भारत सरकार
GOVERNMENT OF INDIA
नाभिकीय ईंधन समिश्र
NUCLEAR FUEL COMPLEX

TECHNICAL SPECIFICATIONS

TENDER NO: NFC/EP/09/2026

Name of the Work: Design, Supply, Installation, Testing and commissioning of 2MW$_p$, 415 V grid interactive solar PV systems on roof tops of PFFF buildings along with 5 years of Annual comprehensive maintenance at Nuclear Fuel Complex (KOTA), Rawatbhata, Rajasthan

CONTENTS

1. INTRODUCTION

The Nuclear Fuel Complex (NFC) is set up at Rawatbhata near Kota, Rajasthan for production of PHWR Fuel tubes and Zircaloy components to cater the requirements of upcoming nuclear reactors. It is a major industrial unit of Department of Atomic Energy, Government of India.

Department of Atomic Energy as a part of its contribution to renewable energy generation plan of the country has a commitment to implement Solar PV system at its various units. NFC Kota has the concrete rooftops on PFFF building for installation of around 2000KWp Solar PV rooftop panels.

The power generated out of these units shall be completely for internal captive consumption only. To prevent back flow of power to the grid suitable reverse power relays are already in place.

2. PROJECT LOCATION AND SITE DETAILS

NFC, Kota is located near NPCIL power plants, Rajasthan State, INDIA. The working hours of the organization starts at 09:00 hrs and concludes at 17:00 hrs IST.

Rawatbhata coordinates	75.59 deg E, 24.93 deg N
Height above MSL	+ 360M
Max. Temp / Min Temp	45 deg C / 5 deg C
Average annual radiation	5.5 – 5.8 kWh/m^2/day
Number of sunny days in a year	300
Solar window duration	Avg 5.5-6.5 hours
Nearest Railway station	Kota Rajasthan
Nearest airport	Jaipur International Airport

Table 1-Site information

The roof top proposal for grid connected solar PV system of capacity 2000 KWp (DC rating) are planned on the rooftop of two modules of (Module-1, Module-2) PFFF building. The roof plans are as per the attached Roof layout document. The building is well connected to the nearest load center with existing overhead cable tray structure.

- Area available on PFFF Module-1 rooftop is 10000 m^2.
- Area available on PFFF Module-2 rooftop is 10000 m^2.

3. SCOPE OF THE WORK

Work is proposed to be executed in EPC mode which includes Design, engineering, supply, installation, Testing, commissioning and guarantee of grid interactive roof top solar PV system of total capacity 2000KWp at 415V on PFFF building on turnkey basis along with required SCADA system. The work also includes five-year comprehensive operation and maintenance of supplied roof top solar PV systems.

The scope of work shall include the following but not limited to:

- Design and Engineering of Civil, Mechanical, Electrical, Instrumentation & Quality Assurance aspects of the Solar PV system for completion of the project in all respects as per attached specification and standards.
- Submission of Design basis report along with filled in guaranteed technical particulars to the department for approval.
- Supply and Installation of Solar PV system with all components like PV panels with mounting structure and their interconnection with required protections, String Inverters, DC and AC cabling, AC power distribution boards, Switch gear etc required for connectivity to the grid.
- Installation of Weather monitoring systems, SCADA, metering etc. with required cabling.
- Earthing and lightning protection required for the system.
- Auxiliary works like illumination of the yards, running water lines along the periphery of the yard and also along the panels with spray nozzles for cleaning.
- Additionally dry type semi-automatic robotic cleaning system shall be deployed.
- Submission of final as built drawings/schematic and datasheets of each component.
- Registration and obtaining statutory approvals of CEA, RRECL, Rajasthan State Electricity Board as required along with registration and processing fee.
- Documentation, Technical Support & Coordination for getting clearance from statutory authorities like CEA, PCB, DISCOM, CERC, MNRE, REC registry etc. as required.
- Comprehensive Operation & Maintenance of the systems for five years.
- Any other material and consumables, lubricants, tools & tackles, man power etc. required for successful completion of job.

4. SCHEME AND GRID CONNECTIVITY DETAILS

The rooftop power system is being planned to be connected to respective plant power control centers at 415V level. The typical schematic is shown in the following figure.

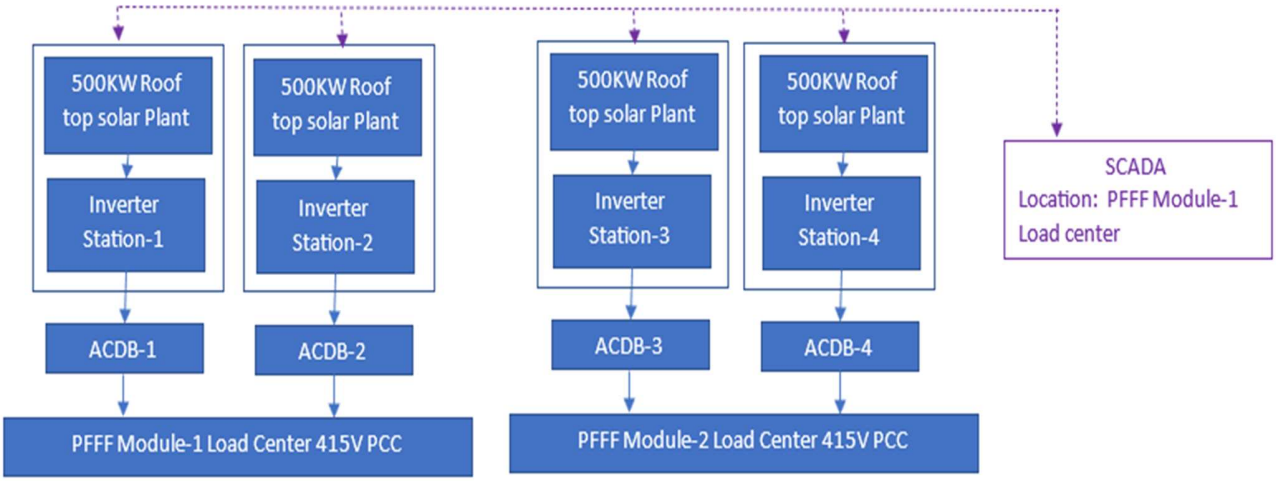

Fig: 1- Schematic of Grid connection

The 2 MWp rooftop solar PV plant shall be installed on the rooftops of Module-1 and Module-2 of PFFF building at Nuclear Fuel Complex (NFC) Kota.

The PFFF substation receives power at 11 kV from the 33/11 kV Main Receiving Substation (MRSS) of NFC Kota. NFC Kota in turn receives power at 33 kV from the Rajasthan Atomic Power Project (RAPPS) Township Substation.

The solar plant is proposed to be operated as a captive solar power plant within the internal electrical network of NFC Kota and is not directly interconnected with the State DISCOM grid.

Two (02) nos. of existing 415V load centres of Module-1 and Module-2 are available on either side of the PFFF building. The 2MWp solar plant shall be in sections of 500kWp each. The output of 2 Nos of 500KWp solar PV system shall be connected to two Nos 415V 1000A ACBs in PFFF Module-1 Load Center. Output of other 2 Nos of 500KWp solar PV system shall be connected to two Nos 415V 1000A ACBs in PFFF Module-2 Load Center. The load centers are approximately

250m away from the PFFF building. Over head cable tray structure exists connecting the PFFF building with the load centres as indicated in attached layout.

The power generated out of each solar plant is for internal consumption only, as the load on each of the bus is always more than the generation out of solar plant. In extreme cases when power demand on the connected AC bus is less than the solar power generated, power may flow back to the upstream 11KV grid where it shall be consumed.

5. GENERAL INSTRUCTIONS FOR EXECUTION OF THE WORK

The work has to be executed in accordance with detailed site use drawings/instructions which will be issued progressively after the placement of the work order to suit the progress of work at site.

The logistics involved in handling heavy equipment among the following items may be submitted to the department along with original documents of vehicles and test certificates of critical components used in handling.

The tenderers are advised to visit the proposed site of work to acquaint themselves with the site and the working conditions.

1. The tenderers shall carefully go through the clauses in the notice inviting tenders, Tender and contract, General Rules and directions, conditions of contract, clauses of contract, safety code, model rules for Labour Regulations, etc. and special instructions to the renderers as also specifications and shall include in their rates, any sum they consider necessary for the fulfilment of the various clauses contained therein. The items of work and unit rates quoted in the schedule of quantities shall be inclusive of everything necessary to complete the said items of work within the contemplation of the contract and the rates may be quoted accordingly. Makes indicated in this document are suggestive makes. No extra payment beyond the quoted unit rates shall be allowed for incidental or contingent work, labour, materials or plant unless the exclusions are specifically brought out in schedule of quantities.
2. The rates quoted by the tenderer shall **include:**
    i. Necessary care and precaution against damage/theft to equipment/materials, if any, supplied by the Department.
    ii. Safe custody and storage of materials at site.
    iii. Accommodation of contractor's staff
    iv. Protecting all installed equipment's in the area of work falling within the scope of the contract
3. The payment of minimum wages as notified by the State/Central Government and implementation of all regulations under contract Labour (Regulations and Abolitions) Act1970 (Central) and Central Rules 1971 and the rules and orders issued there under from time to time as amended up to date. Necessary books of account and other document for the purpose of this condition as may be necessary and shall allow inspection the same allowed by a duly

authorized representative of Government and further such other information/document as the Engineer-in-charge may require.

4. For enforcement of the building and other construction workers (Regulations Employment & Conditions of Service) Act 1996 and building and other construct Workers (RE & CS) Central Rules 1998.
5. All wastages and taxes including seigniorage tax, educational cess, VAT/turnover service tax, labour welfare cess etc., as applicable.
6. Following all the safety and security rules and regulations as required by the Department including deploying supervisor exclusively for safety.
7. Contractor shall take the responsibility for the safe execution of the work following safety instructions issued by Safety Engineering Division of NFC
   i. Non deployment of safety supervisor at site will be charged as per schedule 'F'
   ii. Minimum quantity of PPE proposed to be brought to site for use for implementation at site.
   iii. Delay in progress of work/completion of work in the effort of complying of safety whatsoever pertaining to it will not be considered as a genuine reason/cause for extent of time/or any other financial implications.
   iv. Record of safety compliance to maintained.
   v. Contractor shall be responsible for any unsafe incident/accident during the course of work and shall be penalized in the event of any accident including fatality.
   vi. All the tools including tools required for digging should be properly insulated to the satisfaction of Engineer-in-charge.
8. **Police verification certificate shall be taken for all labourers engaged in the work and also medical certificate indicating their fitness. Following the procedure envisaged in Special instructions to the contractors for entry and exit of men and materials or as per latest criteria envisaged by security Personnel**.
9. Contractor has to submit medical certificates, ESI &PF particulars for staff engaged for the work. The workmen employed for this work shall have a distinct uniform. The contractor is responsible for removal / shifting to an identified location the debris/ scrap produced during the execution of the work.
10. Contractor shall follow and plan the works to meet the policies of NFC line ISO 9001, ISO 14001 & 18001.

11. Procurement source and makes for the materials shall be got approved from the Department well in advance before initiating procurement.
12. Provided that where any provision of the specification is repugnant to or at variance unless a different intension appears, the provision of the schedule of quantities shall be deemed to override the provision of the specifications and shall to the extent of such repugnance or variation prevail.

6. TECHNICAL SPECIFICATION OF COMPONENTS

This specification is intended to cover the design, Supply, Installation, testing at manufacturer's works, installation, testing and commissioning of Solar PV panels, Inverter, LT solar cabling etc. required for setting up 2MWp, 415 V, grid interactive solar PV systems on roof tops of PFFF buildings.

The contractor shall, at its own cost, arrange and maintain comprehensive insurance coverage for all equipment, materials, tools, accessories, and works forming part of the Solar PV System from the date of dispatch / commencement of work till successful installation, testing, commissioning, and handing over of the system to the Owner.

A. SPV MODULE

1. The SPV modules must conform to the applicable standards as listed and must be tested and approved from any of the IEC/BIS/NABL authorized test centres.
2. All the offered solar modules shall be of single make.
3. The panels shall be **bifacial, half cut, PID free, TOPCON or superior panels (Superior technologies shall include HJT, IBC, or other next-generation cell technologies) with best average cell efficiency ≥ 23% at STC** and latest in the market. All Solar PV panels shall be from manufacturers listed in the Approved List of Models and Manufacturers (ALMM) List-I for Solar PV modules, as issued and updated by Ministry of New and Renewable Energy (MNRE), Government of India. All Solar PV modules supplied shall be manufactured using solar PV cells sourced exclusively from manufacturers listed in Approved List of Models and Manufacturers (ALMM) list-II for solar PV cells, as issued and updated by MNRE in accordance with the mandate effective June 1, 2026. Solar PV panels shall have valid BIS registration.
4. The Contractor shall carefully design & accommodate requisite numbers of the modules in the available area to achieve the rated power in his bid. The datasheet of technical specifications for modules/panels shall be submitted for approval. All materials used shall have approved history of reliability and stable operation in external applications.

Type	**TOPCON PID free bifacial with half cut cell configuration**
Cell Efficiency	≥23%
Module minimum rated power	540 Wp or more
Number of cells	As applicable
Bypass diodes	Schottky type as per design
Glass	Low iron and tempered glass of 3.2mm thick with AR coating, It shall be high transmission, toughened glass and durable.
Encapsulation	UV resistant and PID free POE/EVA or superior
Lamination	TPT / TPE type / superior
Degradation warranty	Panel output (Wp) capacity to be >=90% of design nominal power after 10 years and >=80% of design in Nominal power after 25 years from the completion of the trial run.

Module frame	Torsion and corrosion resistant Anodized Aluminum alloy
Bifaciality factor	80–85% (rear Pmax / front Pmax)
Termination box	The terminal box on the backside of module shall be designed for long life out door operation in harsh environment shall have a provision for opening and cable entry, if required. IP 68 & UV resistant.
PID resistant	The crystalline silicon-based modules supplied should be of Potential Induced Degradation (PID) free modules and the test certificate from third party lab complying with the same shall be provided.
RF Identification tag for each solar module	Shall be laminated inside the module and must be able to withstand environmental conditions and last the lifetime of the solar module.
Tolerances	It shall perform satisfactorily in relative humidity up to 100% with temperatures between -10° C and +50° C and shall withstand wind speed up to 44m/s on the surface of the panel. Wind load design shall comply with IS 875 (Part 3). The Panel installation shall be suitable for seismic zone III. Design shall comply with IS 1893 for seismic considerations
Cable & Connector (Protection degree / Type)	IP68 rated / MC4 compatible
Temperature coefficient power	Better than or equal to -0.30%/°C
RF Identification tag data	a) Name of the manufacturer of PV Module b) Name of the manufacturer of solar cells c) Month and year of manufacturer (separately for solar cells and module) d) Country of origin (separately for solar cells and module) e) I-V curve for the module f) W_m, I_m and FF for the module g) Unique Serial No and Module No of the module h) Date and year of obtaining IECPV qualification certificate i) Name of the test lab issuing IEC certificate j) Other relevant information on traceability of solar cells and module as per ISO 9000 standard k) QR code redundancy may be provided

Table 2- Technical Specifications of SPV Modules

5. The interconnected cells shall be laminated in vacuum to with stand adverse environmental conditions. The PV modules shall be suitable for operation in highly corrosive atmosphere throughout their lifetime.
6. The minimum clearance between the lower edge of the modules and the developed ground level shall be 600mm.
7. Surge arresting device to be provided at junction box and module shall be provided with bypass diode. Surge Protection Devices (SPD) shall comply with IEC 61643
8. The power tolerance shall be in line with the market standards.
9. The Contractor shall provide the sample solar PV module electrical characteristics including current-voltage (I-V) performance curves and temperature coefficients of power, voltage & current.
10. The peak power point voltage and the peak power current of any supplied module and/or any module string (series connected modules) shall not vary by more than 2 percent from the respective arithmetic means of all modules and/or module strings as the case may be.
11. Modules shall be provided with a junction box with provision of external screw terminal connection and with arrangement for provision of external & adequate capacity by-pass diode. The box should have hinged, weatherproof lid with captive screws and cable gland entry points.
12. The bidder should get a material warranty from the manufacturer for the Solar Module(s) to be free from the defects and/or failures specified below for a period not less than ten (10) years from the date of purchase which shall not be before the date of LOA.
13. Defects and/or failures due to manufacturing.
14. Defects and/or failures due to quality of materials.
15. Nonconformity to specifications due to faulty manufacturing and/or inspection processes. If the solar Module(s) fails to conform to this warranty, the manufacturer will repair or replace the solar module(s), at the Owners sole option.
16. The Solar PV modules supplied and installed under this Contract shall be warranted for minimum output peak watt capacity as follows:
    a. Not less than 90% of the rated capacity at the end of 10 years from the date of successful completion of Commissioning; and
    b. Not less than 80% of the rated capacity at the end of 25 years from the date of successful completion of Commissioning.

17. All power output measurements and performance verification shall be carried out strictly in accordance with the following IEC standards, as applicable:
    a. IEC 61829: PV array — On-site measurement of current-voltage characteristics;
    b. IEC 60891: Procedures for temperature and irradiance corrections to measured I-V characteristics;
    c. IEC 61724-1: Photovoltaic system performance — Part 1: Monitoring; and
    d. IEC 61853 series: PV module performance testing and energy rating.
18. The minimum sample size shall be the greater of:
    a. 5% of the total installed modules; or
    b. Such number as required to achieve a statistical confidence level of 95% with a margin of error of ±2%, as per IEC 62446.

    The sampling process shall be conducted jointly in the presence of representatives of both the Owner and the Contractor. The Contractor's failure to depute a representative shall not prevent testing from proceeding.
19. In the event that the measured power output of the Solar PV modules at the end of 10 years is found to be below the guaranteed values during the warranty period, after correction and normalization as per the applicable IEC standards, the Contractor shall, at no extra cost to the Owner, carry out one or more of the following remedies within 90 (ninety) days from the date of written notification by the Owner:
    a. Replace the defective or degraded module(s) with new modules of equal or higher rated capacity, of the same or better technology and efficiency, from a manufacturer approved by the Owner; or
    b. Provide additional Solar PV module capacity equivalent to the shortfall in guaranteed output so as to restore the guaranteed performance of the plant.

    In all cases, the Contractor shall bear all costs associated with the remedy, including but not limited to supply, transportation, installation, testing, re-commissioning, and any civil or structural works required.
20. If the Contractor fails to complete the remedy within the 90-day period, the Owner shall be entitled to:
    a. Encash the LTPG in full or part; and/or

b. Engage a third party to carry out the necessary remedial work at the Contractor's cost and risk.

Upon completion of rectification, re-testing shall be carried out as per the protocol specified in this Clause. The LTPG shall be retained until re-testing confirms satisfactory performance

21. The LTPG shall initially remain valid for a period of 2 (two) years from the date of submission and shall be renewed or extended by the Contractor from time to time so as to remain continuously and unconditionally valid up to and including the date falling 6 (six) months after the completion of 10 (ten) years from the date of successful Trial Run/Commissioning.

22. The Contractor shall submit renewal or extension documents at least 60 (sixty) days before the expiry of the LTPG. Failure to do so shall entitle the Owner to encash the LTPG forthwith without any further notice to the Contractor.

23. The LTPG shall be released within 60 (sixty) days after all of the following conditions are cumulatively satisfied:
    a. Successful completion of 10 years from the date of commissioning;
    b. Satisfactory performance verification confirming that the Solar PV modules meet or exceed the guaranteed output values for Year 10 as specified in Clause 1.1; and
    c. No pending rectification obligations or unresolved performance shortfalls under this Contract.

    If any of the above conditions are not met, the LTPG shall be retained and may be encashed by the Owner to the extent of the loss or shortfall of units as per prevailing rates at that time, without prejudice to any other rights of the Owner under the Contract. If the contractor is totally unresponsive, then the LTPG shall be the property of the Department only.

24. The Contractor shall, prior to release of the LTPG, Submit manufacturer's warranty certificates directly enforceable by the Owner and

25. To ensure direct enforceability, the Contractor shall arrange for the module manufacturer to execute a Tripartite Warranty Agreement among the module manufacturer, the Contractor, and the Owner, in a form approved by the Owner, which shall include:
    a. The module manufacturer shall issue a written declaration confirming that the Owner holds direct beneficiary rights under the module performance warranty and may invoke

and enforce such warranty independently against the manufacturer during the entire warranty period of 25 years.

b. The manufacturer's irrevocable undertaking to honour warranty obligations directly to the Owner in the event of the Contractor's default, insolvency, or dissolution;

c. The specific performance thresholds as set out and

d. The manufacturer's consent to MNRE/NABL accredited laboratory testing and on-site testing for performance verification.

26. End of life management for solar PV panels:

The Solar PV Module manufacturer / producer shall possess valid registration under applicable Extended Producer Responsibility (EPR) provisions and shall comply with the Waste Management Rules and other applicable regulations notified by the Government of India pertaining to Solar PV Modules / Panels.

The bidder shall obtain and submit an undertaking from the Solar PV Module manufacturer confirming compliance with applicable EPR requirements and commitment towards environmentally sound collection, take-back, recycling, and disposal of damaged, defective, and end-of-life PV modules through authorized recyclers / dismantlers in accordance with prevailing statutory regulations. The undertaking shall also confirm availability of an appropriate take-back mechanism and compliance with all applicable waste management rules, notifications, and amendments issued by competent authorities from time to time.

During the Operation & Maintenance period, any PV modules replaced due to failure, degradation, breakage, or manufacturing defects shall be safely removed and recycled / disposed of in compliance with applicable environmental and EPR regulations at no additional cost to the Owner.

Upon completion of the useful life of the Solar PV Plant or during decommissioning, the Solar PV Module manufacturer shall facilitate environmentally sound recycling / disposal of PV modules and associated electronic waste in accordance with prevailing statutory requirements and environmental regulations.

27. Testing:

Following tests shall be witnessed at OEM facility by Departmental representative:

a. Visual inspection.
b. Electrical test (I-V test) on all panels.
c. Electroluminescent test (EL test) on all panels.
d. Hipot test on 1% sample.
e. The complete test as per IEC 61215/IS 14286 and IEC 61730 to be conducted on one of the PV modules (random sampling). This test to be conducted at IEC/NABL accredited laboratory. The report for the same shall be submitted before commencement of trial run. This shall be one of the criteria for final acceptance of the system.
f. The flash test on minimum one module out of 1000 modules to be arranged by the bidder before supply of the SPV module. The flash test shall be conducted at one of the approve lab by IEC / NABL.
g. Modules shall be tested for LID and LeTID degradation as per IEC TS 63342 or equivalent.

Type test certificate shall be submitted for UV test of PV modules as per the IEC 61345 & Salt corrosion test as per IEC 61701.

Additionally, the performance of PV module at STC conditions must be tested and approved by one of the IEC / NABL accredited laboratory

Other Applicable Standards:

i. IEC 61215 (design qualification)
ii. IEC 61730 (safety)
iii. IEC 61701 (salt mist corrosion)
iv. IEC 62716 (ammonia corrosion)
v. IEC 62804 (PID)

Any deviation from the above specifications must be explicitly stated by the bidder; otherwise, it will be assumed that the offered product fully complies.

B. MODULES MOUNTING STRUCTURE

1. The PV modules shall be mounted on fully modular structures having adequate strength and appropriate design, which can withstand the load of the modules and high wind velocities of respective regions of installation.

Wind velocity withstanding Capacity	Design wind load shall be based on **IS 875 (Part 3)** using site-specific basic wind speed with appropriate terrain category, topography factor, and importance factor
Structure material	Hot dip galvanized steel with an average galvanization thickness of 100 microns with Minimum local thickness ≥85 microns
Bolts, nuts, spring washers etc.	Stainless steel of grade SS 304 /316 (M6, M10 etc. with 2 set of washers) with anti-seizing compound
Mounting arrangement for PV module	Using prefabricated fully modular hot dip galvanized MS frame work for holding the PV panels comprising of L brackets, Rafters, Purlin's, Vertical posts, Column Bracings, Rear Bracings, Block Tray Members, Base Plates etc. It shall be suitable for bifacial panels.
Mounting arrangement for Dead weight /pedestal	As per design calculations approved by the Department
Installation	The structures shall be designed for simple mechanical on-site installation without any welding work. No grouting or tampering of waterproofing is allowed on the roof.
Minimum distance between roof edge and mounting structure	1500 mm
Access for panel cleaning and Maintenance	All solar panels must be accessible from the top and bottom for cleaning and from the bottom for access to the module junction box.
Panel orientation	Preferably South facing.
Dead Weights for PV panels	M20 grade PCC blocks. PCC blocks shall be properly secured and placed on the rooftop

Table 3- Technical Specifications of Module Mounting Structure

2. Structure material shall be corrosion resistant and electrolytic compatible with the materials used in the module. Structural steel shall conform to IS 2062 (Grade E250 or higher). No welding is allowed on mounting structure. Puncturing shall be avoided on the roof slabs.
3. Ballasted mounting system shall be used without any penetration, grouting, or chemical bonding to the roof surface. Ballast weight calculation shall be submitted with design ensuring safety against sliding, overturning, and uplift
4. Each structure shall be electrically bonded and connected to earthing grid
5. The detailed design calculations considering the site wind velocities shall be supplemented with neat sketch and reference to various clauses of technical specification and Indian

standards. For MMS design analysis and determination of forces, where computer program (preferably STAAD) is used, the contractor shall submit a write- up on computer program used and its input and output data for review and approval to the department.

6. The structures shall be designed to allow easy replacement, repairing and cleaning of any module. The array structure shall be so designed that it will occupy minimum space without sacrificing the output from the SPV panels.
7. Adequate spacing shall be provided between two panel frames and rows of panels to facilitate personnel protection ease of installation, replacement, cleaning of panels and electrical maintenance. Suitable shadow analysis report has to be provided.
8. Each structure should have optimum angle of inclination suitable for bifacial panels depending on site constraints, shadow analysis, design calculations as per PVSyst to maximize the insolation and also considering to withstand wind velocities.
9. The minimum clearance between the lower edge of the modules and the developed ground level shall be 600mm.
10. All solar panels shall be accessible from the top and bottom for cleaning and from the bottom for access to the module junction box.
11. The structure shall be designed to allow easy replacement of any module.
12. The Bidder is responsible for the waterproofing of the roof disturbed/ pierced for installation of Project throughout the Project installation period and Comprehensive O&M period. The Bidder should immediately take necessary action to repair to the waterproofing.
13. Bidder shall submit detailed GA drawings, structural calculations, ballast calculations, and shadow analysis report for approval prior to execution
14. Inspection and Testing: All fabrications shall be inspected at Galvanizers works for

    a. Visual inspection and bill of material

    b. Acceptance tests for galvanizing material as per IS 4759, IS 2633, IS 2629, IS 6745

        i. Adhesion/hammer test

        ii. Knife test

        iii. Zinc coating thickness test

        iv. Preece test-copper sulphate test

        v. Mass of zinc - stripping test

    c. Supplier shall submit the chemical test report of the all-Mild steel HR sheet materials.

C. INVERTER/POWER CONDITIONING UNIT

1. The Inverter shall comply with CEA Technical Standards for Connectivity of Distributed Generation Resources Regulations as amended and as per IEC 61727 (grid interface).
2. Power Conditioning Unit (PCU) consists of an electronic Inverter using IGBT/MOSFET switching devices along with associated control, protection, isolating device and data logging devices. The PCU output shall AC three phase, four wire system of suitable capacity.
3. The power conditioning unit/inverter shall be grid connected. Inverter output should be compatible with the grid voltage & frequency.
4. The inverter used shall be string type uni-directional inverter confirming to the relevant national / international Electrical Safety Standards. The inverter shall have IP 65 enclosure and suitable for outdoor installation. The ambient temperature to be considered is -20^0C to 60^0C.
5. Inverter shall provide individual string current monitoring for each input string. String-level current, voltage, and power data shall be available on the monitoring platform at minimum 15-minute resolution. Inverter shall generate automatic alerts for string underperformance deviation exceeding 10% from expected value.
6. The continuous power rating of this individual inverter shall be equivalent to minimum 100% of peak power rating of each array connected to this inverter. It shall have overload capacity of up to 20%.
7. System shall be designed for AC:DC ratio in the range of 0.8 -0.85
8. The PCU shall have a minimum comprehensive warranty of 10 years.
9. DC/AC ratio shall be between 1.1 to 1.5 depending on design optimization of connected PV modules at STC.
10. The inverter control unit shall be so designed so as to operate the PV system near its maximum Power Point (MPP), the operating point where the combined values of the current and voltage of the solar modules result in a maximum power output.
11. The AC output voltage and frequency of the inverter must synchronize automatically to the exact AC voltage and frequency of the grid. Grid voltage shall be continuously monitored and in the event of voltage going below or above a preset value, the solar system shall be disconnected from the grid within the set time and again the solar system is resynchronized with the grid automatically after the restoration of grid. Both over voltage and under voltage relays shall have adjustable voltage setting and time settings (0 to 5 seconds).

12. Inverters shall be decided based on array design/suitable rating in case of string design, associated control and protection devices etc all integrated into PCU. It shall provide necessary protections for Grid Synchronization. Design calculations to be submitted.
13. The system shall be suitable to run in synchronization with grid supply of 415 V ± 10 %, 50 Hz ± 3%. All three phases shall be supervised with respect to rise/fall in programmable threshold values of frequency.
14. PCU shall confirm to IEC 60068-2 standards for Environmental Testing.
15. The minimum efficiency of the inverter shall be 96% at 75% load.
16. Total harmonic distortion shall be within limit as per IEEE 519 / CEA Regulations on grid connectivity. THD (current) ≤3%, "DC injection ≤0.5% of rated current.
17. A manual disconnect switch to be provided at inverter O/P side.
18. Built in with data logging to remotely monitor plant performance through external PC shall be provided.
19. The PCU shall have internal protection arrangement against any sustained fault in the feeder line and against lightning in the feeder line.
20. The PCU shall have the required protection arrangements against earth leakage faults.
21. The PCU must have the feature to work in tandem with other similar PCU's and be able to be successively switched "ON" and "OFF" automatically based on solar radiation variations during the day.
22. The PCU shall have anti-islanding protection as per IEC 62116 or equivalent standard. In the event of captive bus failure, the inverter automatically switches to off- within 20-50 milliseconds. The Solar system shall be able to synchronize with the captive bus immediately after the restoration of captive bus.
23. The PCU front panel shall be provided with a display (LCD or equivalent) of all important parameter
    a. Inverter per phase Voltage, current, kW, kVA and frequency
    b. Grid Voltage and frequency,
    c. Inverter (Grid) on Line status,
    d. PV panel voltage,
    e. Solar charge current.
    f. Individual power stage heat sink and cabinet temperature,

g. Inverter Import export kWh summation
h. Solar kWh summation
i. Inverter on
j. Grid on
k. Inverter under voltage/over voltage
l. Inverter over load
m. Inverter over temperature

24. Indications through LED/LCD display
    a. Inverter ON
    b. Grid ON
    c. Inverter Under / Over Voltage
    d. Inverter Overload
    e. Inverter Over Temperature
    f. PV panel voltage
25. It should have keypad for system control, monitoring instantaneous system data, event logs, data logs and changing set points. Control and read-out should be provided on an indicating panel integral to the Inverter. Display should be simple and self-explanatory display to show all the relevant parameter relating to PCU operational data and fault condition in form of front Panel LEDs or two-line LCD Display.
26. The PCU shall be capable of operating in parallel with the grid utility service and shall be capable of interrupting line fault currents and line to ground fault currents.
27. The PCU shall be able to withstand an unbalanced load conforming to IEC standard (+/-5% voltage) and relevant Indian electricity condition. The PCU shall include appropriate self-protective and self-diagnostic features 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 feature, shall be cleared by the PCU protective devices and not by the existing site utility grid service circuit breaker.

28. The DC bus system can be an integral part of the inverter panel and inverter panel should be of adequate size to accommodate the DC bus, DC breaker, Inverter module, O/G breaker/isolator, protections and any other required system.
29. Integrated DC isolator shall be provided.
30. The inverter panel should be well ventilated and shall use intelligent cooling (forced or natural) suitable for outdoor operation. While designing the system contactor must take care that in any case the temperature difference of inlet and outlet air should not go more than 10 deg C. Proper ducting arrangement if required shall be made for discharging the outlet air to atmosphere.
31. AC converted by the inverter is to be transmitted through the appropriate cables to AC panel having Protection Relays, fuses, annunciations and remote operating and controlling facility from the SCADA software.
32. The PCU/ inverters shall be tested from the MNRE approved test centres / NABL /BIS accredited testing- calibration laboratories. In case of imported power conditioning units, these should be approved by international test houses.
33. The inverter shall include adequate internal cooling arrangements for operation in a non-AC environment.
34. AI/analytics-based fault detection mode preferred.
35. The inverter shall have following modes of functioning: -

<u>Standby Mode</u>

a. The control system shall continuously monitor the output of the solar power plant until preset value of voltage, frequency is exceeded.
b. Basic system operation (Full Auto Mode). The system shall automatically "wake up" in the morning and begin to export power provided there is sufficient solar energy and the grid voltage and frequency is in range.
c. Maximum Power Point Tracker (MPPT). MPPT control algorithm shall adjust the voltage of the SPV array to optimise solar energy fed into the grid.

Sleep Mode

a. Automatic – "sleep" mode shall be provided so that unnecessary losses are minimized at night. The power conditioner must also automatically re-enter standby mode when threshold of standby mode reached.

36. The degree of protection of the unit shall be at least IP 65. Other than this, the following specifications shall be incorporated.
    a. Maximum input DC power: As per design
    b. Maximum DC input voltage: 1000V
    c. Nominal output frequency: 50Hz
    d. Nominal output voltage: 415 V (shall follow AC voltage and frequency of the grid)
    e. Nominal AC voltage tracking range: +20%, -20%
    f. Nominal AC frequency tracking range: 47.5 Hz to 52 Hz
    g. Inverter shall have suitably sufficient number of independent MPPT inputs. Each MPPT shall have independent input current monitoring. MPPT voltage range shall be 200–800V DC minimum to accommodate partial shading conditions and varying string configurations across rooftop sections. Max DC voltage shall be 1100 V
    h. Inverter shall support full reactive power control with power factor adjustable from 0.80 lagging to 0.80 leading at full active power output. Inverter shall support Q(U) and Q(P) reactive power control modes as per grid operator requirement. Static and dynamic grid support functions shall be configurable remotely.
    i. Waveform: Pure Sine Wave
    j. Harmonics AC side total harmonic current distortion <3%
    k. AC side single frequency current distortion <3%
    l. Ripple DC voltage ripple content shall be not more than 3%
    m. Efficiency >98% at full load and >95% at 20% load
    n. Losses: Maximum losses in sleep mode: less than 3W for 50 kWp/2W for 20 kWp
    o. Operation completely automatic including wake up, synchronization (phase locking) and shut down.
    p. MPPT range shall be suitable to individual array voltages
    q. Enclosure IP rating: Minimum IP65 (except cooling section if application)

37. Protections:
    a. Surge protection both on AC and DC side
    b. Ground fault protection
    c. Over voltage; both input & output
    d. Over current; both input & output
    e. Over/Under grid frequency
    f. Over temperature
    g. Short circuit
    h. Lightning
    i. Surge voltage induced at output due to external source
    j. Anti-Islanding
    k. Emergency switch off button
    l. AFCI (Arc Fault Circuit Interruption)

Additional parameters requiring automatic disconnection are

    a. Over current
    b. Earth fault
    c. And reverse power

In each of the above cases, tripping time should be less than a few seconds.

38. The inverter shall support following minimal functions for grid connectivity:

	Function
1	Low Voltage Ride Through
2	High Voltage Ride Through
3	Frequency Ride Through (47.5–52 Hz)
4	Reactive Power / PF Control (0.8 lag–lead)
5	Active Power Curtailment (remote)
6	Ramp Rate Control (±10%/min)
7	Anti-Islanding
8	SCADA Telemetry (IEC 60870-5-104 / Modbus TCP)
9	Power Quality (THD, DC injection)
10	Protection Settings (remotely configurable)

39. Inverter shall support the following communication protocols as standard:

    a. Modbus RTU (RS485)
    b. Modbus TCP/IP (Ethernet)
    c. IEC61850
    d. SunSpec Modbus

40. **Number of communication ports:** at least 2× RJ-45, 2× RS-485, 1× RS-232 shall be available
41. The following parameters shall be natively measured for each inverter.

Parameter	Unit	Resolution	Update Rate
AC Active Power (per phase + total)	kW	0.1 kW	1 s
AC Reactive Power (per phase + total)	kVAR	0.1 kVAR	1 s
AC Apparent Power (per phase + total)	kVA	0.1 kVA	1 s
AC Voltage (L-L and L-N per phase)	V	0.01 V	1 s
AC Current (per phase)	A	0.01 A	1 s
Grid Frequency	Hz	0.001 Hz	100 ms
Power Factor (per phase + total)	—	0.001	1 s
DC Input Voltage (per MPPT)	V	0.1 V	1 s
DC Input Current (per MPPT)	A	0.01 A	1 s
DC Input Power (per MPPT)	kW	0.1 kW	1 s
IGBT / Module Temperature	°C	0.1 °C	10 s
Transformer Temperature	°C	0.1 °C	10 s
Ambient Temperature (internal)	°C	0.1 °C	60 s
Cooling Fan Speed	RPM / %	1 RPM	10 s
Inverter Efficiency	%	0.01%	1 s
Energy Generated (lifetime)	MWh	0.001 MWh	1 s
Energy Generated (daily, resettable)	kWh	0.1 kWh	1 s
Insulation Resistance (DC)	MΩ	0.1 MΩ	60 s
DC Arc Fault Status	Boolean	—	100 ms
Fault/Warning Code (32-bit bitmap)	—	—	100 ms
Inverter Operating Status	Enum	—	1 s

42. Inverter shall have onboard datalogger with minimum 90-day local storage at 5-minute resolution. Remote firmware upgrade capability via network shall be provided. Inverter shall be compatible with third-party SCADA systems without proprietary hardware.
43. The complete Modbus register map shall be provided as a machine-readable Excel or CSV file. Register map document shall be publicly available (no NDA restriction) or made available at point of tender. Register map shall include: register address, data type, scaling factor, units,

access (R/W/RW), description. IEC 61850 SCL (System Configuration Language) .CID file and .ICD file shall be provided.

44. The power conditioning units/inverters shall comply with applicable IEC/equivalent BIS standard for efficiency measurements and environmental tests as per standard codes IS/IEC 61683 and IEC 60068 2 (6, 21, 27, 30, 75, 78).
45. The MPPT units shall qualify IEC standards. The junction boxes/enclosures shall be IP 65 and as per IEC 62208 specifications.
46. The PCU/ inverters should be certified from MNRE approved test centres / NABL /BIS accredited testing calibration laboratories. In case of imported power conditioning units, these should be approved by international test houses.
47. Required shed for housing the inverters and ACDB on the rooftop shall be made available by the department.

D. DC CABLES

1. Cables of 1500 V DC grade**,** flexible annealed electrolytic grade Class-5 tinned copper conductor, flame retardant low smoke halogen-free type, Electron Beam (E-Beam) cross-linked XLPO insulated and sheathed, UV stabilised and conforming to IS 17293:2020 / EN 50618 / IEC 62930 / TÜV 2PfG 1169 with latest amendments shall be used for all DC wiring in the Solar PV system.
2. All DC cables shall carry a valid BIS licence mark as mandated under the Solar DC Cable and Fire Survival Cable (Quality Control) Order, 2023 issued by the Government of India. Cables without BIS certification shall not be accepted.
3. All cables shall be FRLS-HF type, UV resistant, ozone resistant, moisture resistant and suitable for continuous outdoor solar applications over a design life of 25 years.
4. Cable Construction:
    a. Conductor Specification

    i. Material: Annealed bare tinned electrolytic grade copper
    ii. Conductor class: Class 5 (flexible/stranded) as per IEC 60228 / IS 8130
    iii. Tinning: Hot-dipped or electro-tinned to prevent oxidation and ensure reliable termination
    iv. Conductor operating temperature: 90°C continuous
    v. Short circuit temperature: 250°C

    b. Insulation and Sheath

    i. Insulation material: E-Beam cross-linked polyolefin (XLPO), halogen-free
    ii. Sheath material: E-Beam cross-linked polyolefin (XLPO), halogen-free, UV stabilised
    iii. Insulation colour: Positive — Red or Brown; Negative — Black or Blue
    iv. The insulation and sheath shall withstand prolonged UV exposure without cracking, hardening, or loss of mechanical properties for the entire design life of the plant
    v. Halogen content: Nil (zero halogen as per IEC 60754-1)
    vi. Smoke emission: Low smoke as per IEC 61034
    vii. Flame retardancy: As per IEC 60332-1-2

5. Electrical Ratings

a. Rated voltage: 1500 V DC

b. System voltage: Up to 1500 V DC

c. Rated current: As per cable size and applicable derating factors

d. Insulation resistance at 20°C: > 10^{14} Ω

e. Insulation resistance at 90°C: > 10^{11} Ω

f. Surface resistance of sheath: > 10^{9} Ω

6. Cable Sizing and Voltage Drop

Cable sizes shall be selected based on the following criteria:

a. Current carrying capacity: The cable shall be sized to carry at least 1.25 times the short circuit current (Isc) of the connected string/array under STC, with applicable derating factors for: Ambient temperature, Cable grouping / bunching, Installation method (tray, conduit, direct sun exposure).

b. Voltage drop limits:

Segment	**Maximum Permissible Voltage Drop**
Module string to Array Junction Box (AJB)	1.0% of string Vmp
Array Junction Box to Inverter DC input	0.5% of string Vmp
Overall DC side (Module to Inverter)	1.5% cumulative of string Vmp

Table 4- Voltage Drop limits for DC cabling system

If voltage drop in any segment exceeds the above limits, the next higher standard cable size shall be selected.

c. Minimum cable sizes:

Application	**Minimum Cable Size**
Module to module (inter-module)	1C × 4 sq. mm
Module string to Array Junction Box(AJB)	1C × 4 sq. mm (or higher as per voltage drop)
Array Junction Box to Inverter DC input	As designed based on number of strings, current, and cable length

Table 5- DC Cable sizing requirements

All cables from AJB to inverter shall be sized individually for each run based on actual connected string current and cable route length.

7. Installation Requirements

a. Positive and negative DC cables of each string shall be routed together at all times to minimise inductive loop area and reduce electromagnetic interference
b. All DC cables on rooftop shall be routed through 2 mm thick hot dip galvanised (HDG) perforated cable trays of required width (minimum 150 mm width, or as designed), with HDG galvanising thickness of not less than 85 microns
c. Cable tray covers shall be perforated type to ensure adequate ventilation and heat dissipation
d. Cable trays shall be supported at maximum 1.5 m intervals on rooftop structures
e. Each cable tray shall have two runs of 25 × 3 mm hot dip GI earth strip with welded/bolted connections at every joint for continuity
f. DC cables shall be properly bunched and secured to cable trays using metallic cable ties or straps at intervals not exceeding 300 mm
g. Minimum bending radius of cables during installation shall not be less than 6 times the cable outer diameter
h. Cables shall not be laid in direct contact with sharp edges, metal surfaces, or abrasive materials without adequate protection
i. All cable terminations shall be made using crimped copper lugs of appropriate size; no bare wire insertion into terminals shall be permitted
j. Identification cable tags of aluminium shall be provided at both ends of each cable and at every 10 m interval along the cable route, clearly indicating cable ID, size, source, and destination
k. No DC cable splicing shall be permitted in the open. All cable joints, if unavoidable, shall be made only inside IP65-rated or higher junction boxes using approved connectors
l. Panels connected to a particular string shall be clearly labelled/ identified using marking/painting on the ground.

8. MC4 Connectors*:* All DC cable connections between modules, strings, and junction boxes shall use MC4 type connectors conforming to IEC 62852 / IS 16781 with the following specifications:

   a. Rated voltage: 1500 V DC minimum
   b. Rated current: 30A minimum
   c. IP rating: IP67 minimum (IP68 preferred for ground-mounted and rooftop exposed locations)
   d. Contact material: Tinned copper or silver-plated copper
   e. Housing material: UV-stabilised, halogen-free polymer
   f. Temperature range: -40°C to +90°C
   g. Locking mechanism: Positive snap-lock with tool-release only (no accidental disconnection)
   h. Connectors and cables shall be from the same manufacturer or shall be a proven compatible pair certified by the connector manufacturer. Cross-brand MC4 mating between uncertified pairs shall not be permitted under any circumstances
   i. All mated connectors shall be fully seated, locked, and visually inspected before energisation

9. The contractor shall furnish valid type test reports from an NABL accredited / BIS certified laboratory for the offered cable confirming compliance with IS 17293:2020 / IEC 62930 / EN 50618. Type test reports shall not be older than 5 years from the date of supply. The following type tests shall be covered:

No.	Type Test	Standard
1	UV resistance / weathering	IEC 60068-2-5
2	Thermal ageing	IEC 60216
3	Ozone resistance	IEC 60811-403
4	Tensile strength and elongation at break (before and after ageing)	IEC 60811-501
5	Flame retardancy	IEC 60332-1-2
6	Halogen content (zero halogen)	IEC 60754-1
7	Low smoke emission	IEC 61034-2
8	Water immersion test	IEC 60811-401
9	Oil resistance (for ground-mounted)	IEC 60811-404
10	Cold bend / cold impact test	IEC 60811-506

Table 6- List of Type tests

10. Routine Tests (To Be Conducted at Manufacturer's Works)

The following routine tests shall be conducted at the manufacturer's works in the presence of Departmental personnel on every drum of cable supplied, and test certificates shall be submitted to the Department before despatch:

No.	Type of Test	Test Conditions / Standard
1	Conductor resistance	As per IEC 60228 / EN 50395
2	High voltage test	**15 kV DC** for 5 minutes on complete cable as per IEC 62930
3	Spark test (100% during production)	**6 kV AC** on insulated core during extrusion as per IEC 60230
4	Surface resistance of sheath	$> 10^9\ \Omega$
5	Insulation resistance at 20°C	$> 10^{14}\ \Omega$
6	Insulation resistance at 90°C	$> 10^{11}\ \Omega$
7	Dimensional check	Wall thickness, outer diameter as per drawing
8	Conductor cross-section verification	Actual cross-section ≥ nominal cross-section

Table 7- List of Routine Tests

E. AC CABLES

1. The cable shall be 1.1 KV grade, 3.5 core, XLPE insulated, stranded Aluminum conductor cable with cores suitably laid up, extruded PVC ST-2 inner sheathed, GI flat wire armored and overall extruded FRLSH PVC ST2 outer sheathed conforming to IS: 7098 – Part-I with latest amendments.
2. The size of each type of AC cable selected shall be based on minimum voltage drop however; the maximum drop shall be limited to 2 %. AC cables are to be laid from each of the inverter to the ACDB from where cables are to be extended to ACB panel extension board. Cable sizing calculations based on amperage and length are to be submitted to the department for approval.
3. Installation of MV (1.1 kV grade XLPE) cables on wall/ceiling/through sleeves/on beams etc. as per site conditions with all materials required for installation such as suitable size of G.I. clamps with screws, G I spacers fixed with suitable screw, saddles, etc. including minor breaking of wall, metal sheets etc. complete in all respects and as directed by Engineer-in-Charge.
4. 2 nos. hot dip galvanised GI strip (size based on fault level) shall be run throughout the cable tray and connected at both ends. Engraved anodized Aluminium cable tags indicating cable number, length, size, from and to, shall be provided at regular intervals of 20 meter. Cable trays are already available in the proposed route and can be utilized for laying of cables. However, cable trays of appropriate size to the extent of 50 meters shall be supplied. Cable trays shall be 2mm thick hot dip galvanized perforated cable trays with tray covers.
5. The fire barrier (3 Hr. Rating) to be installed at opening or cable passing from one bldg. / room to another location either from wall or floor. The Fire barrier should be a non-Cementous type.
6. End jointing of MV cable of 1.1 KV grade XLPE insulated, armored power cable including supply and installation of all jointing materials such as heavy-duty double compression weather proof type cable glands, crimping type heavy duty long neck copper lugs, insulation tape, including earthing of cable gland with copper earth wire from the nearest earth ring.
7. Acceptance tests as per IS shall be performed at manufacturer works before Dispatch of the cables.

F. AC DISTRIBUTION BOARD AND ITS CONNECTIVITY

1. The power distribution board shall be constructed considering the type of the inverters being designed for this project. If string inverters are being proposed, the rating of the incomer feeders of the AC power distribution board shall be designed with suitable capacity microprocessor based adjustable MCCBs. The outgoing feeder shall be suitably rated ACB (Minimum 1000A rating).
2. In case of designing a centralized inverter, a standalone power distribution board with 1000A ACB feeder shall be designed as per the specifications.
3. The panel shall be indoor, IP54, dead front, sheet steel enclosed type, vermin and dust proof construction suitable for installation in dusty atmosphere, metal clad floor mounting & draw out type for ACB feeders. They shall withstand 50KA/1sec fault current, arc resistant with internal arc tested for 50KA/0.3 sec and air insulated. The associated LT cabling shall be suitable for this fault rating. The design and construction of the panel shall be such that the same can be extended on either side.
4. Panel shall be type tested as per IS 61439, Form IV B construction of approved OEMs or channel partners as mentioned.
5. The equipment shall be suitable for use in 415 V + 6% 3 phase 4 wire system having a symmetrical short circuit rating of 50 KA /1sec as specified in SOQ.
6. The panel shall be made out of 2 mm thick sheet steel and gland plate shall be 3mm thick. The panel shall be painted with synthetic enamel paint both inside and outside with approved color shade. Before painting all the metal parts shall be subjected to seven tank pre-treatment processes.
7. The maximum operating height of any feeder shall be restricted to 1800 mm from the floor level and minimum operating level for switches shall be 300mm from the operating level.
8. Each circuit breaker shall be housed in a separate cubicle complete with individual front access door. Each vertical section shall have a removable back door. All the doors shall be fixed with gaskets.
9. Switch gear cubicle shall be sized such that the front door can be closed even if the circuit breaker is in draw out / isolated condition.
10. All the meters, indicating lamps etc shall be flush type.

11. Suitable shrouds shall be provided to the live parts to avoid accidental contact whenever the doors are open.
12. The bus bars shall be of TPN high conductivity E91EWP grade aluminium sized for specific current ratings with maximum temperature rise limited as per the relevant Indian Standards.
13. All the bus bar joints shall be maintained with adequate contact pressure by using double bolts, plain and spring washers. Bimetallic connectors shall be provided for connections between dissimilar materials.
14. Bus bars and connections shall be fully insulated with colour coded sleeves for working voltage and with adequate clearances. Insulation shrouds shall be provided for bus joints.
15. Bus bar supports shall be flame retardant type with high creepage surface.
16. Bus bars shall be designed and supported to with stand the forces developed during short circuit and to take care of the thermal expansion.
17. Horizontal and vertical bus bars shall be housed in separate compartments so that no live bus bar is accessible while working on outgoing of any breaker. Adequate clearances shall be provided between bus bars of different phases for easy maintenance.
18. The circuit breaker shall be Three pole, air break, draw out and electrically operated.
19. Electrically operated breaker shall be provided with spring charging motor operated on 230V 50 Hz power, pistol butt type Trip, Neutral, Close spring-operated switch for controlling the breaker.
20. The circuit breaker shall be provided with Service, Test & Isolate position indicators.
21. The draw out contacts shall be made of copper/copper alloy faces with silver plating.
22. Pad locking arrangement shall be provided for rack in operation of breaker as well as for the panel door meeting LOTO requirements.
23. Separate copper earth bus rated to carry maximum fault current for the specified time of 1 second shall be provided along the full length of each board. Each stationary unit shall be earthed directly to this earth bus by two separate and distinct connections and also the earthing contact bar of all breakers shall be brazed to it.
24. Hinged doors shall be earthed through flexible earthing braids. All non-current carrying metal parts shall be effectively bonded to the earth bus.
25. Positive earthing of circuit breaker frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

26. Door interlock shall be provided to prevent opening of the door when the switch is in Service Position. However, a defeat mechanism may be provided to this feature to use in case of emergency.
27. Automatic safety shutter shall be provided to all the breakers to fully cover the live parts (primary disconnectors) when the breaker is drawn out.
28. Safety interlock shall be provided to avoid drawing out the breaker or racking in when the breaker is in ON position
29. For motor operated breaker the spring charging shall start after each breaker closing operation. Alternate manual spring charging mechanism shall also be provided in case of problem with motor or power failure
30. Each breaker shall be provided with emergency manual TRIP button, mechanical ON/OFF indicator, mechanical spring charge / discharge indication
31. Each breaker shall be provided with auxiliary switches. There shall be at least 4 NO and 4 NC (potential free) spare contacts after using the required contacts for the control wiring.
32. The ACB feeders shall be provided with following indications
    a. Power indication - R Y B
    b. Breaker Open - Green
    c. Breaker Close - Red
    d. Breaker Trip - Amber
    e. Spring Charged – Blue
33. All MCCB feeders shall be provided with ON/ OFF/ TRIP indications.
34. All the indications shall be provided with relevant markings and shall be of LED type operated on 230 V AC.
35. **Multi-function meter** shall be provided on all incoming feeders and shall monitor and display voltage, current, power factor, frequency, power, energy, phase angle, no. of on-hours, date, time etc. It shall have a suitable communication interface and MODBUS TCP/IP or MODBUS RTU/IEC 61850 protocol. It shall communicate all the above parameters to a PC. It shall be connected on SCADA network. Current transformer required for MFM and the MFM shall be of Accuracy class 0.2S
36. All the meters shall be switch board type, flush mounted digital type, anti-glare glass and accuracy class of 2%.

37. CT wiring shall be with 2.5 Sq.mm FR copper wire and other wiring with 1.5 Sq.mm HFFR Copper wire.
38. All the feeders shall be provided with overload, short-circuit and ground fault protection releases. Necessary Current Transformers on the 3 phases and neutral shall be provided to achieve the desired protections.
39. The switchgear shall be fully wired at factory to ensure proper functioning of the control, protections and interlocking schemes. The ACB shall be equipped with anti-pumping function.
40. The ACB shall have an in-built microprocessor-based release for LSIG protection.
41. The ACB shall communicate on MODBUS TCP/IP/IEC 61850 over Ethernet.
42. Each wire shall be identified at both ends with permanent markers / ferrules
43. All terminations shall be with suitable crimping type connectors, insulation sleeves etc.
44. The terminal block used for the panel shall be 660 V grade box clamp type with marking strips similar to Elmex make. Terminals for the CTs shall be shorting and disconnection type.
45. Not more than 2 wire shall be connected in any terminal. 20 % of the terminals used shall be provided as spare terminals in each vertical section
46. Location of the terminal block shall be such that they can be accessed easily
47. All openings in sheet steel partitions for carrying out inter-panel wiring shall be provided with rubber/PVC grommets.
48. The switchgear shall be designed for cable entry from the bottom
49. All provisions and accessories shall be provided for termination and connection of cable including removable gland plates, cable supports, chrome plated terminal bolts and nuts with spring washers
50. All connecting bus shall have the same continuous rating as associated switchgear bus and shall be fully supported to with stand the specified short circuit currents.
51. Nameplates of approved design shall be furnished at each cubicle and at each instrument and device mounted on or inside the cubicle. The material shall be lamicoid or approved equal, 3 mm thick with white letter on black background.
52. The nameplate shall be held in place with self-tapping screws. Nameplate size shall be minimum 20 x 75 mm for instrument/devices and 40 x 150 mm for panels.
53. Caution notice on suitable metal plate shall be affixed at the back of each vertical panel.

54. Each PDB shall be provided with thermostat-controlled space heater and 5A, 3 pin plug socket in any one vertical panel.
55. Bus-wires of adequate capacity shall be provided to distribute the incoming supplies to different cubicles. Isolating switch-fuse units shall be provided at each cubicle for A.C supplies.
56. One number of height adjustable breaker handling truck shall be provided with required guide rails and stops.
57. 25 Sq.mm Flexible single core copper cable shall be brought up to cable chamber for feeders of rating up to 63 A and terminals shall be provided. 16Sq.mm Single Core copper cable shall be used for 32A feeders. For feeders of 125 A and above rating, bus bars of adequate cross section shall be brought up to cable chamber.
58. All MCCBs shall be microprocessor based of suitable rating with earth fault release, rotary handle for door interlock.
59. Spreader links shall be used for all the feeders for obtaining suitable clearance between bus bars.
60. All feeders shall be identified by painting after the feeders are connected to the respective loads.
61. The clearances and creepage distances shall be as per IS.
62. Make of the components shall be strictly as per specification.
63. Tropical Protection

    All equipment, accessories and wiring shall have fungus protection, involving special treatment of insulation and metal against fungus, insects & corrosion.

    Screens of corrosion resistant material shall be furnished on all ventilating louvers to prevent the entrance of insects.
64. Painting

    All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease & rust.

    After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality primer and stoves after each coat.

    The switchgear shall be finished in light grey (shade no. 631 of IS-5) with two coats of synthetic enamel paint.

    Sufficient quantity of touch-up paint shall be furnished for application at site.

65. Guaranteed Performance: The performance figures quoted in the Technical Particulars sheets shall be guaranteed within the tolerance permitted by relevant standards. In case of failure of the equipment to meet the guarantee, the purchaser reserves the right to reject the equipment until the new equipment meeting the guarantee requirement is supplied by the supplier. However the supplier will be given an opportunity to rectify his equipment at his own cost. Also purchaser reserves the right to use rejected equipment till it is rectified. The period of guarantee of the equipment shall be as per the NIT.

G. METERING & INSTRUMENTATION

1. **Solar Irradiance**: Two numbers of integrating Pyranometer / Solar cell based irradiation sensor (along with calibration certificate) to be provided, with the sensor mounted in the plane of the array. Readout shall be integrated with data logging system.
2. **Temperature Sensing**: Temperature probes for recording the Solar panel temperature and ambient temperature to be provided complete with readouts integrated with the data logging system.
    a. For ambient temperature monitoring, atleast 2 no of temperature probes shall be supplied.
    b. For panel temperature monitoring, atleast 10 no of probe shall be supplied.
3. **Data Concentrator**:
    a. The Data logger / monitoring /Acquisition system shall be provided for the solar PV system. Data Logging Provision for plant control and monitoring, time and date stamped system data logs for analysis with the high quality, suitable latest PC as per specification. Metering and Instrumentation for display of systems parameters and status indication to be provided.
    b. As a minimum data concentrator shall have separate power supply module, CPU module and I/O module. To achieve redundant architecture, either separate data concentrator shall be considered or data concentrator shall have redundant power supply module and redundant CPU module. The CPU module shall have sufficient communication ports depending on relay LAN requirement.
    c. The Data Logger shall natively support the following protocols-
        - MODBUS TCP/IP and MODBUS RTU
        - IEC-61850
        - IEC 60870-5-104
    d. The Data Concentrator shall act as a robust gateway to the upper-level Central Control Room (CCR). Communication to the CCR shall be executed exclusively over a redundant Industrial Ethernet network utilizing the IEC 60870-5-104 protocol.
    e. Physical Ports: The master module shall provide onboard communication interfaces including:
        - Minimum 2 x Ethernet (10/100/1000Base-TX) ports.
        - Minimum 1 x Serial RS-232 and 1 x Serial RS-485 interface.

- Port density shall be expandable via plug-in communication modules to support legacy IEDs and future network expansions

f. The Data concentrator shall acquire analog data from Inverters & associated sensors, such as:

- Solar system generation (kW export, frequency etc)
- Solar irradiation/insolation
- Ambient temperature and humidity near the PV array.
- Status of each inverter
- DC current and Voltages of each inverter
- O/P AC Power, voltage, current and power factor of each inverter
- Total power generation
- Fault and Alarm display
- Time active, time idle, time disabled
- Digital data like status of circuit breakers (ON/OFF/TRIP) etc.

And transfer that information to local monitoring station PC at PFFF SS02-M01 and to Central Monitoring Station Servers via IEC-60870-5-104.

g. General I/O Requirements

- All I/O modules shall be highly modular, DIN-rail mountable, and capable of operating in the extended temperature range of -40°C to +70°C.
- Modules shall feature front-facing LED indicators for the operational status of each individual channel (e.g., ON/OFF status for discrete points) and module health.
- Process wiring shall be terminated using removable, plug-in screw or spring-clamp terminals to allow rapid module replacement without disturbing field wiring.
- All field I/O channels must be galvanically isolated from the internal logic and communication buses of the data concentrator.

h. Digital Input (DI) Modules

- Nominal Voltage: The DI modules shall be specifically rated for a nominal input voltage of 110V DC, directly interfacing with the substation's station battery system.
- Operating Range**:** The inputs must safely operate within standard substation battery voltage fluctuations, typically supporting an operating range of at least 88V DC to 132V DC (-20% to +20% of nominal).
- Isolation: Inputs shall be opto-isolated to protect the internal circuitry from field transients.

- Time-Stamping & SOE: The modules must support Sequence of Events (SOE) recording with a local time-stamping accuracy of 1 millisecond (1 ms) or better for all input state changes.
- Filtering: Software-configurable debounce filtering (e.g., 1 ms to 255 ms) shall be available per channel or per module to prevent false signaling from relay contact bounce.
- Analog Input (AI) Modules
    - *Signal Type*: The AI modules shall be configured to accept standard 4-20 mA DC signals from field transducers and sensors.
    - *Resolution & Accuracy:* The analog-to-digital (A/D) conversion shall have a minimum resolution of 16 bits to ensure high-accuracy measurements, with a baseline accuracy of at least ±0.2% of the full-scale range.
    - *Diagnostics (Wire-Break):* The modules must feature built-in under-range detection to automatically flag a "wire-break" or sensor failure alarm when the signal drops below 4 mA.
    - *Configurability:* Scaling factors, dead bands, and threshold alarms (High, High-High, Low, Low-Low) shall be fully configurable via the data concentrator's engineering software.
- In addition to the central I/O modules at the Data Concentrator rack, the Contractor may provide Remote I/O Units (RIOs) installed within individual solar power plants.
- It shall be possible to increase the number of communication ports in the data concentrator by addition of cards, if required in future.
- As a minimum, the data concentrator must accept this baseline I/O capacity.

Sl No	Name of Solar PV plant	DI Count	DO count	AI count
1	PFFF M01	>100	>16	>8
2	PFFF M02	>100	>16	>8
	TOTAL	>200	>32	>16

i. The data concentrator shall have additional wired available reserve capacity of twenty percent (20%) for each type of points. This reserve capacity shall be used without any additional hardware such as I/O cards and terminal blocks.

j. The data concentrator shall be capable of interfacing to the inverter's communication system to gather all inverter parameters. It shall be capable of accepting DI inputs from remote / distributed DI modules via relevant industrial communication protocols.

k. The data concentrator shall have an internal clock. It shall be synchronized through synchronization message from master station at every 10 minutes using IEC 60870-5-101/104 protocol. However, all the data concentrator shall have a suitable interface for receiving synchronization signals from a local GPS receiver.

l. Data logging system/software shall enable automatic long-term storage of measured data from PV plant. It shall also support measurements from the external sensors like Pyranometer / irradiation sensor etc. Data from the weather station, inverters, combiner boxes, meters and transformers will be collected in data loggers and passed to a local monitoring station, typically via Fiber Optic Cable.

m. It is envisaged that there will one PC with latest specification as below or better which is compatible with Solar PV system which shall permit the operator to monitor the plant normal operation as well as during start-up, shutdown and process upset conditions.

4. Computer specifications:

Component	Minimum Specification
Processor	Intel Core i7 / i9 (14th/15th Gen) or Intel Xeon W-2400 series. Minimum 16 Cores, Base clock 2.5 GHz or higher.
Operating System	Windows 11 Professional (64-bit) or Windows 11 IoT Enterprise LTSC.
Memory (RAM)	Minimum 32 GB (2 x 16GB) DDR5 4800MHz or higher. (ECC required if Xeon processor is selected).
Storage (Primary)	Dual 1TB NVMe PCIe Gen 4 M.2 Enterprise SSDs. Configured in Hardware RAID 1 (Mirroring) for OS and SCADA software redundancy.
Graphics Card	Dedicated Workstation GPU: NVIDIA RTX A2000 (Ada Generation) or equivalent with minimum 8GB/12GB GDDR6 VRAM and 4x DisplayPort outputs.
Network Interfaces	Minimum Dual (2x) 10/100/1000/2500 Mbps Gigabit Ethernet RJ45 Ports (for separate Station Bus and Control Center network isolation).
Optical Drive	External/USB DVD-RW (Internal optical drives are deprecated in modern workstations).

Display	34-inch Curved LED/IPS Monitor, Minimum WQHD (3440p x 1440p) resolution, flicker-free, anti-glare.
Peripherals	Industrial ergonomic keyboard with integrated biometric/smart-card reader and wired optical scroll mouse.
Power Supply	Minimum 750W, 80 Plus Platinum Certified high-efficiency power supply.
Form Factor	Small Form Factor (SFF) or Standard Tower, Tool-less chassis for easy maintenance.

5. The solar PV system shall consist of a communication interface which shall be able to support:
    - Real time data logging
    - Event logging
    - Set point editing
6. The following minimum parameters shall also be measured and displayed continuously:
    - Solar system generation
    - Solar irradiation/insolation
    - Ambient temperature and humidity near the PV array.
    - Status of each inverter
    - DC current and Voltages of each inverter
    - O/P AC Power, voltage, current and power factor of each inverter
    - Total power generation
    - Fault and Alarm display
    - Time active, time idle, time disabled
    - Provision for downloading the data shall be incorporated.
    - Any other parameter considered necessary by supplier of the solar PV system based on prudent practice.
7. The communication interface shall be an integral part of inverter and shall be suitable to connect with PC. The System shall have incorporated system security feature in its design which would protect its data base and functioning against viruses, Trojans and works through integrated antivirus, for the system. Effective and suitable Antivirus software shall be loaded on PC.

8. The installed SCADA shall be compatible with existing departmental SCADA by transmitting data to Central Monitoring Station via IEC- 60870-5-104 protocol.

9. Scada Software

SCADA system shall be capable of the following functions from PC/ Engineering-cum-operator work station at the local control room of PFFF substation:

Requirement with respect to Solar Plant monitoring-

a. Monitoring & Supervision of parameters from all Inverters and all MFMs and ACB/MCCB statuses (ON/OFF/TRIP), at regular intervals not greater than 10 seconds.
b. The following parameters shall be monitored-
   Inverter: Status of each inverter i.e. INV ON/OFF status, Output 3 Phase AC Voltages and Currents and Power Factor, Output Active, Reactive and Apparent Powers, Energy output, Input DC voltage and Currents to Inverter, Frequency, Total power generation, Fault and Alarm display, Time active, time idle, time disabled of each inverter, Ambient temperature near the PV array, Panel Temperature of PV arrays, Solar irradiation / insolation, any other critical parameter available in Inverter
c. Event logging and alarm handling
d. Historical data storage and retrieval
e. Report generation: Daily, Weekly, Monthly, Yearly and Custom reports for Energy Produced by each inverter and total energy injected to grid etc, Daily, Weekly, Monthly, Yearly reports Report for MFM data.
f. Trending of voltage, current, power, energy (historical and real-time)
g. ON/OFF control of all ACBs/MCCBs and Inverters from the local SCADA.
h. All Grid Support & Advanced Control Functions of Inverter

10. Software Requirement:

All the software being supplied (including SCADA software, firmware of data concentrator, OS, antivirus, web server application software etc.) shall be of latest and licensed versions only along with the connecting cables.

11. Software Development:

The Supplier shall develop the complete application software to suit the process requirement which includes logic development, implementation, mimic development, alarm generation &

its segregation in different categories, datalogging, report generation, trend generation, event logging, alarm logging, any other programming / configuring that is required for fulfilling the requirements. The programming shall be carried out as per the Requirement furnished by Purchaser during execution of the project.

Mimics shall be generated for-

a. PFFF M01 Solar Power Plant: from Inverters upto Point of Connection at SS02-M01 LT PCC panel
b. PFFF M02 Solar Power Plant: from Inverters up to Point of Connection at SS02-M02 LT PCC panel

The software development will tentatively include the following:

i. Generation of Trends (both pre-defined and customizable as and when required)
ii. Generation of Daily, monthly, quarterly and yearly reports
iii. Generation of any other customized reports, trends as per NFC requirement,
iv. which shall be given during detailed engineering
v. Generation of plant wise monthly energy generation reports and Total energy generation and Consumption Reports
vi. Generation of Three levels of login - Operator level, Officer In charge level & Administrative level, with predefined authorizations at each level
vii. Self-Diagnosis & signalling of mal-operation of communication of each communicable device/ IED shall be alarmed to the user. Failure of communication of MFM/NRs / any communication capable device shall be alerted on SLD by turning the device inactive. Proper legible discrimination shall be made on the SLD screen between devices which are communicating and which are not communicating, alerting the operator of communication failure of a device
viii. Alarm logging with audio-visual alarm to alert the operator
ix. Event logging
x. Diagnostic screen shall be developed indicating communication status of eachand every device included in the SCADA architecture. Diagnostic screen shall be provided indicating healthiness of communication of data concentrator, servers, operator stations, Inverters, DI modules etc

xi. Forecasting and Scheduling: SCADA shall provide day-ahead and weak ahead forecasting and scheduling for solar power generation at the plant

The above quantity is indicative, same will be finalized during execution of the project. Any change in the requirements at later date shall be carried out by Supplier without any price implication.

The offered Solar SCADA software shall be based on a platform that has been commercially deployed and successfully operating for at least five (5) years, with a minimum of [3] verifiable installations in solar PV or energy management applications of capacity not less than [500 kWp] each. The latest stable version of the software shall be supplied for the project. The bidder shall furnish OEM certification and client references as documentary proof. All minor updates and security patches shall be provided at no additional cost during the Defect Liability Period.

12. UPS

a. The Contractor shall be responsible for the complete design, sizing, supply, installation, testing, and commissioning of the UPS systems and associated battery banks for both PC system and Data Concentrator power supplies.

b. The substation where PC and data concentrator will be installed shall be provided with a dedicated True Online Double-Conversion UPS.

c. Input/Output Requirements:
   i. Input: Single-phase 230V AC or Three-phase 415V AC (tapped from the substation PDB), ±10% voltage tolerance, 50Hz ±5%.
   ii. Output: Single-phase 230V AC, pure sine wave, ±1% voltage regulation, 50Hz ±0.1%.

d. Bypass Mechanism: The UPS shall be equipped with an automatic static bypass switch. In the event of an inverter failure or severe overload, the load shall be seamlessly transferred (<4ms) to the raw bypass mains. A manual maintenance bypass switch shall also be provided.

e. Harmonics & Efficiency: Total Harmonic Distortion (THD) at the output shall be less than 3% for linear loads. The overall efficiency of the UPS shall be greater than 90% at full load.

f. SCADA Integration: The UPS shall be provided with dry contacts and an SNMP/Modbus TCP communication card to integrate alarms (e.g., "Mains Fail," "Battery Low," "UPS on Bypass") directly into the SAS Data Concentrator

13. Battery Bank Specifications

a. Backup Duration: Both the Local Substation UPS and the CCR UPS systems shall be equipped with battery banks sized to provide a minimum of two (2) hours of uninterrupted backup time at the fully designed load (including the 50% expansion headroom).

b. Battery Technology: The Contractor shall supply industrial-grade batteries of either of the following approved types:

   i. **Option A:** Nickel-Cadmium (Ni-Cd) pocket plate batteries (transparent/translucent containers).
   ii. **Option B:** Sealed Maintenance Free (SMF) Valve Regulated Lead Acid (VRLA) batteries.

c. Battery Sizing Standard: The battery Ah (Ampere-hour) capacity shall be calculated based on IEEE 485 standards (for VRLA) or IEEE 1115 (for Ni-Cd), accounting for an aging factor of 1.25, a design margin of 1.1, and temperature correction factors.

d. Enclosures & Racks:
   i. SMF batteries shall be housed in powder-coated, ventilated MS racks or cabinets.
   ii. Ni-Cd batteries shall be mounted on FRP-coated or acid/alkali-resistant treated wooden/steel racks.
   iii. All inter-cell and inter-row connectors shall be heavy-duty copper with anti-corrosive shrouds.

H. LIGHTNING PROTECTION SYSTEM:

1. The rooftop mounted Solar PV plant shall be provided with a complete Lightning Protection System (LPS) designed to protect the PV modules, module mounting structures, DC cabling, inverters and associated electrical equipment against direct lightning strikes and lightning induced surges. The system shall be designed, installed, tested and commissioned in accordance with IS/IEC 62305, IS 3043, IEC 62561 and relevant provisions of the National Building Code (NBC).
2. The proposed lightning protection arrangement shall consist of a horizontal ridge type air termination network using 25 × 6 mm hot dip galvanized (HDG) GI strip installed continuously along the rear/top edge of each rooftop PV module row. The ridge conductor shall be mounted approximately 50–100 mm above the top edge of the solar modules on supports fixed to the module mounting structure or dedicated support brackets.
3. The ridge conductor shall act as the primary air termination conductor and shall form the highest point in the module row profile. The system shall be designed using the Rolling Sphere Method as per IS/IEC 62305-3 such that the rolling sphere corresponding to the selected Lightning Protection Level touches the ridge conductor and not the PV module surface.
4. The arrangement shall be designed to prevent shadow of the ridge conductor on the panels and also avoid additional spacing requirements between module rows.
5. The ridge conductor shall be supported at intervals not exceeding 1.0 metre using insulated standoff supports capable of withstanding wind loads, UV exposure and rooftop environmental conditions. The supports shall electrically isolate the lightning conductor from aluminium module frames and mounting structures while maintaining the required separation distance in accordance with Clause 6.3 of IS/IEC 62305-3.
6. Dedicated down conductors using GI strip shall be provided from the ridge conductor network and routed through the safest and shortest path to the rooftop earthing network. Down conductors shall preferably follow building columns, parapet walls or service shafts and shall be securely fastened using suitable corrosion resistant saddles and clamps. Sharp bends and loops shall be avoided to minimize lightning impedance and prevent side flashing.

7. All ridge conductors of adjacent module rows shall be electrically interconnected through lateral bonding conductors to ensure equipotential equalization and multiple current dissipation paths. The lightning protection network shall be connected to the building lightning protection system and common earthing grid.
8. All metallic parts of the rooftop PV plant including module mounting structures, module frames, cable trays, inverter structures and metallic raceways shall be bonded to the common earthing system to maintain equipotential bonding and reduce the risk of dangerous potential differences during lightning discharge.
9. The complete earthing system shall comply with IS 3043 and shall include lightning earths, equipment earths and clean earths interconnected through a common earth grid. Earth electrodes shall be copper bonded or GI type as per approved design. Earth resistance values shall be maintained within permissible limits.
10. An integrated module cleaning arrangement may also be provided below the ridge conductor using UV stabilized HDPE/UPVC water pipelines fitted with spray nozzles for periodic cleaning of the PV modules. The water pipeline shall be installed below the lightning conductor with adequate separation distance and insulated supports so that the cleaning system does not interfere with the electrical performance or continuity of the lightning protection system.
11. Suitable bimetallic connectors, washers and corrosion resistant hardware shall be used wherever GI strips are connected to aluminium module frames or mounting structures in order to prevent galvanic corrosion. All fasteners shall be stainless steel SS304/SS316 grade suitable for rooftop outdoor environments.
12. Surge Protection Devices (SPDs) conforming to IEC 61643 shall be installed on the DC side, AC side and communication/control circuits to protect the solar plant equipment against transient over voltages induced due to lightning activity.
13. The contractor shall carry out complete lightning protection design calculations, rolling sphere analysis, protection zone verification, earthing calculations and testing prior to commissioning. Earth resistance tests, continuity checks and visual inspections shall be conducted for the complete lightning protection and earthing system. All test certificates, design calculations and as-built drawings shall be submitted for approval.

14. A sample diagram may be referred below:

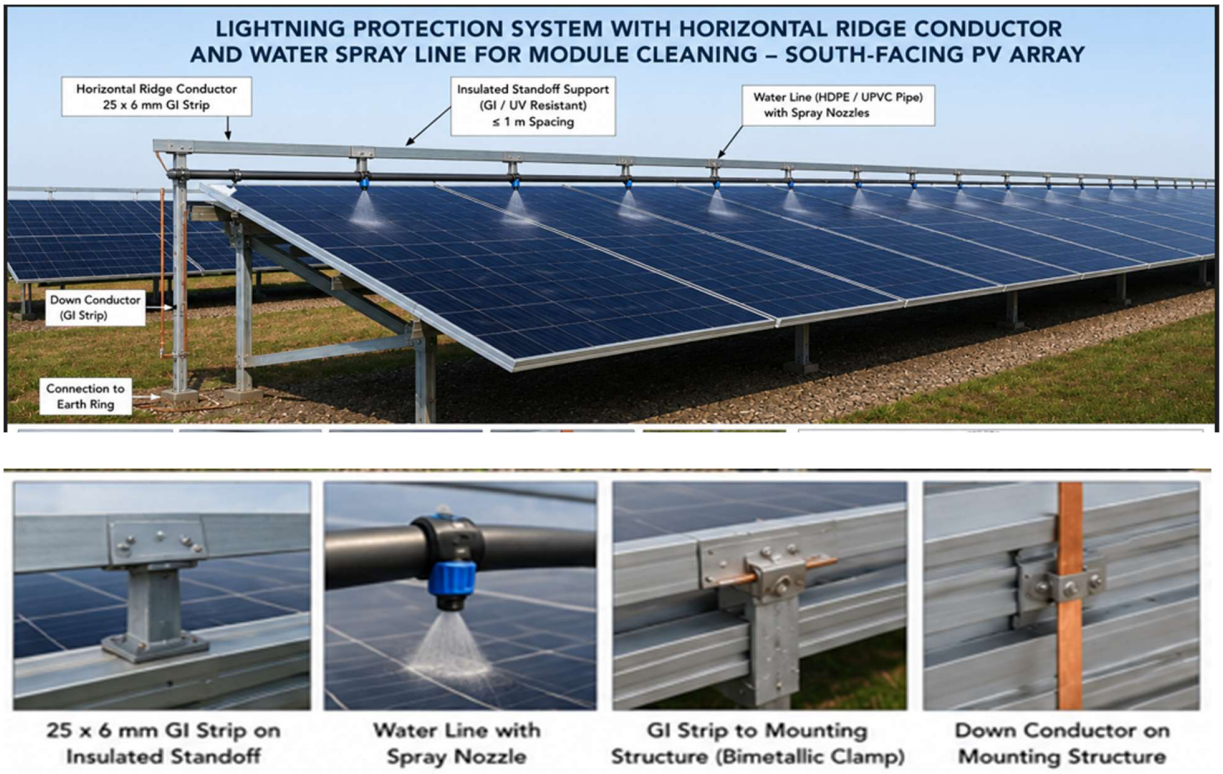

Fig.2- Model of Lightning protection system

I. EARTHING

1. Supply, Installation, Testing & Commissioning of maintenance free earthing system & associated works, etc. complete as per below specifications & instructions of E-I-C.
2. Providing an earth station using 25 mm dia 3M long earthing electrode of high tensile low carbon steel rod molecularly bonded 250-micron copper coating on the outer surface suitable for 35kA Irms for 1 sec, filling the bore with suitable environment friendly earth enhancement compound as per manufacturer's standard surrounding the earth electrode complete with all required materials & as per the instructions of EIC. All the components shall comply to IEC-62561, IS 3043, IS 2309 as applicable.
3. The scope includes:
   a. Installation of earth rods including making pit/ drilling suitable size bore holes in normal soil/ hard rock as per manufacturer's recommendations & design. Bore hole shall be made using machine only.
   b. Interconnection of earth electrodes along with required SS double sided universal clamps with GI strip. 50 x 6 mm & 150 mm long GI equipotential bar also shall be mounted inside chamber as per instructions of EIC.
   c. Providing & making concrete chamber (1:2:4) of size 600 x 600 x 600 mm (inside dimension) with 10 mm thick MS hinged cover mounted on 40 x 40 x 5 mm thick angle iron frame, 50 x 6 mm & 150 mm long GI equipotential bar mounted inside chamber as per instructions of EIC.
   d. The Earth pit marker of 250mmX200mmX4mm MS sheet shall be welded to an 25mmX25mmX3mm angle of 300mm long shall be fixed on a concrete block. The marker shall be painted with black paint base and values written in yellow paint.
4. The complete earthing system shall be mechanically & electrically connected to provide independent return to earth. All equipment shall have two distinct earth connections. The earth strips shall be Hot dip Galvanized of appropriate size to carry the fault current. The earth strips shall be joined through welding. Two runs of earth strips shall run all along the cable trays. The Module mounting structure shall be connected to the earth strips running in the cable tray. The AC earthing shall be provided for the ACDB which shall be hooked up to existing earthing. The DC earthing shall be done as per provisions of relevant

standard. It shall be ensured that all the earthing points are bonded together to make them at the same potential.

5. Contractor shall submit Theoretical design calculations and drawings for approval by NFC.
6. Required number of earth pits shall be provided to obtain grid resistance below 1 Ohm.

J. WARRANTY AND GUARANTEE:

The warranty as indicated in below table for each of the component has to be provided.

S.No	Description	Warranty
1	Solar PV Modules – Manufacturing Defect Warranty	10 Years
2	Solar PV Modules - Limited Power Warranty	25 Years
3	Module Mounting Structure	1 year
4	Solar Inverters	10 Years
5	Solar cable	1 year
6	LV switchgear Panel	1 year
7	LV cables	1 year
8	Plant Monitoring	1 year
9	Dry type solar cleaning system	1 year

Table 8- Warranty & Guarantee

K. WATER CLEANING SYSTEM:

1. This specification covers the design, supply, installation, testing, and commissioning of a dedicated water cleaning system for solar PV modules. The system shall provide effective, uniform, and periodic cleaning of all solar panels at least once in a month to maintain optimum power generation efficiency.
2. The system comprises the following primary sub-systems:
    - Main GI pipeline running along the terrace periphery
    - UPVC/CPVC branch pipeline running along the length of each panel row
    - Individual panel sprinkler nozzles mounted on each solar module
    - Tapping points, isolation valves, and hose connections
    - Pipe supports, hangers, and hardware
3. The cleaning system is designed to ensure that every solar panel receives uniform water coverage. The architecture follows a trunk-and-branch principle:
    - A 25mm Class C GI pipe serves as the main supply line running along the periphery of the terrace, connected to the building's tap water supply.
    - UPVC/CPVC branch pipes (20mm dia) run longitudinally along the top edge of each row of solar panels.
4. Individual micro-sprinkler nozzles are installed at each panel, fed from the branch pipe, to spray water uniformly across the entire panel surface from top to bottom.
5. Tapping points with gate/ball valves at suitable intervals allow localized cleaning using an extendable flexible hose for manual spot-cleaning.
6. The system is designed for gravity-assisted spray with mains pressure and does not require any pump where adequate municipal/tap water pressure (minimum 0.5 kg/cm2) is available at the terrace level.

7. **Particulars of GI Pipe and Pipe Fittings**

Parameters	**Technical Particulars**
Type	GI pipe & GI fittings
Application	Domestic pipe line
Applicable Standard	IS: 1239 Part I & II
Grade	Class 'C' (Heavy)
Pressure rating	Suitable for 10 kg/cm² working pressure
Size	25mm
Thickness	As per Std
Tolerance	As per Std
Minimum Length of pipe	5.5 meter
End Finish	Threaded
Finish	GI
Pipe Fittings (elbows, bends, reducers, clamps etc.	With ISI mark, heavy duty part of this item
Hardware	Includes all nut, bolts washers and gaskets
Pipe Fittings	Shall be measured along the length of pipe
Painting	Apply cold zinc spray on welded portion of pipe

Table 9- Technical Specifications of GI pipes and fittings

8. Pipe Support:

a. Main GI supply line shall be laid along the full periphery of the terrace at a height of approximately 300mm above the terrace surface.

b. The pipe shall be anchored to the parapet wall or structural members using GI saddle clamps at 1.5 m intervals.

c. Branch connections (reducing tee 25mm x 20mm) shall be provided at each panel row to feed UPVC/CPVC branch lines.

d. The pipeline shall be laid with a minimum slope of 1:200 toward the drain/outlet to allow complete drainage. All thread joints shall be sealed with PTFE tape and pipe joint compound to prevent leakage.

e. The entire GI pipeline shall be painted with 2 coats of red oxide primer after manual wire-brush cleaning of the surface, followed by 2 coats of heat-resistant black bituminized paint.

f. Tapping point with valve shall be provided on the pipeline run along the periphery at suitable intervals to enable cleaning of each panel with an extendable flexible hose.

9. UPVC/CPVC Branch Pipe Technical Particulars:

Parameter	Technical Specification
Material	UPVC (Unplasticized PVC) or CPVC (Chlorinated PVC) — UV stabilized grade
Application	Solar panel cleaning branch line and sprinkler feed line
Applicable Standard	IS: 4985 (UPVC) / ASTM D 2846 (CPVC)
Nominal Size	20 mm OD (branch line) / 15 mm OD (sprinkler sub-line)
Pressure Rating	PN 10 (10 kg/cm²) minimum
Wall Thickness	As per IS: 4985 for PN 10 class
UV Resistance	UV stabilized compounding — suitable for outdoor/exposed installation
Color	Grey (UPVC) / Cream/Off-white (CPVC) — ISI marked
Fittings	UPVC/CPVC elbows, tees, reducers, end caps, union joints — solvent welded
Jointing Method	Solvent cement jointing (ASTM D 2564 / IS: 14182)
Temperature Range	Suitable for 0°C to 60°C (UPVC) / 0°C to 93°C (CPVC)
Length per Pipe	3 meters or 6 meters per piece
Clamps / Supports	UV resistant PP/nylon pipe clips at 600 mm intervals on panel frames

Table 10- Technical Specifications of UPVC / CPVC pipes

10. Sprinkler Nozzle Specification

Type	Flat fan mist nozzle for panel wash
Material	UV stabilized polypropylene (PP) body with stainless steel orifice insert
Connection	15mm BSP male threaded connection to UPVC/CPVC branch pipe socket
Coverage per Nozzle	To cover full width of one solar module (typically 1000–1100 mm)
Operating Pressure	0.5 to 3.0 kg/cm² (self-regulating pressure-compensating type preferred)
Nozzle Orientation	Positioned at top edge of panel, angled downward at 10–15° to spray across full panel surface
Quantity	One (1) nozzle per solar panel — full coverage of every module

Table 11- Technical Specifications of sprinkler Nozzle

L. SEMI-AUTOMATIC DRY TYPE CLEANING SYSTEM

1. The proposed system shall consist of a semi-automatic, pick-and-place type robotic cleaning machine designed for dry cleaning of rooftop solar photovoltaic (PV) modules without the use of water. The robotic cleaner shall be suitable for rooftop mounted crystalline silicon solar PV modules installed on fixed tilt module mounting structures.
2. The robotic cleaning system shall be capable of removing dust, loose dirt, bird droppings, and other contaminants from the module surface using rotating non-abrasive brushes. The system shall improve module performance by minimizing soiling losses while eliminating manual cleaning risks and water consumption.
3. The scope shall include supply, testing, commissioning, training, and warranty of semi-automatic robotic dry-cleaning equipment complete with:

    a. Portable robotic cleaning unit
    b. Pick-and-place arrangement
    c. Rechargeable battery system
    d. Battery charger
    e. Non-abrasive dry-cleaning brushes
    f. Remote/manual control unit
    g. Safety sensors and edge detection
    h. Carrying handles and transport accessories
    i. Necessary interconnection accessories
    j. O&M manuals and training

4. The robotic cleaning system shall operate on a pick-and-place principle wherein the robot shall be manually positioned on the PV module row by operators. The robot shall autonomously traverse the module row and perform dry cleaning using rotating brushes. At the end of the row, the robot shall stop automatically and shall be shifted manually to the next row.
5. The cleaning system shall not require water during normal operation. The system shall be suitable for operation during early morning, evening, or night time conditions without affecting power generation.

6. The robotic cleaning system, though intended for dry cleaning, shall be suitable for outdoor rooftop environments and capable of withstanding incidental water exposure including rain, dew, and accidental splashing without damage or safety hazard
7. Technical Specifications:

Parameter	Specification
Type	Semi-Automatic Pick-and-Place Robotic Cleaner
Cleaning Method	Dry cleaning using rotating soft brushes
Application	Rooftop Solar PV Modules
Cleaning Medium	Waterless / Dry Type
Brush Material	UV resistant non-abrasive nylon / microfiber / PBT
Brush Arrangement	Counter rotating dual brush system
Cleaning Efficiency	Minimum 95% dust removal
Cleaning Speed	10–15 m/min minimum
Operating Mode	Autonomous travel after placement
Deployment	Manual pick-and-place
Drive System	Battery operated motorized drive
Battery Type	Rechargeable Lithium-Ion / LiFePO4
Minimum Runtime	3–5 hours continuous operation
Charging Time	Maximum 4 hours
Control System	Onboard controller with remote/manual controls
Safety Features	Edge detection, anti-fall sensors, overload protection
Structure Material	Lightweight aluminium alloy / SS / FRP
Protection Class	Minimum IP54
Operating Temperature	0°C to 60°C minimum
Wind Resistance During Operation	Up to 40 kmph
Module Tilt Compatibility	Up to 25° minimum
Maximum Robot Weight	Preferably less than 45 kg
Noise Level	Less than 70 dB
Cleaning Width	Suitable for standard PV module width
Mobility	Portable with lifting handles
Surface Compatibility	Glass-glass and glass-backsheet modules
Panel Safety	Shall not cause scratches, microcracks, or ARC coating damage

Table 12- Technical Specifications of Robotic Cleaner

8. The robotic cleaning system shall be tested for safe operation on solar modules and shall not adversely affect module warranty.
9. The robotic cleaning system shall have the following minimum functions:

    a. Automatic forward movement over PV modules

    b. Automatic stop at row end

c. Anti-slip traction mechanism
d. Dry cleaning without water consumption
e. Uniform brush pressure control
f. Capability to clean framed solar modules
g. Easy manual relocation between rows
h. Protection against accidental falls
i. Easy brush replacement and maintenance

10. Construction Requirements

a. The robot chassis shall be corrosion resistant and suitable for outdoor rooftop conditions.
b. Brushes shall be UV stabilized and anti-static.
c. Wheels/tracks shall not damage module frames or glass.
d. The system shall be compact and lightweight for rooftop handling.
e. Fasteners shall be SS304 or better grade.
f. All electrical components shall be enclosed within weatherproof housing.

11. Safety Features

a. Edge detection sensors
b. Emergency stop provision
c. Battery protection system
d. Motor overload protection
e. Reverse/stop mechanism at row edge
f. Anti-collision logic
g. Low battery indication

12. Performance Requirements

a. The robotic cleaner shall clean the PV module surface uniformly without leaving visible streaks.
b. Cleaning operation shall not require demineralized water.
c. The robot shall be capable of operating under dusty Indian environmental conditions.
d. The system shall minimize manpower requirement and cleaning time.

13. Inspection & Testing

    The following tests/documents shall be furnished:

    a. Functional test certificate
    b. Battery test certificate
    c. IP protection compliance
    d. Brush material test data
    e. Demonstration of cleaning operation
    f. OEM technical datasheets
    g. Warranty certificate

14. Warranty

    The complete robotic cleaning system shall be warranted for minimum 12 months from date of commissioning against manufacturing defects and operational failures.

    Battery warranty shall be minimum 1 year.

15. 4 Nos of these units shall be supplied.

M. FIRE PROTECTION SYSTEM

The SPV plant shall be equipped with suitable fire protection & firefighting systems like fire extinguishers, sand buckets etc for protection of entire equipment including SPV, inverter room, solar control room as per CEIG/ standard requirements. The installation shall meet all applicable statutory requirements, safety regulations in terms of fire protection.

N. OBTAINING STATUTORY APPROVALS

The 2 MWp rooftop solar PV plant shall be installed on the rooftop of PFFF building at Nuclear Fuel Complex (NFC).

Two (02) nos. of existing 415V load centres are available on either side of the PFFF building. The output of each 1 MWp solar PV system shall be connected to one respective 415V switchboard of the PFFF load centres.

The PFFF substation receives power at 11 kV from the 33/11 kV Main Receiving Substation (MRSS) of NFC Rawatbhata. NFC Rawatbhata in turn receives power at 33 kV from the Rajasthan Atomic Power Project (RAPPS) Township Substation.

The solar plant shall operate as a captive solar power plant within the internal electrical network of NFC Rawatbhata and is not directly interconnected with the State DISCOM grid.

1. RRECL Registration / Renewable Energy Approval

The contractor shall carry out online registration of the project on the Rajasthan Renewable Energy Corporation Limited (RRECL) Unified Web Portal, if required under prevailing regulations.

The scope shall include:

- Submission of all required documents for project registration
- Payment of registration fee, security deposit, REDFC charges, processing charges, and other statutory charges, wherever applicable
- Obtaining In-Principle Clearance from State Level Sanction Committee, if applicable
- Obtaining final project approval from competent authorities before commencement of execution work

2. Electrical Inspector / CEIG Approval

The contractor shall obtain approval from the appropriate electrical inspection authority, including either:

- Chief Electrical Inspector to Government (CEIG), or
- State Electrical Inspectorate, Rajasthan

as applicable.

Scope includes:

- Submission of Single Line Diagram (SLD)
- Protection scheme drawings
- Earthing layout drawings
- Lightning protection drawings
- Fault level calculations
- Work completion reports
- Payment of statutory inspection fees
- Coordination during inspections
- Obtaining final charging/energisation approval prior to commissioning

Mandatory tests:

- Insulation resistance testing
- Earthing resistance testing
- Relay testing
- Protection system testing

3. Protection and Safety Requirements

The contractor shall provide complete protection systems including but not limited to:

- Anti-islanding protection
- Over-current protection
- Earth fault protection
- Surge protection
- Reverse power protection (if required)
- Synchronization protection

All systems shall comply with:

- Central Electricity Authority (CEA) regulations
- Indian Electricity Act
- National Electrical Code
- Applicable IS/IEC standards

4. Coordination with NFC Authorities

The contractor shall coordinate with Nuclear Fuel Complex (NFC) for:

- Work permits
- Security clearances
- Shutdown coordination
- Site access permissions
- Safety compliance during execution

5. Contractor Responsibility

Obtaining all approvals, clearances, statutory permissions, inspection approvals, and associated documentation required for successful commissioning shall be entirely within the contractor's scope.

O. PRE-COMMISSIONING CHECKS AND DOCUMENTATION:

1. Following checks shall be conducted on equipment after erection and before energizing from point of view of completeness in the presence of employer:
    - Visual inspection of total system
    - Checking of continuity of power and control cables.
    - Checking of insulation resistance for inter-connected links or cables.
    - Calibration of meters by secondary injection or by primary injection
    - Checking of protective schemes
    - Setting of relays, and the checking of their operation with one lower and one higher setting.
    - Checking of control scheme of breakers, etc. as per approved drawings and as per actual requirement
    - Checking of alarm scheme by simulation of faults.
    - Checking of name plate data of complete system.
    - Verification of earthing resistance.
    - Checking of cable terminations and laying, dressing etc.
    - Checking for safe accessibility of components.
2. Following drawings and documents shall be submitted before commissioning:
    - General Equipment layout plan including Solar PV arrays on the proposed buildings.
    - Single line diagram with rating of all equipment, cable sizes and details of protection and metering
    - Front view, general arrangement of equipment with plan and sectional views; clearly showing the position of various components, and clearance between components. The make and type of components, together with vital technical parameters shall also be furnished along with GA drawings.
    - Calculation for design of LT bus duct, sizing of bus bars, bus bar supports considering the temperature rise and fault current.
    - Calculations for design of supporting structures for outdoor switchyard w.r.t. wind pressure, short circuit forces etc. (if applicable).
    - Control, alarm, indications, interlocking and other schematics

- Lighting layout drawings with illumination levels, type and make of fittings.
- Wiring terminal plan drawings with cable connections
- Earthing scheme and layout of earthing network with design calculations.
- Cable layout drawings, cable channels details

Any other document as required during approvals.

7. PERFORMANCE GUARANTEE TEST:

- A Pyranometer / irradiation sensor (supplied by contractor) shall be installed at a suitable location. The output of this Pyranometer / irradiation sensor shall be recorded for one month of the PG test. Actual energy generation from all the solar PV plant shall be noted individually for one month. This measured value of total energy generation shall be compared with "Base Generation" for the PG test of particular month submitted by bidder).
- "Base Generation" for a month is the quoted generation by the bidder in the Technical Data sheet with a correction factor to take into account the actual average global solar radiation measured by the calibrated Pyranometer / irradiation sensor for one month.
- Plant shall be designed and guaranteed by the bidder for total annual generation of minimum generation of each plant as given below. Bidder shall submit calculations in support of minimum generation units. Any reduction in units guaranteed, recovery shall be applicable.

Month	Global Solar Radiation (kwh/ m2/ day) a	Quoted Generation (KWhr) by the Bidder b	Measured average Global Solar Radiation(kwh/ m2/ day) By pyranometer c	Actual measured net Energy in KWhr at 415V Feeder d	The calculated "Base Generation" in kWhr (b x c)/a e	Shortfall in energy for PG test (e-d) f
MAY						
JUNE						
JULY						

Table 13- Calculation of Shortfall in Generated Units

- The PG test shall be deemed to be successfully completed if the value (d) – (e) is not be less than zero for each month. However no additional payment or incentive shall be given for excess generation over and above guaranteed value.
- Each Solar PV modules used in solar power plants/ systems must be warranted for their output peak watt capacity, which should not be less than 90% at the end of 10 years and 80% at the end of 25 years from the completion of the trial run. Hence the bidder whose offer is accepted is required to submit **LTPG (long term performance guarantee) of 5% of**

tendered and accepted value valid for two years and extendable up to ten years six months within a period of 7 days from the date of issue of LOA. The LTPG shall be released at the end of 10 years after successful performance test (flash test at MNRE/NABL approved lab or on-site test as per IEC), conducted for similar number of modules as was done during acceptance test and on production of work completion certificate from concerned officer-in-charge.

8. COMPREHENSIVE OPERATION AND MAINTENANCE:

1. The comprehensive operation and maintenance of the Solar PV Power system for a period of 5 years from the date of commissioning is in the scope of the supplier. Zero date of operation and maintenance shall begin after successful completion of trial run of the Solar PV system.
2. As the nature of maintenance is comprehensive type i.e., all spare, parts, equipment, etc. needs to be replace during maintenance shall be done by contactor without additional cost. Required number of manpower shall be mutually agreed upon during execution of the work.
3. The Selected Bidder shall be responsible for following activities:
    - Regular operation and maintenance of the plant system.
    - Monitoring of plant performance and supply of all technical, production/operation data and information through a monthly report.
    - Undertake regular checks and maintenance activities, required to be carried out, as recommended by the manufacturer of the equipment, on all the components of the power plant to minimize breakdowns and to ensure smooth and trouble-free operation of the plant and to get maximum output from the plant. The contractor shall be responsible to carry out routine, preventive and breakdown maintenance and replacement of each and every component/equipment of the power plant and he shall provide all labour, material, consumables etc. for routine and preventive maintenance at his own cost.
    - Carry out maintenance activities as a result of sudden failure/breakdown of any particular component or equipment. It shall be responsibility of contractor to carry out breakdown maintenance of each and every component of the power plant and shall provide the required manpower, materials, consumables, components or equipment etc. for breakdown maintenance at his own cost irrespective of the reasons of the breakdown/failure.
    - Undertake major overhaul of any component or equipment of the plant necessary on account of excessive wear & tear. Such maintenance of plant and structures shall normally be planned to be carried out on an annual basis.
    - Prepare and maintain records on daily basis towards maintenance of the plant, electricity generation, electricity injected into the distribution system etc.

4. The successful Bidder shall be responsible for undertaking the operation and maintenance of the plant for a term of five (5) years from the date of commissioning of the plant. Failure to carry out the above listed activities during O&M period shall attract penalty.
5. Failure to rectify the problem:
    - All repairing & replacement works are to be completed by the Contractor within 24 hours from the time of occurrence of fault or defect. If it is not possible to set right the equipment within this time, the Contractor shall notify the Owner indicating nature of fault & cause of damage etc. within 12 hours from the time of occurrence of the fault.
    - If the successful bidder fails to rectify the plant downtime within seven (7) days from the date of identification of such defect, unless the time to restore is mutually discussed and agreed between the bidder and purchaser. The same shall be rectified by purchaser at the expenses of the successful Bidder.
6. Plant shall be guaranteed for total annual generation of minimum as indicated. The charges of recovery units shall be prevailing units' charges at that time based on number of reduced units' generation. However, if the net penalty for a year on account of reduced generation exceeds the annual O&M charges, then PSD shall be encashed suitably. There will be no incentive to the bidder for more than guaranteed generation.
7. Force Majeure: - Reduction in generated electricity/damage due to earthquake, war, other natural calamity & other acts of god, the above penalty clause shall not apply.
8. A Diploma Engineer (with min. 5 year experience) needs to visit at least once a month during 5 year O&M period as per schedule-F.
9. Plant shall be designed and guaranteed by the bidder for total annual generation as given below. Bidder shall submit calculations in support of these minimum generation units:

	2 MWp system
First Year	.....Units (kWh)
Second Year	.....Units (kWh)
Third Year	.....Units (kWh)
Fourth Year	.....Units (kWh)
Fifth Year	.....Units (kWh)

Table 14- Guaranteed Generation

10. Minimum Specific Energy production of 1600 kWh/kWp/year shall be guaranteed. Recovery" if any" shall be applicable on the reduction in minimum generation units as guaranteed above. The charges of recovery units shall be prevailing units' charges at that time. 90% of total value of Security deposit for items executed (O&M security deposit- Refer NIT) shall be released on acceptance of plant completion date by department. The balance 10% of total value of items executed shall be released at the rate of 2% over a period of 5 years after end of each year considering recovery" if any" due to lower value of energy generated as described above.
11. Handing Over The Site After O&M Term:
    - After the expiry of term, contractor shall hand over the plant to the purchaser in excellent working condition. While handing over the plant contactor shall hand over all technical documents, literature, instruction manuals, lists of spares part & tools and tackles. Contactor will also hand over all the relevant record/documents.
    - On completion of O&M term the Contactor will apply to the Engineer in-charge for the issue of Handling Over Certificate and the same will be issued within 2 months of Handing Over in all respects, after verifying from the documents & tests and satisfying himself that the Operation and Maintenance has been competed in accordance with details set out in the control documents.
    - Such certificate shall not relieve the Contractor of any of his obligations which otherwise survive, by the terms and conditions of the Contract after issuance of such certificate.

9. ADDITIONAL CONDITIONS & CLAUSES:

1. Bidders are free to choose their design within the technical parameters of individual component specification.
2. All items of the work are required to be carried out as per the safety regulations/Indian Electricity rules whether or not explicitly mentioned.
3. Entire structure shall be designed to withstand the load of the PV panels and cyclonic wind forces of 150kmph.
4. The design of the structure shall be got proof checked from purchaser. All recommendations/changes suggested shall be incorporated before fabrication.
5. The contractor shall furnish following documents/ information along-with the offer:
    - General description of equipment offered specifying the important features, make, technical parameters, materials of construction, etc. to enable the department to have proper understanding of the equipment offered and its operation.
    - Technical literature, catalogue and publications
    - Layout of Complete Solar PV system Installation showing location of all major sub-systems
    - Single line diagrams of all systems and sub systems of the entire power
    - Typical general arrangement and foundation details
    - General illumination details of entire area.
    - Type tests certificates of all major equipment like switchgear, Inverters, Solar Modules etc.
    - Single line schematic diagram of electrical system for grid interfacing and grid interconnection from Solar plant
    - General arrangement drawings and circuit diagrams of Module, Inverters and overall solar plant arrangement.

6. Danger boards inscribing 'ISOLATED', 'DO NOT CLOSE, MEN AT WORK' in English, Telugu, Hindi and Local languages shall be provided in sufficient numbers as per IE Act. /IE rules as amended up to date.

7. All the electrical installations shall conform to the Indian Electricity Act, Indian Electricity Rules, and regulations.
8. The mechanical and Civil installation shall conform to the applicable Acts and Rules of corresponding Inspectorate and other relevant authorities, if any.
9. Cable glands used shall be of heavy-duty weather-proof type, ferrules, copper cable lugs, Anodised Aluminium tags, fire sealing kits shall be arranged as per approved makes.
10. Supply and installation of first aid boxes, shock treatment charts, rubber mats etc. as required for CEA clearances.
11. Erection, testing & commissioning of equipment shall be done as per manufacturer's instructions.
12. The minimum bending radius of envisaged LT cables shall be 15D and 12 D for respective cores.
13. Interplant cables shall be laid using overhead structure as per site conditions. Digging and refilling of cable trenches if required during erection shall be in the scope of work of the contractor.
14. Special care shall be taken to make the enclosed equipment protected against entry of rats, lizard, and creeping reptiles which may create electrical short circuits.
15. Approved cable markers of reinforced concrete shall be provided and fixed to mark each and every diversion of all buried cable routes. A marker shall also be placed every 10 meters along straight portions of each route. A concrete cable marker shall also be provided and fixed to mark the position of every buried joint.
16. The workmanship in mounting Inverters, Electrical panels, DC and AC junction boxes, Monitoring systems shall be to the satisfaction of the department.
17. Nameplates/ Rating plates to be provided on individual components and shall be as per best practices of the industry.

ITEMS	ACCEPTABLE MAKES
PCU/INVERTER	SMA, FIMER, SIEMENS, SCHNEIDER, DELTA Electronics
DC Solar cables	Polycab India Ltd, KEI Industries Ltd, Siechem, Elegar Kerpen Kabel India Pvt Ltd, APAR industries Ltd
POWER CABLES	Uiversal Cables Ltd, Torrent Power Ltd, KEI Industries Ltd, KEC International Ltd
SWITCHGEAR	L&T, SIEMENS, SCHNEIDER
STEEL	JINDAL, TATA, SAIL, RASTRIYA ISPAT NIGAM LTD
ENGINEERING WORKSTATION/PC	HP/DELL/LENEVO
DATA CONCENTRATOR	SCHNEIDER/ SIEMENS/ABB
ETHERNET SWITCHES	Allied Telesis/ Advantech/ D-Link/ Moxa/ Schneider
CAT-6 Cable	Tyco/ Commscope / Systimax/ Panduit
Fiber Optic Cable	Tyco/ Commscope / Systimax/ Panduit
UPS	APC/Eaton/Emerson/Delta/DB Power
Battery	AMCO YUASA/EXCIDE/PRESTOLITE