RECIENT

Tender for Design, Engineering, Supply, Construction, Erection, Testing, Commissioning and O&M of 100 MW (AC) Solar PV Project with Land at Chhattisgarh, India

2 Brief Scope of Work

Scope of Supply & Work includes identification and arrangement of Land, transfer of the same in the name of the Employer for the development of the Project(s), design & engineering, procurement & supply of equipment and materials, testing at manufacturers works, multi – level inspections, packing and forwarding, supply, receipt, unloading and storage at site, associated civil works, services, permits, licences, installation and incidentals, insurance at all stages, erection, testing and commissioning for 300 MW (AC) Grid Interactive Solar PV Power Projects, and performance demonstration with associated equipment and materials on turnkey basis along with 10 (Ten) years comprehensive operation and maintenance from the date of Operational Acceptance. All works shall be executed as per Technical Specifications given in Section VII-B. Section VII-C lays down Special Technical Specifications with reference to site specific design requirements. However, in case of any conflict in requirements between Section VII-C and Section VII-B, Section VII-C shall have the precedence.

3 Design and Engineering

- 3.1 The Contractor shall prepare the detailed design basis report (DBR) along with relevant standards (with respective clause description), PERT Chart and MDL. The Contractor shall submit a copy to Employer for review and approval prior to detail engineering.
- 3.2 All documents and drawings shall be submitted to the Employer both in soft as well as hard copies (5 nos.) for review and approval. Every drawing shall also be submitted in '*.dwg' format. In case of design calculations done in spread sheet, editable (working) soft copy of the spread sheet shall also be submitted along with 'pdf' copies during every submission. The Employer shall return, as suitable, either soft or hard copies to the Contractor with category of approval marked thereon. The drawings/documents shall be approved in any one of the following categories based on nature of the comments/ type of drawing or document.
 - Category-I: Approved
 - Category-II: Approved subject to incorporation of comments. Re-submit for approval after incorporation of comments
 - Category-III: Not approved. Re-submit for approval after incorporation of comments
 - Category-IV: Kept for record/ reference

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• Category-IV (R): Re-submit for record/ reference after incorporation of comments (Note: Approval of document neither relieves the Vendor/ Contractor of his contractual obligations and responsibilities for correctness of design, drawings, dimensions, quality & specifications of materials, weights, quantities, assembly fits, systems/ performance requirement and conformity of supplies with Technical Specifications, Indian statutory laws as may be applicable, nor does it limit the Employer/ Purchaser's rights under the contract)

- **3.3** Submission of basic design data, design documents, drawings and engineering information including GTP and test reports to Employer or its authorized representative for review and approval in hard copy and soft copy from time to time as per project schedule. The documents typically include, but not limited to, the following:
 - Solar insolation data and basis for generation
 - Detailed technical specifications (GTP) of all the equipment
 - General arrangement and assembly drawings of all major equipment
 - Schematic diagram for entire electrical system (DC, AC and auxiliary systems)
 - GTP & G.A. drawings for all types of structures/ components, 220 kV, 132 kV, 66 kV or 33 kV switchgears (as applicable) & other interfacing panels
 - Test reports (for type, routine and acceptance tests)
 - Relay setting charts
 - Design calculations and sheets (licenced software as well as design templates)
 - Geo technical investigation data and Topographical survey report including topographical survey data in digital format (Excel file) and Contour plan of the area.
 - GA drawings of the entire project including equipment rooms/ inverter control rooms, office cum control room, roads, storm water drainage, sewage networks, security gate, fire protection system, perimeter fencing, transformer yard fencing etc.
 - Transmission line drawings and erection plans as per DISCOM/ STU guidelines
 - Quality assurance plans for manufacturing (MQP), Standard Operating procedure (SOP) and field activities (FQP)
 - Detailed site EHS plan, fire safety & evacuation plan and disaster management plan.
 - Detailed risk assessment and mitigation plan.
 - O&M Instruction's and maintenance manuals for major equipment
 - As-built drawings / documents and deviation list from good for construction (GFC)

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- **3.4** Estimation of the plant generation based on Solar Radiation and other climatic conditions prevailing at site.
- 3.5 Design of associated civil, structural, electrical & mechanical auxiliary systems includes preparation of single line diagrams and installation drawings, manuals, electrical layouts, erection key diagrams, electrical and physical clearance diagrams, design calculations for Earth- mat, Bus Bar & Spacers indoor and outdoor lighting/ illumination etc., GTP and GA drawings for the major equipment including transmission line, design basis & calculation sheets, and other relevant drawings and documents required for engineering of all facilities within the periphery to be provided under this contract.
- 3.6 All drawings shall be fully corrected to match with the actual "As Built" site conditions and submitted to Employer after commissioning of the project for record purpose. All as-built drawings must include the Good for Construction deviation list.

4 Procurement & Supply

- 4.1 The equipment and materials for Grid Interactive Solar PV Power Plant with associated system (Typical) shall include but not limited to the transit insurance, receipt, unloading, storage, erection, testing and commissioning of all supplied material for the following:
- 4.1.1 Complete transfer of ownership of encumbrance free land with minimum area as mentioned in Clause 1 of Scope of Works in favour of the Employer.
- 4.1.2 Adequate capacity of Solar PV modules of suitable rating including module mounting structures, fasteners, suitable MMS foundations and module interconnections.
- 4.1.3 Array Junction boxes, distribution boxes and Fuse boxes with string monitoring capabilities: MCBs/ isolators, Surge Arrestors and with proper lugs, glands, ferrules, terminations and mounting structures.
- 4.1.4 DC and AC cables of appropriate sizes with adequate safety and insulation
- 4.1.5 Power Conditioning Units (PCU) with SCADA compatibility, common AC power evacuation panel with bus bars and circuit breakers, LT & HT Power Interfacing Panels, Plant Monitoring Desk, AC & DC Distribution boards and UPS for emergency power supply along with required batteries
- 4.1.6 Step up transformers (inverter duty) in relevance with state grid code and inverter manufacturer requirements.
- 4.1.7 Power Transformer in relevance with technical specifications provided in this document and state grid code requirements.
- 4.1.8 Auxiliary transformer (s) along with cables and accessories for plant internal

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consumption.

- 4.1.9 Relay and protection system along with battery system.
- 4.1.10 LT Power and Control Cables including end terminations and other required accessories for both AC & DC power
- 4.1.11 Internal 415V interconnection & Indoor feeder panels to cater auxiliary needs of plant
- 4.1.12 Indoor panels / outdoor structures having incoming and outgoing feeders with VCBs, CTs, PTs, Bus bars, cables terminals kits and Bus coupler having Main and transfer Bus. Each bay shall consist of VCB, CT, Isolators with earth switch, LAs and PT's etc.
- 4.1.13 Installation, Testing and Commissioning of ABT meters with AMR facility and all necessary metering rated CTs and PTs as per CEA Metering Regulation 2006 as amended time to time and state metering code.
- 4.1.14 Providing necessary communication and Data Acquisition System to transfer real time data to SLDC/RLDC as per the specifications of SLDC/RLDC wing and as per grid connectivity approving authority.
- 4.1.15 Lightning arrestors for entire plant area.
- 4.1.16 HDPE pipes, cable conduits, cable trays and accessories/trenches.
- 4.1.17 Earthing of the entire plant as per relevant standards.
- 4.1.18 Control room equipment
- 4.1.19 Testing instruments for maintenance and monitoring of equipment.
- 4.1.20 Mandatory spares as per Annexure-D for each package
- 4.1.21 CCTV cameras for plant surveillance
- 4.1.22 Fire protection system in buildings and fire extinguishers.
- 4.1.23 Weather monitoring station shall include but not be limited to the following:
 - Pyranometers 3 nos. (1 no. for horizontal plane & 2 nos. for tilted plane) for each location
 - Ultrasonic Anemometer (wind speed and direction) 1 no. for each location
 - Temperature Sensor 3 nos. (1 no. for ambient & 2 nos. for module surface) for each location
 - Power source to all sensors
 - Data Logger
- 4.1.24 Construction of suitable structures for termination of transmission line for taking off from plant end and receipt of lines at Substation end.
- 4.1.25 Design & construction of Transmission line/ cable at required voltage level from plant take off point to the evacuation grid substation including right of way (ROW) and

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construction of bay at designated substation as per CTU requirements/procedures.

- 4.1.26 Any re-arrangement/ replacement of substation equipment/ materials, including bay construction, if required, at the evacuating substation necessary for evacuation of power from the Plant.
- 4.1.27 All safety equipment including PPE, mats etc. for safe working environment
- 4.1.28 Materials and accessories, which are required for satisfactory and trouble-free operation and maintenance of the above equipment like module cleaning system, supply of spares for all equipment, supply of tools and tackles etc.,
- 4.1.29 Any other equipment / material, not mentioned but required to complete the Solar Power Plant facilities in all respect.

5 Construction and Erection Works

- 5.1 The items of civil design and construction work shall include all works required for solar PV project and should be performed specifically with respect to following but not limited to:
- 5.1.1 Conducting geotechnical investigation and topographical survey of the given area.
- 5.1.2 Earthwork for site grading, cutting, filling, levelling & compaction of land.
- 5.1.3 Construction and erection of boundary fence around the entire land area and main/ security gate(s).
- 5.1.4 Construction of foundation for mounting structures for SPV panels.
- 5.1.5 Civil foundation work of transformers, switchgears, equipment, Water tank etc.
- 5.1.6 Construction of internal roads with WBM base.
- 5.1.7 Construction of Equipment room with necessary illumination system and finishing as required.
- 5.1.8 MCR Building(s) (1 building for every pooling substation) with Supervisor room, pantry, wash room, conference room etc. along with requisite furniture, workstations, air conditioning, internal and external illumination, other equipment as per provided drawings and details.
- 5.1.9 Guest House Building(s) (1 building for every pooling substation) as per provided drawings and details.
- 5.1.10 Supply and erection of Site Office (Portable Cabin type) for Owner during Construction as per the specifications in Section VII B: Technical Specifications.
- 5.1.11 Suitable arrangement of water shall be ensured to cater to day-to-day requirement of drinking water and permanent water supply for module cleaning (in case of wet-type



module cleaning system) and other needs of SPV power plant during entire O&M period.

- 5.1.12 SCADA and Energy Management System with remote monitoring capabilities and internet facility equipped with functionality as per Central Electricity Authority (Technical Standards for Connectivity to the Grid) (Amendment) Regulations, 2019.
- 5.1.13 Telemetry System for communication of Plant Data to the Transmission System Operator as per Central Electricity Authority (Technical Standards for Communication System in Power System Operations) Regulations, 2020
- 5.1.14 Suitable earthing for plant, switchyard, substations along with earth pits as per standards
- 5.1.15 Construction of Storm water drainage to its nearest outfall point & sewage network including rain water harvesting mechanism.
- 5.1.16 Erection of Perimeter lighting along with all accessories and cabling.
- 5.1.17 Laying of underground / over ground cables (all types, as applicable) with proper arrangements along with appropriate sized ferrules, lugs, glands and terminal blocks. Laying of cables inside the building trench and other locations as required shall be over GI cable trays with proper support and accessories.
- 5.1.18 Construction of transmission line including Design, route survey, foundation, erection stringing, commissioning as per CTU procedure from take-off point at plant end/ substation to the delivery point at the evacuation substation as per Project Particulars provided above.
- 5.1.19 All approvals, for equipment, items and works, which are not otherwise specifically mentioned in this document but are required for successful completion of the work in all aspects, including construction, commissioning, O&M of Solar PV Power Plant and guaranteed performance are deemed to be included in the scope of the contractor.

6 Statutory Approvals

- 6.1 Obtaining statutory approvals /clearances/ compliances on behalf of the Employer from various Government Departments, not limited to, the following: -
 - Banking and Wheeling of Power to the Drawl Points (SECL's estimated annual Consumption and Drawl points are provided as Annexure H
 - Pollution control board clearance, if required
 - Mining Department, if required
 - Forest Department, if required

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- All other approval as and when, as necessary for setting up of the solar power plant including CEIG/ CEA, power evacuation, etc. as per the suggested guidelines. Grid connectivity approval will be in the Scope of the Owner.
- Open Access approvals
- 6.1.1 All statutory approvals/permissions and/or No Objection Certificates (NoC) etc. from CTU for obtaining connectivity at the substation as per Project Particulars provided above.
- 6.1.2 All other statutory approvals and permissions and their respective compliances, not mentioned specifically but are required to carry out hassle free Construction and O&M of the plant.
- 6.1.3 Adequate and seamless insurance coverage during EPC and O&M period to mitigate all risks related to construction and O&M of the plant to indemnify the Employer.
- 6.2 The Contractor shall comply with the provision of all relevant acts of Central or State Governments including payment of Wages Act 1936, Minimum Wages Act 1948, Employer's Liability Act 1938, Workmen's Compensation Act 1923, Industrial Dispute Act 1947, Maturity Benefit Act 1961, Mines Act 1952, Employees State Insurance Act 1948, Contract Labour (Regulations & Abolishment) Act 1970, Electricity Act 2003, Grid Code, Metering Code, MNRE guidelines or any modification thereof or any other law relating whereto and rules made there under or amended from time to time.

7 Operation and Maintenance

- 7.1 Total Operation & Maintenance of the SPV Plant shall be with the Contractor, after operational acceptance of the plant till culmination of the O&M period and shall include deployment of engineering personnel, technicians and security personnel.
- 7.2 To provide a detailed training plan for all O&M procedures to Employer's nominated staff, which shall have prior approval from the Employer.
- **7.3** Employ and coordinate the training of contractors' personnel who will be qualified and experienced to operate and monitor the facility and to coordinate operations of the facility with the grid system.
- 7.4 Discharge obligations relating to retirement/ Superannuating benefits to employees or any other benefit accruing to them in the nature of compensation, profit in lieu / in addition to salary, etc. for the period of service with the contractor, irrespective continuance of employees with the project as employees of Contractor, after conclusion of O&M period.



- 7.5 To maintain accurate and up-to-date operating logs, records and monthly Operation & Maintenance reports at the facility. Contractor shall keep the measured daily data at regular intervals and provide the same to Employer in electronic form, compatible in CSV format. The right to use the data shall remain with the Employer.
- 7.6 The Contractor shall establish forecasting tools for submitting schedule and comply with respective SERC Regulations on Forecasting, Scheduling and Deviation settlement of generation. The scope under this Clause shall also include establishing and maintaining forecasting tools and appointment of QCA/Aggregator, if required. % Error (Deviation) shall be calculated as per the said regulations and DSM Charges in case of deviation beyond the permissible limits shall be borne by the Contractor.
- 7.7 Procurement of spare parts, overhaul parts, tools & tackles, equipment, consumables, etc. required for smooth operation and maintenance of the plant as per prudent/ standard utility practices, OEM recommendations and warranty clauses for the entire O&M period
- **7.8** To upkeep all administrative offices, roads, tool room, stores room, equipment in clean, green and workable conditions.
- **7.9** To carry out periodic overhauls or maintenance required as per the recommendations of the original equipment manufacturer (OEM) and to furnish all such periodic maintenance schedules at the time of plant commissioning/ start of O&M contract.
- 7.10 Handover the system to maintain an inventory of spare parts, tools, equipment, consumables and supplies for the facility's operation along-with required details of recommended spares list with all associated information regarding replacement records, supplier details, tentative cost, storage details, specifications on the basis of replacement frequency and mean time between failures and mean time to restore at the culmination of penultimate year under O&M period.
- 7.11 Availability of vehicles for Employer staff during construction and O&M period as per requirement may be ensured, failing which Employer shall have full right for alternate arrangement at the risk & cost of the contractor.
- 7.12 The contractor shall be responsible for all the required activities for the successful running, committed energy generation & maintenance of the Solar Photovoltaic Power Plant covering:
 - Deputation of qualified and experienced engineers and technicians at the facility.
 - Deputation of Security personnel for the complete security of plant.
 - Successful running of Solar Power Plant for committed energy generation.

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- Co-ordination with CTU/other statutory organizations as per the requirement on behalf of Employer for Joint Metering Report (JMR), furnishing generations schedules as per requirement, revising schedules as necessary and complying with grid requirements.
- Monitoring, controlling, troubleshooting maintaining of logs & records, registers.
- Furnishing generation data monthly to Employer/Owner by 1st week of every month for the previous month to enable Employer raise commercial bills on consumers.
- Periodic cleaning of solar modules as approved by the Employer and water quality as per the recommendations of OEM
- Replacement of Modules, Invertors/PCU's and other equipment as and when required during the O&M period without additional cost to Employer
- 7.13 Continuous monitoring the performance of the Solar Power Plant and regular maintenance of the whole system including Modules, PCU's, transformers, overhead line, outdoor/indoor panels/ kiosks etc. are necessary for extracting and maintaining the maximum energy output from the Solar Power Plant.
- **7.14** Preventive and corrective O&M of the Solar Photovoltaic Power Plant including supply of spares, consumables, wear and tear, overhauling, replacement of damaged modules, invertors, PCU's and insurance covering all risks (Fire & allied perils, earth quake, terrorists, burglary and others) as required.
- 7.15 The period of Operation and Maintenance will be deemed to commence from the date of completion of performance demonstration/Operational acceptance and successively the complete Solar Photovoltaic Power Plant to be handed over to the O&M contractor for operation and maintenance of the same. O&M contract shall further be extended on the mutually agreed terms and conditions for the mutually agreed period.
- **7.16** All the equipment required for Testing, Commissioning and O&M for the healthy operation of the Plant must be calibrated, time to time, from the NABL accredited labs and the certificate of calibration must be provided prior to its deployment.
- 7.17 The Contractor shall ensure that all safety measures are taken at the site to avoid accidents to his or his sub-contractor or Employer's Workmen. This will include procurement of all safety gadgets during Construction and O&M period including but not limited to, rubber mats of appropriate grade, PPE, rubber gloves and suitable shoes etc.



8 Operation and Performance Monitoring

- 8.1 Operation part consists of deputing necessary manpower necessary to operate the Solar Photovoltaic Power Plant at the full capacity. Operation procedures such as preparation to starting, running, routine operations with safety precautions, monitoring etc., shall be carried out as per the manufacturer's instructions to have trouble free operation of the complete system.
- 8.2 Daily work of the operation and maintenance in the Solar Photovoltaic Power Plant involves periodic cleaning of Modules including periodic tilt angle change as and when required, logging the voltage, current, power factor, power and energy output of the Plant at different levels. The operator shall also note down time/ failures, interruption in supply and tripping of different relays, reason for such tripping, duration of such interruption etc. The other task of the operators is to check battery voltage-specific gravity and temperature. The operator shall record monthly energy output, down time, etc.
- 8.3 Earth resistance of Plant as well as individual earth pit is to be measured and recorded every month. If the earth resistance is high (compared to standards) suitable action is to be taken to bring down the same.
- 8.4 A maintenance record is to be maintained by the operator/ O&M-in-charge to record the regular maintenance work carried out as well as any breakdown maintenance along with the reasons for the breakdowns and steps taken to attend the breakdown, duration of the breakdown etc.
- 8.5 The Preventive Maintenance Schedules will be drawn such that some of the jobs other than breakdown, which may require comparatively long stoppage of the Power Plant, shall be carried out preferably during the non-sunny days or evenings. Prior information shall be provided to the Employer for such preventive maintenance prior to start.
- 8.6 The Contractor will attend to any breakdown jobs immediately for repair/ replacement/ adjustments and complete at the earliest working round the clock. During breakdowns (not attributable to normal wear and tear) in O&M period, the Contractor shall immediately report the accidents, if any, to the Employer showing the circumstances under which it happened and the extent of damage and/or injury caused.
- 8.7 The contractor shall at his own expense provide all amenities to his workmen as per applicable laws and rules.
- 8.8 If negligence / mal operation of the contractor's operator results in failure of equipment, such equipment should be repaired/replaced by the contractor free of cost.

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9 Security Services

- **9.1** The contractor has to arrange proper security system including deputation of security personnel at his own cost for the check vigil for the Solar Power Plant for the complete scope of works including comprehensive O&M period.
- 9.2 The security staff may be organized to work on suitable shift system; proper checking & recording of all incoming & outgoing materials vehicles shall be maintained. Any occurrence of unlawful activities shall be informed to Employer immediately. A monthly report shall be sent to Employer on the security aspects.
- **9.3** Any other activities required for completion of project, but not specified in the above shall be in the scope of contractor. The Contractor must provide the BOM of the plant as per the design during the time of submission of design basis report. The detailed technical specifications of major equipment to be followed strictly and are described in the technical specification section.



SECTION - VII B. TECHNICAL SPECIFICATIONS

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DISCLAMIER:

- 1. Though adequate care has been taken while preparing the Bidding documents, the Bidders/Applicants shall satisfy themselves that the document is complete in all respects. Intimation of any discrepancy shall be given to this office immediately. If no intimation is received from any Bidder within twenty (20) days from the date of notification of NIT/ Issue of the NIT documents, it shall be considered that the NIT documents are complete in all respects has been received by the Bidder.
- 2. Solar Energy Corporation of India Limited (SECI), the Employer, reserves the right to modify, amend or supplement this NIT documents including all formats and Annexures.
- 3. While this bidding documents have been prepared in good faith, neither Employer or its authorized representatives nor their employees or advisors make any representation or warranty, express or implied, or accept any responsibility or liability, whatsoever, in respect of any statements or omissions herein, or the accuracy, completeness or reliability of information, and shall incur no liability under any law, statute, rules or regulations as to the accuracy, reliability or completeness of this bidding documents, even if any loss or damage is caused by any act or omission on their part.
- 4. The specifications mentioned for all the equipment which include Solar modules, PCU, combiner boxes, DC cables, module mounting structures, transformer, CT, PT, LT/ HT cables, interfacing panels, switch gears & other associated equipment etc., to complete the power generation and evacuation to the designated substation, in the present bidding documents are for the **reference** only. It is subject to revise/ alter as per the design/ planning/ good engineering practices etc., to be carried out by the selected bidder, to the satisfaction of the Employer or its authorized representatives. It is advised that the bidders must satisfy himself with the prevailing site conditions before design/ plan. The design must be optimized as per the site conditions and directed to achieve the maximum output from the installed capacity at all times. Moreover, the components not separately mentioned, but are required to complete the plant for operation is also included in the scope of bidder and shall be vetted by the Employer or its authorized representatives.

Place:

Date:

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(Signature) Name and Designation of bidder

> Signature of Bidder



A Design Philosophy

- 1 The main objective of the design philosophy is to construct the plant with in-built Quality and appropriate redundancy to achieve high availability and reliability with minimum maintenance efforts. In order to achieve this, the following principles shall be adopted while designing the system.
- 1.1 Adequate capacity of SPV modules, PCUs, Junction boxes etc. to ensure generation of power as per design estimates. This will be done by applying liberal de-rating factors for the array and recognizing the efficiency parameters of PCUs, transformers, conductor losses, system losses, site conditions etc.
- 1.2 Use of equipment and systems with proven design and performance that have high availability track records under similar service conditions.
- 1.3 Selection of the equipment and adoption of a plant layout to ensure ease of maintenance.
- 1.4 Strict compliance with approved and proven quality assurance (QA) systems and procedures during different stages of the project, starting from sizing, selection of make, shipment, storage (at site), during erection, testing and commissioning.
- 1.5 Proper monitoring of synchronization and recording, to ensure availability of power to the grid.
- 1.6 The plant instrumentation and control system should be designed to ensure high availability and reliability of the plant to assist the operators in the safe and efficient operation of the plant with minimum effort.
- 1.7 It should also provide the analysis of the historical data and help in the plant maintenance people to take up the plant and equipment on predictive maintenance.
- 1.8 System design shall have intelligent protection mechanism which may include very fast responsive microprocessor-based relays etc., so that any disturbance from the grid will not cause any damage to the equipment of the Solar Power Plant.
- 2 The basic and detailed engineering of the plant shall aim at achieving high standards of operational performance especially considering following:
- 2.1 SPV power plant should be designed to operate satisfactorily in synchronization with the grid within permissible limits of high voltage and frequency fluctuation conditions. It is also extremely important to safeguard the system during major disturbances, internal and external surge conditions while ensuring safe operation of the plant.
- 2.2 The Module Mounting Structures shall be designed for such that SPV arrays produce

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maximum energy during the period of respective tilt.

- 2.3 Shadow free plant layout to ensure minimum losses in generation during the day time.
- 2.4 Higher system voltage and lower current options to be followed to minimise ohmic losses.
- 2.5 Selection of PCUs with proven reliability and minimum downtime. Ready availability of requisite spares.
- 2.6 Careful logging of operational data / historical information from the Data Monitoring Systems, and periodical analysis of the same to identify any abnormal or slowly deteriorating conditions.
- 2.7 The designed array capacity at STC shall be suitably determined to meet the proposed guaranteed generation output at the point of interconnection by the contractor in his bid. The contractor shall take care of first year degradation also by installing additional DC capacity as the CUF calculations will not factor the first-year degradation of the modules.
- 2.8 Each component offered by the bidder shall be of established reliability. The minimum target reliability of each equipment shall be established by the bidder considering its mean time between failures and mean time to restore, such that the availability of complete system is assured. Bidder's recommendation of the spares shall be on the basis of established reliability.
- 2.9 Bidder shall design the plant and equipment in order to have sustained life of 25 years with minimum maintenance efforts.
- 2.10 The work execution planning for supply, erection, commissioning and all other allied works for SPV Power Plant shall be such that it is completed within stipulated time from the date of order/ LOI/ NTP, whichever is later.
- 3 The specifications provided with this bid document are functional ones; any design provided in this document is only meant as an example. The Contractor must submit a detailed design philosophy document for the project to meet the functional requirements based upon their own design in-line with the above. The bidders are advised to visit the site and satisfy themselves before bidding.



B Electrical System

1 Photovoltaic Modules

1.1 <u>Standards and Codes</u>

Photovoltaic Modules shall comply with the specified edition of the following standards and codes.

Standard	Description	
IEC 61215-1:2016	Terrestrial photovoltaic (PV) modules - Design qualification	
Ed.1	and type approval - Part 1: Test requirements	
IEC 61215-1-1-2016	Terrestrial photovoltaic (PV) modules - Design qualification	
Fd 1	and type approval - Part 1-1: Special requirements for	
	testing of crystalline silicon photovoltaic (PV) modules	
	Terrestrial photovoltaic (PV) modules - Design qualification	
IEC 61215-1-2:2016	and type approval - Part 1-2: Special requirements for	
E0.1	testing of thin-film Cadmium Telluride (CdTe) based	
	photovoltaic (PV) modules	
IEC 61730-1:2016	Photovoltaic (PV) module safety qualification - Part 1:	
Ed.2	Requirements for construction	
IEC 61730-2:2016	Photovoltaic (PV) module safety qualification - Part 2:	
Ed.2	Requirements for testing	
IEC 61701:2011	Salt mist corrosion testing of photovoltaic (PV) modules	
Ed.2	(Applicable for coastal and marine environment)	
IEC 62716:2013	Photovoltaic (PV) modules - Ammonia corrosion testing (if	
Ed.1	applicable)	
	Photovoltaic (PV) modules - Test methods for the	
IEC TS 62804-1:2015	detection of potential-induced degradation - Part 1:	
Ed.1	Crystalline silicon (under conditions of 85°C/85% RH for	
	minimum 192 hours)	
As per the Solar Ph	otovoltaics, Systems, Devices and Components Goods	
(Requirements for Com	pulsory Registration) Order, 2017, PV Modules used in the	
grid connected solar p	ower projects shall be registered with BIS and bear the	
Standard Mark as notified by the Bureau of Indian Standards.		

Further, PV Modules should have been included in the ALMM list as per MNRE Approved Models and Manufacturers of Solar Photovoltaic Modules (Requirements for Compulsory Registration) Order, 2019.

1.2 <u>Technical Requirements</u>

Parameter	Specification
Cell/ Module Technology	Multi-crystalline or Mono-crystalline

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	As per Public Procurement (Make In India)
	Order 2017 dated 15 June 2021, at least
Origin of DV (Madulaa	50% Modules shall be from a Local Supplier
Origin of PV Modules	where the Local Supplier is a supplier of PV
	Modules that meets the minimum local
	content specified in the said order.
Madula Efficiency	≥ 17% for Multi-crystalline
	≥ 19% for Mono-crystalline
Rated power at STC	No negative tolerance is allowed
Temperature co-efficient of power	Not less than -0.40%/°C
Application Class as per IEC 61730	Class A

1.3 <u>Supplier Qualification Criteria</u>

1.3.1 The PV Modules Supplier should have supplied minimum 5 GW capacity globally or 500 MW in India in the past 5 years (as on last date of Bid submission).

1.4 <u>Component Specifications</u>

- 1.4.1 The PV Modules glass panel shall be:
 - (i) For PV Modules with backsheet, toughened low iron glass with minimum thickness of 3.2 mm for multi or mono-crystalline modules.
 - (ii) In case of glass-glass PV Modules, glass thickness shall be minimum of 2 mm on each side. It shall be laminated using a laminator with symmetrical structure, i.e., heating plates on both sides.
 - (iii) The glass used shall have transmittance of above 90%.
- 1.4.2 The back sheet used in the PV modules shall be three-layered structure with outer (air side) layer having fluoropolymer or a material with superior UV stability properties. The back sheet shall have the following properties.

Parameter	Value
Material thickness	≥ 300 micron
Water vapour transmission rate	< 2 g/m²/day
Partial discharge test voltage	≥ 1500 V
Elongation at break	> 100%
Adhesion strength with encapsulant	> 40 N/cm
Interlayer adhesion strength	> 4 N/cm

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The Employer reserves the right to conduct Pressure Cooker (PC) test/ Highly Accelerated Stress Test (HAST) to confirm the durability of the back sheet in accelerated conditions.

1.4.3 The encapsulant used for the PV modules should be UV resistant and PID resistant in nature. No yellowing of the encapsulant with prolonged exposure shall occur. The encapsulant shall have the following properties.

Parameter	Value
Gel content	> 75%
Volume resistivity	> 1×10 ¹⁴ Ω.cm
Peeling strength with glass	> 40 N/cm

1.4.4 The sealant used for edge sealing of PV modules shall have excellent moisture ingress protection with good electrical insulation (Break down voltage >15 kV/mm) and with good adhesion strength. Edge tapes for sealing are not allowed.

- 1.4.5 The module frame shall be made of anodized Aluminium, which shall be electrically & chemically compatible with the structural material used for mounting the modules. It is required to have provision for earthing to connect it to the earthing grid. The anodization thickness shall not be less than 15 micron.
- 1.4.6 The material used for junction box shall be UV resistant to avoid degradation during module life. The degree of protection of the junction box shall be at least IP67. Minimum three number of bypass diodes and two number of IEC 62852/EN 50521 certified MC4 compatible connectors with appropriate length of IEC 62930/EN 50618 certified 4 sq.mm copper cable shall be provided. The cable length shall be in accordance with the PV Module wiring strategy and adequate to ensure that the cable bending radius standard is not exceeded.
- 1.4.7 Each PV Module shall be provided a RFID tag which is embedded inside the module lamination and must be able to withstand harsh environmental conditions. The RFID data base shall contain the following information. RFID scanner and database of all the modules containing the following information shall also be provided.
 - (i) Name of the manufacturer of PV Module
 - (ii) Name of the Manufacturer of Solar cells
 - (iii) Type of cell: Mono / Multi
 - (iv) Month and year of the manufacture (separately for solar cells and module)
 - (v) Country of origin (separately for solar cells and module)

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- (vi) I-V curve for the module
- (vii) Peak Wattage, I_m , V_m and FF for the module
- (viii) Unique Serial No. and Model No. of the module.
- (ix) Date and year of obtaining IEC PV module qualification certificate
- (x) Name of the test lab issuing IEC certificate
- (xi) Other relevant information on traceability of solar cells and modules as per ISO 9000 series.

1.5 <u>Warranty</u>

- 1.5.1 PV modules must be warranted with linear degradation rate of power output except for first year (maximum 3% including LID) and shall guarantee 80% of the initial rated power output at the end of 25 years.
- 1.5.2 The modules shall be warranted for minimum of 10 years against all material/ manufacturing defects and workmanship.
- 1.5.3 The above warranties shall be backed by third party insurance.

1.6 <u>Approval</u>

- 1.6.1 The Contractor shall provide Guaranteed Technical Particular (GTP) datasheet and Bill of Materials (BOM) of the module that is submitted for approval along with the datasheets of each component. The component datasheet shall contain all the information to substantiate the compliance for component specifications mentioned above.
- 1.6.2 The Contractor shall also provide test certificates corresponding to the standards mentioned above along with complete test reports for the proposed module. The tests should have been conducted at a test laboratory compliant with ISO 17025 for testing and calibration and accredited by an ILAC/IECEE member signatory. Laboratory accreditation certificate or weblink along with scope of accreditation shall also be submitted.
- 1.6.3 The BOM proposed shall be the subset of Constructional Data Form (CDF)'s of all the test reports.
- 1.6.4 The Contractor shall submit a detailed Manufacturing Quality Plan (MQP) for the PV Module with list of checks/tests performed during incoming material inspection, production, pre-dispatch and package.
 - 1.6.5 The Contractor shall obtain the approval of the proposed module make & model prior to manufacturing/ inspection call.



1.7 Manufacturing and Inspection

- 1.7.1 The Contractor shall inform the module manufacturing schedule to the Employer at least 7 (seven) working days before the start of proposed schedule.
- 1.7.2 The Employer shall perform material inspection at the Manufacturer's factory before the start of proposed manufacturing schedule. Proof of procurement of components as per the approved BOM mentioning manufacturer name, manufacturing date and relevant test certificate shall be submitted during material inspection for verification.
- 1.7.3 The Manufacturing shall start only after the clearance by the Employer after the material inspection.
- 1.7.4 The cells used for module making shall be free from all defects like edge chipping, breakages, printing defects, discoloration of top surface etc. Only Class A solar cell shall be used.
- 1.7.5 The modules shall be uniformly laminated without any lamination defects.
- 1.7.6 Current binning of modules shall be employed to limit current mismatch of modules. Different colour codes shall be provided on the modules as well as pallet for identification of different bins. Maximum three nos. of bins will be allowed for each module rating.
- 1.7.7 Pre-dispatch inspection of modules shall be performed as per the inspection protocol attached in Annexure A.

1.8 <u>Transportation, Handling, Storage and Installation</u>

- 1.8.1 Transportation, handling, storage and installation of modules shall be in accordance with the manufacturer manual so as not to breach warranty conditions. The Standard Operating Procedure (SOP) for the same shall be shared by the Contractor prior to dispatch.
- 1.8.2 It is required to construct a temporary platform (graded) while keeping the modules at least above the highest flood level. If the contractor scheduled/ planned to mount the modules immediately after the receipt at site, then the module shall be kept in common storage area with proper arrangement.
- 1.8.3 Modules shall be dispatched in line with the Construction schedule. If Modules are dispatched ahead of schedule, following measures shall be undertaken:
 Modules shall be covered with tarpaulin sheet. Alternatively, the Modules, properly stacked as per OEM recommendations, shall be stores under a temporary shed. Further, the temporary platform for keeping the modules shall be treated with anti-

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termite treatment.

2 String Combiner Box (SCB)

2.1 <u>Standards and Codes</u>

Standard/Code	Description
IEC 60529	Enclosure Ingress Protection
IEC 62262	Enclosure Impact Protection
IEC 60269	Fuse
IEC 61643-11	Surge Protection Device
IEC 62852 or EN 50521	Solar cable connector
IEC 60695-2-11	Fire hazard testing

2.2 <u>Construction</u>

- 2.2.1 SCB enclosure shall be made of UV resistant, fire retardant, thermoplastic material. Enclosure degree of protection shall be at least IP65 and mechanical impact resistance shall be at least IK08.
- 2.2.2 Not more than two strings can be connected in parallel to a single input of SCB. One spare input terminal along with connector shall be provided for each SCB.
- 2.2.3 Every SCB input shall be provided with fuses on both positive and negative side. In case of negative grounded system, fuse at positive side only is acceptable. The rating of the fuses shall be selected such that it protects the modules from reverse current overload. The fuses shall be 'gPV' type conforming to IEC 60269-6.
- 2.2.4 DC switch disconnector of suitable rating shall be provided at SCB output to disconnect both positive and negative side simultaneously.
- 2.2.5 Type-II surge protective device (SPD) conforming to IEC 61643-11/IEC 61643-31/ EN 50539-11 shall be connected between positive/negative bus and earth.
- 2.2.6 Resistance Temperature Detector (RTD) type or semiconductor type temperature sensor shall be provided to monitor the cabinet temperature.
- 2.2.7 MC4 connector conforming to IEC 62852 or EN 50521 shall be provided at each SCB input. Cable gland (double compression metallic) of suitable size for DC cables shall be provided at the SCB output.
- 2.2.8 UV resistant printed cable ferrules for solar cables & communication cables and punched/ embossed aluminium tags for DC cables shall be provided at cable termination points for identification.



2.3 <u>Warranty</u>

The SCB unit shall be warranted against all material/ manufacturing defects and workmanship for minimum of 2 (two) years from the date of supply.

2.4 <u>Tests</u>

Routine tests and acceptance tests for the assembled unit shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

3 Solar and DC Cables

3.1 <u>Standards and Codes</u>

Cable	From	То	Conductor/ Insulation	Voltage Rating	Applicable Standard
Solar Cable*	Module	SCB	Copper/ XLPO	1.5 kV DC	IEC 62930 / EN 50618
DC Cable	SCB	PCU	Copper or Aluminium/ XLPE	1.5 kV DC	IS 7098 Part II
* Cable used for module interconnection shall also be referred as solar cable.					

- 3.2 Solar cable outer sheath shall be flame retardant, UV resistant and black in colour. Solar cable with positive polarity should have marking of red line on black outer sheath.
- 3.3 DC cables shall be single core, armoured, Flame Retardant Low smoke (FRLS), PVC outer sheath conforming to IS 7098-II. DC cable with positive polarity should have marking of red line on black outer sheath.
- 3.4 In addition to manufacturer's identification on cables as per relevant standard, following marking shall also be provided over outer sheath.
 - (i) Cable size and voltage grade
 - (ii) Word 'FRNC/ FRLS' (as applicable) at every metre
 - (iii) Sequential marking of length of the cable in metres at every metre
- 3.5 Cables shall be sized based on the following considerations:
 - (i) Rated current of module
 - (ii) In case of central inverters, average voltage drop in the cables (from PV Modules to PCU) shall be limited to 1.5 % of the rated voltage. In case of string Inverters, average voltage drop (from PV module to string inverter) shall be limited to 0.5% of the rated voltage drop. The Contractor shall provide voltage drop calculations in excel sheet.



- (iii) Short circuit withstand capability
- (iv) De-rating factors according to laying pattern

3.6 <u>Warranty</u>

The cables (Solar and DC) shall be warranted against all material/ manufacturing defects and workmanship for minimum of 1 (one) year from the date of supply.

3.7 <u>Tests</u>

Type test, routine test and acceptance tests requirements shall be as per IEC 62930/EN 50618 for solar cables and IS 7098-II for DC cables.

3.8 Installation

- 3.8.1 Cable installation shall be as per IS 1255.
- 3.8.2 Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted.
- 3.8.3 Solar cables shall be provided with UV resistant printed ferrules and DC cables shall be provided with punched/ embossed aluminium tags. The marking shall be done with good quality letter and numbers of proper size so that the cables can be identified easily.
- 3.8.4 Cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles. Bimetallic lugs shall be used for connecting Cu bus bar and Al cables or vice-versa.
- 3.8.5 Solar cables, wherever exposed to direct sunlight and buried underground, shall be laid through Double Wall Corrugated (DWC) HDPE conduits. The size of the conduit or pipe shall be selected on the basis of 40% fill criteria.
- 3.8.6 Solar cables shall be aesthetically tied to Module Mounting Structure using UV resistant cable-ties suitable for outdoor application.
- 3.8.7 A.C and D.C cables shall be kept in separate trenches. The horizontal and vertical clearances between power and communication cable shall not be less than 300mm.

4 **Power Conditioning Unit**

4.1 <u>Standards and Codes</u>

Power Conditioning Unit (PCU) shall comply with the specified edition of the following standards and codes.

Standard Description

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IEC 61683 Ed. 1	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency	
IEC 62109-1 Ed. 1	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements	
IEC 62109-2 Ed. 1	Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters	
IEC 61000-6-2 Ed. 2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments	
IEC 61000-6-4 Ed. 2.1	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments	
IEC 62116 Ed. 2	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures	
IEC 60068-2-1:2007	Environmental testing - Part 2-1: Tests - Test A: Cold	
IEC 60068-2-2:2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat	
IEC 60068-2-14:2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature	
IEC 60068-2-30:2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)	

CEA Technical Standards for Connectivity to the Grid Regulations 2007 with 2013 and 2019 Amendment

As per the Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017, Inverters used in the grid connected solar power projects shall be registered with BIS and bear the Standard Mark as notified by the Bureau of Indian Standards.

4.2 <u>Supplier Qualification Criteria</u>

The Inverter Supplier should have supplied minimum 5 GW capacity globally or 500 MW in India in the past 5 years (as on last date of the bid submission).

4.3 <u>Technical Requirements</u>

Parameter	Specification
Rated AC power	As per design
Maximum input voltage	1500 V
Rated AC output voltage	As per design
Tolerance on rated AC output voltage	+/-10%

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Rated frequency	50 Hz
Operating frequency range	47.5 Hz to 52 Hz
Power factor control range	0.9 lag to 0.9 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	Central Inverter – IP 20 (Indoor)/IP 54 (Outdoor), String Inverter – IP 65

- 4.3.1 The rated/ name plate AC capacity of the PCU shall be AC power output of the PCU at 50°C.
- 4.3.2 Maximum power point tracker (MPPT) shall be integrated in the PCU to maximize energy drawn from the Solar PV array. The MPPT voltage window shall be sufficient enough to accommodate the output voltage of the PV array at extreme temperatures prevailing at site.
- 4.3.3 The PCU output shall always follow the grid in terms of voltage and frequency. The operating voltage and frequency range of the PCU shall be sufficient enough to accommodate the allowable grid voltage and frequency variations.

4.4 <u>Construction</u>

- 4.4.1 Power Conditioning Unit (PCU) shall consist of an electronic three phase inverter along with associated control, protection, filtering, measurement and data logging devices.
- 4.4.2 Every DC input terminal of PCU shall be provided with fuse / MCB / MCCB of appropriate rating. The combined DC feeder shall have suitably rated isolators for safe start up and shut down of the system. One spare DC input terminal shall be provided for each PCU. String inverters without DC fuse may be acceptable in case not more than two strings are connected to the same MPPT.
- 4.4.3 Type-II surge protective device (SPD) conforming to IEC 61643-11 / IEC 61643-31 / EN 50539-11 shall be connected between positive/ negative bus and earth.
- 4.4.4 In case external auxiliary power supply is required, UPS shall be used to meet auxiliary power requirement of PCU. It shall have a backup storage capacity of 2 hours.
- 4.4.5 Circuit Breaker or Relay of appropriate voltage and current rating shall be provided at the output to isolate the PCU from grid in case of faults.
- 4.4.6 The PCU shall be tropicalized and the design shall be compatible with conditions

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prevailing at site. Suitable number of exhaust fan with proper ducting shall be provided for cooling keeping in mind the extreme climatic condition of the site as per the recommendations of OEM to achieve desired performance and life expectancy.

- 4.4.7 All the conducting parts of the PCU that are not intended to carry current shall be bonded together and connected to dedicated earth pits through protective conductor of appropriate size. DC negative terminal shall be grounded. In case DC negative grounding is not possible, appropriate anti-PID device shall be provided.
- 4.4.8 Dedicated communication interface shall be provided to monitor the PCU from SCADA.
- 4.4.9 PCU front panel shall be provided with LCD/ LED to display all the relevant parameters related to PCU operation and fault conditions. It shall include, but not limited to, the following parameters.
 - (i) DC input power
 - (ii) DC input voltage
 - (iii) DC input current (for each terminal)
 - (iv) AC output power
 - (v) AC output voltage (all the 3 phases and line)
 - (vi) AC output current (all the 3 phases and line)
 - (vii) Frequency
 - (viii)Power Factor

In case of outdoor PCU, PCU without LCD display with provision for Data access over Bluetooth / WiFi shall be acceptable.

- 4.4.10 String inverter, if installed in open, shall be placed inside a canopy shed with at least 15 cm in all directions. Alternatively, the Contractor may 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.
- 4.4.11 AC combiner box for string inverter configuration shall comply with Clause 9 of the Technical Specifications with exception of rated system voltage.
- 4.5 <u>Operating Modes</u>

Operating modes of PCU shall include, but not limited to, the following modes. These operating modes and conditions for transition are indicative only. The Contractor shall

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provide the detailed flow chart indicating the various operating modes and conditions for transition during detailed engineering.

4.5.1 Standby Mode

The PCU shall continuously monitor the input DC voltage and remain on Standby Mode until it reaches the pre-set value.

4.5.2 MPPT Mode

When the input DC voltage is above the pre-set value and AC grid connection conditions are fulfilled, the PCU shall enter into MPPT mode.

4.5.3 Sleep Mode

When the AC output power/DC input voltage decreases below the pre-set value for pre-set time delay, the PCU shall switch into Sleep Mode.

4.6 Protection Features

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.

The PCU shall provide protection against the following type of faults, among others.

- (i) DC/AC over current
- (ii) DC/AC over voltage
- (iii) DC reverse polarity
- (iv) DC earth fault
- (v) AC under voltage
- (vi) AC under frequency/over frequency
- (vii) Islanding
- (viii) Over temperature
- (ix) Lightning surges

4.7 Grid Support Functions

4.7.1 Active power regulation

The PCU shall be able to limit the active power exported to the grid based on the

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set point provided through PCU front control panel. The PCU shall also be able to automatically the limit the active power after an increase in grid frequency above a pre-set value. The ramp rate shall be adjustable during operation and start-up after fault. The applicability of the requirement shall be as per CEA regulation and compliance.

4.7.2 Reactive power control

The PCU shall be able to inject /absorb reactive power to/ from the grid based on the set point provided through PCU front control panel. The same shall be performed automatically with adjustable ramp rate based on dynamic changes in grid voltage or reactive power reference.

4.7.3 Voltage Ride Through

The PCU shall remain connected to the grid during temporary dip or rise in grid voltage as per the LVRT and HVRT requirements of CEA Technical Standards for Connectivity to the Grid Regulations. The PCU shall also be able to inject reactive power during the period of voltage dip.

4.8 <u>Warranty</u>

The complete Power Conditioning Unit shall be warranted against all material/ manufacturing defects and workmanship for minimum of 5 (five) years.

4.9 <u>Tests</u>

4.9.1 Type Tests

The type test certificates as per the standards mentioned above should be from any of the ILAC/IECEE member signatory accredited test centres. Laboratory accreditation certificate or weblink along with scope of accreditation shall also be submitted. It is the responsibility of the Contractor to substantiate the compliance for CEA Regulations using test reports.

4.9.2 Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

5 Inverter Transformer and Auxiliary Transformer

5.1 <u>Standards and Codes</u>

Inverter transformer and auxiliary transformer, wherever applicable, shall comply with the latest edition of the following standards and codes including amendments.

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Standard	Description	
IS 2026, IEC 60076	Specification of Power Transformers	
IS 11171, IEC 60076	Dry-Type Power Transformers	
IS 2099, IEC 60137	Bushings for alternate voltage above 1000 V	
IS 335, IEC 60296	Insulating oil	
IS 3639	Fittings and Accessories for Power Transformers	
IS 12063	Degree of protection provided by enclosures	
CBIP publication no. 295		
Indian Electricity rules and other statutory regulations		

5.2 <u>Technical Requirements</u>

Parameters	Inverter Transformer	Auxiliary Transformer	
VA Rating	As per system design requirement		
Voltage Ratio	33 kV / Inverter output voltage	As per system design	
Duty, Service & Application	Continuous Solar Inverter application and converter Duty (Outdoor)	Continuous application (Outdoor/Indoor)	
Winding	As per system design requirement	2	
Frequency	50 Hz	50Hz	
Nos. of Phase	3	3	
Vector Group & Neutral earthing	As per system/inverter manufacturer requirement	Dyn11	
Cooling	ONAN	ONAN / AN	
Tap Changer	OCTC, No. of steps shall be as	s per system requirement	
Impedance at 75°C	As per Inverter Manufacturer requirement	cturer As per system requirement	
Permissible Temperature rise over an ambient of 50°C (irrespective of tap)			
Top Oil	50°C	As per IS/IEC	
Winding	55°C	As per IS/IEC	
SC withstand time (thermal)	2 second	2 second	

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5.3	3 Short Circuit Apparent As per system requirement		
	Termination	As per system requirement	
	Bushing rating, Insulation class (Winding & bushing)	36 kV – porcelain bushings 1.1 kV – epoxy bushings	As per the system requirement
	Noise level	As per NEMA TR-1	
	Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-3%, also transformer shall be capable of being loaded in accordance with IEC 60076-7	
 Not to exceed 1.9 Wb/sq.m. at any tap position combined frequency and voltage variation from ratio by 10% corresponding to the tap. Transformals also withstand following over fluxing condition combined voltage and frequency fluctuations: a) 110% for continuous rating b) 125% for at least one minute c) 140% for at least five seconds. Bidder shall fluxing characteristic up to 150% 		any tap position with ge variation from rated V/f the tap. Transformer shall uxing conditions due to cy fluctuations: ds. Bidder shall furnish over %	
	Air Clearance As per CBIP		

ansformer shall be provided with conventional single compartment conservator with prismatic toughened glass oil gauge. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather with transparent enclosure. Silica gel shall be isolated from atmosphere by an oil seal. Inverter transformers shall be provided with Magnetic Oil Gauge (MOG) with low oil level alarm contact.

- 5.3.2 It is the responsibility of the Contractor to ensure that the inverter transformer comply with all the requirements of inverter provided by the inverter manufacturer.
- 5.3.3 Inverter Transformer shall be designed for at least 5% total harmonic distortion (THD) to withstand distortion generated by the inverter as well as possible outside harmonics from the network.
- 5.3.4 The transformer shall be suitable for continuous operation with a frequency variation of \pm 2.5% from nominal frequency of 50 Hz without exceeding the specified temperature rise.
- 5.3.5 Inverter Transformer shall have shield winding between LV & HV windings. Each

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LV winding must be capable of handling non-sinusoidal voltage with voltage gradient as specified by the inverter manufacturer. Also, shield winding shall be taken out from tank through shield bushing and the same shall be brought down to the bottom of the tank using copper flat and support insulator for independent grounding.

- 5.3.6 Neutral bushing of Inverter duty transformer shall be brought outside the tank for the testing purpose. It shall be covered with MS sheet and a sticker "For testing purpose only. Do not earth". Neutral bushing of auxiliary transformer shall be brought outside the tank for earthing.
- 5.3.7 Transformer shall have 150 mm dial type Oil Temperature Indicator (OTI) and Winding Temperature Indicator (WTI) with alarm and trip contacts. All indicators shall have accuracy of 1.5%. For inverter transformers, WTI shall be provided for all the windings.
- 5.3.8 The radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/ valve at the bottom and air release plug at the top.
- 5.3.9 Marshalling Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 10% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Wiring scheme (TB details) shall be engraved in a stainless-steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.
- 5.3.10 Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement shall be provided.
- 5.3.11 Inverter transformer shall be provided with spring operated Pressure Relief Device (with trip contacts) with suitable discharge arrangement for oil. For Auxiliary transformers, diaphragm type explosion vent shall be provided.
- 5.3.12 Filter valve at top the tank and drain cum sampling valve at bottom of the tank shall be provided.
- 5.3.13 All external surface of the transformer shall be painted with two coats of epoxybased paint of colour shade RAL 7032. Internal surface of cable boxes and marshalling box shall be painted with epoxy enamel white paint. The minimum



dry film thickness (DFT) shall be 100 microns.

- 5.3.14 LV and HV cable box shall be provided with disconnecting chamber to facilitate the movement of transformer without disturbing cable box and termination.
- 5.3.15 Air release plug, bi-directional wheel/skids, cover lifting eyes, transformer lifting lugs, jacking pads, towing holes, core and winding lifting lugs, inspection cover, rating plate, valve schedule plate, accessories and terminal marking plates, two nos. of earthing terminals shall be provided.
- 5.3.16 Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.
- 5.3.17 The accessories listed above are indicative only. Accessories which are not mentioned above but required for satisfactory operation of the transformers are deemed to be included in the contract without extra charges.
- 5.3.18 Fire-protection for inverter transformer shall be provided in accordance with relevant CEA regulations as amended time to time.

5.4 Dry Type Auxiliary Transformer

- 5.4.1 Transformer shall be cast resin encapsulated dry type transformer, made of cold rolled grain-oriented silicon steel laminations of M4 grade or better. Winding conductor shall be electrolytic grade Copper/Aluminium and insulation shall be Class F or better.
- 5.4.2 The transformers shall be housed in a metal protective housing, having a degree of protection of IP 23 suitable for indoor installation. The enclosure shall be provided with suitable hardware and accessories required for satisfactory operation of the transformer per the relevant standard.

5.5 <u>Warranty</u>

The transformer shall be warranted against all material/ manufacturing defects and workmanship for minimum of 5 (five) years from the date of supply.

5.6 <u>Testing and Inspection</u>

5.6.1 Type Tests and Special Tests

The following type test and special test reports shall be submitted during detailed engineering. The tests should have been conducted on the similar transformer by NABL accredited laboratory.

5.6.1.1 Type Tests

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- Lightning impulse (Full & Chopped Wave) test on windings as per IEC 60076-3
- (ii) Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076-2
- 5.6.1.2 Special Tests
 - (i) Measurement of zero-sequence impedance as per IEC 60076-1
 - (ii) Measurement of harmonics of no-load current as per IEC 60076-1
 - (iii) Measurement of acoustic noise level as per NEMA TR-1
 - (iv) Short-circuit withstand test as per IEC 60076-5

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by Employer.

- 5.6.1.3 Type and Special tests are not required for auxiliary transformers of rating including 100 kVA and below. However, auxiliary transformer shall have minimum 3-star BEE rating as per BIS guidelines.
 - 5.6.2 Routine Tests

Each completed transformer shall be subjected to following routine tests as per the latest edition of IEC 60076 unless specified otherwise.

- (i) Measurement of winding resistance at each tap
- (ii) Measurement of voltage ratio between HV and LV windings at each tap
- (iii) Check of vector group
- (iv) Measurement of no-load loss and no-load current
- (v) Measurement of short-circuit impedance and load loss
- (vi) Magnetic balance test as per CBIP manual publication no. 295
- (vii) Separate source voltage withstand test
- (viii) Induced over voltage withstand test
- (ix) Measurement of insulation resistance
- (x) Marshalling box functional test
- (xi) IR Measurement on wiring of marshalling box
- (xii) Breakdown voltage test on transformer oil as per IS 335
- (xiii)Oil leakage test on completely assembled transformer along with radiators
- 5.6.3 Tests at Site

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After erection at site all transformer(s) shall be subjected to the following tests.

- (i) Measurement of voltage ratio
- (ii) Check of vector group
- (iii) Magnetic balance test
- (iv) Measurement of insulation resistance
- (v) Breakdown voltage test on transformer oil

In case the equipment is not found as per the requirements of the Technical Specifications of NIT, all expenses incurred during site testing will be to the Contractor's account and the equipment shall be replaced by him at free of cost.

6 HT Switchgear

6.1 Standards and Codes

All equipment provided under HT switchgear shall comply with latest editions and amendments of the relevant IEC standards and IS codes. In particular, the switchgear shall comply with the following standards and codes.

Standard/Code	Description
IS/IEC 62271-1	High Voltage Switchgear and Control gear - Part 1: Common Specifications
IS/IEC 62271-100	High Voltage Switchgear and Control gear - Part 100: AC Circuit Breakers
IS/IEC 62271-102	High Voltage Switchgear and Control gear - Part 102: AC Disconnectors and Earthing Switches
IS/IEC 62271-200	High Voltage Switchgear and Control gear - Part 200: AC Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
IEC 61869	Instrument Transformers
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment
IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV

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IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 3070-3	Lightning Arresters for Alternating Current Systems - Part 3: Metal Oxide Lightning Arresters Without Gaps
IEC 62052-11	Electricity metering equipment (A.C.) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) - Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

6.2 <u>Technical Parameters</u>

Parameter	Specification
System Parameters	
Highest system voltage	36 kV
Rated system voltage	33 kV
Rated frequency	50 Hz
Number of phases	3
Power frequency withstand voltage	70 kV (r.m.s.)
Lightning impulse withstand voltage	170 kV (peak)
System fault current	As per system requirement
Internal Arc Classification Rating	System Fault Current for 1 s
Circuit Breaker	
Туре	Vacuum type
Operating duty cycle	O – 0.3sec – CO – 3min – CO
Short circuit breaking current	As per system requirement
Short circuit making current	2.5 times S.C. breaking current
Re-strike performance class	C2
Mechanical endurance class	M1
Current Transformer	
Accuracy class	0.2 for metering (0.2s for metering at outgoing feeder), 5P20 for protection
Rated VA burden	As per requirement
Insulation class	Class E or better
Voltage Transformer	

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Accuracy class	0.2 for metering, 3P for protection
Rated VA burden	As per requirement
Insulation class	Class E or better

6.3 Switchgear Panel

- 6.3.1 The switchgear panel shall be free standing, floor mounted, single front, single tier fully compartmentalized, metal enclosed construction. Each panel shall have separate compartments for circuit breaker, bus bars, cable termination and auxiliary circuit.
- 6.3.2 The circuit breakers shall be mounted on horizontally withdrawable trucks with locking facility in SERVICE and TEST positions.
- 6.3.3 The panel enclosure shall be constructed with CRCA steel/Aluzinc sheet. The thickness of load bearing members shall be minimum 3 mm and that of non-load bearing members shall be minimum 2 mm.
- 6.3.4 All surfaces shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. The minimum dry film thickness (DFT) shall be 100 microns.
- 6.3.5 The circuit breaker and auxiliary circuit compartments provided on the front side shall have separate concealed hinged doors. Cable and bus bar compartments provided on the rear side shall have separate bolted covers. All doors and covers shall be provided with neoprene/synthetic rubber gaskets to prevent entry of vermin and dust.
- 6.3.6 Pressure relief device shall be provided in each high voltage compartment of a panel to safely vent the gases in the event of internal arc. Seal-off bushing arrangement shall be provided between the breaker compartment and bus bar/cable compartments to prevent transfer of arc from one compartment to other.
- 6.3.7 Automatic safety shutters shall be provided to cover up the fixed high voltage contacts on bus bar and cable sides when the truck is moved to TEST position.
- 6.3.8 Degree of protection shall not be less than IP 5X for auxiliary circuit compartment. However, for remaining compartments it shall not be less than IP 4X. For outdoor panels, degree of protection shall not be less than IP 55.
- 6.3.9 Mechanical /Electrical interlocks shall be provided to prevent mal-operation and in particular to ensure the following.
 - (i) The breaker shall be operated only if it is in SERVICE or TEST position.

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- (ii) Movement of the breaker truck between SERVICE and TEST positions shall be possible only if the breaker is OFF.
- (iii) It shall be possible to open the door only when the breaker is in TEST position.
- 6.3.10 Panel shall be provided with local bus-bar protection
- 6.3.11 Each switchgear panel shall be provided with thermostatically controlled space heaters, separately for breaker, cable and bus bar compartments, to prevent condensation within the compartment. The space heater shall be connected to 240 V, 50 Hz, single phase AC supply through suitable switch and fuse.
- 6.3.12 240 V, 5 A, SPN industrial socket-outlet with ON/OFF switch shall be provided in each panel.
- 6.3.13 Each panel shall be provided with LED lamp rated for 240 V, 50 Hz, single phase AC supply for interior illumination controlled by door switch.
- 6.3.14 Gapless, metal-oxide surge arrestors shall be provided between line and earth in cable compartment of the switchgear panel.
- 6.3.15 Suitable lifting hooks shall be provided for each panel.

6.4 <u>Circuit Breakers</u>

- 6.4.1 Circuit breakers shall be of vacuum type. It shall comprise of three separate identical single pole units operated through the common shaft and shall be fully interchangeable both electrically and mechanically.
- 6.4.2 The circuit breaker operating mechanism shall be based on motor operated spring charging and it shall be re-strike free, trip free both electrically and mechanically, with anti-pumping feature.
- 6.4.3 The rated control voltage of the spring charging motor shall be 110 VDC/230 VAC. Closing coil shall operate at all values of voltages between 85% and 110% of rated voltage. Opening coil shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity and at all values of supply voltage between 70% and 110% of rated voltage.
- 6.4.4 The spring charging motor shall have adequate thermal rating such that continuous sequence of the closing and opening operations is possible as long as power supply is available to the motor. It shall also be possible to charge the spring manually and close the breaker in the event of failure of motor / control supply to motor. Operating handle shall be provided for charging the operating mechanism. After failure of control supply to the motor, one open-close-open operation shall be possible with the energy contained in the operating

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mechanism.

- 6.4.5 The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring. Closing action of the circuit breaker shall compress the opening spring ready for tripping. When closing springs are discharged after closing the breaker, they shall be automatically charged for the next operation.
- 6.4.6 Mechanical indicators shall be provided to indicate OPEN/CLOSED positions of the circuit breaker and CHARGED/ DISCHARGED positions of the closing spring. An operation counter shall also be provided. These indicators and counter shall be visible from the panel front door without opening it.

6.5 <u>Relays</u>

- 6.5.1 All relays shall be microprocessor based numerical type. However, auxiliary relays can be static or electromechanical type. The relays shall be flush mounted on panel front with connections from the inside.
- 6.5.2 The relays shall be capable of operating continuously between 80 120% of auxiliary voltage.
- 6.5.3 All numerical relays shall have adequate number of freely configurable, optically isolated, Binary Inputs (BI) and potential free Binary Outputs (BO).
- 6.5.4 All numerical relays shall have minimum four no. of current inputs, three for phase current and one for earth current, suitable for CT secondary current of 1A. The current inputs shall be compatible with both residual connected CT and Core Balance CT (CBCT). In addition, numerical relay in main outgoing feeder shall have three no. of voltage inputs for Under Voltage/Over Voltage protection.
- 6.5.5 All I/O's shall have galvanic isolation. Analog inputs shall be protected against switching surges and harmonics.
- 6.5.6 Making, breaking and continuous capacity of the relay contacts shall be adequate enough for the circuits in which they are used.
- 6.5.7 The numerical relay shall have the following protection functions with at least two independent protection setting groups. The protection functions shall be selectable from any of the IEC characteristic curves.
 - (i) Definite time (DT) phase over current protection
 - (ii) Inverse Definite Minimum Time (IDMT) phase over current protection
 - (iii) Definite time (DT) earth fault current protection
 - (iv) Inverse Definite Minimum Time (IDMT) earth fault current protection

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- (v) Under Voltage protection
- (vi) Over Voltage protection
- 6.5.8 Transformer feeder protection relay shall have provision for the following protection functions.
 - (i) Buchholz alarm & trip
 - (ii) Oil Temperature Indicator (OTI) alarm & trip
 - (iii) Winding Temperature Indicator (WTI) alarm & trip
 - (iv) Pressure Relief Valve (PRV) trip
 - (v) Magnetic Oil Gauge (MOG) alarm
- 6.5.9 All numerical relays shall have provision for measurement and storage of electrical parameters such as voltage, current, frequency, active power, reactive power etc.
- 6.5.10 The numerical relay shall be able to record faults and events in non-volatile memory.
 - (i) Fault record At least 5 recent faults including the protection function operated, operating phase(s), voltages and currents along with date and time stamp.
 - (ii) Event record At least 200 events with date and time stamp.
- 6.5.11 The numerical relay shall have trip circuit supervision facility to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions. The relay shall also be able to provide circuit breaker monitoring, CT and VT supervision.
- 6.5.12 The numerical relay shall have self-diagnostic feature with separate output contact for indication of any internal relay failure.
- 6.5.13 The numerical relay shall have RS-232/RS-485/RJ-45/USB ports on front side for local communication with PC and on rear side for remote communication to SCADA system.
- 6.5.14 The numerical relay shall have feature for time synchronization through the SCADA System / networking.
- 6.5.15 The numerical relay shall be provided with backlit alphanumeric LCD to access protection settings, measurement parameters, fault and event records. Read and write access to protection settings shall be password protected.

6.6 <u>Instrument Transformers</u>

6.6.1 Instrument transformers shall be completely encapsulated cast resin type, suitable for continuous operation at the ambient temperature prevailing inside

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the switchgear enclosure, when the switchgear is operating at its rated load and the outside ambient temperature is 50°C.

- 6.6.2 Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.
- 6.6.3 Voltage transformers shall be single phase units. Bus voltage transformers shall be housed in a separate panel on withdrawable truck.
- 6.6.4 HRC fuses of suitable rating shall be provided on primary side of voltage transformers. For secondary side, four pole Miniature Circuit Breakers (MCB) shall be provided with its supervision facility.

6.7 <u>Earthing</u>

- 6.7.1 An earth bus made of copper shall be provided throughout the length of the panel. It shall be bolted to the framework of each panel and brazed to each breaker earthing contact bar.
- 6.7.2 The earth bus shall have sufficient cross section to carry maximum fault current without exceeding the allowable temperature rise.
- 6.7.3 All non-current carrying conductors of the panel shall be connected to the earth bus. All joints to the earth bus shall be made through at least two bolts. Hinged doors shall be earthed through flexible earthing braid of adequate cross section. Suitable provision shall be provided at each end of the earth bus for connection with Owner's Earth conductor.
- 6.7.4 Positive earthing of the breaker truck and frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.
- 6.7.5 All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth bus by independent copper wires of size not less than 2.5 sq. mm with green colour insulation.
- 6.7.6 Instrument transformer secondary neutral point shall be earthed at one place only on the terminal block. Such earthing shall be made through links so that earthing of one circuit may be removed without disturbing the earthing of other circuits.
- 6.7.7 Separate earthing trucks shall be provided for earthing of busbars and incoming/outgoing feeders. The trucks shall have voltage transformer to indicate presence of voltage prior to earthing. An audible alarm shall also be provided in case of voltage on the earthing terminal. Integral earth switches may also be

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considered instead of earthing trucks. The earthing truck/switch shall have short circuit withstand capability equal to that of the associated switchgear panel.

- 6.7.8 The interlocks shall be provided to ensure the following.
 - (i) It is not possible to rack-in the earthing truck/close the earthing switch when the breaker truck is in SERVICE position.
 - (ii) It is not possible to rack-in the breaker truck into SERVICE position when earthing truck is connected/earthing switch is in closed position.

6.8 <u>Bus bar</u>

- 6.8.1 Bus bar shall be made of copper or aluminium with uniform cross section throughout their length. They shall be adequately supported on insulators to withstand electrical and mechanical stresses due to specified short circuit current.
- 6.8.2 All bus bars joints shall be thoroughly cleaned and anti-oxide grease shall be applied. Plain and spring washers shall be provided to ensure good contacts at the joints and taps. Wherever aluminium to copper connections are required, suitable bimetallic connectors or clamps shall be used.
- 6.8.3 Bus bars shall be provided with heat shrinkable sleeves of suitable insulation class throughout their length with proper colour coding. All bus bar joints and taps shall be shrouded.
- 6.8.4 Bus bar support insulators shall be made of non-hygroscopic, arc and track resistant, high strength material suitable to withstand stresses due to over voltage and short circuit current.
- 6.8.5 The Contractor shall submit busbar sizing calculation for specified continuous and short time current ratings during detailed engineering.

6.9 Measuring Instruments

- 6.9.1 All the measuring instruments shall be digital, flush mounting type with communication facility.
- 6.9.2 All feeders except main outgoing feeder shall be provided with digital Multi-Function Meter (MFM). Tri Vector Meter (TVM) shall be provided for the main outgoing feeder (in the HT Panel). Accuracy class of MFM shall be 0.2 and that of TVM shall be 0.2S.
- 6.9.3 Measuring instruments shall have provision to display the following parameters.
 - (i) Line and phase voltages
 - (ii) Line and phase currents
 - (iii) Active power, Reactive power, Apparent power

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- (iv) Frequency
- (v) Power factor
- (vi) Total Harmonic Distortion (THD)
- 6.10 <u>Wiring and Terminal blocks</u>
 - 6.10.1 All internal wiring shall be done with 650 V grade, 1.5 sq.mm. PVC insulated stranded flexible copper wire. For CT secondary circuits, 2.5 sq.mm copper wire shall be used.
 - 6.10.2 Wire terminations shall be made with solderless crimping type tinned copper lugs, which shall firmly grip the conductor. Insulation sleeves shall be provided at all the wire terminations.
 - 6.10.3 Printed identification ferrules, marked to correspond with panel wiring diagram shall be provided at both ends of each wire. The ferrules shall be firmly located on each wire so that they cannot move or turn freely on the wire. Wire identification shall be done in accordance with IS 11353.
 - 6.10.4 The Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.
 - 6.10.5 All internal wiring to be connected to the external equipment shall terminate on terminal blocks. Terminal blocks shall be rated for 650 V, 10 A and made of non-inflammable material.
 - 6.10.6 CT and VT secondary circuits shall be terminated on stud type, nondisconnecting terminal blocks.
 - 6.10.7 At least 10% spare terminals shall be provided on each panel and these spare terminals shall be distributed on all terminal blocks.

6.11 Warranty

The HT panel unit shall be warranted against all material/ manufacturing defects and workmanship for minimum of 2 (Two) years from the date of supply.

6.12 <u>Testing and Inspection</u>

6.12.1 Type Tests

The switchgear panel shall be of type tested design. The following type test reports shall be submitted during detailed engineering. The tests should have been conducted on the similar equipment by NABL accredited laboratory.

Tes	st		Standard		Relev Claus	vant IEC se	
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Switchgear Panel		
Dielectric tests		
Power frequency voltage test	IEC 62271-200	6.2.6.1
Lightning impulse voltage test	IEC 62271-200	6.2.6.2
Dielectric tests on auxiliary and control circuits	IEC 62271-200	6.2.10
Measurement of the resistance of the main circuit	IEC 62271-200	6.4.1
Temperature-rise tests	IEC 62271-200	6.5
Short-time withstand current and peak withstand current tests	IEC 62271-200	6.6
Verification of the IP coding	IEC 62271-200	6.7.1
Verification of making and breaking capacities	IEC 62271-200	6.101
Mechanical operation test	IEC 62271-200	6.102
Internal arc test	IEC 62271-200	6.106
Circuit Breaker	·	
Mechanical operation test at ambient air temperature (M2 Class)	IEC 62271-100	6.101.2
Basic short-circuit test-duties	IEC 62271-100	6.106
Relays	1	1
Vibration tests	IEC 60255-21-1	
Shock and bump tests	IEC 60255-21-2	
Seismic tests	IEC 60255-21-3	
Electromagnetic compatibility requirements	IEC 60255-26	
Product safety requirements	IEC 60255-27	
Common requirements	IEC 60255-1	
Functional requirements	Relevant parts of IEC 60255-100 series	
Communication requirements	IEC 61850	
Current Transformers	•	
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Impulse voltage withstand test on primary terminals	IEC 61869-2	7.2.3
Tests for accuracy	IEC 61869-2	7.2.6
Short-time current tests	IEC 61869-2	7.2.201
Voltage Transformer		
Temperature-rise test	IEC 61869-3	7.2.2
Impulse voltage withstand test on primary terminals	IEC 61869-3	7.2.3
Test for accuracy	IEC 61869-3	7.2.6
Short-circuit withstand capability test	IEC 61869-3	7.2.301

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by Employer.

6.12.2 Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

7 AC Cables

7.1 <u>Standards and Codes</u>

All AC Cables shall conform to the following standards and codes.

IS 7098	Crosslinked polyethylene insulated PVC sheathed cables, Part 1: For working voltage up to and including 1100 V
IS 7098	Crosslinked Polyethylene Insulated Thermoplastics Sheathed Cables Part 2: for Working Voltages from 3.3 kV up to and Including 33 kV

- 7.2 All AC cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses develop under steady state and transient operating conditions.
- 7.3 Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted. However, cable joints may be allowed if the route length is more than maximum available drum length subject to Employer's approval.
- 7.4 In addition to manufacturer's identification on cables as per relevant standard, following marking shall also be provided over outer sheath.
 - (i) Cable size and voltage grade
 - (ii) Word 'FRLS' at every metre

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- (iii) Sequential marking of length of the cable in metres at every metre
- 7.5 Cables shall be sized based on the following considerations:
 - (i) Rated current the equipment
 - (ii) In case of Central inverters, maximum voltage drop in LT cable (from PCU to inverter transformer) shall be limited to 0.5% of the rated voltage. In case of String inverters, maximum voltage drop (from string inverter to LT combiner panel and from LT combiner panel to Inverter duty transformer) shall be limited to 1.5%. For HT cables (from inverter transformer to plant take off point), maximum voltage drop shall be limited to 0.5 % of the rated voltage. The Contactor shall provide voltage drop calculations in excel sheet.
 - (iii) Short circuit withstand capability as per design for 1s.
 - (iv) De-rating factors according to laying pattern
- 7.6 <u>Warranty</u>

All cables shall be warranted for minimum of 1 (one) year against all material/ manufacturing defects and workmanship.

7.7 <u>Testing</u>

Type, routine and acceptance tests requirements shall be as per relevant standards for all cable sizes.

7.8 Installation

- 7.8.1 Cable installation shall be as per IS 1255.
- 7.8.2 Cables within transformer yard and switchyard shall be laid through RCC cable trench

with supports.

- 7.8.3 Cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles. Bimetallic lugs shall be used for connecting Cu bus bar and Al cables or vice-versa.
- 7.8.4 All AC cables shall be provided with punched/embossed aluminium tags. The marking shall be done with good quality letter and numbers of proper size so that the cables can be identified easily.

8 Auxiliary Supply System

- 8.1 Scheme for Auxiliary supply system shall be submitted by contractor during detailed engineering for the approval by Employer.
- 8.2 It shall mainly comprise of auxiliary transformer, AC distribution board(s) (ACDB),

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Battery & battery charger system, emergency lighting network, Uninterrupted power supply (UPS), distribution cables and metering & protective devices.

- 8.3 Auxiliary system shall be provided with two independent sources for reliable auxiliary power supply.
- 8.4 Following consideration shall be taken into account while sizing the auxiliary transformer:
 - (i) 20% future load margin
 - (ii) 20% design margin
 - (iii) Total connected load at 0.8 power factor

9 LT Switchgear

9.1 <u>Standards and Codes</u>

All equipment provided under LT switchgear shall comply with latest revisions and amendments of the relevant IEC standards and IS codes. In particular, the switchgear shall comply with the following standards and codes.

Standard/Code	Description
IEC 61439-1	Low-voltage switchgear and control gear assemblies - Part 1: General rules
IEC 61439-2	Low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies
IEC 60947-1	Low-voltage switchgear and control gear - Part 1: General rules
IEC 60947-2	Low-Voltage Switchgear and Control gear: Circuit Breakers
IEC 60947-3	Low voltage switchgear and control gear: Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IEC 60947-4-1	Low-voltage switchgear and control gear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor- starters
IEC 60947-5-1	Low-voltage switchgear and control gear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
IEC 62052-11	Electricity metering equipment (a.c.) - General requirements, tests and test conditions - Part 11: Metering equipment
IS 694	Polyvinyl chloride insulated unsheathed-and sheathed cables/ cords with rigid and flexible conductor for rated voltages - up to and including 450/750V
IEC 61869	Instrument Transformers

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IS 3043	Code of practice for earthing
IEC 60255	Measuring relays and protection equipment - Part 1: Common requirements

9.2 <u>Technical Parameters</u>

System Details				
Rated system voltage	415 V ± 10%, 3 Phase, 50Hz, 4 wire, Neutral Solidly Earthed			
Digital Multifunctional Meter (M	Digital Multifunctional Meter (MFM)			
Accuracy class	0.5 class for main distribution board at main control room and 0.5 class for DB at inverter room(s)			
Communication with SCADA	RS485 communication with Modbus RTU			
Current transformer (CT)				
Туре	Cast Resin Bar Primary			
Voltage class and frequency	650 V, 50 Hz			
CT Secondary Current	1 or 5 A			
Class of insulation	Class F			
Accuracy class & burden				
a) For Protection	5P20, 5VA PS Class for REF and core balance CT (CBCT)			
b) For Metering	Class 0.5, 5VA (min)			
Minimum primary earth fault current to be detected by CBCT	1 A			
Instrument Security Factor for metering CT	5			
Voltage transformer (VT)				
Туре	Cast Resin			
Accuracy class	0.5			
Rated Voltage factor	1.1 continuous, 1.5 for 30 seconds			
Class of insulation	E or better			
Moulded case circuit breaker (MCCB)				
Rated voltage	415V			
Release	Thermal-Magnetic/Microprocessor			
Rated current	As per system requirement			

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Poles	4 poles
Rated insulation level	690V
Rated ultimate and service short circuit breaking Capacity	As per system requirement
Rated Making capacity (as per system requirement)	2.1 X Short circuit breaking Capacity
Utilization category	Α

9.3 <u>Constructional Details</u>

- 9.3.1 The panel shall be metal enclosed, free standing, floor mounted, modular type with compartmentalized construction having degree of protection of IP 24 (Indoor) and IP54 (outdoor) as per IS/IEC 60529. All doors and covers shall be provided with neoprene gaskets to prevent entry of vermin and dust.
- 9.3.2 All switches, push buttons etc. shall be operated front and shall be flush/semiflush mounted.
- 9.3.3 The panel shall be fabricated from 2 mm CRCA sheet steel for frame & load bearing surfaces. Partitions may be fabricated from 1.6 mm CRCA if no components are mounted on them.
- 9.3.4 Cable entries shall be from bottom. The opening of cable entry shall be covered by 3mm thick gland plates with proper sealing to avoid water and rodent entry.
- 9.3.5 Earthing bus bar of suitable cross section shall be provided throughout the length of panel.
- 9.3.6 The panel shall be duly wired with suitable size of 1.1kV, PVC insulated cable and terminals shall be brought out for cable connections. 10% spare terminals subjected to minimum one of each rating shall be provided on each distribution switchgear. All wire shall have ferrules as per wiring diagram.
- 9.3.7 The panel shall be painted with 2 coats of primer after pre-treatment and 2 coats of Polyurethane / epoxy paint with shade as decided by the Owner.
- 9.3.8 The panel shall be of dead front construction suitable for front operated and back maintained functioning.
- 9.3.9 240 V, 5 A, 3 pin industrial socket-outlet with ON/OFF switch shall be provided in each panel.
- 9.3.10 Each panel shall be provided with LED lamp rated for 240 V, 50 Hz, single phase AC supply for interior illumination controlled by door switch.
- 9.3.11 Suitable lifting hooks shall be provided for each panel.

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- 9.3.12 Each switchgear panel shall be provided with thermostatically controlled space heaters to prevent condensation within the enclosure. The space heater shall be connected to 240 V, 50 Hz, single phase AC supply through suitable switch and fuse.
- 9.3.13 Earth leakage relay with Core balance CTs (CBCT) shall be provided on main incoming feeders having phase CT ratio more than 50/1A. CBCT's shall be circular window type with window size based on the overall diameter of the cables, to be finalized during detailed engineering.

9.4 <u>Warranty</u>

Distribution panels (ACDB and DCDB) shall be warranted against all material/ manufacturing defects and workmanship for minimum of 1 (one) year from the date of supply.

9.5 <u>Testing</u>

Routine test and acceptance tests requirements shall be as per relevant standards for all cable sizes.

10 Uninterrupted Power Supply

10.1 <u>Standards and Codes</u>

Standard/Code	Description
IEC 62040-1	Uninterruptible power systems (UPS) - Part 1: General and safety requirements for UPS
IEC 62040-2	Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements
IEC 62040-3	Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements

10.2 <u>General Requirements</u>

- 10.2.1 The Uninterrupted Power Supply (UPS) system shall be designed to supply power to following loads (but not limited to).
 - (i) Data logger / SCADA
 - (ii) Fire Detection/ Alarm Panel
 - (iii) HMI of SCADA
 - (iv) Emergency Lighting
 - (v) Inverter's Auxiliary supply (if applicable)
 - (vi) HT panel auxiliary

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