

marked signage of SS sheet of 1mm along with engraving words and filled with black color at all facilities within Control cum Conference room and on all equipment. The lighting points and fixtures shall be of Anchor/Philips make. The fans shall be of Khaitan/Usha/Bajaj make and lights (only LED shall be used) shall be of Philips/Syska/Havells make.

**iv. Structural Steel, Insulated Walls and Roof for Super structure (prefabricated inverter room):**

Design of Super-Structure i.e. Steel Structure like purlin, rafter, columns, truss etc. for fixing the Pre-Fabricated Panels conforming to relevant IS codes and of Jindal/Tata/ RINL make. It shall include all necessary fitting like nuts, bolts, washers etc. of good quality. All structural steel shall be treated with two coats of red oxide and three coats of Oil paint (Asian Paints, Berger, Durex). The gap between base plate of structural members and concrete top of foundation shall be filled with GP-2 grouting material of reputed make. The material of all J-bolts shall be of 8.8 Class. The Insulated panels should be of required size for roof and walls. The insulated wall and roof panels shall be sandwich type. The panels shall be made out with 0.35 mm thick pre coated steel sheet on both side of Poly Urethane Foam (PUF) for both wall and roof. The density of PUF shall be  $40 \pm 2$  kg/m<sup>3</sup> and thermal conductivity shall be within range of 0.019-0.021 W/m<sup>2</sup>K at 10°C. The total thickness of the panels for walls shall be 60mm and for roof is 40mm. The panels shall be joined together by tongue and groove method. The joints of the panels shall be filled with silicon or equivalent filling material. Panels shall be cuts such that the exposure of PUF and patch work is avoided. The fixing of the panels shall be such that there should not be any gaps at joints like wall and roof, wall to wall, etc. from which air and water particle can pass (Air and Water tight). Roof panel shall be extended 300 mm from the eaves wall and 150 mm from Gable walls. Rain water gutter shall be provided throughout the periphery with rain water pipes (CPVC pipes) with proper clamping at regular interval. Provision of future installation of Solar panels on the top of the roof shall be done by I or C section with Small base plate assembly.

**v. Landscaping:**

Landscaping in surrounding area of 2 meter of Main Control Room is to be done using aesthetically pleasing and suitable varieties of flora.

**vi. Flooring:**

Best quality Vitrified tile flooring having min size of 600 mm x 600 mm x 8-10 mm thickness of standard manufacturers as approved by EIC.

**vii. Toilet:**

Toilet shall be designed for 10 persons; and constructed with following finish

- Floor: Vitrified tiles
- Door and window: made out of aluminum brown anodized sections, 6mm float glass
- Ventilators: Mechanical exhaust facility
- Plumbing fixtures: Jaquar and Kohler make
- Sanitary ware: Hindware, Cera or equivalent make
- EWC: 390 mm high with health facet, toilet paper roll holder and all fittings
- Urinal (430 x 260 x 350 mm size) with all fittings.
- Wash basin (550 x 400 mm) with all fittings.

- Bathroom mirror (600 x 450 x 6 mm thick) hard board backing
- CP brass towel rail (600 x 20 mm) with C.P. brass brackets
- Soap holder and liquid soap dispenser.

**vii. Doors and Windows:**

Doors and windows shall be made of aluminum sections. All sections shall be 20 microns anodized. Sections of door frame and window frame shall be adopted as per industrial standards. Door shutters shall be made of aluminum sections and combination of compact sheet and clear float/wired glass. All windows of Control cum conference room shall be protected by Sun film protection sheet. The control room shall require a number of windows/louvers to be provided for ventilation/ fresh air circulations. All fixtures for doors and windows shall be of Dorma, Godrej and Kich make.

**viii. Water Supply for Toilets:**

GI pipes (B class) Tata or equivalent make. Separate Overhead water tank Sintex or equivalent of 2,000 liter capacity.

**ix. Drainage for Toilets:**

Drainage pipes shall be of CPVC (6 kg/cm<sup>2</sup>) Supreme, Prince or equivalent make. Gully trap, inspection chambers, septic tank for 10person and soak well to be constructed for abovementioned requirement.

**x. Air Conditioner for Control Room:**

The control room shall be equipped with appropriate numbers of fans for effective heat dissipation. The SCADA cabin and Conference room shall have split type air conditioning units.

**xi. Fire Extinguishers:**

Liquefied CO<sub>2</sub> fire extinguisher shall be up right type of capacity 10 kg having IS: 2171. 7 IS: 10658 marked. The fire extinguisher shall be suitable for fighting fire of Oils, Solvents, Gases, Paints, Varnishes, Electrical Wiring, Live Machinery Fires, and All Flammable Liquid & Gas. Bidder shall provide at least 10 no. of portable fire extinguisher.

**xii. Sand Bucket:**

Sand buckets should be wall mounted, made from at least 24 SWG sheet with bracket fixing on wall conforming to IS 2546. Bucket stands with four buckets on each stand shall be provided in the Transformer Yard – 4 Nos.

**xiii. Sign Boards:**

The sign board containing brief description of various components of the power plant as well as the complete power plant in general shall be installed at appropriate locations of the power plant.

- For Switchyard and Transformer Yard:

The Sign boards shall be made of steel plate of not less than 3 mm. Letters on the board shall be with appropriate illumination arrangements.

- All Inverter Rooms and Control and Conference Room:

The name boards shall be made of acrylic sheet of 300mm height and fixed at the entry of the all facilities.

The Contractor shall provide to GSECL, detailed specifications of the sign boards.

### **5.2.19 Module Mounting Structures (MMS):**

The Contractor shall design and construct appropriate civil foundations for MMS.

The array structure shall be so designed that it will occupy minimum space without sacrificing the output from Solar PV panels at the same time it will withstand severe cyclonic storm with wind speed as per IS 875 for calculations of  $V_z$ . Bidder shall take basic wind speed value i.e. 180 KMPH for respective sites as per following.

#### **Site wise wind speed to be mentioned here as per IS875.**

Pile casting for testing shall be as per IS before approval of drawing & design. Testing of pile by NABL accredited laboratory

It shall support Solar PV modules at a given orientation, absorb and transfer the mechanical loads to the ground properly. There shall be no requirement of welding or complex machinery at site and is strictly not allowed.

Seismic factors for the site to be considered while making the design of the foundation/ramming etc. or any technology. The design of array structure shall be based on soil test report of the site and shall be approved from GSECL/Consultant.

The Contractor has to plan for pilot test like pull out; lateral and compression of minimum 10,10,3 are required to be conducted for each floor at strategic location, immediately. Based on the results of above-mentioned tests, final approval for design of pile shall be provided.

The material of construction, structural design and workmanship shall be appropriate with a factor of safety of not less than 1.5.

For multiple module mounting structures located in a single row, the alignment of all modules shall be within an error limit of 5 mm in vertical / horizontal line.

The Contractor shall provide to GSECL the detailed design, specifications and calculations of the MMS and take approval from GSECL.

The Contractor shall specify installation details of the Solar PV modules and the support structures with appropriate diagrams and drawings.

The Module Mounting Structure design shall be certified by a chartered structural engineer and it is mandatory.

The Contractor should design the structure height considering highest flood level at the site. The minimum clearance between the lower edge of the module and the ground shall be the higher of (i) above highest flood level at the site and (ii) minimum 500 mm.

The Contractor shall provide to the Company the detailed design, specifications and calculations of the MMS during **detailed engineering**.

Curing of all piles shall be done thrice a day and be maintained for a period of seven days from the date of casting.

The Contractor has to ensure sufficient lighting arrangement for all concreting activities during night time. Sufficient illumination should be ensured in and around areas wherever civil and construction activities take place during night time.

The Contractor shall specify installation details of the Solar PV modules and the support structures with appropriate diagrams and drawings.

The Bidder shall be permitted ramming of the module mounting structure provided that they obtain consent of EIC. EIC shall provide such consent once it is convinced that such ramming shall not in any way deteriorate the strength of the structure and shall not reduce the structure's strength to enjoy a working life of more than 25 years.

Civil foundation design for Module Mounting Structures (MMS) as well as control room, inverters room shall be made in accordance with the Indian Standard Codes and soil conditions, with the help of Chartered Structural Designer having substantial experience in similar work. The Successful Bidder shall submit the detailed structural design analysis along with calculations and bases/ standards in the Bid.

Module Mounting Structures Design is to be certified by Chartered Structure Engineer and certificate to be produced along with the design details for approval by GSECL. Switchyard structures / transmission line structure designs shall be strictly as per GETCO design.

All the civil defects, rectification, repairing, replacement related to civil works shall be in the scope of contractor during the O&M period, the Contractor shall be responsible for rectification of any defect in the civil work and maintain the structure/buildings in good condition with proper maintenance. The Contractor shall be responsible for the maintenance of each civil works carried out as mentioned below.

1. Buildings Control room premises, Underground water tank includes:
  - I. Water tightness/ leak proof of roof and walls.
  - II. Painting to the structure either PEB/ RCC Framed structure at regular interval (not more than five years).
  - III. Plumbing & Sanitation related defects/replacement.
  - IV. Chalking / overflow of septic tank and soak pit.

- V. Replacement / repairing of water tank if major/minor leakage observed.
- VI. Leakage of water to be attended by suitable crack filler.
- VII. Repairing/replacement of doors, windows, ventilators & rolling shutter.
2. Road WBM or Bitumen:
  - I. Crack repairing of the road surface.
  - II. Pot-holes over the top road surface to be rectify.
  - III. Maintenance of shoulders for the rain cuts or damage due to some external reasons.
  - IV. Re-carpeting of the road surface at every five years interval.
3. Storm water Drainage:
  - I. Before and after the monsoon season the storm water drainage shall be maintained & cleaned for smoother flow of storm water.
4. Main Entry gate & Fencing:
  - I. Maintain the elegance of entry gate with painting as & when required.
  - II. Repairing & painting of precast boundary wall as & when required.

The above list is not exhaustive but indicative only. Although most of the structures are covered here in, any other system (Civil, Structural and Architectural) required for successful operation and maintenance of the works shall form a part of this contract and shall be deemed to be included in the scope of works. The scope of Bidder/EPC Contractor shall include supply of all required materials, mobilization of labour, and arrangement of required tools tackles and equipment to carry out all above civil maintenance works.

## **5.2 DETAILED ELECTRICAL WORK (For each S/s)**

### **5.3.1 Photovoltaic modules**

The Contractor shall employ solar PV module of Crystalline-Si (Poly / Multi or Mono / Single) 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<sup>2</sup>, and cell temperature 25°C) as per the latest edition of IEC 61215 and IEC 61730 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 RFP. PV module must be registered with BIS.

- i. The PV modules to be employed shall be of minimum 72 cell configuration with rated power of **module  $\geq 300$  Wp** as certified for solar PV module power performance test as prescribed by latest edition of IEC 61215 and IEC 61730 and as tested by IEC / MNRE recognized test laboratory. The maximum tolerance in the rated power of solar

PV module shall have maximum tolerance up to +3%. No negative tolerance in the rated capacity of solar PV module is allowed.

- ii. PV module must be registered with BIS.
- iii. All modules shall be certified IEC 61215 2nd Edition (Design qualification and type approval for Crystalline Si modules), IEC 61730 (PV module safety qualification testing @ 1000 V DC or higher). IEC 62804 Certified PV modules should be PID free, documents for the same should be submitted with conditions of the PID test should be for a humidity of 85 % and a cell temperature of 85<sup>0</sup> C at 1000Volts , IEC 62716 , IEC 61701.
- iv. The certified Bill of Material (BOM) to be used in the PV Modules should be the same as used during the IEC certification of reference PV Module certified by renowned agency like TUV, UL, etc.
- v. Minimum certified module efficiency shall be 15% for crystalline with minimum fill factor of 0.75. The permissible maximum temperature coefficient of power (Pmpp) shall be -0.43%/ <sup>0</sup>C or better.
- vi. All photovoltaic modules should carry a performance warranty of >90% during the first 10 years, and >80% during the next 15 years.
- vii. Further, module shall have performance warranty during the first year of installation as under.
  - Mono > 97%
  - Poly > 97.5%
- viii. The module mismatch losses for modules connected to an inverter should be less than **1%.(Maximum)**
- ix. 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.
- x. The PV modules shall be equipped with IP67 or higher protection level junction box with min. 3 by pass diodes of appropriate rating and appropriately sized output power cable of symmetric length with twist locking connectors.
- xi. The SPV module shall be made up of high transmittivity glass & front surface shall give high encapsulation gain and the module shall consists of impact resistance, low iron and high transmission toughened glass. The module frame shall be made of corrosion resistant material, which shall be electrically compatible with the structural material used for mounting the modules.
- xii. 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.

- xiii. The module frame should have been made of Aluminium or corrosion resistant material, which shall be electrolytically compatible with the structural material used for mounting the modules with sufficient no. of grounding/installation.
  - xiv. All materials used for manufacturing solar PV module shall have a proven history of reliability and stable operation in external applications. It shall perform in relevance as per IEC standards.
  - xv. Modules only with the same rating and manufacturer shall be connected to any single inverter. 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.
  - xvi. The Bidder shall provide to GSECL in the Bid, power performance test data sheets of all modules. The exact power of the module shall be indicated if the data sheet consists of a range of modules with varying output power.
  - xvii. Only those crystalline modules (above 300Wp) of the same module manufacturer which has supplied for a capacity more than 0.75MW x \*awarded project capacity, in other projects in India with minimum 1 project size of 0.075MW x\*awarded project capacity. On this account, the Contractor shall provide full information, to the satisfaction of GSECL, before placing final order for the modules. The Contractor shall also submit the proof of original purchase.
- \* this is to be noted that , cumulative capacity of awarded project shall be considered in case of single bidder are awarded project for more than one Site.
- xviii. GSECL or its authorized representative reserves the right to inspect the modules at the manufacturer's site prior to dispatch.
  - xix. The Bidder is advised to check and ensure the availability of modules prior to submitting the Tender Document.
  - xx. The Contractor would be required to maintain accessibility to the list of module IDs along with the above parametric data for each module.

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

Sr.	Particulars
<b>1</b>	Name of the manufacturer of the PV module and RFID code
<b>2</b>	Name of the manufacturer of solar cells
<b>3</b>	Month & year of the manufacture (separate for solar cells and modules)
<b>4</b>	Country of origin (separately for solar cells and module)
<b>5</b>	I-V curve for the module at standard test condition (1000 w/m <sup>2</sup> , AM



	1.5, 25°C
<b>6</b>	Wattage, Imp, Vmp, Isc, Voc, temperature co-efficient of power and FF for the module
<b>7</b>	Unique Serial No. and Model No. of the module
<b>8</b>	Date and year of obtaining IEC PV module qualification certificate
<b>9</b>	Name of the test lab issuing IEC certificate
<b>10</b>	Other relevant information on traceability of solar cells and module as per ISO 9001 and ISO 14001

#### 5.1.5 Junction Box/ Combiner Box

- i. The Contractor shall provide sufficient no. of Array Junction Boxes / PV combiner boxes / DCDBs.
- ii. 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 Chief Electrical Inspector of Government (CEIG). All live terminals and bus bars shall be shrouded. The outgoing terminals shall be suitable for connection to suitable runs and size of cables required for the Inverter/Transformer rating.
- iii. The degree of protection for following equipment shall be:
  - Indoor Junction box : IP 21
  - Outdoor Junction Box: IP 65
- iv. 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.
- v. 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. 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.

Each Array Junction Box shall have suitable Reverse Blocking Diodes / Fuses 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 dis-connectors with shoes. All incoming & outgoing cables must be terminated with Brass Gland for Cu Cables & Steel Gland for Al



Cables. Bidder can also provide polyamide glands and MC4 connector. 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.

- vi. The Junction Boxes shall have suitable arrangement for the followings
- vii. Combine groups of modules into independent charging sub-arrays that will be wired into the controller.
- viii. Provide arrangement for disconnection for each of the groups.
- ix. Provide a test point for each sub-group for quick fault location.
- x. To provide group array isolation
- xi. The rating of the Junction Boxes shall be suitable with adequate safety factor to inter connect the Solar PV array.
- xii. The junction boxes shall be dust, vermin, and water proof 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 21(indoor) and Protection Class II or higher.
- xiii. The terminals shall be connected to copper bus-bar arrangement of proper sizes. The junction boxes shall have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables.
- xiv. The current carrying rating of the Junction Boxes shall be rated with standard safety factor to interconnect the Solar PV array.
- xv. 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.
- xvi. Adequate capacity solar DC fuses & isolating miniature circuit breakers / MCCB should be provided if required. Fuses for string and outgoing DC dis-connector for SMB are allowed. The Junction Box must have space for the maintenance and 10% Spare Install Capacity for future integration.
- xvii. Detailed junction box specifications and data sheet shall be provided in the Technical Bid document.
- xviii. 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 cables of 600-1800 Volts Dc for outdoor installations should comply with the draft EN 50618 for service life expectancy of 25 years.

#### 5.1.6 Inverter and Power Conditioning Unit (PCU)

Bidder shall consider Central or String Inverters as per specifications mentioned in NIT

**(A) Central Inverters**

- i. Only those PCUs/ Inverters which are commissioned for more than \*\*0.75 MW<sup>1</sup>x awarded project capacity, capacity in other solar PV projects till date shall be considered for this project. The Contractor has to provide sufficient information to the satisfaction of GSECL 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, protection and data logging devices and must be fully communicable to SCADA with OPEN Communication Protocol. If any software required for the communication & SCADA, the same to be made available within the EPC package by the Contractor.
- ii. All PCUs should consist of associated control, protection and data logging devices and remote monitoring hardware, software for string level monitoring.
- iii. Dimension and weight of the PCU shall be indicated by the Bidder in the Bid.
- iv. Capacity of single unit of inverter shall be min. 1,000 kW. This plant shall be divided into 40-50 identical Solar PV arrays “sections”, wherein the capacity of each section varies depending upon supplier’s product capacity.
- v. No. of inverters to be supplied shall be worked out by the Contractor based on DC rating of inverter, Pnom ratio, limit on overloading capacity.
- vi. 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.
- vii. DC Injection into the grid: This shall be avoided by using a step-up transformer at the output of the inverter. DC injection shall be limited to 1% of the rated current of the inverter as per IEC 61727.
- viii. Inverters shall be capable of operating at varying power factor preferably between 0.85 lag to 0.85 lead and shall be able to inject or absorb reactive power.
- ix. Inverters shall operate at ambient temperature of 50°C without deration.
- x. 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.

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\*\*This is to be noted that 0.75 MWx awarded project capacity is for the Inverter manufacturer to test their strength and capability for supplying for this Project. Also, cumulative capacity of awarded project shall be considered in case of single bidder awarded project for more than one site.

- xi. All inverters shall be tested for IEEE 519 & IEC 62116 standard.
- xii. DC input terminals must be in enough numbers so as each terminal is connected to dedicated single input. Two DC inputs can not 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 DC junction box with protection devices such as fuse, DC disconnects may be incorporated in to design. The Bidder has to indicate the selected parameters in the Bid.
- xiii. The minimum European efficiency of the inverter shall not be less than 98% measured at 100% load as per IEC 61683 standards for measuring efficiency. The Bidder shall specify the conversion efficiency at different loads i.e. 25%, 50%, 75% and 100% in the Bid. The Bidder should specify the overload inverter capacity in the Bid.
- xiv. 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.
- xv. The inverters shall have Protection Class II or higher and minimum protection of IP as under:  
Outdoor : IP 65(Electronics )/ IP 54 (Magnetic)  
Indoor : IP 21
- xvi. Nuts & bolts and the PCU enclosure shall have to be adequately protected taking into consideration the atmosphere and weather prevailing in the area.
- xvii. (Grid Connectivity) Relevant CERC/GERC 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.
- xviii. All three phases shall be supervised with respect to rise/fall in programmable threshold values of frequency.
- xix. 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. The inverter shall be self-commutated with Pulse width modulation technology.
- xx. This should be capable to synchronize maximum within 1 Minutes.
- xxi. The PCU shall be capable of controlling power factor dynamically.
- xxii. 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 conform to IEC 62093 or **EN50330** for design qualification.

- xxiii. 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.
- xxiv. 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.
- xxv. 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.
- xxvi. 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.
- xxvii. 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.
  - a. Earth Leakage Faults: The PCU shall have the required protection arrangements against earth leakage faults and –Ve DC directional protection.
  - b. 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).
  - c. 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.
  - d. Galvanic Isolation: The PCU inverter shall have provision for galvanic isolation. 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.
  - e. Anti-islanding (Protection against Islanding of grid): The PCU shall have anti islanding protection. (IEEE 1547/UL 1741/ equivalent BIS standard).
  - f. Unequal Phases: The system shall tend to balance unequal phase voltage.
  - g. Heat Transfer / Cooling / Built in Ventilation Systems must be provided with 20% Spare capacity. Bidders to Submit Heat Rejection / Transfer calculation for Air Conditioning of Inverter Room.

- h. Inverter must be provided with –Ve earthing for protection of PV modules against possible “Potential Induced Degradation”.
- xxviii. 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.
- xxix. 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.
- xxx. 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.
  - a. Sinusoidal current modulation with excellent dynamic response.
  - b. Compact and weather proof housing.
  - c. Direct use in the outdoors with outdoor housing.
  - d. Comprehensive network management functions (including the LVRT and capability to inject reactive power to the grid).
  - e. No load loss < 1% of rated power and maximum loss in sleep mode shall be less than 0.05%.
  - f. Unit wise & integrated Data logging
  - a. **Bidder shall consider as per standard design of vendor for Ethernet networking.**
  - b. 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,
- xxxii. It shall have bus communication via interface for integration, remote control via telephone model or mini web server, integrated protection in the DC and three phase system, insulation monitoring of PV array with sequential fault location. Alternatively, the same can be provided through SCADA.
- xxxiii. Ground fault detector which is essential for large PV generators in view of appreciable discharge current with respect to ground.
- xxxiiii. 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.
- xxxv. Over voltage protection against atmospheric lightning discharge to the PV array is required.

xxxv. 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.

**xxxvi. Standards and Compliances:**

The Bidder also has to confirm the PCU specifications in the Bid.

**Table 5-2 Detailed Specifications of PCU**

Sr.	Particulars	Details
1	PCU Mounting	As per the design
2	Nominal AC Output Power	≥ 1000 kW
3	Nominal AC Output Voltage	415 Volts +15%/-10% AC / 270 V / As per design
4	Maximum Input Voltage	1500 V DC
5	Wave Form	Pure Sine wave
6	DC voltage range, MPPT	450 to 1000 volts DC / As per design
7	Minimum Efficiency at 100% load The rated European efficiency (Euro Eta Efficiency) and peak efficiency	≥ 98%, measured as per IEC 61683 standard for measuring efficiency. * Inverter No Load / Full Load Loss Calculation must be submitted by the Bidder.
8	Output frequency	50 Hz +3% to - 5% Hz
9	Power Factor	0.85 lag- 0.85 lead
10	Max. THD at rated power	Less than 3 %
11	Ambient dry bulb temperature range	0 to 50° deg C
12	Humidity	15% to 95 % non- condensing
13	Enclosure	IP 20/ IP 65 (Indoor/ Outdoor rated) IEC-60068-2 (environmental)
14	Protection rating (as per IEC-60721-3-3)	Classification of chemically active substances: 3C2
15	Grid Specifications	IEC 61727, VDE 0126

<b>16</b>	Nominal Voltage & Frequency	415 Volts & 50 Hz
<b>17</b>	Voltage Tolerance	+ 10% and -10% or better than that

- a. PCU shall confirm to IEC 60068-2 standards for Environmental Testing.
- b. All inverters shall be IEC 61000 compliant for electromagnetic compatibility, harmonics, etc.
- c. All inverters shall be safety rated as per IEC 62109 (1 &2), EN 50178 or equivalent DIN or UL standard.
- d. Each PCU shall be compliant with IEEE standard 929 – 200 or equivalent. The Bidder should select the inverter (Central / String) as per its own system design so as to optimize the power output.

xxxvii Display

- a. The PCU shall have local LCD (Liquid crystal display) and keypad for system control, monitoring instantaneous system data, event logs, data logs and changing set points. Control and read-out should be provided on an indicating panel integral to the Inverter. Display should be simple and self-explanatory. Display to show all the relevant parameter relating to PCU operational data and fault condition in form of front panel meters/ LEDs or two line LCD Display.
- b. PCU front panel shall be provided with display (LCD or equivalent) to monitor the following
  - Instantaneous DC power input
  - DC input voltage
  - DC Current
  - Instantaneous active AC power output
  - Instantaneous reactive AC power output
  - AC voltage ( all the 3 phases and line)
  - AC current ( all the 3 phases and line)
  - Power Factor
  - kWh Produced during entire day
  - Total kWh produced during its life time
  - Thermal loading (percentage)

PCU must be provided with display and also the same has to be made available at the SCADA monitoring & controlling desk installed in Main Control Room through Universal Open Protocol of Communication.

xxxviii Documentary Requirements & Inspection.

- a. The bill of materials associated with PCUs should be clearly indicated while delivering the equipment.



- b. The Contractor shall provide to GSECL 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.

**Note:**The Company or its authorized representative reserves the right to inspect the PCUs/ Inverters at the manufacturer’s site prior to dispatch.

**(B) String Inverters**

**Technical specifications for string Inverter**

**(1) CODES AND STANDARDS**

The PCU shall conform to all applicable IEC standards. Where an applicable IEC standard is not available, IS/ any applicable international standard shall be referred to as best practice.

IEC-61683	Energy efficiency requirements
IEC 61000	Emission/ Immunity requirement
IEEE 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
IEC 60068-2-1, 2, 6, 14, 27 & 30	Environmental Testing
IEC 62116	Testing procedure—Islanding prevention measures for power conditioners used in grid-connected photovoltaic (PV) power generation systems
IEC 62109-1 & 2	Safety of power converters for use in photovoltaic power systems
EN 50530	Overall efficiency of grid connected photovoltaic inverters
BDEW 2008	Technical Guidelines for Generating plant connected to Medium voltage network
IEEE 1547	Standard for interconnecting distributed resources with electrical power systems.
IEC 60529	Ingress protection test
Grid Connectivity	Relevant CEA Regulations (including LVRT/HVRT compliance) and Grid Code as amended and revised from time to time.

**(2) GENERAL REQUIREMENTS OF PCU**

- The minimum euro efficiency of the PCU as per IEC 61683 shall be 97%. The bidder shall specify the conversion efficiency at following load conditions i.e. 25%, 50%, 75% and 100% during detail engineering, which shall be confirmed by type test reports.
- The PCU shall remain connected to the grid as per Central Electricity Authority Technical (standards for connectivity to the grid) regulation 2007 with all latest amendments and its components shall be designed accordingly.
- In case auxiliary supply of PCU is met internally, then it should have sufficient power backup to meet the LVRT requirement. Bidder needs to submit the detail auxiliary supply arrangement for PCU during detail engineering stage.

- The PCU shall be capable of operating in the frequency range of 47.5 Hz to 52 Hz and shall be able to deliver rated output in the frequency range of 49.5 Hz to 50.5 Hz.
- The monitoring/measurement of DC inputs and AC output shall be done using transducers/instruments having sensor accuracy of 0.5 class or better.
- Internal Surge Protection Device (SPD) shall be provided in the PCU on DC and AC side. It shall consist of Metal Oxide Varister (MOV) type arrestors. The discharge capability of the SPD shall be at least 12.5kA at 8/20 micro second wave as per IEC 61643-12.
- The PCU shall be capable of supplying reactive power as per grid requirement (manual intervention through SCADA) during solar generation hours. However, reactive power support, below 0.95 power factor, might be as the behest of active power.
- The PCU shall have protection against any sustained fault in the feeder line and against lightning discharge in the feeder line.
- The Contractor shall ensure by carrying out all necessary studies that the PCU will not excite any resonant conditions in the system that may result in the islanded operation of PV plant and loss of generation. In case there is excitation of any resonant condition in the system during PV plant operation that may result in the islanding/tripping of the PV plant and affect the power transfer, it shall be the responsibility of contractor to rectify the design and carryout required modification in the equipment of his supply.
- The PCU must be self-managing and stable in operation.
- In case of grid failure, the PCU shall be re-synchronized with grid after revival of power supply. Bidder to furnish the time taken by PCU to be re-synchronized after restoration of grid supply during detailed engineering.
- 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.
- PCU shall have active power limit control, reactive power and power factor control feature. Plant operator shall be able to provide (manual intervention) Active power, reactive power and power factor control/limit set point through SCADA HMI and local control display unit (or Laptop computer). PCU shall be provided with remote start and stop facility from SCADA HMI. All required hardware and software required for this purpose shall be provided by Bidder.
- PCU shall have necessary limiters in build in the controller so as to ensure safe operation of the PCU within the designed operational parameters.
- PCU shall have thermal overloading protection to prevent failure of switching devices (i.e. IGBT) and other components of Inverter. PCU controller shall automatically regulate/limit the power output in order to reduce the PCU cabinet and switching devices temperature. Bidder to submit the PCU power vs ambient temperature curve during details engineering stage. PCU shall be able to provide inverter inside cabinet

and IGBT's (switching device) temperature (in soft analog value) to SCADA system for remote monitoring, storing and report generation purpose.

- PCU shall have the following feature,
  - a) AC & DC overcurrent protection.
  - b) Synchronization loss protection.
  - c) Over temperature protection.
  - d) DC & AC under and over voltage protection.
  - e) Under & over frequency protection.
  - f) Cooling system failure protection
  - g) PV array ground fault monitoring & detection
  - h) PV array insulation monitoring
  - i) LVRT
  - j) Anti-islanding protection
  - k) Grid monitoring
- One number of laptop PC shall be supplied for PCU configuration and troubleshooting purpose. Laptop shall be supplied with complete set of hardware & software accessories. Laptop detailed configuration must ensure suitability for the required applications. Supplied Laptop shall be protected with the latest anti-virus software and shall be provided 3 Years onsite warranty including its battery. At least two sets of communication cable for Laptop to PCU communication shall be provided.
- PCU shall be provided with Mobile user interface facility for monitoring of inverter by plant O&M personal for better O&M and highest yield from PV plant. In case PCU does not have this facility, then bidder can provide the same facility through plant SCADA system.
- PCU shall have AC and DC side monitoring capability and reporting to SCADA system (measured analog and digital value measured within PCU). Any special software if required for this purposes shall be provided for local and remote monitoring and report generation.
- DC Overloading: Maximum PCU DC overloading shall be limited to its design PV Array power to PCU nominal AC power ratio. Bidder needs to submit all the relevant technical documents/test report from PCU manufacturer (OEM) during detailed engineering stage in support of declared PCU design DC overloading capacity.

**(3) EARTHING OF INVERTERS:-**

The PCU shall be earthed as per manufacturer recommendation. During detail engineering the Bidder needs to submit the details earthing arrangement of PCU and system earth pit requirement during detail engineering stage. The detail specification for panel earthing for safety has been mentioned elsewhere in this specification

**(4) OPERATING MODES OF PCU**

- a) Low Power Mode: - The PCU shall be able to wake-up automatically when PV array open circuit voltage value is equal/more than preset value in the PCU program. Once it starts generation the PCU shall automatically enter maximum power mode.
- b) Maximum Power Point Tracking (MPPT):- In order to maximized the energy collection from solar PV array, the PCU shall have inbuilt maximum power

point tracker (MPPT) controller and MPPT shall be able operate the PV array at its maximum power point by adjusting output voltage of PV array system according to atmospheric condition. PCU MPPT controller shall ensure that it operates the PV array system at its global maximum power point and it shall not trap into PV array local maximum power point during cloudy atmospheric condition. The PCU shall operate within its MPPT operating input DC voltage range (window). The PCU MPPT operating DC voltage range shall be large enough so that it shall be able to satisfactorily operate the PV modules exposed to the maximum ambient temperature of 500C or any other condition. In case the solar PV array operating maximum power point voltage fall below (or above) the PCU MPPT operating voltage range, then the PCU controller shall automatically adjust the PCU input voltage so that PCU shall not enter into sleep mode. If the PV array output power fall below the PCU minimum preset power value then PCU shall automatically switched to sleep mode. In case, PV modules connected to Inverter are in Flickering shading zone of Wind turbines, Suitable MPPT algorithm shall be adopted for those Inverters to optimize Energy Yield.

- c) **Sleep Mode:** - PCU shall automatically go into sleep mode when the output voltage of PV array and/or output power of the inverter falls below a specified limit. During sleep mode the inverter shall disconnect from grid. Inverter shall continuously monitor the output of the PV array and automatically start when the DC voltage rises above a pre-defined level. During evening and night (non solar generation hours) the PCU shall be in sleep mode in order to minimize the internal power loss. Maximum loss in sleep mode shall be less than 0.05% of PCU rated power.
- d) **Standby Mode:** - In standby mode the PCU DC & AC contactor are open, inverter is powered on condition and waiting for start command.

**(5) PCU shall meet the following technical parameter**

Nominal output voltage frequency	50Hz
Continuous operating frequency range	47.5 Hz to 52 Hz
Continuous operating AC voltage range	± 10% rated AC voltage
Operating power factor range	Operating power factor (adjustable) shall be 0.9 Lead to 0.9 Lag.
Maximum input DC voltage	1000V or 1500V as per application
Current THD value	< 4% at nominal load
Operating ambient temperature	0 to 50 ° C
Humidity	95 % non-condensing
Maximum Noise level (at 1 meter distance)	75 dBA for indoor type PCU
DC Injection	<0.5 % at rated current
Flicker	As per IEC61000

**(6) Inverter Details**

- The string inverter enclosure protection class shall be IP 65 or better protection.

- The string inverter should be placed inside a canopy shed with atleast 15 cm in all direction, if installed in open. Alternatively, the Bidder can also install the inverter on the column post of the module mounting structure, below the modules. In such case, the canopy is not required and the column and foundation shall be designed accordingly.
- String inverter shall have suitable communication port (RS485/TCP-IP/PLC) for SCADA integration. All necessary hardware, software and accessories used for communication with SCADA (including Data logger if supplied) at both the ends shall be provided by the bidder.
- String inverter shall have string monitoring capability and reporting to SCADA system. Any special software if required for this purposes shall be provided for remote monitoring and report generation.
- Anti-PID device along with all hardware and communication cable/device shall be provided in case negative grounding of PV string provision is not available in string inverter. Data logger used in Anti-PID device shall be integrated with SCADA system.
- DC fuse requirement for PV string at string inverter end shall be as per string manufacturer/system requirement and same shall be finalized during detail engineering stage.
- Provision for AC electrical isolation device (such as MCB/MCCB/Isolator) inside string shall be as per string inverter manufacturer practice.
- Local Display unit for viewing important parameters, configuration and troubleshooting purpose shall be provided as per string inverter manufacture practice.

#### **(7) TYPE TESTING**

During detailed engineering, the contractor shall submit all the type test reports including temperature rise test and surge withstand test carried out within last ten years from the date of techno-commercial bid opening for Owner's approval. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of techno-commercial bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.

#### **5.3.4 Cables and Wires**

- i. 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)
- ii. Wires with sufficient ampacity and parameters shall be designed and used so that average voltage-drop at full power from the PV modules to inverter should be 2% (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 disconnecter with the THHN/THWN-2 sunlight resistant with 90°C 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 **during detail engineering. Bidder shall also allow following EN 50618, IEC 60228 and IS7098 (Part-2).**
- iii. All cables shall be supplied in the single largest length to restrict the straight-through joints to the minimum number. Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted. All wires used on the LT side shall conform to IS and should be of appropriate voltage grade. Copper conductor wires of reputed make shall be used. Armoured Aluminium cable connecting SMB and Inverter and also for LT applications are allowed.
- iv. All wires used for connecting the modules and array should conform to the NEC standards. Modules should be connected with USE-2/RHW-2 cables array to junction box conductors and junction box to photovoltaic dis-connector with the THHN/THWN-2 sunlight resistant with 90°C wet rated insulation cable.
- v. All high voltage cables connecting the main junction box/string inverters to the transformers should be PVC insulated grade conforming to IS 1554 and cables shall also conform to IEC 60189 for test and measuring the methods.
- vi. 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 for working voltage less than 150 V control cable shall be of minimum 500 V grade, the control and power cable shall have to be laid separately. All LT XLPE cables shall confirm to IS: 7098 Part I & II. All HT XLPE Cables (up to 33kV) Shall confirm IS: 7098 **PART-2** & IEC -60287, IEC-60332 and the Contractor to submit technical data sheet, Voltage drop calculation, Power Loss Calculation and type test report for the approval of client / consultants
- vii. 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.
- viii. **Bidder shall also allowed for cable testing and measurement as per IS 7098 (Pt-2) 2011, IS 8130 (2013) and IS 3975 (1999).**

**Table 5-3 Relevant Codes & Standards for Cable**

Sr.	Item	Relevant IS	Relevant IEC
1	Conductors of Insulated Cables	IS: 8130 - 1984	<b>IEC: 228</b>
2	Impulse tests on cables and their accessories		<b>IEC: 230</b>
3	Extruded solid dielectric-insulated power cables for rated voltage from 1 KV upto 30 KV.	<b>IEC: 502</b>	
4	Test methods for insulations and sheaths of electric cables and chords.	<b>IEC: 540</b>	
5	Test on cable over a sheath which has special protective functions and are applied by extrusion.	<b>IEC: 229</b>	
6	Calculations of continuous current rating of cables (100% load factor).	<b>IEC: 287</b>	
7	Cross-linked polyethylene insulated PVC sheathed cable for voltage from 3.3 KV up to 33 KV.	IS: 7098 (Part II)	
8	PVC insulation & sheath of electrical cables.	IS: 5831 - 1984	
9	Mild steel wires, formed wires and tapes for armouring of cables.	IS: 3975	
10	Electrical test methods for electric cables partial discharge test.	<b>IEC: 885(2) - 1987 (Part II)</b>	
11	Methods of test for cables.	IS: 10810	
12	Common test methods for insulating and sheathing materials of electric cables.		
13	Impulse test on cables & other accessories		
14	Cable termination for gas insulated switchgear.		

### 5.3.5 Technical Specification for LT XLPE Cable