PACKAGE- 4C

ENGAGING DESIGN, PROCUREMENT, INSTALLATION, COMMISSIONING & TESTING CONTRACTOR FOR SETTING UP 5 MW AC CAPACITY GRID CONNECTED GROUND MOUNTED SOLAR PV SYSTEM AT PERMANENT CAMPUS OF NALANDA UNIVERSITY, RAJGIR, BIHAR.

AT

NALANDA UNIVERSITY, AT RAJGIR, BIHAR.

DESIGN, PROCUREMENT, INSTALLATION & COMMISSIONING & TESTING TENDER DOCUENT

Technical Part

(5 MW AC CAPACITY SOLAR FARM)

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This ON-GRID PV Power Project is recognised and registered under CPSU (Tranche-II) Phase-II Scheme being run by the **"Solar Energy Corporation of India Limited under Ministry of New and Renewable Energy, Govt of India",** and hence the bidder has to mandatorily comply the technical requirement published under the CPCU scheme. In addition, to the mandate of the CPCU scheme and SECI requirement, the published technical specification herewith by the university shall be followed as per the design confirmation after issuance of the contract award. The successful bidder will be bound to support the stage confirmations, information required to the SECI in future (if any) related to the project with any delay.

Content

1. Introduction and Background

Nalanda University is an Educational Campus proposed at Rajgir, BIHAR, The site is located along the Patna - Rajgir Highway and is well connected with the city of Rajgir, Bihar. Total area of the site is approximately 455 acres ("Site").

The proposed campus of Nalanda University is planned to be developed on a mostly flat terrain in the foot hill of Nalanda Hills. The site is located in Gangatic plains area of Southern Bihar.

Entire campus is planned to be constructed in two phases. The first phase will be of approximately 140,200 Smt. of built up area.

This tender is for setting up of Solar farm of 5 MW Capacity under including all related works in Civil, Electrical and plumbing work and power evacuation as per the campus requirement.

2. Scope of Work and Technical Specifications

2.1 Scope of Work

2.1.1 The scope of work shall include overall design, engineering, approval from client & NISE team, quality surveillance, testing, technical & documentation for liaising, packing, supply, erection, & testing and commissioning and performance testing of grid interactive solar photovoltaic system of 5000 KW to be installed at PERMENANT CAMPUS OF NALANDA UNIVERSITY - RAJGIR, BIHAR. It shall be responsibility of the Bidder to ensure that all the works as per scope of the specification are completed in totality for safe and efficient working of the system.

Formula for performance testing is given in this document as annexure – P for perusal.

2.1.2 These systems shall be complete with PV modules, inverter, metering, junction boxes, AC, DC distribution boards and cables, communication interface, and any other equipment necessary for safe and efficient operation of the grid connected Ground Mounted Solar PV systems.

2.1.3 The scope of supply shall also include comprehensive insurance, storage and transportation, necessary fabrication works for installation of complete system etc. No civil construction work including foundation, roads & paved streets will be provided by client, everything shall be under scope of solar vendor as per requirement & approved design. This includes all other civil activity like cleaning & surface of ground, required trench / pipe network laying, related excavation backfilling, etc shall be part of this scope of work & solar vendor has to do the same as per standard practise & requirement of site in-charge.

2.1.4 The proposal submitted by the bidder should be inclusive of O&M charges for 5 (five) years from the date of successful commissioning of grid connected Ground Mounted solar PV project.

2.1.5 The contractor should maintain all necessary spares for breakdown to maintain zero breakdown time.

2.1.6 The equipment offered shall conform in all respects to high standards of engineering, design and workmanship and be capable of performing in commercial operation up to Bidder's guarantee in a manner acceptable to the purchaser, who will interpret the meaning of drawings, specification and

shall have the power to reject any work or materials, which is his judgment are not in full accordance therewith.

2.1.7 It shall be responsibility of the Bidder to obtain all necessary statutory & other clearances in well advance from the competent authorities.

2.1.8 All the necessary co-ordination with regard to Sub-Contracted items shall be carried out by the Bidder. The purchaser/Engineer will communicate only with the Bidder for all matter pertaining to this contract.

2.1.9 The total price for this contract shall be on lump sum all-inclusive Basis and shall cover all items and service necessary for successful completion of the contract. Even if all components of a system included in this specification are not explicitly identified and /or listed herein, these shall be supplied under this contract to ensure completion of the system and facilitate proper operation and easy maintenance of plant.

2.1.10 Considering the reliability of the grid, no electrical storage batteries shall be required as excess electricity generated by the solar panels which are not required by the equipment/ devices in the building premises shall be exported to grid.

2.1.11 All the fittings and accessories that might not have been mentioned specifically in the Specification but are necessary for the plant, shall be deemed to be included in the specification and shall be supplied and furnished by the Contractor without any extra charge.

2.1.12 This scope also includes to design, supply, installation, testing, commissioning, operating & maintaining a complete day night CCTV Surveillance system for the solar farm covering all key areas from surveillance point of view. The system shall include high quality day/night vision outdoor rated IP base cameras with required mounting arrangement, IP rated termination boxes, cables, hoods, etc along with a centralised DVR system which shall be capable to have last 180 days 24X7 Data Storage of CCTV footage in it. Remote base operation facility shall be provided for the system. All the components of the system shall be in line with latest IEC codes & relevant standards.

2.1.13 This scope also includes to design, supply, installation, testing, commissioning, operating & maintaining LED based area lighting for the solar farm covering all key areas for O&M purpose. Fixture shall be minimum IP 66 rated along with minimum IP 65 rated control gear, luminance efficacy of the fixture shall be more than 70%, colour temperature shall be 3000~4000 K to match the peripheral area lighting of the campus. GI / PU Painted poles as per IS guideline, shall be used made of B class pipes with preferable integral junction box & sufficient protection per pole. This shall includes all necessary electrical cabling, earthing Timer based control panel etc as required to complete the system. Average 30 Lux to be maintained through the solar farm when all the lights are on.

2.1.14 Client will provide Power, Water Supply & One Internet Connection at one predefined point to the solar farm, from that point onwards, everything shall be in the scope of Solar Contractor. Power will be measured through a sub meter which shall be arranged by the contractor as per given specification in this

document. Charges for the power & internet to be reimbursed to the main campus organisation, while provision for water meter to be kept in the system at present for water part of this.

2.1.15 Any kind of coordination, liaison, authority supervision / approval etc & preparation of related documents etc shall be in the scope of solar contractor. All kind of required approvals shall be taken by the contractor on behalf of client. No extra charges to be paid to contractor for these.

2.1.16 This scope shall include design, approval, supply, installation, testing & commissioning of Complete SCADA System as per requirement provided in this document & as required for such setup.

2.1.17 This scope shall also include providing competent manpower for dealing with SLDC requirements to generate & provide adequate data to State Load Dispatch Centre on behalf of client as per requirement.

2.1.18 All Electrical High Side Equipments starting from Bus-duct, Transformer of 415 V to 11 KV, its related earthing, UPS for 11 KV System, Safety Equipments for 11 S/S, 11 KV Panels etc will be provided by client at desired location.

2.1.19 All Indoor electrification for client provided constructed areas like 11 KV Sub-station Panel Rooms, Utility Room, Supervision Rooms etc will be provided by client as per requirement. All other construction for LT panel rooms, O&M staff, UPS & Battery rooms, Local Scada Centre, external lighting within solar farms & near vicinity to solar farms to be designed & provided by solar vendor.

2.1.20 The contractor has to ensure cleaning/washing as per the approved schedule. The contractor will submit the cleaning schedule on a monthly basis in advance, and a monthly certification shall be submitted for the compliance of the approved program. CCTV,Pump & pipes, manual & robotics cleaning shall be within the schedule of O&M requirements. The minimum 3 Nos skilled manpower requirement at the site to be deployed by the contractor. Minimum once in 15 Days cleaning shall be performed by the contractor.

2.1.21 The Contractor has to design, supply, installation & testing of required complete Plumbing system for cleaning of solar modules etc as may be required.

2.1.22 The Contractor has to design & provide all the safety measures related systems & equipments including & not limited to Fire Detection System / Fire Fighting System etc as per standards requirements.

2.1.23 The contractor has to arrange complete visit & give a call for Pre Dispatch Inspection in prior (at least 15 days). All related cost for PDI to be bared by the contractor

2.1.24 The contractor has to submit all final data & as built drawings & details in 5 sets of hard copy including soft copy in pdf & AutoCAD at the time of completion.

2.1.25 All necessary support as on required shall be extended by the contractor for subsidy to the client for the project.

2.1.26 A licensed PV System Software shall be provided by the contractor for plant analysis and its performances verifications.

2.1.27 The scope of design supply & installation of all metal structure shall be in the scope of contractor. The design requirement for bearing capacity against the wind speed/load impact / forces need to be indicated in DPR. The maximum wind speed experienced during the last 50 years date to be consider. It shall

be designed for minimum wind speed of 150KM/hrs. in general, but this must be in consultation through a structural specialist by the vendor.

2.1.28 The contractor shall submit the detail design and dimension & other requirements of the structure in advance (at least 3 months) for foundation development by the University.

2.2 Codes and Standards

The PV modules used in the grid connected solar power projects must qualify to the latest edition of Mono / Poly Crystalline Silicon Solar Cell Modules as per IEC 61215 or equivalent BIS standards. In addition, PV modules must qualify to IEC 61730 for safety qualification testing at 4100 V DC or higher. the modules must conform to IEC 61730 Part-1 - requirements for construction & Part 2 – requirements for testing, for safety qualification or equivalent IS.

2.2.1 For the PV modules to be used in a highly corrosive atmosphere throughout their lifetime, they must qualify to IEC 61701. The bidder needs to provide relevant certifications for the same.

2.2.2 The PV modules must be tested and approved by one of the IEC authorized test centres. In addition a PV module qualification test certificate as per IEC standard, issued by ETDC, Bangalore or Solar Energy Centre MNRE, New Delhi will also be valid. The bidder needs to provide relevant certifications for the same.

Other subsystem / components used in SPV power plant (Cables, Connectors, Junction Boxes, Surge Protection Devices, etc.) must also confirm to the relevant international / national Standards for Electrical Safety besides that for Quality required for ensuring Expected Service Life and Weather Resistance.

2.3 Warranty

2.3.1 The mechanical structures, electrical works and overall workmanship of the grid solar power plants must be warranted for a minimum of 15 years. PV modules used in grid connected solar power plants must be warranted for output wattage, which should not be less than 90% at the end of 10 years and 80% at the end of 25 years. Contractor shall install the performance evaluation system, and the contractor or the contractor through manufacturer will submit the performance certificate on a yearly basis. The suggestions and remedial for better performances shall be submitted by the contractor and/Or manufacturer. A Back to back tripartite agreement to be signed between the client, contractor, and Manufacturer.

2.4 Identification and Traceability

Each PV module used in any solar power project must use a RF identification tag. The following information must be mentioned in the RFID used on each module (This can be inside or outside the laminate but must be able to withstand harsh environmental conditions.)

a. Name of the manufacturer of PV Module
b. Name of the Manufacturer of Solar cells
c. Month and year of the manufacture (separately for solar cells and module)
d. Country of origin (separately for solar cells and module)
e. I-V curve for the module
f. Wattage, Im, Vm and FF for the module

g. Unique Serial No and Model No of the module
h. Date and year of obtaining IEC PV module qualification certificate
i. Name of the test lab issuing IEC certificate
j. Other relevant information on traceability of solar cells and module as per ISO 9000/9001 and ISO 14001

2.5 General Requirements

Design, Equipments & System shall be as per the SBPDCL/BERC guidelines for

ON-GRID Connection Solar PV system.

2.5.1 Solar PV system shall consist of following equipment:

i) Solar PV modules consisting of required number of PV cells.

ii) Power Conditioning Units/ Inverters with SCADA

iii) Mounting structures (metal part & construction part) including grouting by contractor.

iv) Cables and hardware including but not limited to required size & strength of Nut Bolts. (A detail fabrication drawing to be provided by the contractor for approval showing all the fabrication arrangements for approval)

v) Junction box and distribution boxes

vi) Earthing system

vii) Lighting arrestors

viii) PVC pipes and accessories

ix) Tool Kit

x) 2.1 m meter high Chain-link fencing with minimum 6.5 m wide gate, and a Watchman cabin, around the Solar Power Plant.

xi) Minimum 4.0 m. wide internal road with Cement Concrete surface and min. 1.5 m wide Footpaths/pathways from Gate to all the parts of Solar PV Farm required for Smooth operation and Maintenance of the entire Solar PV Farm.

xii) The Bidder will have to Prepare the master plan for the Entire Solar PV farm including Location of Solar PV Panels, Control rooms, Transformer Yard, Location of Grid Connection, Internal Roads & Pathways, gates etc. along with their Bid.

xiii) A complete SCADA setup shall be made available which shall connect all the modules via optimizers, all the PCU / inverters, Power Panel Switchgear & Meters & all other misc components like UPS etc & a final gateway to be provided to communicate & handover control (when & if required) to the master SCADA of the campus. All required hardware, software setups & license, training etc shall be included in this scope.

2.5.2 Installation shall be done by the licensed engineer who has adequate experience with installation of the PV system. The installer must verify that the system has been installed according

to the manufacturer's procedures. A checkout procedure should be developed to ensure an efficient and complete installation.

2.5.3 Modules with output of 300 Wp or above shall be used. Photo / electrical conversion efficiency of SPV module shall be greater than 15%. (mono/multi crystalline)

2.5.4 All grid solar PV power plants must install necessary equipment to continuously measure solar radiation, ambient temperature, wind speed and other weather parameters and simultaneously measure the generation of DC power as well as AC power generated from the plant. They will be required to submit this data to the Ministry on line and/ or through a report on regular basis for the entire duration of Agreement if required.

2.6 PV Arrays

a) Supplier shall follow the latest engineering practice to ensure long-term compatibility requirement and continuity of equipment supply and the safety of the operating staff.

b) The PV project developers are required to optimize generation of electricity in term of kWh generated per kWp of PV capacity installed vis-à-vis available solar radiation at the site (may be obtained through use of efficient electronics, lower cable losses, maximization of power transfer form PV modules to electronics and the grid, maximization of power generation by enhancing incident radiation by optional methods like seasonally changing tilt angles (but not the trackers) etc.)

c) The PV system shall support remote monitoring of important parameters. The system shall be designed such that personal without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personal shall be able to operate the system easily after having received some basic training.

d) The manufacturer shall arrange certification on qualification of PV modules.

e) Stabilized net output of the Solar PV Array for the Solar System should not be less than the Normal design level for the system under Standard Test Condition

f) Fill factor of the module shall not be less than 0.70.

g) The bidder shall provide the sample solar PV module electrical characteristics including current-voltage (I-V) performance curves and temperature coefficients of power, voltage and current. However, the tabulated document with all the relevant data like voltage, current, power output for all the modules also to be provided.

h) The PV modules shall be suitable for continues outdoor use.

i) The PV modules shall be made of high quality laminated in ultra violet stabilized polymer material such as Ethyl Vinyl Accelerate (EVA). High transmission glass is on the top and Tedlar sheet at bottom side of the module should be provided. The size of single crystalline silicon PV cells shall be so chosen so as to maximize energy density and align with economics of scale. The Cells are

encapsulated under vacuum to make the PV module weather proof. The electrical output connections are taken through a weather proof (IP65 rated) junction box.

j) PV module shall be provided with frame of anodized channel for size and simplicity in installation offered as a single module or series parallel combination of modules. The PV module shall be provided with screen- less frame with Solar cable and connector.

a. Cells are encapsulated under high-transmission toughened glass.

b. Laminate edges are sealed by sealant.

c. Framed using weather resistant RTV silicon sealant.

k) The PV module shall be equipped with bypass diode to minimize power drop caused by shade. It should have waterproof terminal box with provision for mounting bypass diodes.

l) The PV modules shall be made of light weight cells, resistant to abrasion, hail impact, rain water and environmental pollution. The PV modules shall be provided with antireflection coating and back surface field (BSF) structure to increase conversion efficiency.

m) The PV modules shall use lead wire weatherproof connector for output terminal.

n) All materials used shall have a proven history of reliable and stable operation in external applications. Whole system shall perform satisfactorily in relative humidity up to 85% with temperatures between -10ºC to +85ºC and withstand gust up to 150 km/h on the surface of panel

2.6.1 The SPV Module must be provided with acceptable Test & Certified documents. The PV shall provide a copy of the type test certificate(s)/ reports(s) with the bid and routine type reports before the dispatch of the equipment.

2.7 Power Conditioner Unit

For Power Conditioners/Inverters[1] following certificates shall be submitted by the bidder

- Efficiency Measurements- IEC 61683
- Environmental Testing- IEC 60068-2 (6,21,27,30,75,78)
- Electromagnetic Compatibility (EMC) IEC 61000 series – relevant parts
- Electrical Safety IEC 62109-1&2
- Protection against islanding of Grid IEEE 1547/UL 1741 / equivalent
- Other sub-system components BIS standards

The DC power produced is fed to inverter for conversion into AC. In a grid interactive system AC power shall be fed to the grid at three phase 11 KV AC bus. Power generated from the solar system during the daytime is utilized fully by powering the loads and feeding excess power to the grid as long as grid is available. In cases, where solar power is not sufficient due to more demand or cloud cover etc. the building loads shall be served by drawing required energy from the grid. The inverter should always give preference to the Solar Power and will use Grid power only when the Solar Power is insufficient to meet the load requirement. Each PCU should be rated minimum 50 KW.

[1] Must additionally conform to the relevant national/international Electrical Safety Standards.

a) The inverter shall be a true sine way inverter for a grid interactive PV system. The output of the inverter must synchronize automatically its AC output to the exact AC voltage and frequency of the grid.

b) Inverter shall continuously monitor the condition of the grid and in the event of grid failure; the inverter automatically switches to off-grid supply within 20-50 milliseconds. The solar system is resynchronized with two minutes after the restoration of grid.

c) Grid voltage shall be continuously monitored and in the event of voltage going below a preset value and above a preset value, the solar system shall be disconnected from the grid within the set time. Both over voltage and under voltage relays shall have adjustment voltage (50% to 130%) and time settings (0 to 5 Seconds).

d) Metal Oxide Varistors (MOVs) shall be provided on DC and AC side of the inverter.

e) The inverter control unit shall be so designed so as to operate the PV system near its maximum Power Point (MPP), the operating point where the combined values of the current and voltage of the solar modules result in a maximum power output.

f) The degree of protection of the outdoor inverter panel shall be at least IP- 55.

g) Typical technical features of the inverter shall be as follows:

Purpose	The power conditioner unit shall convert DC produced by SPV array and adjust the voltage & frequency levels to suit the Grid.
Grid supervision	All three phases shall be supervised with respect to rise / fall in programmable threshold values of frequency & the power section of the plant. The plant shall get disconnected / connected from the grid in case of a grid fault / after normal grid conditions have resumed.
Type & technology	IGBT based and should utilize a circuit topology and components suitable for meeting the specifications.
Output voltage on AC side	415 +10%, - 15% V AC at 50 Hz A dedicated isolation transformer housed in the PCU enclosure shall be supplied to match the PCU output voltage to the utility grid voltage. If necessary, PCU/ Solar Inverter voltage range should be reconfigured as per site requirements.
DC system voltage	The electrical safety of the array installation is of the utmost importance. Array electrical configuration shall be in such a way that, the MPPT shall operate with maximum efficiency, between the low and high temperature of the site.
Maximal Current ripple	5%
Power Factor	0.95 inductive to 0.95 capacitive
No load losses	< 1% of rated power

Ambient room temperature	5 to 55 ºC
Housing Cabinet	a) PCU is housed in suitable switch cabinet, with min IP 21 degree of Ingress Protection. b) Weatherproof, rodents & insect proof c) Components and circuit boards mounted inside the enclosures clearly identified with appropriate permanent designations, which shall also serve to identify the items on the supplied drawings. d) All doors, covers, panels and cable exists shall be gasketed or otherwise designed to limit the entry of dust and moisture. All doors shall be equipped with locks. All openings shall be provided with grills or screens with openings no larger than 0.95 cm (about 3x8 inch).
Display	Liquid crystal display shall at least be provided on the inverters front panel or on Separate data logging/display device to display following • DC Input Voltage • DC Input current • AC Power output(kW) • Current time and date • Time active • Time disabled • Time Idle • Temperatures (c) • Converter status

h) Other important features

Electrical safety Protections a)General	i) The PCU shall include appropriate self-protective and self-diagnostic feature to protect itself and the PV array from damage in the event of PCU component failure or from parameters beyond the PCU's safe operating range due to internal or external causes. The self-protective features shall not allow signals from the PCU front panel to cause the PCU to be operated in a manner which may be unsafe or damaging. Faults due to malfunctioning within the PCU, including commutation failure, shall be cleared by the PCU protective devices and not by the existing site utility grid service circuit
b) Over/under voltage	• Mains (Grid) over-under voltage and frequency protection. • Over voltage protection against atmospheric lightning. • Protection against voltage fluctuations in the grid itself and internal faults in the power conditioner, operational errors and switching transients.

c) Islanding	• Protection against islanding
d) Accidental open circuit	Full protection against accidental open circuit and reverse polarity at the input.
e) Internal Faults	Inbuilt protection for internal faults including excess temperature, commutation failure, overload and cooling fan failure is obligatory
f) Galvanic Isolation	Galvanic isolation is provided to avoid any DC component being injected into the grid and the potential for AC components appearing at the array. - Galvanic isolation shall be provided between the inverter/ PCU and grid to avoid any DC component being injected into the grid and the potential for AC components appearing at the array. - The specification of the isolation transformer shall be as follows: • Capacity: 125% of capacity of the PV modules (i.e., a 12.5 kVA transformer shall be used for a 10 kW PV system, and so on) • System: 3-phase, 4-wire • Input voltage range: 320-480 V AC • Output voltage range: 380-435 V AC • Output voltage for single phase: 220-240 V AC • Tap change: Manual, V+/-20%, V+/-10%, V+/-0% • Operating frequency: 48-52 Hz • Efficiency:>98.5% • Impedance: 4-10% • Output waveform: Zero distortion • Insulation class: Class F • Leakage current: <20 mA • Cooling: AN • Enclosure: IP 21 (if indoors) • IP 54 (if outdoors) • Normal Operating Temperature: 0-60°C • Cable entry: Separate input/ output enclosed cable entry • Standard: IS 2026 - Further, it is also observed at various locations throughout the distribution grid that the grid voltage would consistently be greater or less than the acceptable voltage window of many inverters and PCUs. Moreover, this variation may be only for particular days of a week, seasonal, or for a limited time.

	- In such a case, the Contractor shall study/ measure the point of interconnection of the PV system consistently for at least one week to identify the voltage range experienced at the interconnection point of the distribution grid. Consequently, the Contractor shall adjust the input/ output of the isolation transformer to appropriate tap settings so that the voltage on the inverter side of the transformer is always within the acceptable voltage window of the inverter. The appropriate tap setting shall be conveyed to NALANDA UNIVERISTY by the contractor.
g) Earth Fault Supervision	An integrated earth fault detection device is provided to detect eventual earth fault on DC side and shall send message to the supervisory system
h) Disconnection & Islanding	a) Disconnection of the PV generator in the event of loss of the main grid supply is achieved by in built protection within the power conditioner. This may be achieved through rate of change of current, phase angle, unbalanced voltages, or reactive load variants. b) Operation outside the limits of power quality as described in technical data sheet shall cause the power conditioner to disconnect the grid. Additional parameters requiring automatic disconnection are: • Neutral voltage displacement • Over current • Earth fault & • Reverse power In each of the above cases, tripping time shall be less than 0.5 seconds. Response time in case of grid failure due to switch off or failure based shutdown should be well within 60 seconds.
i) Automatic reconnection after the Grid restoration	PCU has facility to reconnect the Inverter automatically to the grid following restoration of grid, subsequent to grid failure condition.
Array Ground fault	Provided
Operator interface	LCD and keypad operator interface, Menu driven.
Fault conditions	Automatic fault conditions reset for all parameters like voltage, frequency and /or black out.

Control Logic Failure detection	Using watch dog timers.
Parameter access	All parameters accessible through an industry standard communication link.
DC-AC conversion efficiency	• 93% for output ranging from 20% to full load • Idling current at no load shall not exceed 2% of the full load current.
DC isolation	Provided at the output by means of a suitable isolating transformer
Parallel operation with Grid	Provided & capable of interrupting line-to-line fault currents and line to ground fault currents.
Unbalanced output load	PCU is able to withstand an unbalanced output load to the extent of 30%.
PCU generated harmonics	Shall not exceed a total harmonic current distortion of 5%, a single frequency current distortion of 3%, and single frequency current distortion of 1%, when the first through the fiftieth integer harmonics of 50Hz are considered.
Circuit separation	High voltage & power circuits separated from low voltage & control circuits.
Internal wiring	Standard Cu wiring, with flame resistant insulation.
Cabling practice	a) Cables :PVC Cu cables as per relevant international Standards) b) Cable connections : suitable terminations c) PVC channel with covers to house the cables.
High voltage test	PCU with stand high voltage test of 2000 Vrms between either the input or the output terminals and the cabinet (chassis).
EMI (Electromagnetic interface)	PCU shall not produce EMI which cause malfunctioning of electronic & electrical instruments including communication equipments which are located within the facility in which the PCU is housed.
Display on front panel & indicators	a) instantaneous PCU ac power output and the DC voltage current and power input b) Accuracy of display : 3% of full scale factor or better c) Display visible from outside the PCU enclosure. d) Operational status of the PCU, alarms, trouble indicators and AC and DC disconnect switch positions shall also be communicated by appropriate messages or indicator lights on

	the front cover of the PCU enclosure.
Emergency OFF	Emergency OFF button is located at an appropriate position on the unit
Grounding	PCU includes ground lugs for equipment and PV array groundings. The DC circuit ground is a solid single point ground connection.
Exposed surfaces	Exposed surfaces of ferrous parts are thoroughly cleaned, primed, and painted and suitably protected to survive a nominal 30 years design life of the unit.
Factory Testing	• Tested to demonstrate operation of its control system and the ability to be automatically synchronized and connected in parallel with a utility service, prior to its shipment. • Operation of all controls, protective and instrumentation circuits demonstrated by direct test if feasible or by simulation operation conditions for all parameters that cannot be directly tested. • Demonstration of utility service interface protection circuits and functions, including calibration and functional trip tests of faults and isolation protection equipment. • Operation of startup, disconnect and shutdown controls also to be tested and demonstrated, stable operation of the PCU and response to control signals shall also be tested and demonstrated. • Factory testing include measurement of phase currents, efficiencies, harmonic content and power factor. All tests shall be performed 25, 50, 75 and 100% of the rated nominal power. • Factory test report (FTR): Should be supplied with the unit after all tests. The FTR shall include. • Detailed description of all parameters tested qualified and warranted.
MPPT	Maximum power point tracker is integrated in the power conditioner unit to maximize energy drawn from the array. The MPPT shall be microprocessor based to minimize power losses. The MPPT shall have provision (manual setting) for constant voltage operation. The MPPT unit shall confirm to IEC 62093 for design qualification.
Operating Modes	a) Night or sleep mode : where the Inverter is almost completely turned off, with just the timer and control system still in operation, losses < 2 W per 5 kW b) Standby mode: where the control system continuously monitors the output of the solar generator until pre-set value is

	exceeded (typically 10 W). Operational of MPP tracking mode: the control system continuously adjust the voltage of the generator to optimize the power available. The power conditioner shall automatically re-enter standby mode input power reduces below the standby mode threshold. Front panel display providing the status of the PCU, including AC power output & DC current voltage and power input, and unit fault indication. Shut down / standby mode with its contact open under the following conditions before attempting an automatic restart after an appropriate time delay; in sufficient solar power output. ***a) Insufficient solar power input :*** When the power available from the PV array is insufficient to supply the losses of the PCU, the PCU shall go to a standby/ shutdown mode. The PCU control shall prevent excessive cycling during rightly shut down or extended periods of insufficient solar radiation. ***b) Utility -Grid over or under voltage :*** The PCU shall restart after an over or under voltage shutdown when the utility grid voltage has returned to within limits for a minimum of two minutes. ***c) Utility-Grid over or under frequency*** *:* The PCU shall restart after an over or under frequency shutdown when the utility grid voltage has returned to the within limits for minimum of two minutes.
Inverter / Array Size Ratio	The ratio of the Inverter continuous power rating and the array peak power rating shall be between 80 to 90%. This is because better overall annual yield can be obtained by allowing the Inverter to operate for longer periods closer to optimal efficiency.
Data Logging System	All major parameters available on the digital bus and logging facility for energy auditing through the internal microprocessor and can be read on the digital front panel at any time the current values, previous values for up to a month and the average values. The following parameters shall be accessible via the operating interface display : • AC voltage • AC output current • Output power

	• DC input voltage • DC input current • Time active • Time disabled • Time Idle • temperatures (C) • Converter status Protective function limits viz., AC over voltage, AC under voltage, Over frequency, under frequency, ground fault, PV starting voltage, PV stopping voltage, over voltage delay, under voltage delay over frequency, ground fault delay, PV starting delay, PV stopping delay.
Remote Monitoring System	• A remote monitoring system shall be included with each photovoltaic system. • Usually such monitoring systems are connected and synchronized with the inverters. • Such monitoring services are provided by many leading inverter manufacturers and also third party service providers. • The monitoring system should transmit the following data in real-time to a central server and store it: ✓ DC currents, voltages and power. ✓ AC currents, voltages and power. ✓ Irradiation, ambient temperature, module temperature and wind speed. ✓ Error logs. • This data may be transmitted either using the available LAN or GSM/ GPRS, or any other mode of connectivity available at the site. SIM card for the same to be provided by Vendor. • The contractor shall be responsible for data connectivity for monitoring up to the warranty/ O&M period of the PV system, after which, the Contractor shall transfer all ownership rights, account information, instructions, etc. to NALANDA UNIVERISTY. • The stored data should be represented through hourly, daily, monthly, etc. graphs and easily downloadable in .csv or .xls format.

2.8 Protections and Control

2.8.1 PV system software and control system shall be equipped with islanding protection as descried above. In addition to disconnection from the grid (islanding protection i.e. on no supply), under and over voltage conditions, PV systems shall be provided with adequate rating fuses, fuses on inverter input side (DC) as well as output side (AC) side for overload and short circuit protection and

disconnecting switches to isolate the DC and AC system for maintenances are needed. Fuses of adequate rating shall also be provided in each solar array module to protect them against short circuit.

2.8.2 A manual disconnect switch beside automatic disconnection to grid would have to be provided at utility end to isolate the grid connection by the utility personal to carry out any maintenance. This switch shall be locked by the utility personal.

2.8.3 In case grid failure resulting into islanding operation appropriate provisions should be made to utilize the available solar power to continuously supply the connected load.

2.9 Integration of PV Power With Grid

2.9.1 Solar PV systems shall be provided with synchronizing at PCU level having two input for comparison i.e. grid supply vs. solar output, so as to connect the SPV systems in synchronism with grid.

2.9.2 The output power from SPV would be fed to the inverter which converts DC produced by SPV array to AC and feeds it into the main electricity grid after synchronization. In case of grid failure, or low or high voltage, solar PV system shall be out of synchronization and shall be disconnected from the grid.

2.9.3 The solar power would be used for local consumption. The excess power from inverter would be fed at the panel of NALANDA UNIVERISTY.

2.10 Metering Scheme

i) Metering is required to measure the Solar Gross Generation on continuous basis and register cumulative energy based on 15 minute interval basis, daily, monthly and yearly energy generation.

ii) The average voltage and power factor based on 15 minute interval must also be recorded.

iii) Meter must also display on demand, instantaneous, AC system voltages and currents, frequency, reactive power with sign, Total harmonics current and voltage distortion etc.

iv) Meter shall comply with the requirements of CEA “Installation and Operation of meters” Regulations 2006 as amended from time to time. The Meter shall be provided as per the requirement of Local Power Supply Company (Local Grid) & has to be inspected & sealed mutually with the local supply company as per their guidelines.

v) All the required liaising work shall be included in the contractor’s scope weather it is for local power supply company correspondence & or approval or for electrical inspector visit & approval etc.

vi) An integrating pyranometer (class II or better) to be provided, with the sensor mounted in the plane of the array. Readout shall be integrated with data logging.

vii) Meter data and reports should be available online with login and password facility.

viii) In addition to above, a separate LT Multi Function KWH sub meter is also required to measure the auxiliary supply made available to the Solar Farm from the main campus. This shall be class 0.5 &

of suitable capacity, & shall provided with suitable IP rated lockable meter box. Single point 3 Phase / 1 Phase supply (as per requirement provided) will be made available to the solar farm implementer.

2.11 Power Quality Requirements

i) DC Injection into the grid:

The injection of DC power into the grid shall be avoided by using an isolation transformer at the output of the inverter. It is proposed to limit DC injection within 1% of the rated current of the inverter as per IEC 61727.

ii) Harmonics on AC side

Harmonic distortion is caused principally by non-linear load such as rectifiers and arc furnaces and can affect the operation of a supply system and can cause overloading of equipments such as capacitors, or even resonance with the system leading to overstressing (excessive voltage & current). Other effects are interference with telephone circuits and broadcasting, metering errors, overheating of rotating machines due to increased iron losses (eddy current effects), overheating of delta connected winding of transformer due to excessive third harmonics or excessive exciting current.

The limits for harmonics shall be as stipulated in the CEA Regulations on grid connectivity which are as follows:

- Total Voltage harmonic Distortion = 5%
- Individual Voltage harmonics Distortion = 5%
- Total Current harmonic Distortion = 8%

iii) **Voltage Unbalance** – The Voltage Unbalance in the grid shall not exceed 3.0%.

iv) Voltage Fluctuations

- The permissible limit of voltage fluctuation for step changes which may occur repetitively is 1.5%
- For occasional fluctuations other than step changes the maximum permissible limits is 3%
- The limits prescribed in (i) and (ii) above shall come into force not later than five years from the date of publication of these regulations in the Official Gazette.

2.12 Communication Interface

i) The project envisages a communication interface which shall be able to support.

- Real time data logging
- Event logging
- Operational modes
- Set point editing

ii) The following parameters shall also be measured and displayed continuously.

- Solar system temperature
- Ambient temperature
- Solar irradiation / isolation DC current and Voltages
- DC injection into the grid (one time measurement at the time of installation)

- Efficiency of the inverter
- Solar system efficiency
- Display of I-V curve of the solar system
- Any other parameter considered necessary by supplier of the solar PV system bases on prudent practice.

iii) Data logger must record these parameters for study of effect of various environmental & grid parameters on energy generated by the solar system and various analysis would be required to be provided through bar charts, curves, tables, which shall be finalized during approval of drawings.

iv) The communication interface shall be an integral part of inverter and shall be suitable to be connected to SCADA system and also remotely via the Web using either a standard modem or a GSM / WIFI mode.

2.13 Mounting Structures:

Solar Photovoltaic Module is the key element in PV systems which converts the solar irradiation/energy in to DC electrical Power. SPV Module comprises of series combination of many crystalline silicon solar cells. Solar cells are stacked in between two layers of ethylene vinyl acetate (EVA); High transmission glass is on the top and Tedlar sheet at bottom side of the module. The Cells are encapsulated under vacuum to make the PV module weather proof. The electrical output connections are taken through a weather proof (IP65 rated) junction box. Each PV module junction box contains 3 nos. bypass diodes.

Salient features:

- Cells are encapsulated under high-transmission toughened glass.
- Laminate edges are sealed by sealant.
- Framed using weather resistant RTV silicon sealant.
- Employ anodized aluminum frame for resistance to shock and corrosion.
- Have waterproof terminal box with provision for mounting bypass diodes.

2.13.1 Technical Detail for the PV modules

The PV modules are to be mounted on the mounting structure for optimizing the energy generation. Typically, each structure is capable of supporting at least 10 Nos. of PV modules arranged in multiple rows and columns. As each series string is of 20 modules, two adjacent structures are connected in series to form a series string.

The structure shall support SPV modules at a given orientation at required inclination, absorb and transfer the mechanical loads to the ground properly. These structures will be with anti-corrosive surface protection. The frames and legs of structure assemblies shall be made of MS hot dip galvanization sections with minimum thickness of galvanization of 80 microns. PV module mounting rafters used shall be of Aluminum alloy and all the fasteners except foundation bolts shall be of stainless steel - SS304. The mounting structures shall be mounted on RCC pedestals through properly

grouted J bolts. The structure will be designed to withstand the maximum wind speed prevailing at the place and confirming to IS - 875.

i) Hot dip galvanized iron mounting structures may be used for mounting the modules / panels / arrays. These mounting structures must be suitable to mount the SPV modules / panels / arrays on the ground, on the ground or on the poles / masts.

ii) The frame structure should have provision to adjust its angle of inclination to the horizontal between 0 and 45 degrees, so that it can be installed at the specified tilt angle i.e. inclined at 25 degree to horizontal facing due south.

iii) All hardware, nuts, bolts should be cadmium passivated.

iv) The Mounting structure shall be so designed to withstand the speed for the wind zone of the location where a PV system is proposed to be installed. It may be ensured that the design has been certified by a recognized Lab / Institution in this regard.

v) The mounting structure steel shall be as per latest IS 2062: 1992 and galvanization of the mounting structure shall be in compliance of latest IS 4759. The bidder needs to provide relevant certifications for the same.

2.14 String Monitoring Box

Each PV string has to be equipped with a blocking diode which avoids the circulating currents to flow from the healthy strings to unhealthy strings. To place these string blocking diodes along with their heat sinks, Array Junction Boxes are being used, in which additionally protective fuses with fuse blown indicators, Surge Protective Devices (SPDs) are also provided. The earth cable from the SPD is connected to structure to ensure earthing. These AJBs are mounted on an ISMC channel bolted between two leg members of a structure. As these AJBs are rated with IP 65, these can sustain against harsh weather conditions and thus these are outdoor mounted.

Generally, all the positive outputs of series strings are taken into AJBs through 6 sq. mm cabling and MC4 quick connectors are used for connecting these 6 sq. mm cables with quick connectors of PV modules. Other end of the 6 sq. mm cables are properly lugged and also equipped with heat shrinkable sleeves to terminate into the terminal blocks of AJBs. The strings from AJB are taken to a String Monitoring Unit where each string current and voltage is monitored and logged.

As the name indicates, SMB monitors string currents and sends those data signals to SCADA connected to it.

2.15 Power Optimizers

A power optimizer shall be combination of both a string and micro inverter. This module-level power electronic (MLPE) device shall be used to increases the solar panel system's energy output by constantly measuring the maximum power point tracking (MPPT) of each individual solar string and adjusts DC characteristics to maximize

energy output. The panel optimizers relay performance characteristics via a monitoring system to facilitate operations and any necessary solar panel maintenance.

Built-in safety features like rapid-shutdown response etc shall be considered for this product. Efficiency shall not be less than 98%, standby voltage shall not go beyond 1.5 V for safety, optimizer shall be capable to Mitigates all types of module mismatch losses, from manufacturing tolerance to partial shading, provide module / string level monitoring, etc.

2.16 Lightning Arrestor

The Lightning Arrestor (LA) will be Early Streamer Emission (ESE) type. This lightning rod is made of stainless steel and epoxy resin. The specific function of this lightning rod is producing an upward stream of ionized particles pointed towards the clouds that will channel the electrical discharge produced at the time of lightning.

To properly ground the lightning surges, earthing is provided to each lightning arrestor by providing two earth pits which are connected to lightning arrestor with suitable Cu size cable/ Cu Strip.

The source of over voltage can be lightning or other atmospheric disturbances. Main aim of over voltage protection is to reduce the over voltage to a tolerable level before it reaches the PV or other sub-system components. The bidder needs to provide relevant certifications for the same.

Necessary concrete foundation for holding the lightning conductor in position to be made after giving due consideration to shadow on PV array, maximum wind speed and maintenance requirement at site in future.

The lightning conductor shall be earthed through flats and connected to the earth mats as per applicable Indian Standards with earth pits. Each lightning conductor shall be fitted with individual earth pit as per required Standards including accessories, and providing masonry enclosure with cast iron cover plate having locking arrangement, watering pipe using charcoal or coke and salt as required as per provisions of IS.

If necessary more numbers of lightning conductors may be provided.

The Successful bidder shall submit the drawings and detailed specifications of the PV array lightning protection equipment.

2.17 Remote Monitoring System

SCADA:

These systems should encompass the transfer of data between a SCADA central host computer and a number of Remote Terminal Units (RTUs) and/or Programmable Logic Controllers (PLCs), and the

central host and the operator terminals. A SCADA system gathers information (such as where a fault has occurred), transfers the information back to a central site, then alerts the home station that a fault has occurred, carrying out necessary analysis and control, such as determining if the fault is critical, and displaying the information in a logical and organized fashion.

SCADA systems should consist of:

• One or more field data interface devices, usually RTUs, or PLCs, which interface to

field sensing devices and local control switchboxes and valve actuators

• A communications system used to transfer data between field data interface devices and control units and the computers in the SCADA central host. Communication protocol between solar SCADA & central SCADA through interfacing equipment & comply to IEC-60870-104/ IEC-61850/ Modbus.

• A central host computer server or servers (sometimes called a SCADA Center, master station, or Master Terminal Unit (MTU)

• A collection of standard and/or custom software [sometimes called Human Machine Interface (HMI) software or Man Machine Interface (MMI) software] systems used to provide the SCADA central host and operator terminal application, support the

communications system, and monitor and control remotely located field data interface devices

RMS of PCU shall clearly depict the single line diagram of the plant on the monitor. Mimics shall be provided with radio buttons to show the following parameters:

- Solar radiation (W/m2)
- PV module back surface temp
- Ambient temp
- Inverter output power (3 phase)
- Line and phase currents
- Cumulative energy exported

RMS system shall perform following control operations:

- Mimic control through PC key board operation

RMS shall also conform to following features:

RMS system shall incorporate integrated system control and data acquisition facilities. The use of a local operator interface and latest technology features shall be incorporated to enable viewing of instantaneous parameter metering, changing of operator modes and review of system logged events. Further, with PC based latest software technology, solar plant shall be monitored remotely via satellite link. The major RMS features incorporated in to the control system are listed below.

Operator interface of latest technology: Instantaneous grid, array, inverter, AC, and metering of all parameters.

Integrated AC, DC data point logging: Instantaneous logging of all parameters. Including AC parameters, generator run hours and energy details.

Fault and system diagnostics with time stamped event logging.

Selectable event logging resolution for enhanced diagnostics.

Remote SCADA features with specific needs of station monitoring and remote communication are to be incorporated. Remote system access software, secured transmission of data and central PC facility provided.

RTU (REMOTE TERMINAL UNIT)

a. The RTU must be non-PLC based industrial grade and present an open, expandable and future-proof system, by taking into account latest standards, such as e.g. modular system concept, etc.
b. RTU should be having power supply and central processor. The central processor is responsible to communicate all IEDs / meters on RJ45/RS485 connectivity. The central processor should have the capability to integrate IEC 61850, IEC104 and Modbus RTU Master or Open Type as Pre approved. Central Processor will be connected to LAN Switch for communication with HMI. These are responsible for communication between the RTU with Central control centre. The protocol for two way communication between RTU & Central control centre should be IEC 104/IEC 61850 or Open Type as Pre approved.
c. The RTU shall have standardized, parameter-settable acquisition, processing and output functions of the process periphery signals, taking into account the methods and procedures according to IEC 60870-5-104 Open Type as Pre approved for:
    i. Single-Point Information
    ii. Double-Point Information
    iii. Integrated Totals via Count Pulses
    iv. Currents
    v. Pulse commands
    vi. Binary Information Output
    vii. Setpoint Values by means of Currents and Voltages
d. The RTU shall support IEC-103, IEC-104, MODBUS-RTU and many other IEC protocols for substation and tele control level communication.
e. Digital Inputs: All Inputs should be suitable for 48V or 220 VDC. They will be connected to potential free contact from field.
f. Digital Outputs: All Outputs should be suitable for 48V or 220 VDC. They will be connected to potential free contact in field. The control of ACBs shall be through DOs of the RTU.
g. Analog Inputs: Analog signals are to be configurable as 4-20mA as required.
h. Control Voltage: Voltage converter to be provided by bidder for converting control DC voltage to required DC in the RTU Panel in case the control voltage is different from station supply.
i. RTU will read all the signals coming from IEDs & MFMs as Soft signals on standard protocols.

j. Numerical relays in 33 kV and 11 kV HT Switchboard should be IEC 61850 compatible. The relays should have redundant communication port on Fibre Optic medium. All the hardware required to extend the relay signals to the RTU shall be supplied along with the switchboards. All hardware or protocol converters required for compatibility with SCADA shall be in bidder's scope.

k. Programming tool with IEC 61131-3 compliant programming environment for logic programming of functions. These functions shall be supported by offered RTU. All software and configuration tools required for configuration of RTU and Network should be included in scope of supply.

l. The RTU shall be suitable for operation in Substation or High Electromagnetic Interference environment.

m. Sizing & Scalability: The system shall be scalable and shall be able to add more bays in future.

n. Each RTU shall be provided with minimum one AI/ AO/ DI & DO cards. Al each RTU, minimum 30 % spare ports shall be considered for each type of card. Calculation shall be furnished during detailed engineering.

o. RTU shall have redundancy in power supply, communication and processor such that failure of any single component should not result in loss of communication.

P. REDUNDANT WORK STATION:

Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features.
The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

1. Storage of all analogue data (at 2 Minutes interval) and digital data including alarm, event and trend data for thirty (30) days.

2. Storage of all necessary software,

3. 100GB space for OWNER'S use.

Latest Windows OS with full license version shall be made available with adequate RAM & other hardware configurations. Supplier shall demonstrate that the capacity of hard disk & other items is sufficient to meet the above requirement otherwise he shall provide items which are to the satisfaction of client. For Workstation minimum 32" LED screens to be provided in full HD configurations.

2.18 Power and Control Cables:

i) Power Cables of adequate rating shall be required for interconnection of:

- Modules / panels within array
- Array & Charge Controller
- Charge Controller & Battery
- Charge controller & Loads including Inverter (if used) & between load & inverter.

ii) The cable shall be 1.1 KV grade, heavy duty, stranded copper conductor, XLPE insulated. An insulated, galvanized steel wire / strip armored, extruded PVC type ST-2 outer sheathed FRLS Type. The cables shall, in general conform to IS-7098-Part-I & other relevant standards. All cables laid up to load should be without any joint.

iii) The control cable shall be 1.1 KV grades, heavy duty, stranded copper conductor, PVC type. An insulated, galvanized steel wire / strip armoured, flame retardant (FR) extruded PVC type ST-1 outer sheathed. The cables shall, in general conform to IS-1554 P+1 & other relevant standards. Minimum 10% spare to be provided.

iv) The permissible voltage drop from the SPV Generator to the Charge controller shall not be more than 2% of peak power voltage of the SPV power source (generating system). In the light of this fact the cross-sectional area of the cable chosen is such that the voltage drop introduced by it shall be within 2% of the system voltage at peak power.

v) All connections should be properly terminated, soldered and / or sealed from outdoor and indoor elements. Relevant codes and operating manuals must be followed. Extensive wiring and terminations (connection points) for all PV components is needed along with electrical connection to lighting loads.

vi) For Cables & Accessories following certificates are mandatory: (Copy to be provided with tender.)

- General Test and Measuring Methods PVC/XLPE insulated: IEC 60189
- Cables for working Voltages up to and including 1100 : IS 694/ IS 1554
- UV resistant for outdoor installation: IS/IEC 69947

vii) All cables shall be new without any kind or visible damage. The manufacturers name, insulating material, conductor size and voltage class shall be marked on the surface of the cable at every 600 mm centers.

viii) The core insulation shall be with PVC compound applied over the conductor by extrusion and shall confirm to the requirement of IS-5831.

ix) Core identification shall be provided with prominent and indelible Arabic numerals on the outer surface of the insulation colour as under.

Single core	-	Red, Black, Yellow or blue.
Two core	-	Red and Black.
Three core	-	Red, Yellow, and blue.
Four core	-	Red, Yellow, Blue and Black.
3.5 core	-	Red, yellow, Blue and Black.
		(Reduced neutral)

Five core - Red, Yellow, Blue, Black and Light Grey.

x) In case of cables having more than 5 cores two adjacent (counting and directional) in each layer shall be coloured Blue and yellow respectively and the remaining cores shall be light grey.

xi) The inner sheath shall be applied over the laid up cores by extrusion and shall be of extruded XLPE compound.

xii) Armouring shall be applied over the inner sheath. Armour shall be of galvanized round steel wires up to the cable diameter of 13 mm and above 13 mm galvanized flat steel wires shall be provided. Requirement and methods of tests for armoured material and uniformity of galvanism shall be as per IS-3975 and IS -2633.

xiii) The outer sheath for the cables shall be applied by extrusion and shall be of PVC compound confirming to the requirement of compound of IS-5831 for protection of the cable against atmospheric effect. Pollution rodent and termite attack suitable chemical shall be added in PVC compound. Colour shall be black.

xiv) All the cables shall be tested and examined at the manufacturer work. All the materials employed in the manufacturing of cable shall be subject to examination and testing after manufacture of cable.

xv) All routine and acceptance tests in accordance with the relevant standard shall be conducted on each size of cables and shall be submitted to client at the time of hand over.

xvi) Cables shall be dispatched in wooden drums of suitable barrel diameter, securely battened with the take off end fully protected against mechanical damage. The wood used for construction of the drum shall be properly seasoned. Sound and free from defect. Wood preventative shall be applied to the entire drum.

xvii) On flange of the drum, necessary information such as manufacturers name, type, size, voltage grade of cable, length of cable in meters, drum no., cable code, ISI certification mark gross weight etc. shall be printed. An arrow shall be printed on the drum with suitable instructions to show direction of rotation of the drum. Cable shall be supplied in drum length as follows.

xviii) Cable terminations shall be made with copper/Aluminium Heavy duty long nack copper crimping lugs only crimped type solderless lugs for all aluminium cables and stud type terminals. For copper cables copper crimped solderless lugs shall be used.

xix) Crimping shall be done with the help of hydraulically operated crimping tool. All cable lugs should be long neck type only.

xx) Cable glands shall be of heavy duty brass single compression type as specified. Generally single compression type cable glands shall be used for indoor protected locations and double compression type shall be used for outdoor locations. Glands for classified hazardous areas shall be CMRS approved.

xxi) Ferrules shall be of self sticking type and shall be employed to designate the various cores of the control cable by the terminal numbers to which the cores are connected, for ease in identification and maintenance.

xxii) Kit type joint shall be done and filled with insulating compound. The joint should be for 1.1 KV grade insulation.

2.19 Earthing

i) Earthing is essential for the protection of the equipment & manpower. Two main grounds used equipments are:

- System earth: System earth is earth which is used to ground one leg of the circuit. For example in AC circuits the Neutral is earthed while in DC supply +ve is earthed.
- Equipment earth: In case of equipment earthing all non-current carrying metal parts should be bonded together and connected to earth to prevent shock to the man power and also the protection of the equipment in case of any accidental contact.

ii) To prevent the damage due to lightning the one terminal of the lightning protection arrangement is also earthed. The provision for lightning & surge protection of the SPV power source is required to be made.

iii) In case the SPV Array cannot be installed close to the equipment to be powered and a separate earthing has to be provided for SPV System, it shall be ensured that all the earths are bonded together to prevent the development of potential difference between any two earths.

iv) Earth resistance shall not be more than 1 ohms. It shall be ensured that all the earths are bonded together to make them at the same potential.

v) The earthing conductor shall be rated for the maximum short circuit current & shall be 1.56 times the short circuit current. The area of cross – section shall not be less than 1.6 sq mm in any case.

vi) The array structure of the PV modules shall be grounded properly using adequate numbers of earthing pits. All metal casing / shielding of the plant shall be thoroughly grounded to ensure safety of the power plant.

2.19.1 **Surge Protection Device (SPD):** Internal surge protection shall consist of three MOV type arrestors connected from +ve and –ve terminals to earth (via Y arrangement) for higher withstand of the continuous PV-DC voltage during earth fault condition. SPD shall have safe disconnection and short circuit interruption arrangements through integrated DC in-built bypass fuse (parallel) which should get tripped during failure mode of MOV, extinguishing DC arc safely in order to protect the installation against fire hazards. Nominal discharge current (Imin) at 8/20 micro seconds shall be minimum 10 kA with maximum discharge current (Imax) at 8/20 micro seconds minimum 20 kA with visual indication (through mechanical flag) in modules to monitor the life of SPD.

2.19.2 Earthing for PV Array

- The photovoltaic modules and other components of power plant requires adequate earthing for protecting against any serious faults as guided by IEC 60364. The bidder needs to provide relevant certifications for the same.
- The earthing system shall be provided according to the IS 3043 supported with design calculations.
- Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance.
- Each string/ array and MMS of the plant shall be grounded properly. The array structures are to be connected to earth pits as per IS standards. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance.
- The complete earthing system shall be mechanically & electrically connected to provide independent return to earth.
- For each earth pit, a necessary test point shall be provided.
- In compliance to Rule 11 and 61 of Indian Electricity Rules, 1956 (as amended up to date), all non-current carrying metal parts shall be earthed with two separate and distinct earth continuity conductors to an efficient earth electrode.
- The Bidder shall submit the detailed specifications of the array earthing.

2.20 Junctions/ Combiner Boxes & Other Electrical Components

Dust, water and vermin proof junction boxes of adequate rating and adequate terminal facility made of fire resistant Plastic (FRP) shall be provided for wiring. Each solar shall be provided with fuses of adequate rating to protect the solar arrays from accidental short circuit. Junction Box shall have protection class of IP-65.

2.20.1 Protection Features

- The injection of DC power into the grid is avoided by using an isolation transformer at the output.
- Over-voltage protection is provided by using varistors at the output of the inverter.
- Another set of varistors at the input of the inverter provides lightning protection.

2.21 Control & Instrumentation System

The instrumentation and control system for the solar PV power plant will be Distributed Control System (DCS) with electronic instruments. Monitor / Keyboard based Operator Work Stations shall be used for monitoring and control of the power plant from the control room.

2.22 Solar Island

The controls for the PV modules, transformers and switchgears, cabinets, housing, system optimization, control, SCADA, security system, cabling, etc shall be through main plant DCS. In security system each corner and vital locations shall be provided with CCTV camera which shall be given display at security room.

2.23 Other Electrical Equipments:

1.1 LT Panel

1.1 Scope :

The scope covers supply, installation, testing and commissioning of power panels, incorporating circuit breakers, fuse units, busbars, interconnections, earthing etc., meeting the requirements shown in equipment schedule and the drawings.

1.2 Standards :

AS PER SCHEDULE OF INDIAN STANDARD; ATTACHED WITH THE DOCUMENT.

The PCCs & MCCs shall comply with the latest edition of relevant Indian standards and Indian Electricity rules and regulations. The following Indian Standards shall be complied with:

IS : 4237 : General requirements for switch gear and control gear for voltage not exceeding 4100 v.

IS : 375 : Switchgear bus-bars, main connection and auxiliary wiring, marking and arrangement.

IS : 2147 : Degree of protection provided by enclosures for low voltage switch gear and control gear.

IS : 8197 : Terminal marking for electrical measuring instrument and their accessories.

IS : 2557 : Danger notice plates.

IS : 2516 : Specification for AC circuit breaker.

IS : 1818 : Specification for AC isolator and earthing switch.

IS : 3072 : Code of practice for installation and maintenance of switchgear.

IS : 8623 : Specification for factory built as symbolize of switch gear and control gear for voltage up to and including 4100v. A.C.& 1200 v. D.C.

IS : 8828 : Miniature Circuit Breaker.

IS : 4064 : Fuse switch and switch fuse unit.

IS : 9224 : HRC fuse unit.

IS : 2705 : Current transformer.

IS : 3155 : Voltage transformer.

IS : 3231 : Electrical relay for protection.

IS : 1248 : indicating instrument.

IS : 722 : Integrating instrument.

IS : 6875 : Control switches & push buttons.

IS : 2959 : Auxiliary contactor.

IS : 1822 : AC motor starters of voltage not exceeding 4100V.

IS : 13947 : Switch Board General Requirement

1.3 TYPE OF M.V. SWITCH GEAR :

1.3.1 All the PCC's / PDB's / MCC's shall be metal clad, totally enclosed, rigid, floor / wall mounted, air - insulation, cubical type suitable for operation on three phase / single phase, 415 / 230 volts, 50 Hz. neutral effectively / Non effectively grounded at transformer and short circuit level not less than 30 MVA at 415 volts.

1.3.2 The PCC's / MCC's shall be designed the withstand and heaviest condition at site, with minimum expected ambient temperature of 55 degree celsius, 90 percent humidity and dusty weather.

1.3.3 Should confirm to Indian Electricity Act and rules. (as amended up to ate) & approval of FIA. of India.

1.4 STRUCTURE :

1.4.1 The PCCs, MCCs & PDBs shall be metal clad enclosed and be fabricated out of high quality CRCA sheet, suitable for indoor installation having dead front operated and floor mounting type.

1.4.2 All CRCA sheet steel used in the construction of PCCs / MCCs / PDBs shall be 2 mm thick and shall be folded and braced as necessary to provided a rigid support for all components. Joints of any kind in sheet shall be seam welded, all welding slag grounded off and welding pits wiped smooth with plumber metal.

1.4.3 The PCCs / MCCs / PDBs shall be totally enclosed, completely dust and vermin proof and degree of protection being not less than IP-51 to IS 2147. Gaskets between all adjacent units and beneath all covers shall be provided to render the joints dust proof. All doors and covers shall be fully gasket with foam rubber and / or rubber strips and shall be lockable.

1.4.4 All panels and covers shall be properly fitted and secured with the frame, and holes in the panel correctly positioned. Fixing screw shall enter into holes taped into an adequate thickness of metal or provided with bolts and nuts. Self threading screws shall not be used in the construction of PCCs / MCCs / PDBs.

1.4.5 A base channel of 75 mm x 75 mm x 5 mm thick shall be provided at the bottom.

1.4.6 PCCs / MCCs /PDBs shall arranged in multi-tier formation. The PCCs / MCCs / PDBs shall be of adequate size with a provision of 20 percent spare space to accommodate possible future additional switch gear. The size of the PCCs / MCCs / PDBs shall be designed in such a way that the internal space is

sufficient for hot air movement, and the electrical component does not attain temperature more than 45 degree celsius. If necessary openings shall provided for natural ventilation, but the said openings shall be screened with fine weld mesh.

1.4.7 Knockout holes of appropriate size and number shall be provided in the PCCs / MCCs/ PDBs in conformity with number, and size of incoming and outgoing conduits / cables.

1.4.8 Alternatively the PCCs / MCCs / PDBs shall provided with removable sheet plates at top and bottom to drill holes for cable / conduit entry at site.

1.4.9 The PCCs / MCCs / PDBs shall be designed to facilitate easy inspection, maintenance and repair.

1.4.10 The PCCs / MCCs / PDBs shall be sufficiently rugged in design and shall support the equipment without distortion under normal and short circuit condition, they shall be suitable braced for short circuit duty.

1.5 PAINTING :

All sheet steel work shall undergo a process of decreasing pickling in acid, cold rinsing, phosphating, pesivating and then sprayed with a high corrosion resistant primer. The primer shall be backed in an oven. The finishing treatment shall be by application. Three coats of synthetic enamel paint of approved colour shall be applied by spray and stoves in dust free atmosphere or the panel shall be powder coated.

1.6 CIRCUIT COMPARTMENT :

1.6.1 Each circuit breaker and switch fuse units shall be housed in separate compartments and shall be enclosed an all sides. Sheet steel hinged lockable door shall be duly inter locked with the breaker / switch fuse units in ON and OFF position. Safety interlocks shall be from being drawn out when the breaker is in ON position.

1.6.2 The door shall not form as integral part of the drawout position of the circuit breaker. All instruments and indicating lamp shall be mounted on the compartment door. Sheet steel barriers shall be provided between the tires in a vertical section.

1.7 INSTRUMENT COMPARTMENT

Separate and adequate compartment shall provided for accommodating instruments, indicating lamp, control contactors, relays and control fuses etc. These components shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker, switch fuse units, busbars and connections.

1.8 BUSBARS

1.8.1 The busbar shall be air insulated and made high quality, high conductivity, high strength copper and as per relevant IS code. The busbar shall of three phases and neutral system with separate neutral and earth bar. the busbar and interconnection between busbar and various components shall be of high conductivity, hard drawn, electrolytic copper. the busbar shall be of rectangular cross section designed to withstand full load current for phase busbar and full rated current for neutral busbar and shall be extensible type on either side. The busbar shall be rated for the frame size of the main incoming breaker but in any case not less than 200 amp capacity. The busbar shall have uniform cross section through out the length.

1.8.2 The busbar and interconnection shall be insulated with heat shrinkable PVC sleeves and be colour coded in red, Yellow, Blue and Black to identify the three phases and neutral of the system. The busbar shall be supported on unbreakable, non hygroscopic DMC insulated supports at sufficientevely close interval to prevent busbar sag and shall effectively withstand electromagnetic stresses in the event of short circuit capacity of 50 KA RMS symmetrical for one second and a peak short circuit withstand of 105 KA minimum.

1.8.3 The busbar shall be housed in a separate compartment. The busbar shall be isolated with 3 mm thick bakalite sheet to avoid any accidental contact. The busbar shall be arranged such that minimum clearance between the busbar are maintained as per below.

Between phases	:	27 mm min.
Between phases and neutral	:	25 mm min.
Between phases and earth	:	25 mm min.
Between neutral and earth	:	23 mm min.

1.8.4 All busbar connection shall be done by drilling holes in busbars and connecting by chromium plated brass bolt and nuts. Additional cross section of busbar shall be provided in all PCCs / MCCs / PDBs to cover-up the holes drilled in the busbars. Spring and flat washers shall be used for tightening the bolts.

1.8.5 All connection between busbar and circuit breaker / switches and between circuit breaker/ switches and cable terminals shall be through solid copper strips of proper size to carry full rated current. These strips shall be insulated with insulating strips.

1.9 ELECTRICAL POWER & CONTROL WIRING CONNECTION

a) Terminal for both incoming and outgoing cable shall be suitable for 1100 volts grade, aluminum/copper conductor PVC insulated and sheathed, armoured cable and shall be suitable for connections of solder less sockets for the cable size as indicated on the appended drawing for the PCCs, MCCs, PDBs.

b) Both control and power wiring shall be brought out in cable alley for ease of external connections, operation and maintenance.

c) Both control and power terminals shall properly be shrouded.

d) 10% spare terminal shall be provided on each terminal block. Sufficient terminals shall be provided on each terminal block so that not more than one outgoing wire connected per terminal.

e) Terminal strip for power and control shall preferably be separated from each other by suitable barriers of enclosures.

f) Wiring inside the module for power, control protection and instrument etc. shall be done with use of 660/1100 confirming to IS 694 and IS 8130. Power wiring inside the starter module shall be rated for full current rating of contactor, but not less than 4 sq mm cross section area. For current transformer circuits, 2.5 sq mm copper conductor wire shall be used. Other control wiring shall be done with 2.5 sq mm copper conductor wires. Wires for connections to the door shall be flexible. All conductors shall be crimped with solder less sockets at the ends before connections are made to the terminals.

i) Control power for the motor starter module shall be taken from the respective module switchgear outgoing from R phase and Neutral. Control wiring shall have control fuse (HRC type).

j) Particular care shall be taken to ensure that the layout of wiring neat and orderly. Identification ferrules shall be filled to all the wire termination for ease of identification and to facilitate and testing.

Suitable washers shall be used for all copper and aluminium connections.

k) Final wiring diagram of the PCC, MCC, PDB power and control circuit with ferrules number shall be submitted along with the PCC/MCC/PDB as one of the documents.

1.10 TERMINALS

The outgoing terminals and neural link shall be brought out to a cable alley suitably located and accessible from the panel front. The current transformer for instrument metering shall mounted on the disconnecting type terminal blocks. No direct connection of incoming and outgoing cables to internal components connection of the distribution board is permitted, only one conductor may be connected in one terminal.

1.11 WIREWAYS

A horizontal PVC wire way with screwed covers shall provided at the top to take interconnecting control wiring between different vertical sections.

1.12 CABLE COMPARTMENT

Cable compartment of adequate size shall be provided in the PCCs, MCCs, PDBS for easy termination of all incoming and outgoing cables entering from bottom or top. Adequate support shall be provided in the cable compartment shall be brought out to terminal blocks in the cable compartment.

1.13 EARTHING

a) Copper earth busbar of 25 mm x 3 mm shall be provided in the PCCs, MCCs, PDBS for the entire length of panel. The frame work of the PCCs, MCCs, PDBs shall be connected to this earth busbar.

Provisions shall be made for connection from earth busbar to the main earthing bar coming from the earth pit on both side of the PCCs, MCCs, PDBs.

b) The earth continuity conductor of each incoming and outgoing feeder shall be connected to this earth bar. The armour shall be properly connected with earthing clamp and the clamp shall be ultimately bounded with the earth bar.

1.14 LABELS

Engraved PVC labels shall be provided on all incoming and outgoing feeders. Single line circuit diagram showing the arrangements of circuit inside the distribution board shall be pasted on inside of the panel door and covered with transparent laminated plastic sheet.

1.15 NAME PLATE

a) A name plate with panel designation in bold letter shall be fixed at top of the central in panel. A separate name plate giving feeder giving feeder details shall be provided for each feeder module door.

b) Inside the feeder compartment, the electrical component, equipments, accessories like switchgear, contactor, lamp, relays etc. shall suitably be identified by providing stickers.

c) Engraved name plates shall preferably be of 3 ply, (red-white-red or black-white-black) lamicold sheet. However black engraved perplex sheet name plates shall also be applicable. Engraving shall be done with square groove cutters.

d) Name plate shall be fastened by counter sunk screws and not by adhesives.

1.16 DANGER NOTICE PLATE

a) The danger plate shall be affixed in a permanent manner on operating side of the panel.

b) The danger notice plate shall indicate danger notice both in Hindi and English and with a sign of skull and bones.

c) The danger notice plate in general shall meet to requirements of local inspecting authorities.

d) Overall dimension of the danger notice plate shall be 200 mm wide and 150 mm high. The danger notice plate shall be made from minimum 1.6 mm thick mild steel sheet and after due pre-treatment to the plate, the same shall be painted white with vitreous enamel paint on both front and rear surface of the plate.

e) The letter, the figure, the conventional skull and bones shall etc. shall be positioned on the plate as per recommendations of IS : 2551-1982.

f) The said letter, the figure and the sign of skull and bones be painted in single red colour as per IS : 5-1978.

g) The danger plate shall have rounded corners. Locations of fixing holes for the plate shall be decided to suit design of the panel.

h) The danger notice plate, if possible, be of ISI certification mark.

1.17 INTERNAL COMPONENTS

a) The PCC / MCC / PDB shall be equipped complete with all type of required number of air circuit breakers, switch fuse unit, contactor, relays, fuses, meters, instruments, indicating lamps, push buttons, equipment, fittings, busbar, cable boxes, cable glands etc. and all the necessary internal connections /wiring as required and as indicated on relevant drawings. Components necessary for proper complete functioning of the PCC / MCC / PDB but not indicated on the drawings shall be supplied and installed on the PCC / MCC / PDB.

b) All part of the PCC / MCC/ PDB carrying current including the components, connections, joints and instruments shall be capable of carrying their specified rated current continuously, without temperature rise exceeding the acceptable values of the relevant specifications at any part of the PCC / MCC / PDB.

c) All units of the same rating and specifications shall be fully interchangeable.

1.18 INSPECTIONS

Each equipment should inspect and witness by client & consultant.

a) The PCC / MCC / PDB shall be inspected and checked as per inspection manual of the PCC / MCC / PDB manufacturer.

b) Various electrical components and accessories of the PCC / MCC / PDB shall be checked as per drawing for the respective PCC / MCC / PDB.

c) The PCC / MCC / PDB shall be checked for rigid mounting, earthing connections, proper rating and size of components, internal wiring, etc.

d) All mechanical fasteners and electrical connections shall be checked and tightened before installation.

e) Type test certificates for all ACB for similar rating shall be submitted.

f) Test :

a) Prior to dispatch of the PCC / MCC / PDB following tests shall be carried out.

b) Mechanical endurance test shall carried out by closing and opening of all the ACB's, MCB's switches etc.

c) Over voltage and Insulation resistance test shall be carried out between phases and between phase to earth bus, keeping the isolating switch in ON position. Similar test shall be carried out keeping the isolating switch in closed position.

d) All the interlocks, controls and tripping mechanism of the switch gears shall be tested for their proper functioning.

1.19 COMPONENTS :

GENERAL

a) The type, size, and rating of the components shall be as indicated on the relevant drawings.

b) While selection od the capacity of the components resulting from the prevailing conditions like room temperature shall be allowed for the Thermal and magnetic trip rating shall be compensated for the ambient temperature.

c) The rating indicated on the drawings are rating anticipated at prevailing site condition.

A) Air Circuit Breaker

- The Circuit Breakers shall be 3/4 pole as specified, Microprocessor based with LCD display, air break drawout type having electrical closing arrangements as defined in the SLD.ACB shall be provided with built in over load, short circuit and earth fault protection. Circuit Breaker carriage shall be mounted on guides to ensure correct alignment. Isolating contacts shall be of the self alignment type. Breakers shall have three distinct and separate operation positions. Circuit Breaker shall be provided with spring assisted operating mechanism. Circuit breaker Shall be suitable for minimum fault level 50kA for 1 second (Ics = Icu =Icw= 50kA) & Making capacity 2.1 times breaking capacity.

The circuit breaker ratings shall be as follows:

a) Rated Voltage : 415V ± 10%

b) RMS symmetrical breaking capacity at rated voltage : 50 KA (minimum)

c) Rated short time current : Not less than 50KA for 1 sec.

d) Rated operating duty (P2) : 0-3sec-CO-3min-CO

The circuit breaker shall be provided with the following.

a) 6 NO & 6 NC spare auxiliary contacts wired to terminal blocks.
b) 24V DC Shunt Trip Coil for Breakers
c) One mechanical position indicator.
d) indicating lamps to show ‘ON-OFF’, and Auto-Trip conditions.
e) Mechanical emergency trip push button.

f) Easily removable arc chutes for effective arc quenching.
g) Mechanical trip button, integral with the breaker shall be provided at the front.
h) Padlocking facility in 'OFF' position.
i) Operating handle interlocked with the front cover for safety.
j) All breakers to have thermal, magnetic and under voltage releases.
k) Triple pole, ambient temperature compensated, adjustable, direct acting thermal release.
l) Triple pole, direct acting, adjustable upto 12 times rated current short-circuit trips with time delay upto 0.3 seconds for discrimination obtained through rugged and non-aging mechanical means. The timing device shall be independent of power supply.
m) Under voltage releases to have inherent delay to prevent tripping on transient voltage dips

Following safety interlocks shall be provided on the circuit breakers:

a) The operation of the circuit breaker shall not be possible unless it is in :
i. Service Position
ii. Withdrawn to test position.
iii. Fully drawn-out.
iv. Bus coupler interlocking with two incomers (when two incomers are on, bus coupler shall not be possible to close in service position)

Further it shall not be possible to close the circuit breaker without completing the auxiliary circuits between the fixed and moving portion. All interlocks shall be effective in Service Position.

a) The withdrawal or racking in of the circuit breaker without completing the auxiliary circuit between the fixed and moving portion.
b) The door of the circuit breaker portion, if any, shall open only if the circuit breaker is in the open position.
c) Safety shutters operated automatically by the movement of the circuit breaker shall ensure that the live parts are fully shrouded when the circuit breaker is withdrawn.
d) The circuit breaker carriage shall be earthed before the main contacts are plugged in.

Potential free contact for on/off/trip status monitoring to be provided for completely compatible interface with centralized building automation.

Auto self starting required after power failure.

B) MINIATURE CIRCUIT BREAKER

Miniature circuit breakers shall be quick make and break and break type conform with British standard BS : 3871 (Part-I) 1965, IEC 898-1995 and IS :8828 (1996). The housing of MCBs shall be heat resistant and having a high impact strength. The fault current of MCBs shall not be less than 9000 amps, at 230 volts. The MCBs shall be flush mounted and shall be provided with trip free manual operating mechanism with mechanical "ON" and "OFF" indications.

The circuit breaker dollies shall be of trip free pattern to prevent closing the breaker on a faculty current. Tightening torque at terminals shall be not less than 2.5 Nm. Power losses should not be more than as specified in IEC 898-1995.

The MCB contact shall be silver nickel and silver graphite alloy and tip coated with silver. Proper arc chutes shall be provided to quench the arc immediately. MCB's shall be provided with magnetic fluid plunger relay 3 as for over current and short circuit protection. The over load or short circuit devices shall have a common trip bar in the case of DP and TPN miniature circuit breakers. All the MCB's shall be tested and certified as per Indian Standard, prior to Installation.

For protection of electric circuits with equipment that does not cause surge current (i.e. lighting and socket outlet circuits)'B' curve MCB to be used in which magnetic releases operates between 3 and 5 In.

For protection of electric circuits with equipment that cause surge current (i.e. inductive and motor circuits) 'C' curve MCB to be used in which magnetic releases operates between 5 and 10 In.

For protection of electric circuits with equipment that cause surge current (i.e. transformer, heavy start motors circuits) 'D' curve MCB to be used in which magnetic releases operates between 10 and 15 In.

Auto self starting required after power failure.

C) FUSE

Fuses shall be of high rupturing capacity (HRC) fuse links and shall be in accordance with IS : 2000-1962 and having rupturing capacity of not less than 35 MVA at 415 Volts. The backup fuse rating for each motor / equipment. HRC fuses shall be of English Electric make or approved equal.

D) MOULDED CASE CIRCUIT BREAKER

Moulded case circuit breakers shall be conforming with IEC 60947-2 and IS 13947 -2. The MCCB shall be air break type and having quick make quick break with trip free operating mechanism. Housing of the MCCB shall be of heat resistant and flame-retardant insulating material. All the MCCB should be provided with adjustable thermal and magnetic release and with rotary handles.

Operating handle of the MCCB shall be in front and clearly indicate ON / OFF / TRIP positions. The electrical contact of the circuit breaker shall be of high conducting non-deteriorating silver alloy contacts. Shall be equal to system short circuit level i.e. 50 kA/65 kA (Minimum) (Ics =Icu).(Ics) = Service Short circuit breaking capacity (Icu) =Rated ultimate short circuit breaking capacity. Icw as per manufacturer's design for higher ratings, if applicable, shall be 50 kA for 1 sec.

The MCCB shall be provided with thermal / magnetic type bi-metal over load release and electro-magnetic short circuit protection device. All the releases shall operate on common trip busbar so

that in case of operation of any one of the releases in any of the three phases, it will cut off all the three phases and thereby single phasing of the system is avoided.

The MCCB whenever called for in the appendix drawings shall be provided with an earth fault relay. The MCCB shall provide two sets of extra auxiliary contacts with connections for additional controls at future date.

The electrical parameters of the MCCB shall be as per the descriptions given in the appended drawings.

E) CONTACTORS :

The contactor shall meet with the requirements of IS : 2959 and BS : 775.

The contactors shall have minimum making and breaking capacity in accordance with utilization category AC 3 and shall be suitable for minimum class II intermittent duty.

If the contactor forms part of a distribution board then a separate enclosure is not required, but the installation of the contactor shall be such that it is not possible to make an accidental contact with live parts.

F) METER

The meter should meet the following requirement unless and otherwise specified in the bill of material or drawings.

Ameter : The Ameter should be digital type 96 x 96 mm size having facility to read current parameters.

Voltmeter : The Voltmeter should be digital type 96 x 96 mm size having facility to read voltage parameters.

KWH METER : Digital KWH meter 96 x 96 x 80 mm size Acc Class 1.0 suitable for true RMS reading having reverse LED. Optically isolated pulse output having pulse with 500 ms and pulse amplitude 12 volts. It should be with RS 485 port with open protocol.

LOAD MANAGER:

The load manager should meet the following requirement unless and otherwise specified in the bill of material or drawings.

Load Manager (For Incoming Feeders) : The load manager should having facility to read voltage current harmonics power parameters. It should contain real time clock. The meter should be field programmable and to generate high / low profile for all power parameters with date & time, also able to store previous period integrated data. The meter should have RS 485 port with open protocol for networking purpose. All the programming should be pass word protected.

Load Manager (For other Feeders) : Load manager facility to measure A, V, PF, kW, kWH with RS 485 port with open protocol for networking. The meter should be totaly field programmable and having a password protection. Size should be 96 x 96 mm.

G) CURRENT TRANSFORMER

Where ammeter are called for, CT's shall provided for current measuring. Each phase shall be provided with separate CT of class 1 accuracy and suitable VA burden for operation of associated metering and controls. Current transformer shall be in accordance with IS : 2705-19 64 as amended up to date.

H) PUSH BUTTON :

The push button unit shall comprise of the contact element, a fixing holder , and push button actuator. The push button shall be momentary contact type. The contacts shall be of silver alloy and rated at 10 Amps. continuous current rating. The actuator shall be of stranded type and colour as per its usage for ON, OFF and Trip.

J) INDICATING LAMP :

Indicating Lamp shall be transformer operated low voltage rated and shall supplied complete with translucent covers to diffuse the lamp light.

Colour shade for the indicating lamps shall be as below :

ON indicating lamp	:	Red
OFF indicating lamp	:	Green
TRIP indicating lamp	:	Amber
PHASE indicating lamp	:	Red, Yellow, Blue.

1.21 SPECIAL REQUIREMNTS.

a. Bottom most feeder shall be minimum 300 mm above the bottom of panel base frame.
b. Necessary floor stand to be provided whenever required along with the panels

1.22 Testing & Co-ordination :

Testing and setting the relay set – point and co-ordination between relay on LT/HT fuses, breaker, setting shall be done by contractor. The down stream of the setting should be provided.

1. The following drawings shall be submitted before procurement for approval from the client.
    1. General arrangement and Fabrication details.
    2. Power wiring diagram of the panel.
    3. Control wiring diagram of panel.
4. C.T. ratios with connection.

5. Material list with make, catalogue nos and

2. Testing and setting the relay set – point and co-ordination between relay on LT/HT fuses, breaker, setting shall be done by contractor. The down stream of the setting should be provided.

3. The relay should be tested by reputed agencies and test report of the relay should be submitted by the contractor.

Note: Panels shall also equipped with Transient Voltage Surge Suppressor (TVSS) for protection against transient voltage surges. Digital Ammeter & Digital Voltmeter with their inbuilt selector switches and Digital Load manager which performs as a multifunction meter are provided on the front side of the cubicle. LTPDB is also provided with a Breaker Control Switch (TNC) for electrically operating the ACB. NO & NC contacts for ACB are provided to communicate the On, OFF and Trip status & control to/by SCADA.

2.23.1 Other Accessories

To carry the DC power generated from Solar PV modules to PCUs located in the control room, DC cables of 1100 V rated are used, as the system voltage is around 700 V DC cables of appropriate sizes depending on the current ratings will be used as per the IS.

After inversion of power from DC to AC at PCU, appropriate rating AC cables/bus ducts will be used for exporting the power through various panels as listed. All the PVC/XLPE cables used will be confirming to the relevant IS codes.

All terminations of the cables will be done with proper routing, through HDPE Conduits /cable trenches where ever applicable, with appropriate lugs and accessories as per the standards ensuring minimum stress.

PV array yard Earthing will be basically done to ensure safety of the personnel and equipment in the case of high voltages and lightning. In solar PV plant, earthing is provided for array yard, control room and switch yard equipment. For this efficient super earth kits and chemical earthing kits will be used.

Solar lights needs to be installed in area of the solar PV project. The developer needs to carryout survey and propose appropriate number of solar lights for this purpose.

All meters installed for solar power generators should have automatic meter reading facilities. Further, the monitoring of various parameters of solar plant such as module wise and total energy generation, tripping, logs, etc. should be available on website with username and password facilities.

Accommodation of staff, labor etc. shall be arranged by vendor.

UPS:

Separate dual redundant (n+1) UPS with 2hour backup (with Degradation till 5 Years, Bidder have to furnish Calculation) shall be installed at server room. Control rooms for feeding power to SCADA system equipments & all other emergency equipment loads & systems like CCTV etc. The UPS shall be connected to SCADA for necessary monitoring & controls. A bypass switch shall be provided for maintenance purpose.

2.24 CCTV Surveillance System

IP based CCTV system shall be deployed, minimum resolution shall be 1MP 720p HD for dome & 2MP 1080p HD for Bullet cameras, IR based night vision cameras to be used for security purpose. Vendor has to provide complete solution by using fix + PTZ cameras as required to cover the total solar farm area. Sufficient capacity of NVR with minimum 30days back up to be provided with cloud-based backup with necessary licensing etc. All the misc accessories like connecting wires, POE switches, IP66 junction boxes, pole / other mounting arrangements, etc shall be provided as per requirement. Realtime screening via cloud / internet to be made available with access parameters to the client as required.

2.25 Civil Works

The civil work to be carried out by the contract shall include but not limited to following.

- Cutting and clearing of trees / plantation to remove the shadow.
- Providing civil works for Embedment of structures & providing & installation of all metal fabrication & structure suitable for mounding PV modules.
- Laying of earthing equipments / structures and connecting to the main ground mat as per the statutory requirements.
- Construction of cable trenches etc. wherever necessary.
- Constructing LT Panel Rooms & other utility area complete with required internal utilities, UPS room , Scada room, maintenance & training area etc.

Water supply works for cleaning of Solar PV panels: The Contractor shall estimate the water requirements for cleaning the photovoltaic modules at least once a month in order to operate the plant at its guaranteed plant performance. The Contractor shall have to plan, design, provide and lay water supply system for cleaning of Solar PV panels in the entire plant area. The GI piping network is to be designed with considering pressure to provide appropriate head at outlet point i.e. Garden Hydrant. Before execution, the detailed specification and drawing prepared by the Contactor is to be submitted to get necessary approvals from the Client and Consultant.

1 MMS Specification

1.1 Design Parameters

The Ground mounting structure system which constitute a photovoltaic array(s) shall be designed to withstand the extreme fair wind (positive pressure) and adverse wind (negative pressure) on design tilt angle of solar photovoltaic array(s).

The design calculations shall be supplemented with neat sketch and reference to various clauses of Technical specification and Indian standards. For MMS design analysis and determination of forces, where computer program (preferably STAAD) is used, the contractor shall submit a write-up on computer program used and its input and output data for review and approval of Engineer-in-Charge
An increase in allowable stresses of structural materials should not be considered during design analysis.

Wind pressure for following loads shall be considered as follows:

- Dead Load of steel with all members, fittings & panels.
- Load due to fair wind direction on design tilt angles of solar mounting structural members.
- Load due to adverse wind direction on design tilt angles of solar mounting structural members.
- Load on side face of mounting structural members.

Wind pressure coefficient, load and load combination, load test/factor of safety shall be as per Indian standards (latest revision) such as IS: 875, IS: 800, IS: 801, etc. The relevant load combination shall be as per IS codes.

Design analysis and determination of forces (Compressive force, uplift force, shear and moment) from MMS shall be provided for design of foundation system. Limiting deflection shall be as per relevant IS code.

1.2 Foundation System

Top of concrete/ height of collar for MMS foundation shall be minimum250 mm above FGL. The minimum plan area of MMS foundation collar shall be 700 sq.cm. The proposed foundation system for MMS shall be based on findings/results of the approved geo technical investigation. Following kind of foundation may be provided:

- Short pile RCC foundation (Min. 300mm dia.)
- Rock anchor with concrete collar
- Isolated, strip or raft foundation

Yard fencing

Supply and fixing of chain link fencing with angle iron posts 50x50x6mm placed at every 3 Mtr. apart 30cm in ground embedded in cement concrete 1:3:6 (30x30x45cm) corner and every tenth post to be strutted with (50 x 50 x 6cm) angle iron provided, fixed and fitted with posts including earth work in excavation etc. complete in all respect with chain link of sizes 50 mm x 50 mm x 3.15 mm. Providing and erecting Min 6.5 m wide M.S. Gate of approved design.

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

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

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

2.26 Maintenance Requirement

- Easy access shall be provided for all components in the SPV plant and grid connecting equipments. Maintenance platform shall be provided for easy inspection of all the equipments.

- If special tools are required for installation and maintenance, the bidder shall indicate the same and to be supplied free of cost.
- The Bidder shall furnish operating and maintenance instruction manual to enable the purchaser to carry out maintenance of equipment effectively and safely.
- Washing / cleaning of SPV panels would be carried out as per the prudent practice of the supplier.

2.27 Test and Test Reports

- Type test certificates for all the tests specified for the factory built solar PV modules, and the component parts shall be submitted by the Bidder along with the bid.
- The Supplier shall carryout all routine tests as specified in relevant standards on all major components in presence of the purchaser's representative (or third party nominated by NALANDA UNIVERISTY for this purpose) at manufacturer's premises before dispatch of the material and furnish copies of test reports for purchaser's approval. If required, stage wise inspection will be carried out by the purchaser.
- Supplier shall carryout all routine and functional tests as specified in the relevant standards on the assemble SPV Plant with all accessories of the equipment in the presence of the purchaser's representative before dispatch and furnish copies of the test reports for approval before dispatch.
- Equipment shall not be dispatched unless the test certificates are duly approved by the purchaser.
- Two sets of copies of the complied and approved test certificates shall be submitted to the purchaser.

2.28 Rating and Name Plate

- Each main and auxiliary item of plant shall have permanently attached to it a rating name plate in a conspicuous position, This shall be of a non- corrodible material preferably chromium plated steel to stand the prevalent atmosphere condition as indicated. The inscription shall be engraved in black on the plate or as plate or as otherwise specified in section C/D.
- The size of the rating and name palate shall depend upon space availability but an inscription shall be approved by the Engineer. The plates shall be should be reasonably sized of clarity and clear inscription.
- In case of indoor equipment, the plate shall be of transparent plastic material with black lettering engraved on the back.
- The name plates shall be screwed to the body of the equipment.

2.29 Layout Requirements

2.29.1 The Overall dimensions of the SPV plant shall suit provided for the layout requirement. The arrangement to suit this space is to be intimated at the time of approving the general arrangement drawing of the equipments.

2.30 System Documentation

2.30.1 It is essential that the owner have complete documentation on the system. System documentation should include an owner's manual and copies of relevant drawings for whatever system maintenance might be required in the future.

2.31 Drawings

The contractor shall furnish the following drawings

- General arrangement and dimensioned layout
- Schematic Drawing showing the requirement of SV panel, power condition unit(s), junction Boxes. AC and DC Distribution Boards, meters etc.
- Power Flow Schematic
- Earthing & Lightning arrestor Layout
- Structural drawing along with foundation details.
- Itemized bill of material for complete SV plant covering all the components and associated accessories
- Overall layout showing SV Plant in the allocated space of the campus
- Detail architectural, Civil & Structural plan for the buildings to be constructed
- Format for reports and charts for analysis various parameters

2.32 Instruction and O&M Manuals

2.32.1 Two sets of installation manual / user manual shall be supplied along with each power plant. The manual shall include complete system details such as array lay out, schematic of the system, inverter details, working principle etc. Step by step maintenance and troubleshooting procedures shall be given in the manuals. The manual shall also include,

- Detailed instructions and procedures for the installation operation and maintenance.
- Pre-commissioning tests.
- About solar PV system – its components and expected performance.
- Clear instructions about mounting of PV module (s)
- About electronics
- Do's and DON'T's
- Principal of Operation of various equipments
- Safety and reliability aspects
- Metering scheme
- About power conditioning units software and controls
- Clear instruction on regular maintenance and trouble shooting of solar power plant.
- Name and address of the person or service center to be contacted in case of failure or complaint.
- Outline dimension showing relevant cross sectional views, earthling details
- and constructional features.

- Rated voltages, current and all other technical information which may be
- necessary for correct operation of the SV Plant.
- Catalogue number of all the components which are liable to be replaced during life of the SV plant and all the component parts.
- Trouble shooting and diagnostic procedure

2.33 Training

The Successful bidder shall provide necessary training at factor for mutually agreed duration and number of persons to enable the purchaser to maintain the system.

The bidder needs to submit the proposal completed in all aspects and clearly mentioning layout of the modules, actual requirement of the material in line with the price bid, work schedule/ PERT chart along with the implementation schedule etc. NALANDA UNIVERISTY may at its discretion ask for additional material or decrease the material requirements at the price quoted in the price bid.

2.34 Operation & Maintenance

The Successful contractor has to operate & maintain the plant for next 5 years from date of successful handover of the project to client once. During the same all the required maintenance, operational costs, replacements, repairs shall be done by the contractor on behalf of client as per system requirement. A preventive maintenance shall be done by the contractor on specified schedule as per proven practice, such schedule shall be submitted & got approved from client, by the contractor.

3. Make List

Equipment	Make
Modules	**Shall be Domestic Manufactured Only:** Waaree/Vikram/PV-Powertech/REC/LG/VS
Inverter	Schneider/Delta/ABB/SMA/Huwai
Optimizer	Solar edge / equivalent
Mounting Structure	Tata Steel/ Jindal Steel / TISCO / RINL / Asian
String Monitoring Boxes	Trinity Touch/Hensel/VNT/Fairwood/Spillsberg/Eaton Salaris / Statcon /Machine Pulse
TTA LT Panels including switchgears	ABB / Schneider / Siemens / L&T
Control Relay	ABB/Siemens/Schneider/L&T
SCADA	Schneider/ ABB/ GE/ L&T / Ecolibrium/ Neo Silica/ Trinity / Touch/JPION/ICAM/MACH Pulse (Shall be on open protocol)
Meter	Secure / Schneider / L&T / HPL
Cables	DC Cable: Polycab/KEI/Ravin/Lapp/ Apar / Havells AC Cable: Polycab/KEI/Ravin/Lapp/Havells / RR Kables
Plant Lightening Arrestor	Erico /LPI/ Cape /OBO / DEHN
SPD	DEHN / Cape / OBO / Socomech
Connector	Multi contact/Amphenol/Koyo/Bizlink / Elcon / Stsubli
Weather monitoring system	Dynalab / Zonner / Metone / Trinity / KIPP / Webdesign (Shall be With minimum features of wind monitoring, system, temperature system, rain monitoring system, weather forecasting system and pyrometer)
IP Base CCTV	Honeywell/Bosch / Sony

Note: The contractor has to submit the Type approval certificates & type test reports of the Inverts, cables, PV

Panels, etc issued by the NABL & NABL accredited laboratories. The PV Panels and others shall be randomly selected for its type testing as per the MNRE/IEC/NISE guidelines.

Location Data:

Courtesy: Google Earth

Proposed Site & Space allocated (Approx 47,300 Sqm)

Coordinates:

25°00'54.2"N 85°22'26.7"E, 25.015061, 85.374075

4. Site Particulars:

System particulars

a. Nominal system voltage – 415V & Tolerance as per IS
b. Frequency - 50Hz ± 3%
c. No. of phases – Three Phase & Neutral.
d. System neutral - Solidly earthed

Tropical conditions

a. Ambient temperature: 50 degree Celsius
b. Relative humidity (avg.) : 60
c. Isokeraunic level: 33
d. Seismic Zone: Zone-4
e. Climate type: hot and humid

The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

5. List of Abbreviations:

°C : Degrees Centigrade (or Celsius)

µc-Si : Micro-crystalline Silicon

A : Ampere,

AC : Alternating Current ,

AD : Accelerated Depreciation,

APPC : Average Power Purchase Cost, w

BoS : Balance of System,

CCI : Clinton Climate Initiative,

CDM: Clean Development Mechanism,

CdTe : Cadmium Telluride,

CEA : Central Electricity Authority,

CERC : Central Electricity Regulatory Commission,

c-Si : Crystalline Silicon,

CUF : Capacity Utilization Factor,

DC : Direct Current

DHI : Diffused Horizontal Irradiance

DisCom : Distribution Company

DNI : Direct Normal Irradiance

DPR : Detailed Project Report

DSCR : Debt-Service Coverage Ratio

EBV : Evaluated Bid Value

EIA : Environment Impact Assessment

ESCOM : Electricity Supply Company

EVA : Ethyl Vinyl Acetate

FiT : Feed-In Tariff

GBI : Generation-Based Incentive

GHI : Global Horizontal Irradiance.

BERC-Bihar Electricity Regulatory Commission,

SBPDCL-South Bihar Power Distribution Company Limited.

Hz : Hertz

IAM : Incidence Angle Modifier

IEC : International Electro technical Commission

IEX : Indian Energy Exchange

IMD : Indian Meteorological Department

IMP : Current at Maximum Power Point

IREDA : Indian Renewable Energy Development Agency

IRR : Internal Rate of Return

IS : Indian Standards

ISC : Short-Circuit Current

JNNSM : Jawaharlal Nehru National Solar Mission

KPCB : Kerala Pollution Control Board

kV : Kilo-Volt

kW : Kilowatt

kWh : Kilowatt- hour

LCOE : Levelized Cost of Electricity

MMS : Module Mounting Structure

MNRE : Ministry of New and Renewable Energy, Government of India

MOEF : Ministry of Environment and Forest, Government of India

MPPT : Maximum Power Point Tracking

MW : Megawatt

MWh : Megawatt-hour (i.e. 103 kWh)

NAPCC : National Action Plan on Climate Change

NASA : National Aeronautics and Space Administration

NH : National Highway

NOC : No Objection Certificate

NPV : Net Present Value

O&M : Operation and Maintenance

OEM : Original Equipment Manufacturer

PFC : Power Finance Corporation

PMAX : Maximum Power

PPA : Power Purchase Agreement,

PR : Performance-Ratio

REC : Renewable Energy Certificate

RPO : Renewable Purchase Obligation

SCADA : Supervisory Control And Data Acquisition

SERC : State Electricity Regulatory Commission

SNA : State Nodal Agency

STC : Standard Testing Condition

STU: State Transmission Utility

T&D : Transmission and Distribution

THD : Total Harmonic Distortion

VAT : Value-Added Tax

VMP : Voltage at Maximum Power Point

VOC : Open-Circuit Voltage

W : Watt

6. Annexure – P

Performance Ratio Test

1 INTRODUCTION

This document lays down the procedures and requirements for conducting Functional Guarantee tests including scope of the tests, procedures for the tests, reporting formats and process for determining test results in accordance with the Tender Specifications, applicable standards and industry best practices.

2 FUNCTIONAL GUARANTEE TESTS FOR SOLAR PV PLANT

Functional Guarantee for Solar PV Plant shall comprise of following
Guarantees: (1) Performance Ratio Guarantee test for operational
acceptance.

(2) Annual Generation Guarantee up to a period of 5 years (O&M Period), starting from the date of

Operational Acceptance.

2.1 PERFORMANCE RATIO GUARANTEE TEST

A Performance Ratio Guarantee test shall be commenced within 60 days of the commissioning of Plant Facilities to demonstrate that the plant has achieved the Guaranteed Performance Ratio in line with requirements under section VII of the bidding document. This will be one of the pre-conditions for the Plant Operational Acceptance. Performance Ratio (PR) test period would be continuous measurement of 30 consecutive days. The test shall be conducted in accordance with the IEC-61724 as per the methodology described in Technical Specifications under section VII of the bidding document. The procedure of PR test is described further in Section 2.4. The report shall contain all the measured energy and Met data values, calculations, results and conclusions.

2.1.1 Performance Ratio

The Performance Ratio (PR) of the PV Plant is calculated as follows (according to IEC 61724 Ed.2).

$$PR = \frac{E_{out}}{\sum_k \left(\frac{(C_k \times P_o) \times (G_{i,k} \times \tau_k)}{G_{i,ref}} \right)}$$

where

PR Temperature Corrected Performance Ratio

Eout Cumulative AC energy measured at the plant end ABT meter over the duration of reporting period (kWh)

τ_k Duration of the k^{th} recording interval, i.e. (1/60) hour

$\sum k$ Summation over all recording intervals in the reporting period, (1/4) hour

Ck Power rating temperature adjustment factor and can be calculated as below

Ck = 1 + γ x (Tavg_mod,k – Tref)

γ Temperature coefficient of power with negative sign ($°C^{-1}$)

Tavg_mod,k Average PV Module temperature measured at the commencement of time interval 'τ_k' (°C) Tref PV Module temperature at which Po is determined, i.e. 25°C

Po Installed nominal peak power of PV modules, i.e. Nameplate rating at STC (kWp)

Gi,k: Average irradiance measured at the Plane of Array (POA) at the commencement of time interval τ_k (kW/m^2)

Gi,ref Irradiance value at which Po is determined, i.e. 1 kW/m^2

2.1.2 General Requirement

- The Functional Guarantee shall comprise of a set of visual/mechanical/Electrical checks followed by a Performance Ratio (PR) test of the Plant Facilities.
- The PR test shall be carried out for a period of 30 consecutive days at site by the Contractor in presence of the Employer/ Employer's Representative/ Owner's Engineer.

- These tests shall be binding on both the parties to the contract to determine compliance of the equipment with the guaranteed performance parameters.

- The test will consist of guaranteeing the correct operation of the Plant Facilities, by way of the performance ratio based on the reading of the energy produced and delivered to the grid at the plant end ABT meter and the Plane of Array incident solar radiation.

- PR is calculated as per the formula given in Clause no. 2.1 and recorded as per the format provided at ***Annexure 1***.

- All the end of each day, the filled-in format shall be signed by both the parties (Contractor and SECI) and each party will keep one copy for record. **The same will continue for 30 consecutive days.**

- The Functional Guarantee condition for the purpose of Provisional Acceptance of Part 1 of the Plant Facilities shall be considered to have been met if the guaranteed Performance Ratio (PR) is achieved on a daily basis for 30 consecutive days.

- During this PR test, equipment failure/interruption of any kind, except for SCADA communication failures, will not be accountable. In case of a breakdown, the test may be resumed once the complete system is rectified and working properly.

2.1.3 Pre-PR Test

2.1.3.1 The Contractor shall perform start-up tests after successful completion of visual inspection and functional testing. Such testing shall be conducted under the SECI's / Owner's Engineers supervision. The test results shall be recorded as part of a signed-off commissioning record.

2.1.3.2 Preliminary Test Check

The preliminary checks include all the warranty certificates for the major equipment, pre – commissioning test reports, field quality checklists verified through the FQP documents of all equipment and works along with the calibration reports of all the instruments and sensors, wherever applicable.

2.1.3.3 Visual /Mechanical Test

Visual checks shall be done on all the components that form part of the plant including the grid connection equipment in compliance with the field quality plans. The following critical elements as a minimum shall be subjected to visual inspection:

- Module mounting structure and foundations.
- PV module and DC installation.
- Inverters.
- Transformers.
- Switchgear.
- Lightning protection systems.
- Earthing protection systems.
- Electrical protection systems, junction boxes and cabling.
- Grid connection compliance protection and disconnection systems.
- Monitoring systems (including meteorological sensors).

2.1.3.4 Electrical Tests

Subsequent to mechanical completion and visual testing of the plants, following functional electrical tests shall be performed. These tests also referred as start-ups tests shall be the first step for PG guarantee of the plant. These tests shall essentially include:

2.1.3.5 Open circuit voltage (VOC) test.

This test verifies that strings are properly connected (module and string polarity) and that all modules are producing the expected voltage according to the module data sheet. To measure Voc, the following procedure shall be used:

(a) DC string combiner box is opened; fuses leading to the sub main junction box are removed.

(b) The voltage is measured with a calibrated, industry accepted instrument from the negative bus bar to the string positive lead.

2.1.3.6 Functional Guarantee Test shall commence immediately after all issues arising from the functional/

start-up test have been rectified. Note:

(a) All measurement(s) procedure should be carried out taking proper safety precaution.

(b) Also it should be ensured that to avoid any loose connection at the terminal points for which measurement procedure is conducted.

(c) Ensure proper functioning (e.g. Mustimeters shall be calibrated) of all measuring instruments before conducting above measurement procedure.

(d) The above test procedure shall be conducted in presence of site in-charge.

2.1.4 PR Test Procedure

The date of commencement of the PR Test shall be communicated in advance and agreed upon by both parties i.e. SECI and Contractor. Any consecutive 30 days period (excluding interruptions that last entire day on account of grid outage or as per hindrance record maintained at site only) for the purpose of conducting PR test shall be mutually discussed and agreed between SECI and Contractor. It shall comprise of the following procedures.

2.1.4.1 Pre-test Procedure

(1) Before the commencement of Performance Ratio (PR) test, the plant shall have achieved visual/mechanical/Electrical completion as per Clause 2.3 above and SCADA system and WMS shall be fully commissioned and functional.

(2) Trial Run: The PG Test for Plant Facilities shall commence with a trial run for 7 consecutive days.

The Contractor shall provide the data in requisite formats (specified elsewhere in the document) to SECI. SECI shall vet the data for any discrepancies and systemic errors and revert within 3 working days. Post the trial run period, the 30 days PR test will commence after communication from SECI in this regard.

(3) Pyranometer Tilt Angle & Cleanness: The pyranometers & Tilt Angle shall be verified before the test commences and **then visually inspected at regular intervals for cleanliness during the tests**.

(4) The average of all the Pyranometers (GTI) shall be considered for the calculation of PR. The average of module temperatures recorded by all the temperature sensors shall be used for calculation

of PR. The Pyranometers and Temperature sensors used for the purpose of the PR Test shall have valid calibration certificates.

2.1.4.2 Following the completion of the pre-test procedures, Performance Ratio Test of plant shall commence in accordance with the procedures, conditions and requirements provided in the next section.

2.1.4.3 General Procedure for the PR Test

The PR Test Procedure shall include the following components:

- Data Collection: PV Power Plant test related parameters are collected in one-minute and 15 intervals for the 30 (Thirty) days (consecutive) reference period. The data shall consist of the following at a minimum:
- Irradiance at Collector's (i.e. PV Module) POA; (Source: SCADA, Temporal Resolution: 1 minute)
- Other Met Data received from installed WMS; (Source: SCADA, Temporal Resolution: 1 minute)
- Energy generated at Plant (kWh) (Source: Plant MFM Meter from SCADA, Temporal Resolution: 1 minute)
- Energy injected into grid (kWh) (Source: Plant ABT Meter at GSS/injection point, Temporal Resolution: 15 minute)
- PV Module Temperature recorded from the temperature Sensors (oC) (Source: SCADA, Temporal Resolution: 1 minute)

(2) **Data Filtering:** The data shall be filtered so that the data set is free of nuisance data points and bad data that exhibit a high degree of error (such as errors caused by faulty instrumentation). The Contractor shall document the data which is to be eliminated along with reasons. The following criteria shall be excluded from the dataset used for this test:

- Nuisance or bad data – Nuisance data points or bad data that clearly exhibit a high degree of error including required meteorological measurement equipment that is identified as being out of calibration or requiring adjustment. A 15-minute time-block shall be explicitly flagged through a flag parameter on account of this factor after recording reasons thereof (Note: no filtration shall be done at site level). The same shall be corroborated/verified by SECI.
- Time blocks with insufficient (less than equal to 10) 1-minute records.

- Grid Interruptions – Time periods (in 15-minute time blocks) of the grid interruptions at the utility substation, recorded manually jointly by Contractor and SECI representatives shall be eliminated. Grid outage period, if any, shall be verified from SCADA.
- Any Force majeure conditions
- Radiation Criteria – Radiation on Plane of Array (POA) less than 200 W/m2
- Shutdown explicitly demanded by the Owner/DISCOM/STU.
- As per the hindrance record maintained at site.

Note: Minimum 24 Nos of 15-minute time blocks shall be considered to account the day for PR measurement. Otherwise the PR test shall be extended to another day.

2.1.5 Determination of PR Test

Daily PR shall be calculated as the average of the PR calculated for valid 15-minute time blocks (Refer Clause 0) for the 30-day duration. If the Contractor is not able to demonstrate guaranteed PR during this period, the two more chances shall be given to demonstrate the same after incorporation of suitable corrective measures. In case the contractor fails to achieve guaranteed PR even after the two more chances, further action shall be taken as per the provisions of contract.

The test shall be repeated for 30 days in case of any outage of following equipment for more than 7 days.

- Power Transformer
- Power Conditioning Unit
- HT Switchgear Panel
- SCADA and data logger combined
- Tilted pyranometer
- Other WMS sensors.

2.1.6 Raw Data Formats and Reports

The Contractor shall submit to SECI the raw data from the Plant SCADA on daily basis in the following format.

TEMPORAL RESOLUTION: 1 MINUTE

Date & dd/mm/yyyy hh:mm:ss format	Wind Speed (m/s)	Module Temp. (°C)	Ambient Temp. (°C)	Horizontal Irradiance (W/m²)	POA Irradiance (W/m²)	POA Radiation (kWh/m²)	Humidity (%)	Wind Direction (°)	Generation (kWh) (Source: TVM)

TEMPORAL RESOLUTION: 15 MINUTE (EVERY 15TH MIN RECORD FROM THE 1 MIN DATA)

Date & Time dd/mm/yyyy hh:mm:ss format	Wind Speed (m/s)	Module Temp. (°C)	Ambient Temp. (°C)	Horizontal Irradiance (W/m²)	POA Irradiance (W/m²)	POA Radiation (kWh/m²)	Humidity (%)	Wind Direction (°)	Generation (kWh) (Source: TVM)	Explicit Removal Flag* (0 or1)	Remarks

***** Explicit Removal Flag: 0 indicates time block considered; 1 indicates time block not considered.

PR Test Report shall be generated from the Raw Data (Sample Report provided in the Annexure) after data filtering as per criteria laid out in 0. The Report shall contain the signature of both representatives (SECI/Employer & Contractor).

2.2 CAPACITY UTILIZATION FACTOR

Capacity Utilization Factor for Solar Plant shall be calculated as per the following formula.

$$\mathbf{CUF} = \frac{\mathbf{E_{ac}}}{\mathbf{8760 \times P_{ac} \times (1 - DF \times N)}}$$

where,

Eac is the number of units recorded in the plant end ABT meter, kWh

8760 refers to the number of hours in non-leap year. It shall be replaced by 8784 hours during leap year

Pac is the plant AC capacity, kW

DF is module degradation factor, 0.7% per year

N is the number of years of operation after operational acceptance of the plant

CUF shall be calculated on annual basis from the date of operational acceptance of the plant till the end of O&M period.

It is the responsibility of the Contractor to build-in the expected variation of irradiance in their design by installing additional DC capacity to meet the committed CUF. Irradiance variation will not be considered for the calculation of CUF. The contractor has to consider minimum 30% additional capacity or higher as required on compete DC side.

Grid outage hours shall be subtracted from total number of hours in a year. The Contractor shall submit grid outage certification from component authority of STU/DISCOM.

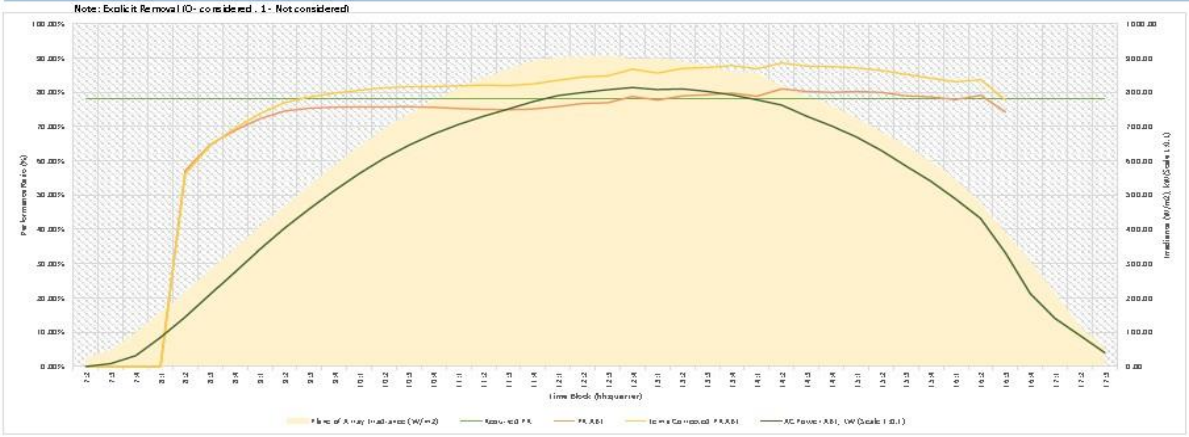
ReportsSample Report for PR Test

PR Guarantee Test Report

Day	20-Nov-2016	Criteria	>200	*Average POA Irradiance in a time block in W/m2*	
No. of Timeblocks considered	36 /42	Tot Gen	53694 kWh	*Source: ABT Meter at GSS*	
Plant PR for the day ABT	80.66%	*Average PR (temp corrected) of 15 min time blocks where POA irradience is greater than 200W/m2 and not explicitly removed*			
	(Guaranteed PR: 78%)				

Time Block (hh:Qtr)	Wind Speed (m/s)	Module Temp. (°C)	Ambient Temp. (°C)	POA Radiation (kWh/m2)	Plane of Array Irradiance (W/m2)	GHI (W/m²)	Humidity (%)	Wind Direction (°)	Generation ABT GSS (kWh)	AC Power ABT, kW (Scale 1:0.1)	PR ABT	Temp Corrected PR ABT	Explicit Removal
7:2	1.62	13.91	15.10	2.17	25.25	27.00	45.92	88.10	0.00	0.00	0.00%	0.00%	0
7:3	1.41	14.47	15.25	12.34	47.92	50.47	45.53	38.35	21.00	8.40	14.73%	14.10%	0
7:4	0.57	15.84	15.73	25.08	98.48	92.93	44.41	0.00	79.00	31.60	27.27%	26.24%	0
8:1	0.26	17.73	16.01	39.51	156.11	143.67	44.55	0.00	212.00	84.80	46.45%	45.07%	0
8:2	0.66	20.64	17.01	54.73	216.78	193.67	42.19	0.00	361.00	144.40	57.10%	56.08%	0
8:3	0.43	24.09	17.94	70.40	279.62	245.80	40.17	0.00	526.00	210.40	64.69%	64.45%	0
8:4	0.71	27.22	18.85	86.46	343.62	291.80	38.39	0.00	688.00	275.20	68.90%	69.52%	0
9:1	0.71	29.93	19.74	102.34	407.36	348.47	36.74	0.00	854.00	341.60	72.25%	73.71%	0
9:2	0.71	32.98	20.73	117.25	466.99	398.00	35.17	0.00	1009.00	403.60	74.51%	76.95%	0
9:3	0.80	35.60	21.52	132.29	527.14	445.27	33.94	0.00	1151.00	460.40	75.33%	78.61%	0
9:4	0.74	38.17	22.31	146.86	585.56	486.27	32.98	0.00	1283.00	513.20	75.64%	79.72%	0
10:1	0.87	40.55	23.23	160.77	641.34	516.87	31.86	0.00	1406.00	562.40	75.72%	80.54%	0
10:2	0.93	42.99	24.08	173.62	692.91	540.33	31.13	0.00	1518.00	607.20	75.70%	81.28%	0
10:3	0.99	43.78	24.78	184.38	736.02	559.67	30.67	0.00	1613.00	645.20	75.74%	81.57%	0
10:4	1.18	44.44	25.53	194.12	775.43	576.53	29.87	12.76	1695.00	678.00	75.60%	81.63%	0
11:1	1.05	46.52	26.17	203.12	811.43	593.60	28.97	0.00	1765.00	706.00	75.23%	81.87%	0
11:2	0.89	48.11	26.74	210.57	841.02	609.07	28.28	0.00	1824.00	729.60	75.00%	82.10%	0
11:3	1.51	47.95	27.61	217.05	867.66	624.60	26.97	0.00	1877.00	750.80	74.87%	81.92%	0
11:4	2.03	48.74	28.04	222.77	890.54	642.47	25.69	76.95	1932.00	772.80	75.09%	82.40%	0
12:1	1.61	49.61	28.91	225.54	902.04	656.13	24.24	0.00	1975.00	790.00	75.82%	83.47%	0
12:2	2.03	49.58	29.45	225.55	902.30	664.40	22.97	129.40	1998.00	799.20	76.69%	84.42%	0
12:3	2.34	49.79	29.73	227.09	907.75	672.60	21.62	131.02	2018.00	807.20	76.94%	84.75%	0
12:4	2.48	49.66	29.92	223.65	895.29	671.87	20.71	96.20	2034.00	813.60	78.74%	86.70%	0
13:1	2.10	49.70	30.20	224.96	899.51	670.93	18.75	0.00	2019.00	807.60	77.71%	85.57%	0
13:2	2.32	49.80	30.31	222.11	889.25	665.80	18.11	22.42	2024.00	809.60	78.90%	86.92%	0
13:3	2.59	49.39	30.42	219.07	877.23	648.13	17.75	219.19	2005.00	802.00	79.24%	87.17%	0
13:4	2.22	49.55	30.70	215.00	859.72	630.67	17.39	0.00	1980.00	792.00	79.73%	87.76%	0
14:1	1.87	49.88	30.98	213.62	855.38	620.80	16.27	0.00	1944.00	777.60	78.79%	86.83%	0
14:2	2.27	47.80	31.28	203.86	816.52	584.27	16.13	19.15	1906.00	762.40	80.95%	88.51%	0
14:3	2.30	47.34	30.99	196.95	788.89	548.20	16.46	38.30	1825.00	730.00	80.23%	87.58%	0
14:4	2.05	47.88	31.01	189.95	760.16	520.20	16.53	7.33	1754.00	701.60	79.95%	87.45%	0
15:1	1.75	45.99	31.44	180.73	724.65	484.80	15.75	0.00	1674.00	669.60	80.19%	87.10%	0
15:2	2.30	44.51	31.33	170.69	684.26	442.27	15.51	95.39	1576.00	630.40	79.94%	86.34%	0
15:3	2.10	44.35	31.19	160.33	642.47	402.40	15.57	28.93	1462.00	584.80	78.95%	85.21%	0
15:4	2.33	41.86	31.19	148.67	596.65	358.47	15.41	45.73	1350.00	540.00	78.62%	84.06%	0
16:1	1.91	41.25	31.19	135.70	544.70	311.80	15.33	90.91	1220.00	488.00	77.84%	83.02%	0
16:2	2.37	38.99	31.12	118.23	475.45	255.73	14.96	5.47	1080.00	432.00	79.09%	83.62%	0
16:3	2.57	36.66	30.95	96.68	389.67	195.27	15.01	86.82	829.00	331.60	74.24%	77.79%	0
16:4	1.60	34.83	30.62	70.86	306.83	143.86	15.44	76.91	531.00	212.40	64.88%	67.50%	0
17:1	1.56	32.61	30.19	52.45	212.88	92.47	15.59	63.97	350.00	140.00	57.78%	59.58%	0
17:2	1.75	29.57	29.68	26.61	117.56	48.14	15.94	103.66	226.00	90.40	73.53%	74.91%	0
17:3	0.84	27.22	28.80	4.19	52.66	21.40	16.82	0.00	100.00	40.00	206.71%	208.59%	0

Note: Explicit Removal (0- considered , 1- Not considered)



7. ANNEXURE B

BILL OF MATERIAL 5 MW GROUND MOUNTED SOLAR FARM - DESIGN, PROCUREMENT, INSTALLATION, COMMISSIONING & TESTING JOB			
Sr. No.	**Description**	**Unit**	**Quantity**
1	Solar Modules: - Solar Modules Of 325 Wp Capacity Manufactured On Automated Production Lines With 18.3 % Cell Efficiency.	Nos.	20020
2	Module Mounting Structure:- 2.5mm Thickness Minimum 120 micron Minimum HDGI	Ton	2600
3	Power Conditioning Unit (Inverters) :- String Inverter Above 98.2 % Efficiency Inverter. Max 10% Overloading. Min 50 KW to Max 100 KW ONLY	Nos.	66 to 132
4	Whether Monitoring System with Minimum features of wind monitoring system, weather forecasting system, pyrometer, Irradiation, Mod Temp and Amb Temp	Nos.	1 + 1 standby
5	DC cables - 1C x 4 or 6 sq mm Tin Copper Solar Cable 1.1kV (Array to Inverter)	M	320000
6	Earthing Cable (Green) - 1C x 6 Sq.mm Cu conductor, PVC 1.1kV	M	6500
7	Interconnecting cables - Communication Cable - RS485 (2 Pair)	M	4000
8	Earthing Kit Complete (600x600*3.15 cu plate Earthing at 2.25 mtr)	Nos.	125
9	Lightning Arrester confirm to latest IS	System	1
10	Cu strip 20x3 for earthing	M	4200
11	Accessories & All The Necessary Equipment MC4 connector, cable Tie, Cable Lugs, Gland, SPDs, SMBs Etc.	LS	1
12	HDPE Pipe 50mm	M	2250
13	Optimizer	Nos.	5005
14	Armoured XLPE Copper & Aluminium AC Cables as required from Inverter to AJB / Panel & AJB/Panel to Panel including laying, termination etc.	LS	1
15	LT PANELs as required from Inverter to Main LT Panel	Nos.	14 to 28
16	Main LT Panel	Nos.	1
17	Auxiliary supply panel as required	Nos.	1

18	Data Logger: Daily Power Generation and Consumption made available through ethernet. Monthly Report of Generation Will Be Forwarded On Selected Email Id's	Nos.	10
19	Complete SCADA System with Pc and License Software etc	Set	1
20	DISCOM Approved Metering System - Solar Generation & Net Meter	Set	1
21	UPS in n+1 formation with 2 hours Battery Backup	Nos.	2
22	External Lighting & Security Lighting with cabling, panel etc	LS	1
23	Module Cleaning Arrangement	Set	1
24	Comprehensive Operation & maintenance contract Beyond the Guarantee Period For Equipment Supplied.	Year	5

Note:

1.) **Above BOQ is provided for ready reference only, contractor has to consider additional items, quantity, scope, costs as may be required to complete the project as defined intent in tender document & as required to complete the system in all manner.**

2.) **Intent of this BOQ is to describe the system component requirements in brief & hence contractor may us enhance products keeping minimum technical criteria given in above line items.**

3.) **Contractor to provide a complete detail line item BOQ for the system designed by their team for review & approval.**