardware for mounting on steel structure.
- A surge counter shall be mounted at a convenient height for reading counter Terminals shall be such as to permit connections with minimum bends.
- A leakage current detector shall be furnished with the counter as an integrate part. This is for monitoring the leakage to indicate any possible breakdown.
- A suitable sized bypass shunt along with necessary terminals shall be furnished for bypassing the discharge counter if required.

d. Terminals

- All connection terminals shall be of corrosion resistant material and shall be provided with complete connection hardware.

1.90 EARTHING FOR PV ARRAY:

a. The photovoltaic modules, BOS and other components of power plant requires adequate earthing for protecting against any serious faults as guided by IEC 60364.

b. The earthing system shall be designed with consideration of the earth resistivity of the project area. The earth resistivity values shall be measured prior to designing the earthing system. Unless otherwise specified, earthing system shall be in accordance with IS: 3043 regulations existing in the location where the system is being installed.

c. The earthing for array and LT power system shall be made of electrodes including accessories, and providing masonry enclosure with cast iron cover plate as required as per provisions of IS: 3043.

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

e. Each string/ array and MMS of the plant shall be grounded properly. The array structures are to be connected to earth pits as per IS standards. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance.

f. The complete earthing system shall be mechanically & electrically connected to provide independent return to earth.

g. In compliance to Rule 11 and 61 of Indian Electricity Rules, 1956 (as amended up to date), all non-current carrying metal parts shall be earthed with two separate and distinct earth continuity conductors to an efficient earth electrode.

h. The Contractor should submit the earthing system design calculations along with the system layout for the Company's approval prior to the installation of the system

- **LIGHTENING PROTECTION FOR PV PLANT & EARTHING**:

a. 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 tolerable level before it reaches the PV or other sub-system components as per IEC 60099 / IS: 2309 – 1989 (Reaffirmed – 2005), Edition 3.1 (2006-01). Lightening Protection System required for Solar PV Plant, Inverter Room, and Substation Structure & Control Room within the EPC scope of work. The intent of specification can be conventional as per IS : 2309 or can be Early Streamer Emission Type depending upon Area, Protected Equipment & Technical feasibility. Necessary concrete foundation 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.

b. The lightning conductor shall be earthed through flats and connected to the earth mats as per applicable Indian Standards with earth pits. 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, chemical compound as per provisions of IS.

c. If necessary more numbers of lightning conductors may be provided as per design calculation

d. The Contractor shall submit the drawings and detailed specifications of the PV array lightning protection equipment.

e. The design, manufacture, inspection, testing and performance of Lightning Arrester shall comply with all currently applicable statutes, safety codes, provision of latest Indian Electricity Act, Indian Electricity Rules and Regulations of Statutory Authorities.

f. Contractor shall provide dedicated two earth pits for Lightening Arrestor as per relevant IS standard.

1.10 METERING SYSTEM

a. The Solar power would be used for captive consumption of HPCL and excess generated power will be fed into the local grid. Bi directional energy meter shall be provided as approved by GETCO/Discom/ CEIG/ GEDA to measure the delivered quantum of energy to the grid for sale. The responsibility of arranging for the meter, its procurement, inspection, calibration, testing charges etc. rests with the Contractor. All charges incurred on Meter testing, shall be borne by the Contractor. Energy metering system is to be approved by DisCom.

b. The Bidder shall provide meters at the interface points. Interface metering shall conform to the Central Electricity Authority (Installation and Operation Meters) Regulation 2006 and amendment thereof Commercial settlement of solar Photovoltaic Grid Interactive based power project shall be in accordance with the HPCL order.

1.11 DETAILED CIVIL AND OTHER NON-ELECTRICAL WORK

All material, installations, fixtures, accessories etc. to be provided shall be as per the relevant IS specifications. These shall be of best quality and of standard manufacturer