

Specifications

Name of work: Bhopal Division: Provision of Solar Power plants at Station, Service Buildings and Platform Sheds.

Scope of work–

1. Scope of work covers provision of Grid Connected solar plants & other related works complete with survey, design, manufacture, supply, installation, testing & commissioning at site as per technical specifications.
2. Work is spread over Bhopal Division. It is to be carried out in small quantities at various locations spread over different stations. Proposed locations/ stations are tentative, which may vary at the time of execution of the work, considering various aspects like feasibility and utility.
3. The unit prices indicated in the Schedule of quantity is inclusive of the prices for design, manufacturing, supplying of materials, multiple loading/unloading required under the particular item of schedule, storing, handling, erection testing and commissioning of installation in conformity of specification. The unit price is also inclusive of all incidental charges for transport, loading/unloading and handling of materials, commission for arranging dispatch direct from manufacturer's factory / authorized dealer / supplier and completing all necessary formalities in this respect, such as submission of forwarding notes, all insurance premium, bankers charges for bank guarantee, indemnity bonds inclusive of cost of stamps, etc. The unit prices shall include all incidental charges duties and levies including GST.
4. All the materials, equipments, its accessories shall be new and preferably of approved make conforming to the relevant IS/IEC/MNRE standards, and in accordance with the specifications of the OEM. Relevant standards shall be followed in carrying out the work, and the decision of department shall be final and binding.
5. During the course of execution of above work electrical fitting, fixtures, wirings etc. needs to be removed and dismantled, shall be done by the contractor and released material shall be transported to store / scrap depot by the contractor for that no extra payment will be done. Any temporary bypass arrangement for continuity of supply if required shall also be done by the contractor under guidance of consignee department.
6. Work is to be executed in consultation with Civil Engineering Dept. and other concerned departments. It is to be carried out with utmost care to avoid any disturbance to the railway operations, station activities or inconvenience to the occupants / users.
7. The work shall be carried out under the supervision and guidance of concerned Sr. Section Engineer/Electrical (SSE), or any SSE Authorized by Sr.DEE(General)Bhopal.
8. Quantity shown in the schedule is approximate and subject to vary at the time of execution of work and will depend upon actual requirement at site.
9. Released materials/ scraps to be properly accounted & handed over to the Railway with proper record.
10. Safety of the contractor's staff/labour engaged in the work will solemnly be the responsibility of the contractor and therefore careful supervision is required during the work to guard and warn his staff/labour against unusual incident / electrical shock

/ moving trains / live OHE lines, etc. The contractor shall make adequate arrangements during the construction period for the safety of workers.

11. Any work / item/ part thereof, whether specially mentioned in the scope of work or not, but necessary for completion of the work and for proper functioning and commissioning of the equipment shall be deemed to be the part of the scope of work. It should be clearly understood, that the work assigned as per the tender documents is a complete turnkey job and complete execution thereof will be the entire responsibility of the successful tenderer unless otherwise specially brought out in the contract agreement and/or the letter of acceptance of the offer.
12. The successful contractor shall arrange of all equipment, tools, consumables, testing meters, Hydra scaffolding, crane, forklift etc. and other required materials for successful completion of the work. Any work not specifically mentioned, but required for successful completion of work is deemed to be included in the work. If any activity required to be included later on due to reliability and safety shall be carried out by contractor without any extra cost.
13. The specifications as referred as standard specifications and technical specifications are expected to be known to the working contractors of the concerned field, however the standard specifications are widely available and specific to the work are enclosed as far as possible. Tenderer should make all the efforts to make fully aware of the scope of work, standard & technical specifications as may be required for satisfactory commissioning of the work.
14. It is not the intent to specify herein complete details of design and construction. The equipment offered shall conform to the relevant standards and be of high quality, sturdy, robust and of good design and workmanship complete in all respects and capable to perform continuous and satisfactory operations in the actual service conditions at site and shall have sufficiently long life in service as per statutory requirements.
15. TESTING & COMMISSIONING: As specified in technical specification of the item/ equipment, the Contractor shall organize testing and commissioning of installation/ equipments and components as decided by engineer's representative and same shall be witnessed by engineer's representative. The contractor shall arrange all pre commissioning routine/ acceptance and other reasonable tests at his cost with a view to ensure the soundness of the equipments and their erection in strict compliance with the specifications.
16. In addition to supply, installation, testing and commissioning of all equipment's as per schedule and specifications of work, following works are deemed to be within the scope of work, to be executed by the contractor, if required.
 - (i) Removal of old electrical arrangements / equipment, necessary to carry out the proposed work. Any minor modification / changes in the existing system / arrangement, with fabrication / drilling or any other means, at site.
 - (ii) All minor building works, such as equipments foundation if required, cutting and making good holes, grouting of channels belts as required. Cutting and making good damages etc.
 - (iii) Provision of supports / clamps for equipments, cables etc. wherever required.
 - (iv) Small wiring, inter-connection etc. inclusive of all materials and accessories, necessary to comply with the regulations as well as proper and trouble free operation of the equipment.
 - (v) Closing of the cable entry points against seepage of water, rodents etc.
 - (vi) Tools and tackles required for handling and installation.
 - (vii) Necessary testing of equipments for commissioning.
 - (viii) Watch and Ward of materials and/or installation and equipments till their handing over to the Railway.

17. CARE OF THE BUILDING -Care shall be taken by the contractor during execution of the work to avoid damage to the building. Contractor shall be responsible for repairing all such damages and restoring the same to the original finish at his cost. Contractor shall also remove all unwanted and waste materials arising out of the installation from the site of work from time to time.
18. CONFORMITY WITH STATUTORY ACTS, RULES, STANDARDS AND CODES - All the material and components shall conform to relevant IS/IEC/MNRE Specifications latest or amended upto date. All works shall conform to National Building code as well as relevant BIS codes.
19. All electrical works shall be carried out in accordance with the provisions of Indian Electricity Act, 2003 and Indian Electricity Rules, 1956 amended to date. All components shall conform to Energy Conservation Building Code 2007 of India as amended or revised up to date.
20. The material supplied and to be used for this contract work shall be strictly as per the approved makes/brands. In addition, the work shall conform to the technical specification/scope of work specified by railway in the tender document.
21. All the safety codes and procedures outlined in the safety codes shall be complied with.
General and safety requirements shall be governed by IS:13947(Pt-I)1993 and IS:8623/1993, latest or bamended up to date.
22. Neutral conductor (incoming & outgoing) shall be connected to a neutral connector link in boards and capable of being disconnected individually for testing purposes. In no case joints in phase & neutral wires is allowed.
23. **Identity cards:** All the staff deputed by the Contractor shall carry identity card with them all the time while present in the railway premises in connection with the work awarded. The identity card having passport size photograph, shall be issued by the contractor at his own cost, countersigned by concerned Railway Authority and the Contractor, with validity of 6 months or as advised by the railway representative.
24. During execution of the contract work, if any electricity is required for installation of solar plant, only power supply will be provided free of cost at the nearest available supply point of the railway. The contractor has to arrange for extending the power supply from the available point to the work site.

General Description

1. **Solar Power Plant:** The scope of work covers design, manufacture and supply of On-Grid connected Solar Plant without battery backup, including all necessary components, sub-components, complete with the following major items, and including all other accessories, Training to the user for operation and maintenance of the system, SEB charges along with installation, testing and commissioning at railway premises on roof top of building / shed top of station platform with all associated works:
 - a) High efficiency Mono-perc /TOPCon Solar PV Modules connected in series
 - b) Solar Grid Connected String Inverter along with Data Logger, with provision for data transferring (RS-485, Wifi, GPRS, RF) to remote service platform for data storage and analysis displayed in various visual and graphical formats on Web-App & big screen display
 - c) Solar PV Module Mounting Structure
 - d) Array Junction Box
 - e) Inverter
 - f) Interfacing Panel
 - g) Import & Export metering
 - g) Fire resistant DC Cables & Fire resistant AC Cables of suitable length as per site requirement for interconnecting panels, array, Junction box, and solar inverter system etc.
 - h) Water Sprinkler System etc for cleaning of PV Modules complete with water tank of minimum 1000 litres capacity at each site.
2. **NET METERING:** The successful tenderer shall be responsible for maintaining liaison with State Electricity Board authorities (SEB/DISCOM) for implementation of net metering for this work. Registration with SEB/ DISCOM is also in the scope of this work. All the related charges shall be borne by the contractor.
3. The contractor will have to quote the rates for the project considering the warrantee period of **FIVE** years inclusive of comprehensive maintenance. Warrantee shall cover repairs, replacements, comprehensive maintenance as per prescribed schedule / OEM guidelines inclusive of all spares, materials, schedule cleaning and labour cost.
4. After award of the contract, the tenderer shall carryout the survey at various locations / stations over Bhopal Division for feasibility of installation of the solar plants. GAD, layout plan, wiring diagram & feasibility report etc. should be got approved before commencing of work.
5. For automatic cleaning of all the solar panels simultaneously, Installation of permanent water pipeline along with required accessories, pump of adequate capacity and water spraying NOZZLE on the top of every panel that will spray high pressure water on the panel in order to clean it. Water tank of minimum 1000 litres capacity at suitable height shall be installed by the contractor at each location.
6. Climbing arrangement (Ladder) made of MS pipes/flats of weight bearing capacity of 500Kg should be made as per site requirement by the contractor.

Scope of Work

1. The quoted price shall be deemed to cover the complete cost of design, engineering, procurement, supply, loading, transportation, unloading at site, installation, testing, and commissioning of the Solar PV Plant in accordance with the latest MNRE guidelines, CEA (Technical Standards), BIS requirements, and applicable State DISCOM Net-Metering Regulations. The scope includes the supply of high-efficiency ALMM-listed Mono-PERC/TOPCon Solar PV Module, hot-dip galvanized module mounting structures designed as per IS wind-load standards with necessary foundations, and suitably rated On-Grid String/Central Inverters equipped with MPPT, THD < 3%, integrated protections, communication interfaces, and remote monitoring capability. It also includes all DC/AC cabling, connectors, junction boxes, ACDB/DCDB with MCB/MCCB, isolators, fuses and SPDs, cabling in hms PVC conduit/casing capping, system signages and display boards, minimum Five separate chemical earthing (One each For Mounting structure, Lightning Arrester, Inverter, DC Circuits and Other AC Circuits/pumps etc) complete with earth pits with proper bonding, lightning arrester and surge protection, inverter platform with canopy, and all related civil, electrical and miscellaneous works required for the complete installation.

The scope further includes provision and commissioning of the Remote Monitoring System (RMS) with required communication SIM/card/chip and associated net charges, along with complete liaisoning with the State Electricity Board/DISCOM for net-metering approval including documentation, application processing, inspection coordination, and necessary solar generation and service connection meters. The contractor shall provide user training on system operation, maintenance and safety, and submit all manuals, datasheets, test reports, and warranty documents. A minimum five-year comprehensive on-site warranty covering preventive and corrective maintenance, module cleaning, service visits, and performance support is included. All works shall be executed in an approved manner as per site conditions and the directions of the Engineer-in-Charge.

2. All solar equipment shall be procured strictly from MNRE-approved and certified manufacturers/sources. The tenderer/bidder shall mandatorily use Indian-manufactured Solar PV (SPV) modules, duly listed in the MNRE/ALMM database. All components and sub-systems of the Solar PV plant shall fully conform to the latest MNRE guidelines, BIS/IEC standards, and applicable statutory requirements. The bidder shall submit valid test certificates, type test reports, compliance documents, and quality assurance certificates for each component of the system (modules, inverters, structures, cables, protection devices, and accessories) prior to commencement of execution. No material shall be installed at site without prior approval of the Engineer-in-Charge.
3. The system description, general specifications, and technical requirements provided in the tender documents are intended for broad guidance only. The supplier/manufacturer shall be responsible for preparing and submitting a complete, site-specific detailed design of the Solar PV generating system for each location. This design shall be developed using appropriate industry-standard software/tools to optimize the configuration of solar modules, inverter capacity, and other system components, taking into account the geographical location, solar insolation levels, shading analysis, load characteristics, structural constraints, and overall system performance requirements. The final design, along with all supporting calculations, drawings, and simulations, shall be submitted for approval prior to execution.

4. The General Arrangement Drawings (GAD), layout plan, wiring diagrams, feasibility report, and all other relevant technical documents shall be submitted by the bidder and obtained approval from the Engineer-in-Charge prior to commencement of any work at site. The scope of work also includes the preparation of all required design drawings and the submission of as-erected/as-built drawings for each site in A3 size, complete with all relevant dimensions, specifications, and installation details. All drawings shall be submitted in 1 + 2 hard copies along with a soft copy in editable and PDF formats. The Supply, Erection, Testing, and Commissioning (SETC) of the Solar PV System/Plant shall strictly conform to the latest MNRE specifications, guidelines, and amendments, as well as the technical requirements detailed herein.

5. **DRAWINGS TO BE FURNISHED BY THE BIDDER AFTER AWARD OF CONTRACT**

- i) **General Arrangement (GA) and Dimensioned Layout Drawings** clearly indicating the placement of all major components, equipment clearances, cable routing paths, service access space, and overall system configuration for the proposed Solar PV Plant.
- ii) **Detailed Schematic Diagrams** covering the complete electrical architecture of the system, including Solar PV module strings, Power Conditioning Unit(s)/Inverters, DC and AC Junction Boxes, DCDB/ACDB, protective devices, metering arrangements, earthing system, lightning protection, and all interconnections required for safe and compliant operation.
- iii) **Structural Drawings with Foundation Details**, including design parameters, structural member specifications, material grades, mounting structure geometry, load calculations, anchoring/fastening arrangements, and foundation drawings suitable for the specific site conditions, duly certified as per relevant IS/BIS codes.
- iv) **Itemized Bill of Materials (BoM)** for the complete Solar PV Plant, covering all equipment, components, consumables, accessories, cables, connectors, and hardware intended to be supplied and installed, along with their technical specifications and makes.
- v) **Solar Power Array Layout**, indicating module placement, string configuration, row spacing, tilt angles, structural orientation, walkway provisions, and any access/maintenance paths required for optimum performance and serviceability.
- vi) **Comprehensive Shadow Analysis Report** of the rooftop or installation area, including sun-path diagrams, shading simulations, obstacle mapping, and loss assessment to justify the proposed array layout and ensure maximized solar energy generation.

6. Before execution of any work at any site, the contractor shall obtain all necessary approvals, permissions, and clearances from the concerned department/authority, and no activity shall commence without such prior approval

7. Miscellaneous works such as cutting or trimming of trees, clearing of vegetation, cleaning of the site, removal of debris, shifting of obstructions, and any other preparatory activities required for proper installation shall be carried out by the contractor entirely at his own cost.

8. Sr. DEE/G/Bhopal reserves the full right to modify, alter, or revise the design, layout, specifications, and configuration of any sub-system or component at any stage, based on site conditions or project requirements, and the contractor shall comply with such modifications without claiming any additional cost.

9. System Description

9.1 The Solar Power Plant shall comprise the following main components:

- i) **Solar PV Modules** of approved make and rating, conforming to MNRE/BIS standards.
 - ii) **Module Mounting Structure**, hot-dip galvanized and designed to withstand site-specific wind loads as per relevant IS codes.
 - iii) **Junction Boxes (AC/DC)** equipped with suitable protection devices, connectors, and weather-proof enclosures.
 - iv) **Power Conditioning Unit (PCU)/Inverter** with MPPT functionality, integrated protections, communication interfaces, and grid-synchronization capability.
 - v) **Import & Export Metering System** as required by the State DISCOM for net-metering or gross metering compliance.
 - vi) **Cables, Wires, Conduits, Earthing Materials, and Associated Accessories**, appropriately rated and compliant with relevant IS/BIS/IEC standards for safe and reliable operation.
 - vii) **All accessories, components, consumables, supports, and parts** necessary for the complete installation, testing, commissioning, and satisfactory performance of the Solar Power Plant, ensuring reliable, efficient, and continuous operation of all subsystems.
 - viii) **Water Sprinkler Arrangement for Cleaning of PV Modules**, comprising a suitably designed sprinkler network with nozzles, piping, valves, supports, and all associated fittings, including provision for a reliable water supply connection with minimum 1000 liters water tank at each location, to enable uniform and effective module cleaning as part of routine maintenance.
 - IX) **Lightening Arrestor (LA)** shall be installed on each array structure of the solar plant. If any such scattered arrays, a separate Lightning Arrestor (LA) shall be installed on each array structure and each LA shall be connected to a dedicated earthing system with a separate earth wire in separate HMS PVC conduit pipe ensuring proper surge protection for each independent rooftop array.
 - (X) **Chemical Earthing: For Solar Plant Capacity above 50 kW** - Minimum 05 Nos separate chemical earthing required (one each for Mounting Structure, Lightening Arrestor, Inverter, DC Circuits and other AC Circuits/Pumps etc)
- For Solar Plant Capacity from 15 kW to 50 kW** Minimum 04 Nos. separate chemical earthing shall be provided.
- For Solar Plant Capacity up to 15 kW** Minimum 03 Nos. separate chemical earthing shall be provided, or as per site requirements.

9.2 The PV array converts the light energy of the sun into DC power. The module mounting structure shall be used to hold the modules in position. The DC power shall be converted into AC by the PCU to supply AC loads within the railway premises. Solar power shall be integrated with the premises' power supply from the electricity authority.

9.3 A DC Distribution Board (DCDB) / Combiner Box shall be provided between the solar array and the PCU. It shall be equipped with a suitably rated DC disconnect/MCCB for safe connection and isolation of the array section. A Type II Surge Arrestor shall be incorporated to protect the system against transient over voltages. The DCDB shall also include meters for measuring array voltage and array current, ensuring proper monitoring and safe operation of the PV array.

9.4 An AC Distribution Board (ACDB) shall be provided between the PCU and the connected loads. The ACDB shall include an integrated energy meter, voltmeter, and ammeter for proper monitoring of system performance. For energy measurements, the parameter of interest shall generally be the aggregate energy output of the inverter(s) feeding the individual AC distribution board(s). Where multiple inverters feed into a single ACDB, the system shall provide the facility to record the energy output of each inverter individually. A Class I + II Surge Arrestor (as per IEC

62305) with 100 kA rating shall be provided to protect the system against transient over voltages and lightning surges.

9.5 No electrical storage batteries shall be required for the system; accordingly, batteries and related components are excluded from the scope of work.

9.6 The Solar PV system shall comply with IEC 60364-7-712 (Requirements for Electrical Installations of Buildings – Solar PV Systems) and IEC 62446 (Grid Connected PV Systems – Documentation, Commissioning Tests, and Maintenance), ensuring safe, reliable, and standards-compliant design, installation, and operation.

10. General Requirements

10.1 The Solar PV generating system shall supply part or full load of railway service buildings/areas, thereby reducing the electrical energy drawn from the grid and contributing to a reduction in CO₂ emissions.

10.2 Solar panels and array junction boxes shall be installed on shade-free rooftops, while transformer-based PCUs, inverters, and AC/DC distribution boards shall be housed inside rooms provided by the Railways. Installation of PV modules on rooftops shall not compromise the existing waterproofing of the terrace. The contractor shall be responsible for restoring the waterproofing to its original condition and providing additional waterproofing at points where RCC blocks or other supports are anchored to the terrace.

10.3 For individual systems above 10 kWp, if the available space on a single rooftop is insufficient, the total system capacity may be distributed across multiple rooftops. Each rooftop array shall be appropriately connected to feed the grid-tied power supply system. For such scattered arrays, a separate Lightning Arrestor (LA) shall be installed on each array structure, and each LA shall be connected to a dedicated earthing system with a separate earth wire, ensuring proper surge protection for each independent rooftop array.

10.4 The array structures, PV yard, and all electrical equipment, including PCU/inverters, shall be properly grounded. The contractor shall supply and install an adequate number of earthing kits compliant with IS:3043 (1987), providing separate earthing for the Module Mounting Structure (MMS), Lightning Arrestors (LA), DC circuits, AC circuits including water pump systems, and the Inverter/PCU. Each earthing system shall have a dedicated earth conductor and shall be installed to ensure safe dissipation of fault currents, reliable system operation, and proper protection of all equipment and personnel.

10.5 Suitable marking and labeling shall be provided on busbars, panels, and equipment for easy identification and operation.

10.6 PV modules may be connected in series up to the maximum allowed operating voltage of the PV modules or the inverter, whichever is lower.

10.7 If blocking diodes are required or provided in series, their reverse current rating shall be at least $2 \times \text{VOC}$ at STC of the PV string.

10.8 All cable entry points into enclosures or buildings shall have proper sealing arrangements, ensuring protection against dust, moisture, and environmental ingress.

11. TECHNICAL REQUIREMENTS

11.1 The DC output from the PV modules shall be fed to the array junction box, and the module strings shall be paralleled at sub-main and main junction boxes. The PCU (Power Conditioning Unit) shall convert the DC energy produced by the solar array into AC energy. The AC output from the inverter shall be fed to the AC Distribution Board, which houses the energy meter, metering panel, and isolation panel. The AC output of the grid-connected SPV system shall be paralleled with the railway's general electric power supply.

11.2 The system shall automatically start in the morning and supply power, provided sufficient solar insolation is available and the grid voltage and frequency are within the permissible range.

11.3 When the grid voltage and/or frequency goes outside the preset limits, the inverter shall immediately disconnect from the grid. The inverter shall reconnect automatically after a pre-determined time once the grid parameters return to within the allowable range.

11.4 The Railways shall provide adequate space and ventilation for the inverter to ensure safe and efficient operation.

11.5 For safety reasons, the PV inverter system shall disconnect from the grid automatically following a fault or loss of supply on the railway's power network.

11.6 The system's performance and energy generation data shall be recorded using a data logger, and the monitoring system shall include the following components:

i) The PCU shall log inverter performance data and transmit it to the data logger. It shall monitor key parameters such as energy generated and system status.

ii) A data logger shall be provided for each Solar PV plant to monitor inverter performance and support measurements from external sensors. It shall also monitor solar insolation and array yard temperature. Free-of-cost access to the web-based monitoring system shall be available during the contractual warranty period. Post-warranty, web-based monitoring shall be provided under AMC, if Railways opts for a separate agreement.

iii) The data logging system/software shall enable automatic long-term storage of measured data, facilitate visualization, monitoring, commissioning, and service of the PV installation, and be web-enabled. Data shall be accessible through standard web browsers such as Internet Explorer or Google Chrome. The contractor shall supply all necessary software, hardware, and executable files free of cost, including CD or other storage devices for accessing and visualizing the data.

iv) Communication interface: The system shall provide RS232/RS485 ports and LAN/WAN interfaces to facilitate remote monitoring of the system.

11.7 Sizing of the SPV System: The SPV system shall be sized considering the load requirements and available installation space. A minimum capacity of 05 KWp shall be installed at each location.

12. PV MODULES/ARRAYS FOR THREE PHASE SOLAR POWER PLANTS

12.1 Solar PV modules shall be of crystalline silicon type, manufactured in India in a plant certified under ISO 9001:2008 and type-tested by an accredited national or international testing laboratory. The PV module manufacturer shall hold approval from MNRE. The modules shall comply with the latest MNRE guidelines, BIS standards, and AMR (Approved Module Requirement) norms.

i.	Solar PV modules type	Solar PV Panels, Mono PERC Half-cut or TOPCon Half-cut, high-efficiency cells, manufactured in India.
ii.	Solar PV modules Rating	585 Wp or above per module.
iii.	Efficiency	Minimum 20%, with higher efficiency preferred for TOPCon modules (up to 23%).
iv.	Performance Warranty	Minimum 90% of rated power for the first 10 years and at least 80% up to 25 years for output peak watt capacity.
v.	Module frame	Silver anodized aluminum frame with twin-wall profile, suitable for outdoor installation and corrosion resistance.
vi.	Junction box, Termination box	Thermoplastic, IP67 rated, UV-resistant, and suitable for rooftop or ground-mounted installations.
vii.	Surge Protection	Low-voltage drop bypass diodes and protective devices against surges at the PV module shall be provided to avoid hot-spot formation.
viii.	Blocking diodes	Schottky type for reverse current protection.
ix.	Tolerance for rated output power of PV module	$\pm 3\%$ of rated output.
x.	The peak power point voltage and the peak power point current of any supplied module	Peak power point voltage (V_{mp}) and current (I_{mp}) shall not vary by more than $\pm 2\%$ from nominal values
xi.	R.F. identification for each solar module	Each PV module shall be equipped with an RFID tag embedded inside the module, designed to withstand environmental conditions throughout the module's service life, providing full traceability. The RFID tag shall include the name of the manufacturer of the PV module and solar cells, month and year of manufacture, country of origin, the I-V curve, maximum power (W_m), current at maximum power (I_m), voltage at maximum power (V_m), fill factor (FF), unique serial and model numbers, and the name of the IEC-accredited test laboratory issuing the type certification. The RFID system shall comply with ISO 9000 or the latest standards to ensure reliable identification and tracking of solar modules and cells throughout their lifetime.
xii.	Compliance with	IEC 61215 / IS 14286 or latest
xiii.	Standards and Codes	IEC 61730 Part 1 & 2 or latest

xiv	Salt Mist corrosion testing	IEC 61701/IS: 61701 or latest
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12.2 SPV module shall contain crystalline high power silicon solar cells. The solar cell shall have surface anti-reflective coating to help to absorb more light in all weather conditions.

12.3 Each module shall have low iron tempered glass front for strength and superior light transmission. It shall also have tough multi-layered polymer back sheet for environmental protection against moisture and provide high voltage electrical insulation. Transitivity of glass shall not be less than 91%.

12.4 Module junction box and terminal block (weather resistant) shall be designed for long life outdoor operation in harsh environment

12.5 Bird spike shall be provided so as to avoid bird sitting on the solar modules at the highest point of the array/module structure, as per requirement.

12.6 SPV module shall be highly reliable, light weight and shall have a service life of more than 25 years. Whenever more than one module is required, identical modules shall be used.

12.7 The solar modules shall have suitable encapsulation and sealing arrangements to protect the silicon cells from the environment. The encapsulation arrangement shall ensure complete moisture proofing for the entire life of solar modules. The terminal block shall be preferably of Noryl rubber with weatherproof design (min. IP 65) and shall have a provision for opening /replacing the cables if required.

12.8 Insulation Resistance: The insulation resistance of each solar module shall be not less than

50 MΩ when measured with a 500 V DC megger, ensuring safe and reliable operation under all conditions.

12.9 **Marking**

Each solar PV module shall carry the following clear, permanent, and indelible markings,

provided either on the nameplate label or as part of the module backsheet printing:

- i) Name, monogram, or symbol of the manufacturer
- ii) Serial number of the module
- iii) Polarity identification of terminals or leads (colour coding permitted)
- iv) Open-circuit voltage (Voc)
- v) Rated operating voltage
- vi) Maximum system voltage for which the module is suitable
- vii) Rated operating current
- viii) Short-circuit current (Isc)
- ix) Date and place of manufacture
- x) Weight of the module
- xi) Module Wp tolerance (may be omitted if impractical or cumbersome to include)

13. Module Mounting Structure

13.1 General Requirements

The PV modules shall be mounted on a fixed metallic structure of adequate strength and suitable design to withstand module load and high wind velocities. The detailed specifications of the mounting structure are given below:

i.	Wind velocity withstanding capacity	Minimum 150 kmph. As per IS 875:1987 (Part 3) or latest version
ii.	Structure material	Hot dip galvanized steel with a minimum galvanization thickness of 120 microns or aluminium alloy - Grade 6063 T6. The mounting structure steel shall be as per latest IS 2062: 1992 and galvanization of the mounting structure shall be in compliance with latest IS 4759.
iii.	Bolts, nuts, fasteners, panel mounting clamps	Stainless Steel - Grade SS 304.
iv.	General arrangement of solar panel mounting	As per Bhopal Division type plan.
v.	Mounting arrangement for RCC-flat roofs	With removable concrete ballast made of prefabricated PCC (1:2:4), M 15
vi.	Civil work/Structure	As per load bearing capacity of roof and the suitable structure based on the quality of roof/ without damaging the roof/shed (should be made leak proof). The price shall cover all civil works. To prevent pilferage, anti-theft fasteners shall be provided at appropriate locations.(The structure installed on the Cover Over Platform (COP) and shed must be completely leak-proof, and proper adhesive/sealant materials should be used to ensure watertight installation.)
vii.	Installation	The structures shall be designed for simple mechanical on-site installation. There shall be no requirement of welding or complex machinery at the installation site. The structures shall be designed to allow easy replacement of any module.
viii.	Distance between roof edge and solar panels	Minimum 500 mm from all roof edges, ridges and all sides.

ix.	Access for panel cleaning maintenance	All solar panels must be accessible from the top for cleaning and from the bottom for access to the module junction box
x.	Panel tilt angle	North-south orientation with a fixed tilt angle (south facing) depending upon location, The module alignment and tilt angle shall be calculated to provide the maximum annual energy output.
xi.	Height of the structure	Height of the structure is so designed that sun light on the panel should not obstructed by any object.

13.2 The total load of the structure (when installed with PV modules) on the terrace should be less than 60 kg/m².

13.3 The prospective installer shall specify the installation details of the solar PV modules/arrays and the support structures with lay-out drawings and array connection diagrams. The work shall be carried out as per the approved designs.

14. SOLAR GRID INVERTERS /POWER CONDITIONING UNIT (PCU) (GRID CONNECTED)

14.1 As the SPV array generates direct current (DC), it is necessary to convert this DC power into alternating current (AC) and adjust the voltage levels to match the grid voltage. This conversion shall be carried out using an electronic inverter along with the required control equipment. The PCU shall also include an MPPT (Maximum Power Point Tracker) to interface between the solar PV array and the inverter. The inverter output shall be fully compatible with the grid frequency.

14.2 These inverters operate in synchronization with the grid supply. The solar grid inverter converts the DC power generated by the solar PV modules into grid-compatible AC power. The inverter shall have inbuilt charge controllers, MPPT controller, anti-islanding protection, DC and AC disconnects, automatic data logging, and all necessary protection features for various system components. These functions make the inverter suitable for applications requiring effective management of power from multiple sources.

14.3 The PCU shall supply the DC energy produced by the solar array to the DC bus for inversion into AC voltage using MPPT (Maximum Power Point Tracking) control to extract maximum power from the array. The PCU shall produce 415 V AC (+15% / -20%), 3-phase, 50 Hz (±5%, i.e., 47.5 to 52.5 Hz) synchronized with the local grid. For sizing of the grid-connected inverter, the array output must remain within the input voltage range of the inverter so that it operates in the MPPT range for most of the solar insolation period throughout the life of the solar array, supported by design calculations. The PCU shall be capable of handling a maximum open-circuit DC voltage of 1,000 V.

14.4 The PCU/string inverter shall provide a 3-phase, 415 V AC output (with grid tracking of +15% / -20%) at 50 Hz (with grid tracking of ±5%, i.e., 47.5 to 52.5 Hz). The AC output shall maintain a voltage THD of less than 3% and a current THD of less than 5%.

14.5 At any site, the combined AC output wattage of all inverters shall not be less than the rated capacity of the solar power plant, ensuring full utilization of the installed PV array capacity.

14.6 Typical technical features of the inverter shall be as follows:

i.	Switching devices	IGBT / MOSFET
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ii.	Control	Microprocessor / DSP (Digital Signal Processors)
iii.	Warrantee	10 years (min.)
iv.	Total output power (AC)	To match solar PV plant capacity while achieving optimum system efficiency
v.	Maximum power point Tracking (MPPT)	Shall be incorporated
vi.	Number of independent MPPT inputs	1 or more
vii.	Operation AC voltage	Three phase, 415 Volt, $\pm 10\%$, Output wave form - Pure sign wave
viii.	Operating frequency range	50 Hz, $\pm 3\%$
ix.	Power Factor of the	Greater than 0.95 at nominal power
x.	Total Harmonic Distortion	Less than 3%
xi.	Inverter efficiency	Greater than or Equal to 95%
xii.	No Load Loss	Less than 1% of rated power
xiii.	Protection degree	IP 65 for outdoor mounting, IP 54 for indoor mounting
xiv.	Anti-islanding protection	As per VDE 0126-1-1, IEC 60255.5/IEC 60255.27
xv.	Operating temperature range	-10° C to +60° C
xvi.	Humidity	0 to 95% RH Non-condensing
xvii.	Communication interface	RS 485/RS 232/RJ 45/Wifi (wireless)
xviii.	Environmental testing	IEC 60068-2 (1, 2, 14, 30) / Equivalent BIS standard
xix.	Efficiency measurement procedure	IS / IEC 61683
xx.	Display type	LCD for data display, LCD/LED for status display
xxi.	Display parameters	Output power (W), cumulative energy (Wh), Daily generation DC Voltage (V), DC Current (A), AC Voltage (V), AC frequency (Hz), AC Current (A), cumulative hours of operation (h)
xxii.	Inverter body material	Aluminium casting
xxiii.	Cooling medium for inverter	Intelligent fan cooling
xxiv.	Standard accessories for inverter	MB4 DC connectors, AC connectors, Mounting Bracket, Nut bolts and inverter manuals.
xxv.	Net Meter	Approved by Govt. of India / State govt. authority concerned for connecting to grid /DISCOM

14.7 The PCU shall be capable of complete automatic operation, including wakeup, synchronization and shut down.

14.8 INTEGRATION OF PV POWER WITH GRID:

- (i) PCU shall be capable of independently and automatically synchronizing or phase-locking with the local grid power line frequency to achieve proper

synchronization.

- (ii) The output power from the SPV system shall be fed to the inverters, which convert the DC power generated by the SPV array into AC and supply it to the main electricity grid after proper synchronization. In the event of a grid failure or abnormal voltage conditions (low or high voltage), the solar PV system shall automatically disconnect from the grid. Once the DG set comes into operation, the PV system shall resynchronize with the DG supply, and the load requirement shall be met to the extent of the available power.

- (iii) Four-pole isolation of the inverter output with respect to the grid/DG power connection shall be provided.

14.9 A built-in meter and data logger shall be provided to monitor plant performance through an external PC.

14.10 Indications (through LEDs/LCD display) for the following conditions shall be provided:

(i) Inverter ON, (ii) Grid ON, (iii) Inverter under-voltage/over-voltage, (iv) Inverter overload, (v) Inverter over-temperature, (vi) Earth fault, and any additional indications finalized at the design stage.

14.11 PROTECTIONS:

Following is an indicative list of protections (the actual scheme will be finalized at design stage):

- i) Over-voltage both at input and output
- ii) Over-current both at input and output
- iii) Over/under grid frequency
- iv) Over temperature
- v) Short circuit on AC side
- vi) Reverse polarity protection
- vii) Array ground fault protection
- viii) Protection against lightning induced surges Class II, 10 kA as per IEC 61643-1
- ix) Protection against surge voltage induced at output due to external source.

14.12 Night consumption of the PCU shall be less than 0.2% of the rated power of the inverter for system capacities of 25KWp or more. It shall be less than or equal to 50W for system capacities of less than 25KWp.

14.13 The noise level of the PCU/Inverter shall be less than 65 dBA (nominal) measured at a distance of 1 metre, under standard operating conditions.

14.14 DC Insulation resistance should be more than 50 Mega Ohm

14.15 The PCU shall comply with the following Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) standards:

- (a) Emitted Interference: Shall conform to IEC 61000-6-4 (Industrial Environment – Emission Standard).
- (b) Immunity Requirements: Shall conform to IEC 61000-6-2 (Industrial Environment – Immunity Standard).

14.16 An integrated earth-fault detection and monitoring device shall be provided in the PCU/Inverter to continuously supervise the DC side. The device shall detect any ground/earth fault occurring in the DC circuit and shall immediately generate an alarm or fault message to the supervisory control system/SCADA. The protection scheme shall comply with relevant IEC standards and shall ensure safe and reliable operation of the PV plant.

14.17 The idling (no-load) current of the PCU shall not exceed 2% of the full-load current under

standard operating conditions.

- 14.18 The PCU shall withstand a high-voltage dielectric test of 2,000 Vrms applied between either the input or output terminals and the cabinet/chassis without breakdown, as per relevant IEC safety standards.
- 14.19 The PCU shall be provided with dedicated grounding/earthing lugs for equipment grounding and PV array grounding. The DC circuit shall have a solid single-point grounding arrangement to ensure system safety and eliminate ground loops.
- 14.20 Where the PCU is not equipped with internal galvanic isolation, a Type-B Residual Current Device (RCD) compliant with IEC 60755 (Amendment 2) shall be installed to ensure automatic disconnection of supply in the event of an earth fault. An inbuilt Type-B RCD in the inverter/PCU shall also be acceptable.
- 14.21 For maintenance and safety purposes, suitable **manual isolators/switch-disconnectors** shall be provided on both the **DC input side** and the **AC output side** of the PCU. These isolators shall comply with relevant IEC/IS standards.
- 14.22 The PCU may be provided either as a centralized inverter unit or as a combination of multiple string inverters, depending on the system design and site requirements. All configurations shall maintain compliance with technical specifications and performance requirements of this tender.
- 14.23 For all components of the Rooftop Solar System (RTS), including PCUs, inverters, and charge controllers, the contractor shall furnish valid test reports/test certificates issued by NABL-accredited or MNRE-approved laboratories, or from the Solar Energy Centre, MNRE, in accordance with relevant BIS/IEC specifications.

The certification shall include environmental testing as per applicable standards (e.g., temperature cycling, humidity, dry heat, cold test, etc.).

- (a) Dry Heat Test – Shall be carried out in accordance with IS: 9000 (Part 3/Sec. 5) 1977 (Reaffirmed 2007) at 55° C for 16 hours.
- (b) Damp Heat – Shall be carried out at upper temperature of 40° C, two cycles of (12 +12) hours each in accordance with IS: 9000 (Part 5/Sec. 2) 1981 (Reaffirmed 2007)
- (c) Cold Test – shall be carried out in accordance with IS: 9000 (Part 2/Sec. 4) 1977 (Reaffirmed 2007) at -10° C for 4 hours

15. JUNCTION BOXES

- 15.1 The module junction box (if any) shall be certified as per IEC 61215. Array sub-main and main junction boxes, shall have the following properties:
- a. They shall be dust, vermin & waterproof and made of Polycarbonate-Glass Fibre Substance (PC-GFS) thermoplastic, with transparent covers. The enclosure should be double insulated with protection class II as per IEC 61439-1. Material and the protection class shall be marked on the enclosure.
- b. The enclosures shall have IP 65/66 protection in accordance with IEC 60529. Third party conformance certificate is required to be given for IP 65/ IP 66 degree of protection.
- 15.2 SPDs Class II as per IEC 61643-1, shall be used at the terminals of array junction boxes for external surge protection. Internal Surge protection (SPDs) shall consist of three MOV (Metal oxide Varistor) type arrestors connected from +ve and -ve terminal to earth (Via Y arrangement) for higher withstand of the continuous PV-DC voltage during earth fault condition. SPD shall have safe disconnection & short circuit interruption arrangement through integrated DC in-built bypass fuse (parallel) which should get tripped during failure mode of MOV, extinguishing DC arc safely (created by inbuilt thermal disconnection) in order to protect the installation against fire hazards. Nominal discharge current (In) at 8/ 20 microseconds shall be minimum 10 KA with maximum discharge current (Imax) of minimum 20 KA at 8/20 microseconds with

visual indication (through mechanical flag) in all modules to monitor the life of SPD. The Iscwpv (Short Circuit current withstand capacity of arrester) would be at least 10% more than Nominal output current of the combiner box and AJB.

- 15.3 Copper bus bars/terminal blocks housed in the junction box with suitable termination threads conforming to IP65 standard and IEC 62208 Hinged door with EPDM rubber gasket to prevent water entry. Single / double compression cable glands. Provision of earthings.
- 15.4 The junction boxes shall have suitable cable entry points with cable glands of appropriate sizes for both incoming and outgoing cables.
- 15.5 Suitable markings should be provided on the bus bar for easy identification, and cable ferrules shall be fitted at the cable termination points for identification.

16. DC DISTRIBUTION BOARD:

- 16.1 A DC Distribution Board (DCDB) / Combiner Box shall be provided between the solar array and the PCU. It shall receive the DC output from the array field and feed it to the PCU.
- 16.2 The DCDB shall be constructed using a thermoplastic, DIN-rail mounting enclosure that is dust Proof and vermin-proof, conforming to IP65 protection requirements. The busbars shall be made of copper, sized appropriately as per the inverter rating.
- 16.3 Suitable capacity DC Disconnectors MCBs/MCCBs shall be provided for connection and disconnection of array sections, and for controlling the DC power output to the PCU. The DCDB shall be equipped with meters for measuring array voltage and array current.
- 16.4 Type II Surge Arrestors shall be incorporated for surge protection.
- 16.5 In case of string inverters, if all functions and protections normally provided by the DC Distribution Board (DCDB) are already fully incorporated within the inverter design, then omission of a separate DC Distribution Board may be considered acceptable if desirable from the system design point of view.

17. AC Distribution Board (ACDB):

The ACDB shall be used to terminate single or multiple PCU outputs. The ACDB must have the following features:

- 17.1 AC Distribution Panel Board (DPB) shall control the AC power from PCU/inverter, and should have necessary surge arrestors. Interconnection from ACDB to mains at LT Bus bar while in grid tied mode.
- 17.2 Cables connecting bus bar should be minimum 3 times capacity of Solar Power plant.
- 17.3 Input Grid Line should come from such Distribution Board of client so that the railway load is fed parallelly by the grid as well as SPV system.
- 17.4 The Solar Power should be exported to the bus bar inside the ACDB through a LCD display Energy Meter. In case the systems are installed on multiple rooftops, then for each individual rooftop system, an independent ACDB shall be generally required.
- 17.5 The Designated Load should be routed through ACDB and an Energy Meter to register the Load Energy Consumption from Solar and Grid during Week Days and Holiday.
- 17.6 ACDB should have Class I + II (as per IEC 62305; IEC 61643 and IEC 60364-5-53), 100 kA Surge Suppression inbuilt for surge protection. Surge protection on

AC side (Type 1 + Type 2) shall consist of Pre wired metal encapsulated spark gap based solution for fire safe and fire proof operation at site, consisting of base part and plug in protection module total discharge capacity /Lightning impulse current(I_{imp}) and nominal discharge current in 8/20 micro sec shall be minimum phase power supply system and 50 KV for single phase power supply system. The discharge capability of L-N concealed module be 25KA at 10 /350 micron sec and 8/2 sec. All the L-N & N-E & N-E

connected arresters shall have built in mechanical health indication. Complete solution shall have voltage protection level (Up) of ≤ 1.5 KV to protect the sensitive electronics inside the Invertors, having follow current extinguishing and limiting capability up to 25 KA rms (at 255V) without tripping of even small rating 32 AGL/gG fuse and approved from international independent test labs like KEMA or VDE or UL as per latest IEC 61643-1 or equivalent EN 61643-11 standard. SPDs on the ACDB shall be provided if the same haven,t been provided on the PCU.

- 17.7 ACDBs shall be of thermoplastic DIN-rail mounting enclosure of dust & vermin proof conform to IP 65 protection.
- 17.8 All switches and the circuit breakers, connectors should conform to IEC 60947, part I, II and III/ IS60947 part I, II and III.
- 17.9 The changeover switches, cabling work should be undertaken by the bidder as part of the project.
- 17.10 All the ACDBs/Panels shall be provided with a thermoplastic DIN-rail mounting enclosure or a metal-clad, totally enclosed, rigid, floor-mounted, air-insulated, cubical-type structure, with IP65 protection, suitable for operation on a three-phase, 415 V, 50 Hz system.
- 17.11 The solar panels shall be designed to operate under a minimum expected ambient temperature of 45°C, 95% relative humidity, and dusty environmental conditions.
- 17.12 All the 415V AC devices / equipment like bus support insulators, circuit breakers, SPDs, VTs etc., mounted inside the enclosure shall be suitable for continuous operation and satisfactory performance.

18. Cables and Hardware

- 18.1 All cables and conduit pipes shall be clamped to the rooftop walls and ceiling with thermoplastic clamps at intervals not exceeding 50 cm. Cables and conduits for DC cabling, UV stabilized single core flexible copper cables shall be used. Multi-core flexible copper cables shall not be used.

For the AC cabling, PVC insulated and PVC sheathed single or multi-core flexible copper cables shall be used. AC Cables shall have a UV stabilized outer sheet. A.C. rating: 1.1 KV, D.C. rating: 1.5 KV

DC Cables from SPV module array shall run through a UV stabilized hmsPVC conduit pipe of adequate diameter with a minimum wall thickness of 1.5 mm. Cables and conduits passing through walls and ceiling shall be taken through a PVC pipe sleeve. Cable conductors shall be terminated with tinned copper end ferrules to prevent fraying and breaking of individual wire strands. The termination of DC and AC Cables at the Solar Grid Inverter shall be done as per instructions of the manufacturer.

- 18.2 The cables used in module/ array wiring shall be TUV 2Pfg 1169/08.2007 or VDE EPV 01:2008-02 or UL4703 certified.
- 18.3 Cables of appropriate size to be used in the rest of the system shall have the following characteristics (or as per MNRE guideline):
 - (i) The cable shall be XLPE insulated, PVC sheathed, confirming to IS: 7098 Part I (amendment 1 or latest) with improved fire retardant features as per category C-2 of IS: 7098 Part I (amendment 1 or latest).
 - (ii) Cable shall be halogen-free, low smoke, low toxicity, flame retardant, fulfilling IEC 60332-1 requirements. Type tests certificates, from NABL approved labs, as per IS: 7098 Part I (amendment 1 or latest) for category C 2, as per relevant Para of IS: 10810 must be submitted with the supply.
 - (iii) Conductor class shall confirm IEC 60228 lass 5.
 - (iv) Test report from accredited lab/ Manufacturer shall be submitted with the supply.

- 18.4 Sizes of cables between array interconnections, array to junction boxes, junction boxes to Inverter etc. shall be so selected to keep the voltage drop (power loss) of the entire solar system to the minimum. Cabling of the system shall be as short as possible to minimize the voltage drop in the wiring. Voltage drop: less than or equal to 2% from PV modules to solar grid inverter, solar grid inverter to building distribution box.
- 18.5 The following colour coding shall be used for cable wires –
 DC positive – Red (the outer PVC sheath can be black with a red line marking) DC negative – Black AC single phase – Phase - Red, Neutral - Black Earth wires – Green.
- 18.6 Components and hardware shall be vandal and theft resistant. All parts shall be corrosion-resistant.
- 18.7 Cable Routing / Marking: All cable/wires are to be routed in a PVC conduit pipe or GRP/GI cable tray, as per site requirement & of suitable size, and suitably tagged and marked with proper manner by good quality ferule or by other means so that the cable easily identified.
- 18.8 The Cable should be so selected that it should be compatible up to the life of the solar PV panels i.e. 25 years.
- 18.9 The cable ratings provided are approximate. The bidder shall indicate the cable size and length as per the system design requirements at site. All cables required for the solar plant shall be supplied by the bidder. Any change in cable sizes, if desired by the bidder, shall be supported with appropriate technical justification and approved prior to implementation. All cable schedules and layout drawings shall be approved before installation.

19. EARTHING for PV array, Balance of System (BOS), lightning protection and other components.

The earthing shall be done in accordance with latest Standards.

The complete earthing network shall comply with IEC 62548, IS 3043:2018, IEEE-80, and relevant CEA grid regulations.

The contractor shall provide minimum five (05 Nos) dedicated, individual earthing system for:

- (i) PV Array/Module Mounting Structures
- (ii) DC Side Equipment (DCDB, String Combiner Boxes, SPDs, etc.)
- (iii) AC Side Equipment (PCU/INV, ACDB, LT Panels)
- (iv) Lightning Arrester (LA) for one LA
- (v) Auxiliary equipment (pumps, motors, metallic supports, etc.)

All earthing components must be non-corrosive, maintenance-free, and should ensure long-term reliability for 25+ years. Earth resistance should be as low as possible and shall never be higher than 5 ohms.

Note: Due to hard/rocky soil condition, if earthing with 3 Meters Earthing Electrode is not possible, than three (03 Nos) earthing with 1 meter earthing electrode is to be done for each such type of earthing and all three earthing electrode should be interconnected with suitable conductor, such as 16x2mm copper strip or 25X3 GI strip or 8mm round solid copper conductor to form one grid.

Components and Technical Specifications

Component	Material	Key Technical Specifications
Earthing Electrode/Rod	Copper-bonded steel or Copper-Bonded	Diameter: Minimum 17.0 mm solid. Length: 3 Meters.

	Galvanized Iron.	Copper Coating: Minimum 150 microns of 99.9% electrolytic grade copper (for copper-bonded).
Earth Enhancing Compound	Mixture of Marconite/Bentonite, graphite, gypsum, and other conductive components	Resistivity: Less than 0.2 to 0.24 Ohm-M Quantity: 25 kg per pit or as per site requirements Properties: Non-toxic, anti-corrosive, moisture-retaining, and enhances soil conductivity.
Conductors/Wires	Bare copper or GI strip/wire	Size (AC side): Minimum 75 x 10 mm GI strip or 25 sq.mm copper wire. Size (DC side/Module Frames): Minimum 25 x 6 mm GI strip or 16 sq.mm copper wire or above as per requirement.
Earthing Pit Chamber	RCC	Dimensions: Approx. 300x300x300 mm (inner). Load Capacity: RCC Pit cover designed to bear a heavy load.
Clamps and Connectors	Copper or galvanized material	Used for secure, corrosion-resistant connections between components made of brass or copper alloy.

19.1 Earthing Protection Standards

- (i) Photovoltaic Modules and BOS Components: Shall be grounded as per IEC 60364, IEC 62548, and the latest revision of IS 3043.
- (ii) PV Array Structure Earthing: Each module mounting structure must be connected to an earth grid. Earth pits/rods shall be interconnected to maintain equipotential bonding
- (iii) Lightning Arrestor Earthing: Lightning protection masts/air terminals shall have separate, dedicated earthing pits, interconnected to the main earthing network, keeping minimum separation as per IEC 62305
- (iv) Testing of Earthing: Earth resistance shall be ≤ 5 ohms at each point. Final acceptance shall be carried out in presence of Railway representatives with a calibrated digital earth tester.
- (v) Earthing Conductor Specifications: Earthing conductors used for various portions of the solar PV plant shall conform to IS 3043:2018 and IEC 60364 standards. The minimum cross-sectional area of conductors shall be as follows:
 - (a) 16 Sq mm Copper/ 25x6 sq mm GI strip: For DC side equipment, module mounting structures, PV modules, DCDB, SPD bonding, and connections requiring superior conductivity and corrosion resistance.
 - (b) 25 Sq mm Copper/ 75x10 sq mm GI strip : For AC side equipment earthing (PCU/INV, ACDB, LT panels), auxiliary equipment as per design.
 - (c) GI/Steel Strip/Flat: For main earth grid, interconnection, structure bonding, and lightning protection down-conductors. HDG steel shall have a minimum zinc coating thickness of ≥ 80 microns and shall be suitable for outdoor environments over a 25-years lifespan.
- (vi) The bidder shall submit a detailed scheme of the earthing and grounding system.
- (vi) The contractor shall supply and install an adequate number and appropriate sizes of earthing kits compliant with IS: 3043-1987, with at least one earthing kit each for the AC circuit, DC circuit, lightning protection system, Module Mounting Structures and PCU/Inverters.

- (viii) The earth electrodes shall have a precast concrete enclosure with a removable lid for the inspection and maintenance. The entire earthing system shall comprise of non-corrosive components.

19.2 LIGHTNING PROTECTION:

- 1) The SPV powerplants shall be provided with lightning & over voltage protection.
- 2) The source of over voltage can be lightning or other atmospheric disturbance. Main aim of over voltage protection is to reduce the overvoltage to a tolerable level before it reaches the PV or other sub-system components. The entire space occupying the SPV array shall be suitably protected against Lightning by deploying adequate required number of Lightning Arrestors. Lightning protection provided should comply with: IEC 62305, IS/IEC 60364-5-53, IEC 61643-11 / EN 61643-11 and MNRE technical guidelines for PV rooftop and ground-mounted systems (latest available). A dedicated Lightning Protection System (LPS) shall be installed using one of the following acceptable solutions - Conventional Franklin Rod type lightning arrestors, OR ESE (Early Streamer Emission) type Lightning Arrestors. The bidder shall choose the suitable type based on site layout, shadow impact, and protection radius requirements.

Rod Material: High-tensile steel core with electrolytic copper coating (minimum 250 microns)

Head Type: Spherical head with five spikes (or latest equivalent design)

Corrosion Resistance: Suitable for outdoor rooftop / ground-mounted solar plant conditions

Degree of Protection (Protection Angle): 45°

Protection Method: Rolling Sphere / Protective Angle Method as per IEC 62305

Effective Coverage Radius: Up to 45–50 meters (depending on installation height)

Current Carrying Capacity: Suitable for lightning impulse currents as per IEC 62305, IS/IEC 60364-53, IEC 61643-11 / EN 61643-11 and MNRE technical guidelines for PV rooftop and

Rod Diameter: Minimum 16 mm or above

Rod Length (Above Structure): 1.5 meters for rooftop solar plants

Mounting: Heavy-duty GI / copper-coated base with insulators and clamps in the centre of the Solar Module Mounting Structure so that complete solar modules are in the protective range.

Down Conductor: Copper strip 25 mm × 2 mm or copper cable of minimum 25 Sq mm or above

Connection: Exothermic welded / bolted with tinned copper lugs

Earthing: Dedicated lightning earth pit with resistance not more than 2 ohm for each Lightning Arrester

No of Lightning Arrester: For Solar Plant upto 50 kW Solar Plant: Minimum 1 Lightning Arrester.
Solar Plant more than 50 kW : Minimum 2 Lightning Arresters depending Plant layout.

In case Solar Modules are installed on scattered structure on roofs, than more than 01 Lightning Arrester should be installed as per plant layout and requirements irrespective of Capacity of solar plants, so that all PV modules are in the protective range.

- 3) Necessary concrete foundation or any other arrangement for holding the lightning conductor in position is to be made after giving due consideration to shadow on PV array, maximum wind speed and maintenance requirement at site in future.
- 4) The lightning conductor and structures shall be earthed through flats as per applicable Indian Standards with earth pits. Each lightning conductor shall be fitted with individual earth pit as per required Standards including

accessories, and providing masonry enclosure. Else, a matrix of lightning conductors is to be created which will be required to be connected to an earth. All down conductors shall be installed in dedicated GI/HDPE protective conduits up to the earth pit. All metallic structures of the PV array shall be bonded to create a common equipotential grounding grid

- 5) If necessary, more numbers of lightning conductors may be provided. The number and height of lightning arrestors shall be designed to cover 100% of the PV array area using standard protection angle / rolling sphere method. Lightning arrestor masts shall be placed such that no shadow falls on PV modules during peak hours
- 6) The protection against induced high-voltages shall be provided by the use of metal oxide varistors (MOVs) and suitable earthing such that induced transients find an alternate route to earth.
- 7) The Bidder shall submit the drawings and detailed specifications of the PV array lightning protection equipment.

19.3 SURGE PROTECTION:

Internal surge protection shall consist of three MOV type surge-arrestors connected from +ve and -ve terminals to earth (via Y arrangement).

GRID ISLANDING:

- 1) In the event of a power failure on the electric grid, it is required that any independent power-producing inverters attached to the grid turn off in a short period of time. This prevents the DC-to-AC inverters from continuing to feed power into small sections of the grid known area to be unpowered, and they may also damage grid-tied equipment. The Rooftop PV system shall be equipped with islanding protection. In addition to disconnection from the grid (due to islanding protection) disconnection due to under and over voltage conditions shall also be provided.
- 2) A manual disconnect 4pole isolation switch beside automatic disconnection to grid would have to be provided at utility end to isolate the grid connection by the utility personnel to carry out any maintenance. This switch shall be locked by the utility personnel.

REVERSE POWER FLOW PROTECTION

The contractor shall provide suitable Reverse Power Protection System for preventing the generated solar power from flowing to SEB/ DISCOM feeder /DG set, if required.

SAFETY MEASURES: The bidder shall take entire responsibility for electrical safety of the installation(s) including connectivity with the grid and follow all the safety rules & regulations applicable as per Electricity Act, 2003, MNRE and CEA guidelines.

DISPLAY BOARD: The bidder has to display a board at the project site mentioning the following:

Plant Name, Capacity, Location, Type of Renewable Energy plant (Like solar, wind etc.), Date of commissioning, Firm Name etc.

20. Water Supply Arrangement for cleaning of SPV Modules:

The Contractor shall provide a complete, permanent, and fully functional water supply arrangement for effective cleaning of SPV modules. Railway shall provide the raw water

supply facility up to the nearest available point, from where the Contractor shall take over and arrange all remaining components of the system. The Contractor shall install a dedicated water distribution network across the array yard, consisting of permanent water pipelines of minimum 1.25 inch (32 mm) diameter, along with high-pressure water-spraying nozzles mounted on the top of each solar panel or panel row to ensure uniform and efficient cleaning. A minimum 1000-litre overhead water storage tank shall be supplied and installed by the Contractor at an appropriate height to maintain adequate gravity head; if the existing structure is unsuitable, an independent MS support structure shall be provided.

The Contractor shall also supply, install, test, and commission adequate capacity single or multiple Centrifugal submersible/Monoblock/Booster pump to meet requirements as per site condition, including its feeder line, control wiring, and necessary protection devices, to ensure optimum pressure at the nozzles for thorough automatic cleaning of the SPV Modules. All required accessories—including pipes, fittings, valves, joints, clamps, supports, sprinkler nozzles, and other hardware essential for a durable and efficient cleaning system—shall be included in the Contractor's scope. The complete installation shall ensure reliable water delivery, easy maintenance, and trouble-free operation throughout the life of the plant.

21. Arrangement of Ladder

- 1) Ladder arrangement for approach to the roof with minimum weight bearing capacity of 500Kg should be installed as per site, if no approach to roof is available at any site.
- 2) The Ladder should be made of MS angle/MS flat and MS rod (2 inch) for holding the ladder. The ladder should have steps size of 75 cm x 25 cm with spacing of 20 cm between each steps.

22. Approval of System Design

- 1) The concept plan/design of each sub-system shall be submitted for approval. The wiring diagram and operation and maintenance information details shall be given.
- 2) Quality Assurance Plan should include design control, process control, quality control, testing of sub-system, integration and bill of material intended to be used.

- 23. INSPECTION OF MATERIAL** All the material, required for this work shall be subject to inspection to ensure that the work is done in accordance with specifications, drawing and is of the best quality suitable for the purpose.

UTES inspection of all Solar PV Modules/Panels and PCU/Solar Inverter is required in this tender. The RITES inspection fee as charged shall be borne by contractor.

The contractor shall ensure quality of material during the work also. All the other material/accessories required for solar plant work shall be inspected by Senior Divisional Electrical Engineer (General), West Central Railway, Bhopal or his authorized representative.

24. INSTALLATION & COMMISSIONING:

The installation shall be done by the supplier/manufacturer who is responsible for system performance, direction of installation and structural stability. The supplier shall conduct a detailed site assessment. The PV installer

shall obtain data specific to the site, rather than relying on general data. While making foundation design, due consideration shall be given to weight of the module assembly, maximum wind speed at the site, etc.

25. METERING AND GRID CONNECTIVITY

An energy meter shall be installed in between the solar grid inverter and the building distribution board to measure gross solar energy. The bidirectional (Import KWh and export KWh) meter shall be installed in conjunction with the existing service connection meter. The successful tenderer shall be responsible for maintaining liaison with State Electricity Board authorities for implementation of net metering for this work. Registration with SEB/ DISCOM is also in the scope of this work. All the related charges shall be borne by the contractor.

26 SYSTEM ACCEPTANCE TESTING:

- 1) By consignee against the test certificate/reports as per relevant standards mentioned in MNRE specification from NABL/IEC accredited testing laboratories or MNRE approved test centers being submitted by the firm for both Solar module and BOS items/components.
- 2) If the results of the testing indicates that the system meets all the requirements set and is capable of generating electrical energy for 5 continuous hours using such instruments and meters as have been installed for such purposes, then the such tests and injection of Power at Delivery Point will be done in consultation with the Railway Representative.
- 3) The date of successful completion of the project including supply, erection, testing, obtaining necessary statutory clearances such as EIG approval etc., if required, Grid Synchronization, Commissioning of the complete project including all solar plants, and handing over to Railways shall be taken as the date of acceptance. The warranty/free maintenance period shall commence from this date.

27 DOCUMENTATION:

The supplier shall provide easy-to-use illustrated installation and operation manual in

English for easy installation and trouble-free usage.

The supplier shall supply the following documentation –

- (a) System description with working principles
- (b) System single line diagram
- (c) Solar PV array layout
- (d) Routing diagram of cables and wires
- (e) Data sheets & user manuals of the solar PV panels and the solar grid inverter
- (f) A system operation and regular maintenance manual, trouble-shooting, emergency shutdown procedure, etc.
- (g) Name, address, mobile number and e-mail address of the Service Centre to be contacted in case of failure or complaint
- (h) Warranty cards

28 APPLICABLE STANDARDS:

Normally latest version of the standards shall be referred to.

IS:12834:1989 (reaffirmed 2000)	Solar Photovoltaic Energy Systems Terminology
IEC 61215/ IS 14286	Design Qualification and Type Approval for Crystalline Silicon Terrestrial Photovoltaic (PV) Modules
IEC 61701	Salt Mist Corrosion Testing of Photovoltaic (PV) Modules
IEC 61853- Part 1/ IS 16170: Part 1	Photovoltaic (PV) module performance testing and energy rating -: Irradiance and temperature performance measurements, and power rating
IEC 62716	Photovoltaic (PV) Modules - Ammonia (NH ₃) Corrosion Testing (As per the site condition like dairies, toilets)
IEC 61723 Ed1.0	Safety Guidelines for grid connected photovoltaic systems mounted on the buildings
IEC: 61730 Pt 1 & 2	Photovoltaic (PV) module safety qualification -Part 1: Requirements for construction Part 2: Requirements for testing
IEC 62109-1, IEC 62109-2	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements, and Safety of power converters for use in photovoltaic power systems Part 2: Particular requirements for inverters. Safety compliance (Protection degree IP 65 for outdoor mounting, IP 54 for indoor mounting)
IEC/IS 61683 (as applicable)	Photovoltaic Systems - Power conditioners: Procedure for Measuring Efficiency (10% , 25%, 50%, 75% & 90-100% Loading Conditions)
IEC 62116/ UL 1741/ IEEE 1547 (as applicable)	Utility-interconnected Photovoltaic Inverters - Test Procedure of Islanding Prevention Measures
IEC 60255-27	Measuring relays and protection equipment - Part 27: Product safety requirements
IEC 60068-2 / IEC 62093 (as applicable)	Environmental Testing of PV System - Power Conditioners and Inverters -
IS/IEC 60947 (Part 1, 2 & 3), EN 50521	General safety requirements for connectors, switches, circuit breakers (AC/DC): (a) Low-voltage Switchgear and Control-gear, Part 1: General rules b) Low-Voltage Switchgear and Control-gear, Part 2: Circuit Breakers Low-voltage switchgear and Control-gear, Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units d) EN 50521: Connectors for photovoltaic systems - Safety requirements and tests
IEC 60269-6	Low-voltage fuses - Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems
BFC 17-102:2011	Lightening Protection Standard
IEC 60364-5-53/ IS 15086-5 (SPD)	Electrical installations of buildings - Part 5-53: Selection and erection of electrical equipment - Isolation, switching and control

IEC 60364-7-712 (2002)	Electrical Installations of Buildings Part 7: requirements for special installations or locations Section 712: Photovoltaic power supply systems.
IEC 61643-11:2011	Low-voltage surge protective devices - Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test methods
IEC 60227/IS 694, IEC 60502/IS	General test and Measuring method for PVC (Polyvinyl chloride) insulated cables (for working voltages up to and including 1100 V, and UV resistant for outdoor installation)
BS EN 50618	Electric cables for photovoltaic systems (BT(DE/NOT)258), mainly for DC Cables
IEC 62561 Series (Chemical earthing) (as applicable)	IEC 62561-1 Lightning protection system components (LPSC) Part 1: Requirements For connection components IEC 62561-2 Lightning protection system components (LPSC) - Part 2: Requirements for conductors and earth electrodes IEC 62561-7 Lightning protection system components (LPSC) - Part 7: Requirements for earthing enhancing compounds
IS 3043 : 1987	Code of Practice for Earthing
IEC 60529	Junction boxes and solar panel terminal boxes shall be of the thermo-plastic type with IP 65 protection for outdoor use, and IP 54 protection for indoor use
IS 16444 or as specified by the SEB/DISCOMs	A.C. Static direct connected watt-hour Smart Meter Class 1 and 2-Specification (with Import & Export/Net energy measurements)
IS 2062 / IS 4759	Material for the structure mounting
IEC 62446 (2009)	Grid connected photovoltaic systems- Minimum requirements for system documentation, commissioning tests and inspection

29. CERTIFICATIONS

PV Module shall comply with BIS compulsory registration scheme and certificate shall furnish to buyer / consignee on demand	Yes
BIS CRS certificate for PV module	As per IS:14286 (for Poly crystalline silicon PV modules)
BIS CRS number must declare	Yes
Availability of type test reports wind load withstand test for mounting structure including calculation sheet from central govt. Lab/ NABL. ILAC accredited lab to prove conformity of specification and agreed to furnish test report and certificates.	Yes
Availability of type test reports for PCUs/ Inverters, PV module to prove the conformity of the specification	From NABL/IEC accredited testing labs or MNRE approved labs
Agreed to furnish all the test report and certification to buyer/ consignee on demand.	Yes

30 **GUARANTEE / WARRANTY -**

1	Minimum Performance guarantee for maintaining of peak	>/=90% at the end of 10 years and >/= 80% at the end of 25 yrs.
2	OEM's Warrantee for PV modules from the date of supply	>/= 25 years replacement warrantee or as per latest railway Board / MNRE guidelines. OEM Warranty Certificate directly to the Railways from OEM to be submitted with supply of material.
3	OEM's Warrantee for inverters from the date of supply	>/= 10 years. OEM Warranty Certificate directly to the Railways from OEM to be submitted with supply of material.
4	Warranty period after successful commissioning of complete Solar Generating system.	Five years from the date of handing over of the installation, after successful commissioning of complete Solar Generating plants. Warrantee shall cover repairs, replacements, comprehensive maintenance as per prescribed OEM Schedule inclusive of all spares, materials and labour cost.
5	The warrantee card/certificate to be supplied with the	Warrantee card shall contain the details of the system and information about the system and conditions of warrantee
6	IOT SIM data validity	Five years data validity for individual inverter (PCU).
7	Refund of Bid Security Deposit	Bid Security Deposit shall be refunded after completion of Five years warranty period. If any penalties levied during the maintenance period same will be deducted from the Bid Security Deposit

30.1 **Maintenance Period**

- 1) After the equipments, system/sub-systems have been installed and commissioned, the contractor shall be responsible for proper maintenance & supervision, free of cost, of the equipments, system/sub-systems till a period of **five years** from the date of commissioning as per final completion report issued by Engineer. In the free maintenance period, contractor will provide all the spares required for such maintenance free of cost. This free maintenance period will include: -
 - i) Maintenance and upkeep of all equipments,
 - ii) Attention and restoration of breakdown **within 48 hours** of intimation.
 - iii) Periodical preventive maintenance,
 - iv) Repair/replacement of defective parts,
 - v) Operating the existing system satisfactorily.
- 2) For this purpose, contractor shall prepare a maintenance plan and make available the services of maintenance Engineer / Staff who will maintain and supervise the system.
- 3) During this free maintenance period, if any deficiency/fault is noticed in the functioning as a result of any defect in design or manufacture, the same will be rectified by the contractor at his own cost. During such rectification if any faulty equipment/modules/cards/system/subsystem/part either in hardware or in software or any other form, need replacement or repair, they shall be provided by the contractor free of cost from the set of equipment or modules that the contractor should bring to the site of installation in addition to all the materials to be supplied against this contract.
- 4) The replacement of the defective component at the cost of Contractor shall be made with

similar and/or equivalent make. The replaced component shall not, in any situation, reduce the performance of the plant.

30.2 Preventive maintenance

Cleaning & Maintenance of SPV Modules:

- 1) Solar PV modules should be cleaned **Monthly**.
- 2) Cleaning of solar PV modules should be done early in the morning or in late evening to avoid the damage of glass in the long run and to prevent electric shocks.
- 3) Use of cleaning agent: A mild, non-abrasive, non-caustic detergent with deionized water may be used. Abrasive cleaners or de-greasers should not be used. Acid or alkali detergent must not be used.
- 4) Removing stubborn marks: To remove stubborn dirt such as birds dropping, dead insects, tar etc., use a soft sponge, micro-fiber cloth or non-abrasive brush. Rinse the module immediately with plenty of water.
- 5) Temperature of water used for cleaning should be same as ambient temperature at the time of cleaning. Cleaning should be carried out when the modules are cool to avoid thermal shock which can potentially cause cracks on the modules.
- 6) Regular visual check of modules should be done during cleaning. As the solar panels are under warranty covering defects arising due to manufacturing or poor workmanship, then if during the term of contract solar panels are found to be having manufacturing defects the same shall be replaced by contractor from the manufacturer.
- 7) Quarterly inspection of modules should be done for discoloration.
- 8) Junction boxes of panels should be checked for terminal loosening/arcing etc. quarterly.
- 9) Output voltage of all PV modules connected with each inverter must be checked once in a Quarter to detect failure of PV modules.
- 10) Cutting of Grass, bushes, shrubs surrounding the SPV module area shall be done by brush cutter or manually. Brush cutter and fuel for the same will be borne by Contractor.
- 11) In case of VIP visit, the contractor has to run a special drive well in advance to make the area more presentable.
- 12) Fasteners should be checked for tightness once in each quarter.
- 13) Any other activity as per OEM recommendation/ Engineer In charge Instructions.

30.3 Inverter intenance:

- 1) Dust blowing and vacuum cleaning in inverters from outside during non-generation hours to remove dust and particles as per instructions of In-charge.
- 2) Cleaning of all fans and filters once a year to ensure smooth flow of air into the inverter.
- 3) Temperature checks of connections on DC side & AC side and control switches has to be done Quarterly during peak hours, any abnormality or temperature beyond permissible limit has to be attended immediately and rectify the cause.
- 4) Visual Inspection of every inverter has to be carried out, to observe the contacts and other components, appearance and cleanliness of the cabinet, ventilation system & insulated surfaces.
- 5) Temperature of each inverter has to noted (Quarterly) during peak generation from display over Inverter and proper maintenance of exhaust needs to be carried to maintain temperature within permissible limits.
- 6) All other maintenance instructions as per OEM recommendation.
- 7) Any other activity as per Engineer In-charge Instructions.

30.4 Cables and Connection Boxes: Monthly

- 1) Check the connections for corrosion and tightness.
- 2) Check the connection box to make sure that the wires are tight, and the water seals are

not damaged.

- 3) There should be no vermin inside the box.
- 4) Check the cable-insulating sheath for cracks, breaks or burns. If the insulation is damaged, replace the wire.
- 5) Make sure that the wire is clamped properly and that it should not rub against any sharp edges or corners.
- 6) If some wire/cable needs to be changed, make sure it is of proper rating and type.

30.5 Earthing & Safety Equipment:

- 1) Measuring the earth resistance value of each pit and maintaining it to the desired level.
- 2) Examining all safety devices and output of solar panels.

30.6 Breakdown Maintenance:

- 1) The firm has to attend to the unscheduled service calls as and when required for locating the faults and rectify the same.
- 2) In case of any break down or any abnormal functioning of the equipment, the same has to be brought to the notice of the Engineer-in Charge immediately and necessary remedial measures would be taken immediately as required / advised.

30.7. Provision of water sprinkling facility for cleaning of solar panels at various locations:

Automatic Solar Panel Cleaning System – Technical Specification

The Contractor shall supply, install, test, and commission an Automatic Solar Panel Cleaning System (SPCS) with water-sprinkling facility, as described below:

System Description & Functional Requirements

The SPCS shall be capable of automatic and manual cleaning of solar panels/modules to remove dust, dirt, pollen, bird droppings, and other deposits that reduce insolation. Cleaning cycles shall be programmable by the user (daily/weekly/seasonal) via an MCU-based controller. The system shall also allow on-demand manual activation. The system shall operate on 230 V, single-phase AC supply, drawing power from local supply or dedicated control power.

Major Components & Materials

<u>Sr No</u>	<u>Component</u>	<u>Specification / Requirement</u>
i	Pump	Centrifugal submersible/Monoblock/Booster pump of adequate capacity: flow rate 4–8 m ³ /hr, head 15–25 m (or as required by roof height & piping layout). Pump casing & impeller should be of stainless steel (SS 304) or heavy-duty engineered polymer resistant to corrosion.
ii	Water supply & filtration	Inlet water filter (mesh or cartridge) to remove sand/silt; filtration to prevent nozzle clogging.
iii	Sprinkler nozzles	Specially designed spray nozzles with full 180° spray projection, fine droplet spray, uniform water distribution, wide coverage to minimize number of nozzles, with UV-resistant polymer or stainless steel body. Nozzles to produce gentle rain-like spray to avoid mechanical stress on modules.

iv	Piping and fittings	UV-resistant PVC / HDPE / CPVC / UPVC pipes and weatherproof fittings, with appropriate diameters to maintain pressure and flow. All piping shall be suitably insulated/exposed to prevent degradation under sun exposure.
v	Support brackets & clamps	Galvanized steel or marine-grade aluminum brackets and clips, hot-dip galvanized or powder-coated for corrosion resistance, designed to fit common module frame profiles.
vi	Control Unit / Timer & Controller	MCU-based programmable controller with digital clock and memory to store multiple cleaning schedules, with fail-safe dry-run protection, water-level sensor (if retention tank used), and manual override.
vii	Electrical Protection	Over-current protection (MCB), leakage protection (ELCB/RCCB), wiring in hms pvc conduits, earth grounding as per electrical standards.
viii	Indicators & Interface	Status indicators (LED/LCD) for power ON, pump ON, fault (dry-run / water-low), manual/auto mode, next cleaning schedule; user-friendly interface with push-button or touchscreen if feasible.
ix	Enclosure & Protection	Control unit to be housed in IP65-rated weatherproof enclosure (for outdoor Mounting), all wiring sealed and protected from UV, dust, water, rodents/insects.

Performance & Technical Parameters

Cleaning coverage: Each sprinkler nozzle should cover approx. 2.5 to 4.0 m² of module area (depending on roof layout and orientation), ensuring full array coverage with minimal nozzles.

Water usage efficiency: Water flow and spray angle shall be optimized to avoid excessive water usage while ensuring effective cleaning; supplier to provide calculations for expected water consumption per cleaning cycle (m³/cycle and liters per module).

Spray pressure: At nozzle outlet — minimum 1.5 bar (when pump and piping layout permit), to ensure even distribution and reach.

Pump runtime / duty cycle: Pump should be rated for intermittent duty, with built-in dry-run cut-off and overheating protection; initial design to consider ~5–10 minutes per cleaning cycle per 100 KWp array, but configurable.

Water quality: The design should allow use of treated / filtered water to avoid mineral deposition on glass surface. If using harvested rainwater / borewell water, filters or softeners are recommended depending on water hardness.

Durability & Maintenance: Components exposed to environment must resist UV, corrosion, temperature cycles, and be designed for **≥ 10 years service life** with minimal periodic maintenance (filter cleaning, nozzle check).

Controls & Automation Features

The controller shall allow **programmable cleaning schedules** (e.g., once daily at predetermined time, or weekly, or based on dust season).

Provision for **manual override** to trigger cleaning outside the schedule.

Safety interlocks: Dry-run protection (auto shutoff if water supply fails), water-level sensing if retention tank used, leak detection if feasible.

Indicator/Alarm: For pump fault, water deficiency, system fault — with visual/audible alert.

Optional Remote Monitoring/Integration: Where feasible, provision to integrate the cleaning system's status with the overall plant monitoring system (could be via basic relay / digital input to central SCADA / RMS).

Scope of Work & Deliverables

Supply of all components (pump, nozzles, piping, control unit, filters, brackets, accessories)

Civil/structural works (if any) for pump base, water tank / retention tank, inlet water connection, drainage / runoff for cleaning water

Electrical wiring, control panel, connectors, earthing as per local electrical norms

Testing and commissioning, including demonstration run, leak checks, spray coverage test, pump dry-run test, water consumption record

Operation & Maintenance (O&M) manual including cleaning schedule settings, maintenance intervals, spare parts list

Warranty: Minimum **5 years** on mechanical and electrical components of the cleaning system (pump, controller, nozzles); workmanship warranty for installation

General Conditions & Compliance

The system design shall ensure **no damage to solar modules**, module glass, frame or electrical connections during cleaning; spray pressure and water flow must be gentle yet effective.

Water drainage after cleaning shall be managed to avoid water pooling on roof or structural load issues; suitable drain outlets must be provided.

If modules are installed on sloped roofs or at height, access for maintenance (filter cleaning, pump checks) must be safe and convenient.

All works shall conform to prevailing standards and good engineering practice regarding water installation, electrical safety, structural load, waterproofing, and environment protection.

31 Penalty

1. **Breakdown Penalty** at the rate of Rs.500/- per calendar day per location will be levied if attention and restoration of breakdown is not done within 48 hours of intimation. The penalty will be deducted from the bid security deposit which will be released after completion of maintenance period.
2. **Preventive maintenance penalty-**
 - A) **Monthly** - Rs.500/- per calendar month per location for non-attending the monthly maintenance
 - B) **Quarterly**- Rs.500/- per quarter per location for non-attending the quarterly maintenance

SPECIAL CONDITIONS OF CONTRACT (SCC)

(Electrical GeneralDepartment)

1.0 General

- 1.1 The contract shall be governed by Indian Railway's standard general conditions of contract (GCC) April 2022 (with latest amendment if any) and special condition of contract (SCC) given below. The following special conditions shall supplement and be read in conjunction together with above General Conditions of Contract (GCC) (with latest amendment if any), General/technical specification, schedule of quantities, explanatory notes, drawings and any other document forming part of this tender.
- 1.2 Work under this contract shall be executed as given in this tender document and as required at site whether specifically shown or not. The Contractor shall carry out and complete the work under this contract in every respect in conformity with the contract documents, as per directions of and to the satisfaction of the Purchasers' Representative.

2.0 Interpretation

In all matters of clarifications, dispute of interpretation, the decision of the engineer in-charge of the work, shall be final and binding.

3.0 Scope of Work

- 3.1 The scope shall include as specified in the Schedule of Rates and Quantities, explanatory notes, technical specifications and other documents of the tender.
Scope of work under this contract shall include provisions as specified in schedule of work, specification as per in GCC, SCC and other documents comprising of tender document but not restricted to.
- 3.2 Tenderer shall go through the specifications, related standards, requirement schedule and other contract conditions and shall include all the provision whether specified clearly or not for successful testing and commissioning. All such provisions are deemed as included unless pointed out while quoting of the offer.
- 3.3 The contractor shall include the supply of entire materials in accordance with specification and the whole of the work necessary for the complete installation as set down in this specification and with the accompanying schedules and drawings. Materials and components not specifically stated in the specifications and/or bill of materials or noted on the drawings (or anywhere in the tender document) but which are necessary for satisfactory installation /commissioning and operation of the system shall be deemed to have been included in the scope of work.

4.0 Intent of Specifications

- 4.1 Technical specifications forming a part of this contract are intended to cover work referred herein enclosed. It is not the intent to specify completely herein all aspects of design, constructional features of equipment and details of the work to be carried out, but nevertheless the intent of the specification is to ensure that the equipment and work shall conform in all respects to the relevant Bureau of Indian Standard Specifications, Codes of Practice, Indian Electricity Act, Indian Electricity Rules and other Statutory Regulations as may be applicable and to high standards of engineering, design and workmanship. The equipment and work shall perform in continuous operation in a manner acceptable to the Purchaser's Representative who will interpret the meaning of the specifications and drawings and shall have the right to reject or accept any equipment or work, which in their assessment is not complete to meet the requirements of this specification and/or applicable Codes and Standards. Any item specially mentioned or not in the scope of work, but required to complete the work shall be deemed to be in the scope as per approved design, drawing & specification.
- 4.2 The work shall conform to all provisions of the relevant Government Legislation, Regulations and Bye- laws of the Central/Local Authorities and of any State Electricity Boards/Companies to whose system the installation is Page 29 of 49 proposed to be connected. The Contractor shall arrange to give all necessary notices required under the said Acts, Regulations and/or Bye- laws.
- 4.3 The contractor shall examine the installations' specifications, drawings & schedule of quantities for feasibility & safety and may suggest or ask for change required if any to provide satisfactory & safe services of the equipment designated for the station but the decision of the engineer in-charge of the work shall be final and binding.

5.0 Specifications and Schedules

- 5.1 The Technical specifications and schedule of quantities & rates shall be considered as part of this contract and any work or materials shown in schedule and not called for in the specifications or vice versa, shall be executed as if specifically called for in both. The drawings if any are for the guidance of the contractor. Exact locations, distances and levels will be governed by the site conditions.
- 5.2 The quantities indicated in Schedule are approximate. The successful tenderer will place the order for materials only after carrying out survey jointly with railways as per site requirement.
- 5.3 Special conditions of contract (SCC) shall be read in conjunction with the general conditions of the contract, technical specifications, schedule of quantities, drawings and any other document forming part of this tender/contract. For any discrepancy between the general conditions and special conditions, provisions of special conditions shall prevail. For any discrepancy between technical specifications and schedule of quantities, the provisions of schedule of quantities shall prevail. The decision of the Engineer in-charge of the work shall be final and binding in the regard.
- 5.4 Wherever it is mentioned in the specifications that the Contractor shall perform certain work or provide certain facilities, it is understood that the Contractor shall do so at his own cost.

Contractor shall get the arranged material inspected/tested as required before use and shall not move/ dispose off the material so arranged without the written permission of authorized representative of Purchaser.

6.0 Site Working Conditions

- 6.1 Tenderers, if they so desire, can, before submitting the tender, inspect the site of the work after obtaining prior approval from Purchasers' Representative in order to familiarize themselves of the conditions of work prevailing at site as also quantum of statutory levies (taxes, duties etc.) applicable. No extra claim on account of lack of such knowledge shall be entertained after award of contract.

All equipments and works covered under this contract shall be capable of operating continuously at optimum efficiency and deliver rated output under extreme conditions prevailing at site throughout the year.

- 6.2 Contractor shall make all arrangements of power distribution and lighting etc at site as required for night working if any.

6.3 Work Under Power Block

Where the work is required to be carried out in Power Block, it shall be arranged & permit to work shall be issued by the Rly. to contractors' representative.

The contractor or his authorized supervisor/ representative shall, before commencement of work, arrange all man and material at site well in advance. Power block shall be arranged for works requiring power blocks according to traffic conditions, however purchaser shall take no responsibility for non-availability of power block or day/ night working and safety to be observed at site and contractor shall keep the purchaser indemnified/ insured against the same. The Contractor is required to flexibly plan activity and mobilize staff so as to complete the planned activity during available power/traffic block. It may be noted that contractor is liable for penalty on overshooting of such power/traffic block affecting train punctuality or any inconvenience to Railways as deemed fit in the opinion of the engineer and may be recovered from dues payable to the contractor.

7.0 Materials and Equipment

- 7.1 Procurement of Material - All materials and equipment shall be new and of the approved make and design, and as per schedule of quantities and specifications of scope of work.
- 7.2 Approved Make - The Contractor shall arrange to provide all equipment/ accessories as required for the work as per the approved list of the makes as specified in the specifications, unless the change is approved by the Engineer, in case of non-availability or better substitute in writing. Where the list of approved is not available, the makes of items shall be approved by the engineer.
- 7.3 Mobilization of material & resources The contractor is required to mobilize all the material, resources and manpower as per the completion period and the agreed schedule with the engineer.
- 7.4 Account of released material: - All released materials/ unused materials should be handed over to the engineer's representative at the nominated depot/ place as directed by the engineer.

8.0 Co-ordination of work at site

The Contractor shall work in co-ordination and co- operation with other agencies at site and shall arrange to execute work as per site conditions. Any hold up shall be the responsibility of the Contractor and shall make him liable for damages as may be considered and levied by the Engineer.

9.0 Workmanship & Quality of work

- 9.1 The contractor is responsible for execution of contract as a whole in accordance with conditions of contract.
- 9.2 Good workmanship is an essential prerequisite to be complied for this work. Skilled workers under competent supervision shall carry out entire work in the most workmanlike manner by skilled workers under competent supervision.
- 9.3 In the event the Engineer or his representative finding the work being carried out in a defective or in an inefficient manner or at a slow rate, the decision of which shall be in the sole discretion of the Purchaser, he may give 7 days written notice, calling upon the Contractor to remove the defects. If the contractor fails to complete with such directions, the contract shall be terminated followed by 48 hours notice, a final termination notice will be issued and the security deposit will be forfeited in whole as liquidated damages.

10.0 Method of Measurement

- 10.1 The progressive work shall be certified progressively for supply installation, testing commissioning for each unit of work as specified in schedule of work to release payment as per payment conditions.
- 10.2 On completion and verification of each stage work as per agreed schedule of payment invoicing, the contractor shall offer for measurement with required details, internal check / quality assurance, abstract sheet and contractor shall produce claim for on account/running payment for verified quantities only.
- 10.3 All the payment claims submitted by the contractor shall be accompanied by the following documents:
 - i. Supplier's challan / manufacturer's challan for major items.
 - ii. Certificate of receipt of materials in good condition at Purchaser's depot/s duly accepted by the Purchaser's Engineer/representative.
 - iii. Test Reports
 - iv. Material Inspection Certificate granted by the Purchaser
 - v. Indemnity Bond in the standard proforma

11.0 Completion of Work

- 11.1 The contractor shall complete the whole of the work in all respect on or before the date fixed in the contract or any authorized extension thereof. The Railway Administration is entitled to recover penalty as stipulated in the General Conditions of contract if the contractor is in default.
- 11.2 Final Acceptance On successful completion of the work and/or completion of guarantee period as the case may be, the Final acceptance certificate shall be issued. The final acceptance of the entire equipment installed on the group shall take effect from the date of expiry of the period of guarantee.

11.3 Refund of security deposit

- 11.3.1 Security deposit shall be returned to the contractor after successful completion of guarantee period as certified by the competent authority. The competent authority shall normally be the authority, who is competent to sign the contract. If the competent authority is of the rank lower than JA grade, then a JA grade officer (concerned with the work) should issue the certificate. Security Deposit shall be refunded to the Contractor on production and surrender of the related receipt granted by the Purchaser, and on production of the "No Claim Certificate" given by the Contractor duly counter – signed by

the Purchaser's Engineer.

- 11.3.2 The Security Deposit shall, however, be liable to be forfeited in case of any breach by the Contractor of any of the conditions of the contract or for non completion of the full contract without prejudice to other rights and remedies of the purchaser whether specifically provided for herein or other wise.

11.4 Settlement:

On final acceptance and successful completion of guarantee period as the case may be, the performance bank guarantee shall be released. The necessary recovery/penalties if any due from the contractor shall be adjusted from payment due or through encashment of Security deposit/Performance bank guarantee.

12.0 Supply of Materials, Tools, Plants and Equipments by the Purchaser.

The Purchaser shall supply no material, tools, plant and equipment. The Contractor has to arrange all tools, plant and equipment as well as materials required for the work.

13.0 Security of men, material & work

The contractor will be responsible for any damage/theft for part of the work completed till entire works be taken over by the Railway.

14.0 Drafting of vehicles

The vehicles and equipment of the contractor can be drafted by Railway administration in case of Accidents/Natural calamities involving human lives.

15.0 Indemnity

The contractor shall furnish the prescribed indemnity bond as per General Condition of Contract, for all Railway material issued to him for execution of work.

16.0 Guarantee/ Defect Liability: Refer Specification & scope of work.

17.0 Tools and Spare Parts

All tools, tackle and M&P required for erection and assembly of the equipments and installation covered by the contract shall be arranged by the contractor himself including consumable material required for successful commissioning.

18.0 Safety Measures

- 18.1 The contractor shall take all precautionary measures and conform to IE rules & regulations of "occupational safety and health hazards" and that of Railway's safety in force for the time being in order to ensure the protection of his own and Railway personnel moving about or working on the Railway premises.
- 18.2 The Purchaser shall remain indemnified by the contractor in the event of any accident occurring in the normal course of work arising out of the failure of Contractor or his men to exercise reasonable precaution at all places of work whether or not, the purchaser decides to safety measures at any particular site of work.
- 18.3 The contractor shall remain fully responsible for ensuring safety and in case of any accident, shall bear cost of all damages to this equipment and men and also damages to Railway and its passengers. Engineer in- charge may impose any other condition necessary for a particular work on site.

TERMS AND CONDITIONS:

Successful contractor should have experience in carrying out such jobs.

- i) The tenderer shall inspect the sites/ locations/stations under proposal and satisfy themselves before quoting. No request for modification or change of equipment will be entertained after issue of letter of acceptance.
- ii) The rates quoted by Contractor / Tenderer and accepted by Railway Administration shall be firm and hold good till the completion of the work and shall not subject to variation. No claims what so ever on this account shall be entertained at any stage. The prices shall be firm & net inclusive of all taxes, duties, freights & other incidental charges.
- iii) Contractor should ensure that the rates quoted by them should comply with the extant provision of Minimum wages act 1948.
- iv) The contractor should submit his address and the telephone numbers of his Registered Office, Service Centre, where complaints shall be communicated.
- v) may
at any

The staff employed by the contractor for performing the duties or any other purpose related with the contractual activities shall be employees of the contractor only and they may in no way whatsoever claim to be employees of the Railways. If Railway is liable to pay claim to the labour on any ground, the contractor will indemnify the Railway Administration for the same. The contractor shall be fully responsible for conduct of the staff deputed by him.

- vi) The successful tenderer must appoint requisite trained staff. They should have proper knowledge of the work being done, as well as knowledge to keep the equipment properly intact and well adjusted. The equipment shall remain efficient, reliable and in safe operation running condition.
- vii) The contractors shall have all facilities, instruments / equipment, tools & plants, staff, technicians, Supervisors, Engineers etc. for the execution of the proposed work, so as to keep minimum down time of the equipment if any. All the materials required for execution of the work including supply of items like brush, broom, cotton duster etc. required for cleaning purpose should be arranged by the contractor.
- viii) The contractors shall issue identity cards at their own cost to the staff for their entry in Railway premises, IDs countersigned by Railway's authorized representative.
- ix) Staff employed should be medically fit and should be in the position of taking instant decision to avoid any eventuality.
- x) The contractor shall provide one mobile phone to their staff, registered on the name of company/ contractors' staff, on which the Railway's representative time, phones shall be maintained in good working condition for smooth & easy communication. Phone Bills shall be paid by the contractor.
- xi) The transportation charges shall be borne by the contractor. The Contractor and his service personnel should make their own arrangement for travel on Indian Railway, Railway will not provide free any traveling facility for them.
- xii) The contractor shall maintain the detailed information of assets handed over to him and same will be verified at the time of taking over from the in - charge.
- xiii) All safety measures shall be taken by contractor's staff to prevent accident while executing the work. No compensation towards any accident will be paid by Railway.
- xiv) The Engineer / Staff nominated by the contractor for the work at any location shall observe all Safety and Security Rules prevailing at the place of work.
- xv) Any damage to Railway equipment/structure, if takes place due to the negligence & carelessness of contractor's staff, the cost of repair of installation/assets will be borne by the contractor.
- xvi) If any accident takes place due to work done / working by contractor or his staff, the liability arising out of this will be of the contractor.
- xvii) The contractor or his staff shall not remove any item / equipment or any part or component of it without prior approval / knowledge of the nominated Railway representative/ Railway Authority.

- xviii) ERROR-OMISSION AND DISCREPANCIES: The tenderers shall not take advantages of any error due to typing or otherwise. If there is any doubt, that shall be brought to the notice of the Sr. Divisional Electrical Engineer (General) Bhopal without delay. In case of any contradiction, only the printed rules and books shall be followed and no claim for the misinterpretation shall be entertained.
- xix) Subletting of contract: The contractor shall not assign sublet the contract in the interest therein or the part thereof to any other party or partner(s) without the consent of the Railway.
- xx) The successful tenderer shall carry out the work to the entire satisfaction of the Railway.
- xxi) Railway reserves all rights to terminate the contract before/after the expiry of the contract period without assigning any reasons with a notice of 15 days. This will normally be as a result unsatisfactory performance of the contract.
- xxii) Disputes, doubts etc: In case if any discrepancies, disputes, doubts arise during the tenure of this contract, such things shall be mutually discussed with Sr.DEE(G)BPL & the decision conveyed by him shall be final binding with both the Railways and the Contractor.