



**TENDER DOCUMENT**

**Tender No. OC10000195/ASH**

**Techno-Commercial Conditions of  
Tender**

# 1MWp SOLAR POWER PLANT at NRL (LSTK)

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# 1MWp SOLAR POWER PLANT at NRL (LSTK)

## 1. PREAMBLE

### 1.1. NAME OF JOB

Supply, Installation, Testing and Commissioning (SITC) on LSTK Basis of 1MWp SOLAR POWER PLANT at Numaligarh Refinery Limited (NRL), Golaghat, Assam.

### 1.2. ABOUT THE COMPANY

NRL is a group company of Bharat Petroleum Corporation Limited. Numaligarh Refinery is located at Numaligarh, District Golaghat, Assam with a capacity of 3 MMTPA. It has in-house captive power generation along with emergency DG backup for various process plants & utilities of refinery. As a good corporate citizen and in furtherance of its commitment towards renewable energy obligation, NRL is planning for installation of a 1.0 MWp Solar Power Plant inside its premise in Numaligarh with the added intent of promoting Government of India's "Make-it-India" initiative.

### 1.3. GENERAL SCOPE OF WORK

- i. Bids are invited for supply, installation, testing, commissioning (SITC) and comprehensive maintenance contract (CMC) of minimum 1.0 MWp Solar Power Plant project on Lump sum Turnkey (LSTK) basis. **The maximum annual generation of power shall not be below 1620 MWh/year** (to be measured at feeder at substation i.e. grid end). The annual average solar insolation level at NRL is to be considered from the published data by NASA/ NREL.
- ii. The general scope of work involves design, engineering, supply, transportation, shifting, installation, testing, commissioning, construction, maintenance on turnkey basis of the grid-connected solar photovoltaic power plant and evacuation of power into the allocated feeder of electrical substations. The scope comprises SITC of SPV modules, support structures, trackers, junction boxes, grid-tied inverters, meters, control panel, power conditioning, hookup with substation feeder, isolation transformers, interconnections, wires, cables, bus bars, plant lighting system, remote monitoring and control hardware and software, protective devices, safety equipment and systems, drainage, cleaning system, site grading, fencing, signage, etc.
- iii. The work is on "turnkey" basis i.e. any material, service or works including any civil, electrical or other work, which is not expressly mentioned or included in this tender document but which is otherwise necessary for the complete commissioning and regular operation of the plant, shall be deemed to be included in the scope of work and supply.

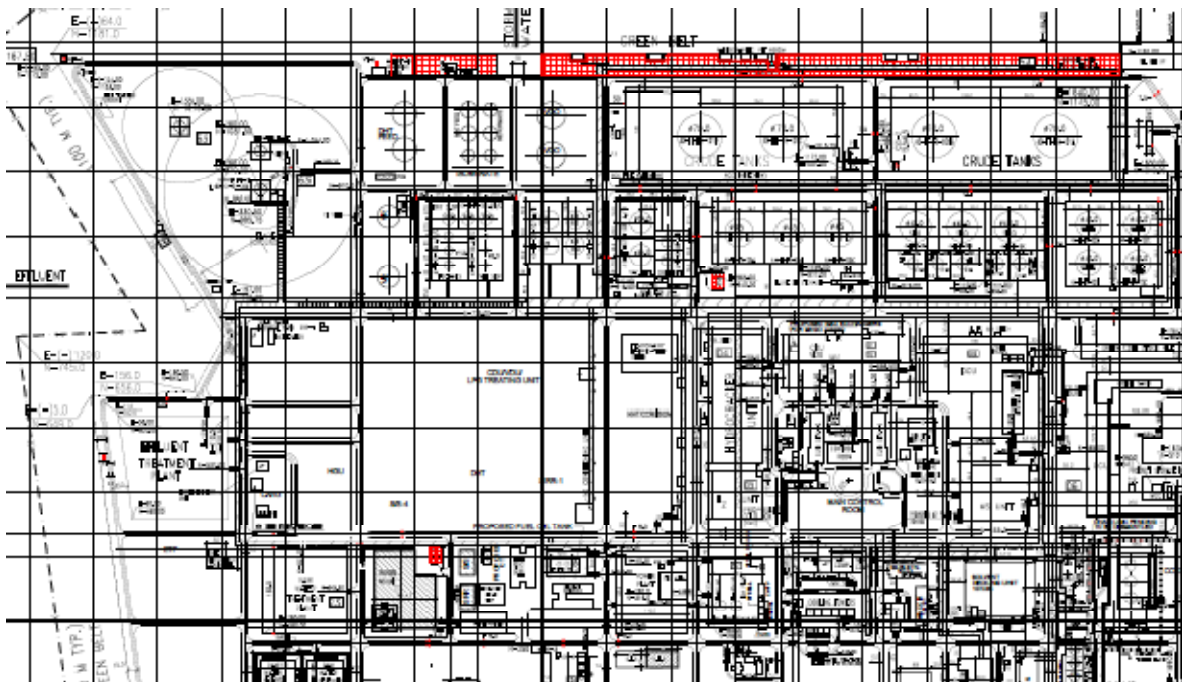
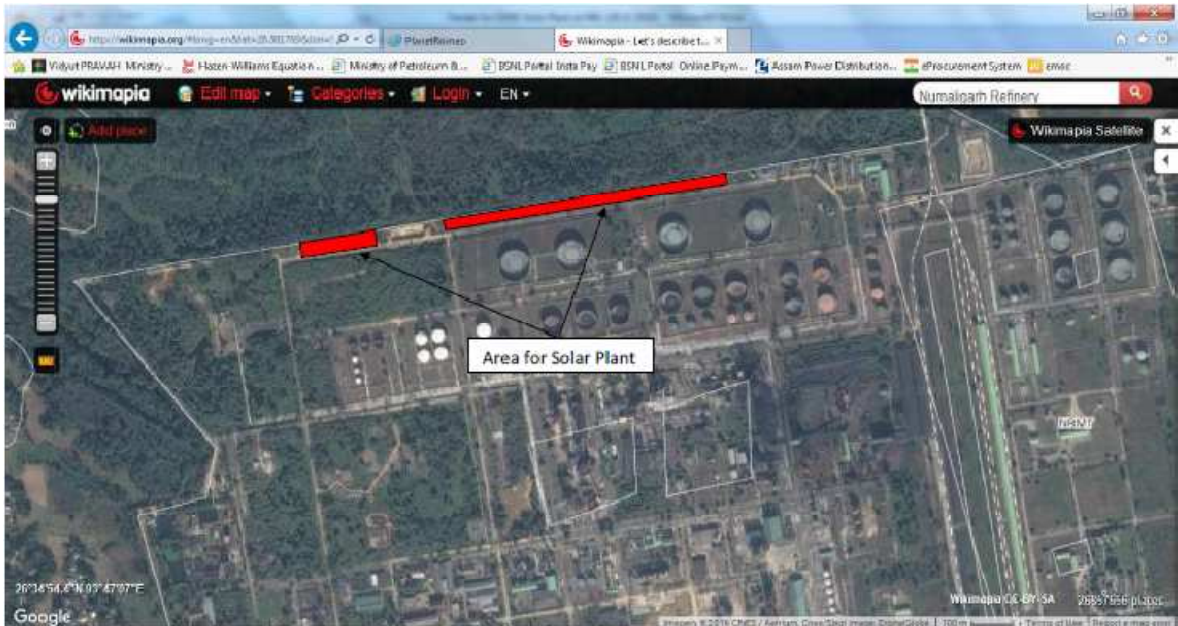
### 1.4. LOCATION OF SOLAR PLANT

- i. NRL has identified a few potential Ground Mounted and Roof Top areas for installation of SPV Panels. In the first phase, for the current tender, NRL will install the panels in Ground at the location marked in the images below. Out of the total available land, 5 acres is offered for the. As Solar Power generation per square meter area depends on the efficiency of the SPV panels, the actual generation capacity of the earmarked area may be higher. As such, the bidder has to indicate maximum capacity of the Solar Power plant which can be accommodated in the area. Accordingly, bidder has to quote separately for:
  - A. 1.0 MWp Solar Power Plant
  - B. Every incremental 100 KWp Solar Power Plant

Terms and conditions of contract shall remain same for incremental capacity increase.

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ii. **Figures showing area earmarked for solar power plant**



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### 1.5. SITE INFORMATION

Plant Location	:	Pankagrant, Numaligarh
Co-ordinates	:	26°37'30" N, 93° 43'30"E
District / State / Country	:	Golaghat / Assam / India
Nearest Railway Station	:	Golaghat
Nearest Airport	:	Jorhat
Nearest Sea Port	:	Kolkata
Nearest National Highway	:	NH-39

### 1.6. METEOROLOGICAL & EQUIPMENT DESIGN DATA

*Some of the relevant meteorological design data required towards preparing engineering specifications are furnished for reference only and bidder has independently crosscheck the same for design and engineering. The design criteria shall match or exceed the meteorological design data.*

Elevation above mean sea level	:	90m
Ambient temperature	:	5°C(min), 38°C(max) (Design at 40°C)
Relative humidity	:	85% max (Design at 100% at 40°C)
Rainfall	:	(a) for 1hr period: 90mm (b) for 24hr period: 160mm
Wind Data:	:	(a) Velocity: 36-140 km/hr, (b) Prevailing wind direction: NE to SW
Earthquake Design Criteria	:	Seismic Zone V (IS:1893)

### 1.7. ELECTRICAL SYSTEM

Captive generation (11kV)	:	30 MW GTG (Gas Turbine Generator) – 2nos
	:	12.5 MW STG (Steam Turbine Generator) – 1 no
Emergency backup DG(415V)	:	1 MW DG (Diesel generator)- 2nos
	:	0.5 MW DG (Diesel generator)- 2nos

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Evacuation of PV Power : 500 KW each at Substation 3 and 5

Hazardous Area classification : Safe Area

**Evacuation of power will be at 500kW each to the two substations highlighted in the plot diagram. Both the two parts shall be capable of independent operation and evacuation of power.** The list of available feeders is mentioned below. Only one feeder will be allocated in each substation. The scope of work shall include connecting the PV generation to these two substations including installation of any additional protection required for synchronization and parallel operation of existing captive generation and proposed solar generation of power. The repair and refurbishment of feeder and already existing relays, protection and switchgear will be in NRL scope.

Substation 5 : PCC 314 Make : GEC Alsthom India Ltd.  
Bus Rating: 2000A, 415V, 50kA(1sec)  
Distance from Solar plant : 600 mtr  
Feeder rating: 800A(3ph-4W)  
*2 feeders each are available on left bus & right bus*

Substation 3 : PCC 313 Make : Control & Switchgear,  
Bus Rating: 3000A, 415V, 50kA(1sec)  
Feeder rating: 1000A(3ph-4W)  
*1 feeders each are available on left bus & right bus*

Grid Specifications : 3phase AC, 415 Volts +/- 10%, , 50 Hz +/-3%

### 1.8. EXECUTING AUTHORITY

Project department of NRL will be the executing authority. General Manager(Project) or his sub-delegated authority shall be the Engineer In Charge (EIC) of the project. All post-order technical correspondence shall be addressed to the EIC.

### 1.9. DISCLAIMER:

The site data provided by NRL are indicative only and vendor should mandatorily visit the plant location and verify the site conditions independently prior to his participation in the bidding process (and prior to any design and engineering). Vendor shall check the space availability, wind speed, safety aspects as well as feasibility of the implementation of the offered technology and technical specifications of the tender. All specifications mentioned in this tender indicates minimum technical requirement. During the pre-bid meeting, vendor may propose alternate specifications or design though the final acceptance of the same rests with NRL. The vendor shall be solely responsible for feasibility of the plant to meet the performance parameters of the tender.



# 1MWp SOLAR POWER PLANT at NRL (LSTK)

## 2. SOLAR PHOTO VOLTAIC (SPV) MODULES

### 2.1. GENERAL REQUIREMENT

- i. The total SPV array capacity should not be less than 1 MWp and should comprise of multi- crystalline SPV modules. SPV modules should be manufactured in India in a plant certified under ISO 9001: 2008 & ISO 14001 and also type tested by any of the IEC / NABL accredited test laboratories. These shall conform to the latest editions of IEC: 61215 (Edition-2), IEC: 61730 – I&II(2007), IEC: 61701.
- ii. The PV modules shall be equipped with bypass diode(s) to minimize power drop caused by shade.
- iii. The PV modules shall be of latest technology, and shall incorporate all features anti-reflection coating, etc., to increase conversion efficiency.
- iv. The SPV module shall perform satisfactorily in relative humidity up to 100% with temperature between -40°C to +85°C and shall withstand adverse climatic conditions, such as high speed wind, blow with dust, sand particles, saline climatic / corrosive soil conditions. All materials used for manufacturing SPV module shall have a proven history of reliability and stable operation in outdoor applications.
- v. All SPV modules should carry a performance warranty of >90% during the first 10 years, and >80% during the consecutive 15 years. Further, module shall have performance warranty of > 97.5% during the first year of installation.

### 2.2. IDENTIFICATION & TRACEABILITY

- i. The Vendor shall provide to NRL the data sheets of all modules which shall generally have uniform ratings. Modules only with the same rating shall be connected to any single inverter. The exact power of the module shall be indicated if the data sheet consists of a range of modules with varying output power. NRL reserves the right to inspect the modules at the manufacturer's site prior to dispatch. The Vendor would be required to maintain accessibility to the list of module IDs along with the above parametric data for each module. Traceability of the origin of SPV cells and modules shall be established by referring to unique module ID.
- ii. Each SPV module must use Identification tag (RFID) as per MNRE, which must contain the following information (encapsulated in the manner so as not to cast shadow on the active area and to be clearly visible from the top):

Name of manufacturer of PV module.
Name of the manufacturer of solar cells.
Month & year of the manufacturer (separately for SPV module & solar cell).
Country of origin (separately for module & solar cell).
I-V curve of the module.
Peak wattage, Im, Vm, FF, Isc, Voc & Temperature co-efficient of power for the module
Unique serial No & Model No of the module.
Date & year of obtaining IEC SPV module qualification certificate.
Name of the Test Lab issuing IEC certificate.
Other relevant information on traceability of solar cells and module as per ISO 9001 and ISO 14001.



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### 2.3. TECHNICAL SPECIFICATIONS OF PV MODULE

i. Vendor to mention their offered specification alongside

Technology	Multi crystalline silicon solar PV cells
Nominal Power Output (W)	310 Wp
Power tolerance (W)	0 to +5% (No negative tolerance)
Module efficiency (%)	15%
Voltage at P Max V mpp (V)	37.3
Current at P max I mpp (A)	8.33
Open-circuit voltage Voc (V)	45.1
Short circuit current I <sub>sc</sub> (A)	8.91
Nominal Operating Cell Temperature (°C)	47+/-2
Fill factor (min)	70%.
Module Dimensions LxWxH (mm)	To be provided by vendor
Module weight (kg)	To be provided by vendor
Nos of cells & size	To be provided by vendor
Frame material	Anodized aluminum (or other approved corrosion resistant material, which shall be electrolytically compatible with the structural material used for mounting the modules and with sufficient no. of grounding.)
Junction Box	Conforming to IP65 standards and IEC 62208
Cable type	Conforming to IEC 60227/IS 694 & IEC 60502/I1554 shall be 1.1 Kv grade as per requirement.

ii. Other general requirement for the PV modules and subsystems shall be as follows:

- Raw materials and technology employed in the module production processes shall have to be certified and a certificate giving details of major materials i.e. cells, glass, back sheet, their makes and data sheets to be submitted for the modules being supplied by the bidder.
- No negative tolerance of the rated output power of any supplied module shall be acceptable. However, in case of less than three technically acceptable bids ( or where such deviations approved in pre-bid) , tolerance of +/- 3% as per MNRE standard specs shall be permitted.
- Except where specified, the front module surface shall consist of impact resistant, low-iron and high-transmission toughened glass.
- The module shall be provided with a junction box with either provision of external screw terminal connection or sealed type and with arrangement for provision of by-pass diode. The box shall have hinged, weather proof lid with captive screws and cable gland entry points or may be of sealed type and IP65 rated and above.

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### 3. TRACKING & MODULE MOUNTING STRUCTURES (MMS)

#### 3.1. TRACKING:

- i. Fully automatic dual axis trackers shall be installed for deriving maximum power from the installed capacity. The angle should be systematically optimized for maximum energy generation throughout the year based on location and local weather variables for each module.

#### 3.2. MODULE MOUNTING STRUCTURES

- i. Vendor shall design fabricate, supply and install module mounting structures with all required accessories like clamps, nuts, bolts, cable ties etc. Modules shall be clamped / bolted with the structure properly. The material of construction shall be GI / Al / Steel. Clamps / bolts shall be designed in such a way so as not to cast any shadow on the active part of a module. All the materials used shall be corrosion proof. The array structure shall be so designed that it will occupy minimum space without sacrificing the output from SPV panels. It should withstand severe cyclonic storm with maximum wind speed mentioned in site data.
- ii. The MMS should be safe, and designed to allow easy replacement of any module and easy access to the Maintenance staff. It should be designed for simple mechanical and electrical installation, should support SPV modules at a given orientation, absorb and transfer the mechanical loads to the ground properly and there should be no requirement of welding or complex machinery at site.
- iii. Modules shall be mounted on a non-corrosive support structures. Modules shall be isolated electrically from the MMS through EPDM sheet of appropriate thickness and all the modules shall be separately earthed through proper earthing. Module mounting structures shall also be earthed through proper separate earthing.
- iv. The frames and leg assemblies of the array structures shall be made of hot dip Galvanized steel per ASTM A123. Inner side should also be completely galvanized. Galvanization should be done after fabrication. In case of any site welding required to be done after galvanization, adequate corrosion protective should be provided and only after prior knowledge and consent of EIC. In case of alternatives to galvanization, same to be proposed on or before the pre-bid.
- v. All fasteners shall be of Stainless steel - SS 304. Nut & bolts, supporting structures including the entire MMS shall have to be adequately protected against all climatic condition.
- vi. Mounting structure should also be equipped with suitably designed spikes (or alternatives) at its high end to avoid bird standing.
- vii. Each MMS shall have a provision to manually adjust its angle of inclination as per the site conditions. The facility of locking the panels at a fixed angle should be provided for each panel in the structure such that the angle shall not be disturbed by wind or weather conditions (within the limits specified in site conditions). Maximum permissible height of trackers will be 3 meters from the finished floor.
- viii. Design shall incorporate special rain protection arrangements of all movable parts of the tracking arrangement like motors, solenoids, pistons/plungers, extensions which are likely to wear out relatively faster when exposed to continuous rain. All equipments in tracking and MMS (including tracking motors) shall be IP65.

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- ix. The MMS should be designed to meet the offered performance for a minimum working life of 25 years. The material of construction, structural design and workmanship shall be appropriate with a factor of safety of not less than 1.5.
- x. For multiple module mounting structures located in a single row, the alignment of all modules shall be within an error limit of 10 mm in vertical /horizontal line.
- xi. The Vendor shall provide to NRL the detailed design, specifications and calculations of the MMS and take approval from client/consultant. The vendor shall specify installation details of the PV modules and the support structures with appropriate diagrams and drawings. Such details shall include, but not limited to, the following:
  - Determination of true south at the site;
  - Array tilt angle to the horizontal, with permitted tolerance.
  - Details with drawings for fixing the modules.
  - Details with drawings of fixing the junction/terminal boxes.
  - Interconnection details inside the junction/terminal boxes.
  - Structure installation details and drawings.
  - Electrical grounding (earthing).
  - Inter-panel/Inter-row distances with allowed tolerances and safety precaution to be taken.

### 3.3. CIVIL

- i. Vendor shall design and construct appropriate civil foundations for MMS and any other relevant structure. The vendor should design the structure height considering highest flood level at the site. The Bidder shall be permitted ramming of the module mounting structure provided that they obtain prior consent of EIC. EIC shall provide such consent once it is established that such ramming shall not in any way deteriorate the strength of the structure during its working life of 25 years.
- ii. Civil foundation design for Module Mounting Structures (MMS) as well as control room/ inverter room shall be made in accordance with the Indian Standard Codes and soil conditions, with the help of Chartered Structural Designer having substantial experience in similar work. The Vendor shall submit the detailed structural design analysis along with calculations and bases/ standards after award of job for review and approval by NRL. A typical foundation drawing of manufacturer shall be submitted with bid. Increase in foundation size, reinforcement, etc during review shall be to vendor's account.
- iii. Irrespective of design requirement, the minimum vertical clearance between the lower edge of the module and the adjacent road shall be 800 mm i.e. the combined height of pavement and supporting structure should be such that the SPV modules are atleast 800mm above the adjacent road.
- iv. The Bidder shall submit in details the specifications, designs, guarantees and warranties and any other claims on performance / output of the solar tracking solutions in the Bid document.

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## 4. POWER CONDITIONING UNIT (PCU)

### 4.1. GENERAL REQUIREMENT

- i. Power Conditioning Unit (PCU) shall consist of a Grid Tie inverter along with associated control, protection and data logging devices and remote monitoring hardware and software. The total capacity should be 1 MVA or above. The PCU should be Hybrid with MPPT (maximum power point tracker) system and required protection conforming to IEC/IS 61683, IEC 60080-2 (1,2,14,30) / Equivalent BIS std for feeding power to the grid.
- ii. The PCUs shall convert DC power produced by SPV modules into AC power and shall have automatic voltage & frequency adjustments to suit the local grid conditions. It should have provision for battery back-up (battery not included in scope).
- iii. Only those PCUs/ Inverters which are commissioned for more than 1 MWp capacity SPV projects till date shall be considered for this project. Bidder has to provide sufficient information to the satisfaction of NRL before placing the final order for PCUs/Inverters.

### 4.2. INVERTER REQUIREMENTS

- i. Grid Connectivity: Statutory electricity regulations and grid code as amended and revised from time to time shall be complied. The system shall incorporate a unidirectional inverter and should be designed to supply the AC power to the grid at load end. The power conditioning unit shall adjust the voltage & frequency levels to suit the Grid i.e. should have built grid synchronizing circuit which automatically follows and synchronizes output to internal grid. This shall be achieved by sensing the grid voltage and phase (by drawing power lines for reference from respective substations) and feeding this information to the feedback loop of the inverter. Thus control variable then controls the output voltage and frequency of the inverter, so that inverter is always synchronized with the grid. No separate synchronizing panel should be required. All three phases shall be supervised with respect to rise/fall in programmable threshold values of frequency. This should be capable of synchronizing in maximum 1 Minutes. The inverter output shall always follow the grid in terms of voltage and frequency.
- ii. Grid Tie Inverters shall be 3 phases, 415V AC output with a minimum of 100KW capacity each which shall operate at very high efficiency (above 96%) to convert DC from PV array to AC and synchronize with the LT grid. It utilizes an inverter module to operate in grid interactive mode to export power generated by the solar arrays directly into the local grid supply.
- iii. The inverter should have inbuilt Filter (or installed additionally) for limiting the Total Harmonic Distortion (THD) such that grid remains protected. Harmonic content should be declared in offer and design of filter should be supported by calculations or demonstrated in FAT itself. The requirement of Galvanic Isolation at grid may be waived off on confirmation of suitable filter design of sufficient capacity to avoid any harm to the grid.
- iv. MPPT : Maximum power point tracker shall be integrated in the PCU to maximize energy drawn from the array. The MPPT should be micro processor based to minimize power losses. The details of working mechanism of MPPT shall be mentioned. The MPPT must have provision (manual setting) for constant voltage operation. The MPPT unit shall conform to IEC 62093 for design qualification.

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### 4.3. OPERATIONAL REQUIREMENTS

- i. **MODE :** The PCU must have the feature to work in tandem with other similar PCU's and be able to be successively switched "ON" and "OFF" automatically based on solar radiation variations during the day. Automatic sleep mode shall be provided so that unnecessary losses are minimized at night. The power conditioner must also automatically re-enter standby mode when threshold of standby mode reached. The system shall automatically "wake up" in the morning and begin to export power provided there is sufficient solar energy and the grid voltage and frequency is in range. **Stand – By Mode:** The control system shall continuously monitor the output of the solar power plant until pre-set value is exceeded & that value to be indicated.
- ii. **MANAGEMENT FUNCTIONS:** PCU should have Comprehensive network management functions including the Low-Voltage Ride Through (LVRT), or Fault Ride Through (FRT), and capability to inject reactive power to the grid). The PCU shall be capable of controlling power factor dynamically. The output power factor of the PCU should be of suitable range to supply or sink reactive power. The power conditioner must be entirely self-managing and stable in operation. A self-diagnostic system check should occur on start up. Functions should include a test of key parameters on start up.
- iii. **PROTECTIONS:** The PCU shall include appropriate self-protective and self-diagnostic feature to protect itself and the PV array from damage in the event of PCU component failure or from parameters beyond the PCU's safe operating range due to internal or external causes. The self-protective features shall not allow signals from the PCU front panel to cause the PCU to be operated in a manner which may be unsafe or damaging. Faults due to malfunctioning within the PCU, including commutation failure, shall be cleared by the PCU protective devices. In addition, it shall have following minimum protection against various possible faults. The PCU shall have internal protection arrangement against any sustained fault in the feeder line and against lightning in the feeder line. PCU shall have arrangement for adjusting DC input current and should trip against sustained fault downstream and shall not start till the fault is rectified. DC lines shall have suitably rated isolators to allow safe start up and shut down of the system. Circuit breakers used in the DC lines must be rated suitably.

### 4.4. SITE REQUIREMENTS

- i. **HOUSING & CANOPY :** The PCU shall be tropicalized and design shall be compatible with conditions prevailing at site. PCU shall have provision of exhaust fan and proper ducting for cooling of PCUs considering the climatic condition of the site. The housing shall be Compact and weather proof for direct use in the outdoors. No air-conditioning facility should be required to be part of the solar plant. Canopy shall be provided above the PCU which shall also be sufficient for sheltering the field maintenance personnel during operation and maintenance of the solar plant. Nuts & bolts and the PCU enclosure shall have to be adequately protected taking into consideration the atmosphere and weather prevailing in the area.

### 4.5. TECHNICAL SPECIFICATIONS:

- i. At least two separate PCUs are envisaged which shall be independent and standalone. The PCUs shall have the following minimum specifications. Bidders are required to mention their offered specification alongside.

1	Nominal DC array Input voltage	To be filled up based on the capacity of PV plant
2	DC array Input operating voltage	-20% to +15% of DC array input voltage in sl.no.1
3	Type of Solar Charge controller	MPPT based solar charge controller.

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4	Switching device	MOSFET /IGBT based (Sinusoidal current modulation with excellent dynamic response. The inverter shall be self commutated with Pulse Width Modulation - PWM).
5	Continuous Inverter output rating	Equal to capacity of PV plant to be mentioned in KVA.
6	Out Put Wave form	Pure sine wave
7	THD (Total Harmonic Distortion)	< 3% with resistive load.
8	Output voltage	415+/- 5% ,3 Phase AC
9	Out Put frequency	50Hz+/- 3%.
10	Power Factor	0.8 lag- 0.8 lead (adjustable)
11	PCU efficiency	>96% at nominal voltage & power. (as per IEC 61683)
12	Idle current	No load loss < 1% of rated loss in sleep mode < 0.05% of rated
13	Regulation	Line regulation & load regulation -2%
14	Overload feature	150% for 1 minute
15	Cooling	Forced air cooling, with temperature controlled cooling fan
16	Operating temperature	0-50 degree C
17	Relative humidity	95% maximum (non- condensing)
18	LED/LCD display	Display shall indicate system functional parameters and protection functional indicator
19	Remote Data monitor, display & controls	RS485,Ethernet or Rs 232 connectivity
19	Local display & monitoring	LCD display or equivalent 1 DC input power, voltage & current 2 AC output power, voltage & current (3 ph – Line) 3 Power Factor 4 Graph display for daily recording KW vs. Clock, peak KWHr generation, cumulative generation record from commissioning (Preferable) 5 Cooling Fan failure (If provided)
20	Protection	1 AC output Under/over voltage, 2 Low/High frequency, 3 Grid input under voltage/over voltage with auto recovery, 4 Short circuit 5 Over current 6 Over temperature, 7 DC Input overvoltage, 8 DC disconnect device, 9 DC reverse polarity 10 Anti islanding (IEEE 1547/UL 1741/ eqv. BIS) 11 Earth Leakage Fault 12 Surge Protection (from input, output, ground and communication signals)
21	Enclosure Protection	IEC 529 : IP 65 IEC- 60068-2 (environmental testing) IEC- 60721-3-3 : 3C2(Chemically active substances 3S2 (Mechanically active substances)
22	Safety	1. IEC 62103

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		2. IEC 62109, EN 50178, eqv. DIN or eqv UL 3. Galvanic Isolation at Input & output through transformer
22	Standard dimension and weight	Bidder to confirm

### 4.6. PLANT METERING/DATA LOGGING :

- i. PV array energy production: Digital Meters to log the actual value of AC/DC Voltage, Current & Energy generated by the PV system shall have to be provided.
- ii. Solar Irradiance an integrating pyranometer (Class II or better) should be provided with the sensor mounted in the plane of the array. Readout should be integrated with data logging system.
- iii. Wind Speed: An integrated wind speed measurement unit is provided.
- iv. Temperature Sensor: Integrated temp, sensors for measuring the module surface temp., inverter inside enclosure temp, and ambient temp to be provided complete with readouts integrated with the data logging system.
- v. One Energy meter each is to be installed in the respective substation feeder. The energy meter shall comply to the existing energy management software of NRL. Accordingly, the energy meter should be same as existing or compatible and equivalent to existing systems. Performance measurement of the system shall primarily be based on the data recorded in these energy meters.
- vi. List of data which shall be monitored by the solar log/Web log for all inverters are as below (Parameters which are listed for local display in the PCU are to be complied. In case of deviations, display in remote data logging can also be considered subject to prior approval of deviation.)

1	DATA UNIT (Vendor to confirm compliance)
2	Last Update Time: sec
3	Inverters status: On/Off
4	Power AC (Pac) :Watts
5	Power DC (Pdc) :Watts
6	Voltage AC (Vac): Volts
7	Voltage DC (Vdc): Volts
8	Temperature : °C
9	Daily Energy :kWh
10	Monthly Energy : kWh
11	Yearly Energy : kWh
12	Cumulative Energy: kWh
13	Solar-Irradiation : m2/W
14	Module temp. : °C
15	Ambient temp. : °C
16	Wind speed : m/s



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### 5. CABLE, WIRES, JUNCTION BOX, DISTRIBUTION BOARDS

#### 5.1. DC CABLES

- i. The DC Cables in a solar PV plant are to be used in the following areas
  - A. Interconnecting SPV modules
  - B. From SPV Modules upto String Monitoring Unit(SMU)
  - C. From SMU upto the Inverter.
- ii. DC CABLES (Interconnecting SPV MODULES and from SPV Modules TO SMU)
  - Cables used for inter-connecting SPV modules as well as Modules to SMU's shall conform to the requirements of TUV specification 2 Pfg 1169/08.2007 applicable for DC cable for photovoltaic system. These cables shall meet the fire resistance requirement as per TUV specification 2 Pfg 1169/08.2007 and shall be electron beam cured. In case 1500 V modules are used, the module inter-connecting wires shall be as per 2Pfg 1190/05.12
  - All cables except module cable used for (+) ve and (-)ve shall have distinct color identification.
  - In addition to manufacturer's identification on cables as per TUV, following marking shall also be provided over outer sheath.
    - (a) Cable size and voltage grade
    - (b) Word 'FRNC' at every 5 metre
    - (c) Sequential marking of length of the cable in metres at every one metre
  - The Printing shall be progressive, automatic, in line and marking shall be legible and indelible.
  - Type test, routine, acceptance tests requirements for these cables shall be as per TUV specification 2 Pfg 1169/08.2007 or 2pfg 1190/05.12 as per requirement Charges of routine and acceptance tests shall be deemed to be included in the cable price. Sampling for acceptance tests will be as per IS 7098.
- iii. DC CABLES (SMU's TO INVERTER)
  - Cables used between SMU's and Inverters shall be of min. 1.5 kV (DC) grade. In case bidder offers 1500V DC system 3.3 kV (E) grade cables shall be provided. These Power cables shall have compacted Aluminium /copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), Armoured/ Unarmoured, FRLS PVC outer sheathed conforming to IS: 7098 (Part-I). These cables shall also confirm to the requirements of the standards, codes and requirement specified for LT POWER CABLES, LT CABLE DERATING FACTORS & TESTS under clause 5.3 5.4 ,5.6 & 5.8.
  - DC CABLES SIZING CRITERIA : The Maximum voltage drop of DC Cables (SPV Modules to Inverters) shall be as follow
    - a) Module to String Monitoring Unit-1.0%
    - b) String Monitoring Unit to Inverter-1.5%

#### iv. CABLE DRUM

For details refer respective clause of "LT Cables"

#### 5.2. LT POWER & CONTROL CABLES

LT Power & control cables shall be of minimum 1100 volts grade XLPE / PVC insulated conforming to IS 1554 for utilization voltages less than equal to 415 V.

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All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

IS :1554 -I	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V.
IS : 3961	Recommended current ratings for cables
IS : 3975	Low carbon galvanised steel wires, formed wires and tapes for armouring of cables.
IS : 5831	PVC insulation and sheath of electrical cables.
IS:7098 (Part -I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100V.
IS : 8130	Conductors for insulated electrical cables and flexible cords.
IS : 10418	Specification for drums for electric cables.
IS : 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
IEC-332	Tests on electric cables under fire conditions. Part3: Tests on bunched wires or cables (Category-B).

### 5.3. LT POWER CABLES

- i. The cables shall be suitable for laying on racks, in ducts, trenches, conduits and underground (buried) installation with chances of flooding by water.
- ii. All cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.
- iii. If cables are to be laid underground, laying shall be as per latest relevant IS code.
- iv. Copper/aluminium conductor used in power cables shall have tensile strength as per relevant standards. Conductors shall be stranded.
- v. XLPE insulation shall be suitable for a continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C.
- vi. PVC insulation shall be suitable for continuous conductor temperature of 70 deg C and short circuit conductor temperature of 160 deg. C.
- vii. The cable cores shall be laid up with fillers between the cores wherever necessary. It shall not stick to insulation and inner sheath. All the cables, other than single core cables, shall have distinct extruded PVC inner sheath of black colour as per IS : 5831. Single core cables shall have no Inner sheath as per IS:7098 Part-I

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- viii. For single core armoured cables, armouring shall be of copper/aluminium wires/ formed wires. For multicore armoured cables, armouring shall be of galvanised steel as follows :

Calculated nominal dia. of cable	Size and Type of armour
Upto 13 mm	1.4mm dia GS wire
Above 13 & upto 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
Above 25 & upto 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
Above 40 & upto 55mm	1.4 mm thick GS formed wire /2.5mm dia GS wire
Above 55 & upto 70 mm	1.4mm thick GS formed wire / 3.15mm dia GS wire
Above 70mm	1.4 mm thick GS formed wire / 4.0 mm dia GS wire

- ix. The aluminium used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264 ohm mm<sup>2</sup> per meter at 20 deg C. The sizes of aluminium armouring shall be same as indicated above for galvanized steel.
- x. The gap between armour wires / formed wires shall not exceed one armour wire / formed wire space and there shall be no cross over / over-riding of armour wire / formed wire. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire / formed wire. Zinc rich paint shall be applied on armour joint surface of GS wire / formed wire.
- xi. Outer sheath shall be of PVC as per IS: 5831 & black in colour for power cables. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.
- (a.) Oxygen index of min. 29 (as per IS 10810 Part-58).
- (b.) Acid gas emission of max. 20% (as per IEC-754-I).
- (c.) Smoke density rating shall not be more than 60 % (as per ASTM D-2843).

Cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted:

1 core	Red, Black, Yellow or Blue
2 core	Red & Black
3 core	Red, Yellow & Blue
4 core	Red, Yellow, Blue and Black

- xii. For reduced neutral conductors (in case of power cable), the core shall be black.
- xiii. In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath. The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.
- (a.) Cable size and voltage grade -To be embossed
- (b.) Word 'FRLS' at every 5 metre -To be embossed
- (c.) Sequential marking of length of the cable in metres at every one metre -To be embossed / printed

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- xiv. All cables shall meet the fire resistance requirement as per Category-B of IEC 332 Part-3.
- xv. Allowable tolerances on the overall diameter of the cables shall be  $\pm 2$  mm maximum, over the declared value in the technical data sheets.
- xvi. Repaired cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

### 5.4. LT CABLE SELECTION & SIZING

- i. Cables shall be sized based on the following considerations:
  - (a) Rated current of the equipment
  - (b) The Maximum voltage drop in the cables (Inverter to Inverter Transformer) shall be limited to 0.5 % of the rated voltage. For other LT cables, Maximum Voltage drop shall be limited to 3% of rated voltage.
  - (c) Short circuit withstand capability
    - i) Fault current-As specified in HT switchgear system
    - ii) Time-As per protection time grading requirement subject to minimum of 0.5 sec

This will depend on the feeder type. For a fuse protected circuit, cable should be sized to withstand the let out energy of the fuse. For breaker controlled feeder, cable shall be capable of withstanding the system fault current level for total breaker tripping time inclusive of relay pickup time.

### 5.5. LT CABLE DERATING FACTORS

De rating factors for various conditions of installations including the following shall be considered while selecting the cable sizes:

- a) Variation in ambient temperature for cables laid in air
- b) Grouping of cables
- c) Variation in ground temperature and soil resistivity for buried cables.

Cable lengths shall be considered in such a way that straight through cable joints are avoided.

Cables shall be armoured type if laid in switchyard area or directly buried.

All LT power cables of sizes more than 120 sq.mm. shall be XLPE insulated.

### 5.6. CONSTRUCTIONAL FEATURES FOR LT POWER CABLES

1.1KV grade XLPE power cables shall have compacted aluminium/ copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), armoured/ unarmoured, PVC outer-sheathed conforming to IS:7098. (Part-I). Cables which are directly buried shall be armoured.

1.1KV grade PVC power cables shall have aluminium/copper conductor(compact type for sizes above 10 sq.mm), PVC Insulated, PVC inner sheathed (as applicable) armoured/ unarmoured, PVC outer-sheathed conforming to IS:1554 (Part-I).

### 5.7. TESTS

- i. Indicative list of tests/checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of LT power and control cables enclosed at relevant section.

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- ii. All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.
- iii. All cables to be supplied shall be of type tested design.
- iv. During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests carried out within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.
- v. However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client /owners representative and submit the reports for approval.
- vi. The type test reports once approved for any projects shall be treated as reference. For subsequent projects of NRL, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.
- vii. The reports for following type tests shall be furnished:

Sl	Type Test	
	Conductor	
1	Resistance test	
	For Armour Wires / Formed Wires	
2	Measurement of Dimensions	
3	Tensile Test	
4	Resistance test	
5	Wrapping test	
6	Torsion test	For GS round wires only
7	Elongation test	For GS wire only
8(a)	Mass& uniformity of Zinc Coating tests	For GS wires/formed wires only.
8(b)	Adhesion test	For GS wires/formed wires only
	For XLPE insulation & PVC Sheath	
9	Test for thickness	
10	Tensile strength and elongation test before ageing and after ageing	
11	Ageing in air oven	
12	Shrinkage test	
13	Hot set test	For XLPE insulation only
14	Water absorption test	For XLPE insulation only
15	Loss of mass test	For PVC outer sheath only.
16	Hot deformation test	For PVC outer sheath only.
17	Heat shock test	For PVC outer sheath only
18	Thermal stability test	For PVC outer sheath only
19	Oxygen index test	For PVC outer sheath only
20	Smoke density test	For PVC outer sheath only
21	Acid gas generation test	For PVC outer sheath only

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22	Flammability test as per IEC-332 Part-3 (Category -B)	For completed cable only
23	Insulation resistance test (Volume Resistivity method)	
24	High voltage test	

### 5.8. CONTROL CABLES

- i. The cables shall be suitable for laying on racks, in ducts, trenches, conduits and under ground (buried) installation with chances of flooding by water.
- ii. All cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification. Conductor of control cables shall be made of stranded, plain annealed copper.
- iii. Outer sheath shall be of PVC as per IS: 5831 & grey in colour for control cables. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.
  - (a.) Oxygen index of min. 29 (as per IS 10810 Part-58).
  - (b.) Acid gas emission of max. 20% (as per IEC-754-I).
  - (c.) Smoke density rating shall not be more than 60 % (as per ASTM D-2843).

- iv. Cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted:

1 core	Red, Black, Yellow or Blue
2 core	Red & Black
3 core	Red, Yellow & Blue
4 core	Red, Yellow, Blue and Black

- v. For control cables having more than 5 cores, core identification shall be done by numbering the insulation of cores sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). The number shall be printed in Hindu-Arabic numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of insulation. The colour of insulation for all the cores shall be grey only. The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm.
- vi. In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath.
  - (a.) Cable size and voltage grade -To be embossed
  - (b.) Word 'FRLS' at every 5 metre -To be embossed
  - (c.) Sequential marking of length of the cable in metres at every one metre -To be embossed / printed

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- vii. The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.
- viii. All cables shall meet the fire resistance requirement as per Category-B of IEC 332 Part-3.
- ix. Repaired cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

### 5.9. CONTROL CABLE SELECTION & SIZING

- i. Control cables shall be sized based on the following considerations:
  - (a) The minimum conductor cross-section shall be 1.5 sq.mm.
  - (b) The minimum number of spare cores in control cables shall be as follows:

No. of cores in cable	Min. No. of spare cores
2C, 3C	NIL
5C	1
7C-12C	2
14C & above	3

### 5.10. CONSTRUCTIONAL FEATURES FOR LT CONTROL CABLES

1.1KV Grade Control Cables shall have stranded copper conductor and shall be multicore PVC or XLPE insulated, PVC inner sheathed, armoured / unarmoured, FRLS PVC outer sheathed conforming to IS: 1554. (Part-I).

### 5.11. CONTROL CABLE DRUMS

- i. Cables shall be supplied in non-returnable wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with water proof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection. However, For Single core cables upto 6 Sq. mm size, supplier can do alternative packaging of whole Drum/Spool to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS: 10418.
- ii. Each drum shall carry manufacturer's name, purchaser's name, address and contract number, item number and type, size and length of cable and net gross weight stenciled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.



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### 5.12. CABLES GENERAL REQUIREMENT

Wherever no specific detail is mentioned in above clause for DC cables, LT Power & Control cables, the following shall generally be applicable:

- i. All the cables shall be supplied conforming to IEC 60227/IS 694, IEC 60502/IS 1554 & IEC 60189 (for testing) shall be 1.1 Kv grade as per requirement. Only annealed tinned copper cables shall be used. Insulation shall be FRLS, Zero Halogen, Heat resistant upto 10000C, UV resistant, solar grade and sheathed as per latest IEC standards for service life expectancy of 25 years.
- ii. Cables which are originating/ terminating outside the solar plant area shall be armored.
- iii. All MV cables connecting the main junction box/string inverters to the transformers/substation feeders should be PVC insulated grade conforming to IS 1554 and cables shall also conform for test and measuring the methods
- iv. The size of the cables between array interconnections, array to Junction Boxes, junction box to PCU, PCU to AC Distribution Box etc shall be so selected to keep the voltage drop and losses to minimum. Permissible wire drop on DC side shall be  $\leq 1\%$  (including diode voltage drop).
- v. All connections are to be made through suitable cable/lug/terminals; crimped properly & with use of Cable Glands. The bidder shall supply installation accessories, which are required to install and successfully commissioning the power plant.
- vi. Vendor shall provide voltage drop calculations in excel sheet and confirm the offered make and specification.
- vii. Only terminal cable joints shall be accepted. No intermediate cable joint to join two cable ends shall be accepted. Cable terminations shall be made with suitable cable lugs & sockets etc, crimped properly and passed through brass double compression type cable glands at the entry & exit point of the cubicles.
- viii. All cable/wires inside the plant area are to be marked in proper manner by good quality ferrule of proper sizes or by other means so that the cable can be easily identified. Cables which are originating/ terminating outside the solar plant area shall be provided with Punched Aluminium tags only. The marking on tags shall be done with good quality letter and number ferrules so that the cables can be identified easily. Cable schedule is to be provided to NRL for information prior to execution.
- ix. The wiring for modules interconnection shall be inside conduits of Solar grade Heavy Duty uPVC Pipe suitable for use in direct sunlight, UV resistant (IEC 61386-1). The fittings shall be matching and of same type. Intermediate gaps shall be avoided. Conduit dia size used shall be 25mm or more.
- x. Irrespective of design (as per voltage drop) minimum conductor size shall be as per chart below.

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xi. The following shall be general specification of DC cables

S.no.			
1		Applicable Standard	
	a	PV1-F Photovoltaic cables	TÜV 2Pfg 1169/08.2007.
	b	Conductors of insulated cables	IEC 60228/VDE 0295:
	c	Weathering/UV Resistant	HD 605/A1
	d	Low Smoke Halogen Free	BS EN 50267-2-1, BS EN 60684-2, BS EN 61034, BS EN 50267-2-2
	e	Ozone Resistant	BS EN 50396
	f	Flame Retardant	BS EN/IEC 60332-1-2
	g	Thermal Endurance	BS EN/IEC 60216-1
	h	Acid-/Alkaline resistant	BS EN 60811-2-1.
	i	Restriction of Hazardous Substances	RoHS Directive 2002/95/EC compliant (Chlorine & Bromine: < 0.1 %, Pluride : < 0.1%)
2		Voltage grade (U0/U)	0.6/1.0 kV AC,0.9/ 1.8 kV DC
3		<b>Conductor</b>	
	a	Material	Tinned Copper (Annealed, Electrolytic, multistrand)
	b	Type	Class 5
	c	Max.dc resistance value at 20°C	5.5 (Ohm/Km)
4		<b>Insulation</b>	
	a	Material	XLPO - HFFR (Cross Linked Halogen Free Fire Retardant) for insulation and outer Sheath
	b	Colour	Black, Red, Blue. Sheath – Black. (Positive and Negative wires should be distinguishable)
	c	Volume Resistivity, min. at 20°C	$1.0 \times 10^{14}$ (OhmCm)
5		Temperature.	Ambient -40 TO 90(°C) Conductor tempr. -40 TO 120(0C)
6		Printing, markings	Marking at each 5 meter (or lesser) in English of following: Make, Voltage grade, PV1-F SOLAR CABLE; TUV 2 Pfg 11 69/ 08.2007 Progressive sequential marking at each 1 meter
7		Minimum conductor size (subject to voltage drop calculation)	
	a	Interconnecting SPV modules	4sqmm
	b	From SPV Modules upto String Monitoring Unit(SMU)	6qmm
	c	From SMU upto the Inverter.	10qmm

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### 5.13. PV GENERATOR JUNCTION BOXES & DISTRIBUTION BOARDS

- i. All junction boxes used on the DC side of the PV Power Plant system such as Array Junction Boxes / SJBs/ Combiner Boxes / String Monitoring boxes shall be treated as PV generator Junction Boxes as per IEC60364-7-712 ( Standard for PV Power plant systems for Grid connected plants )
- ii. All the PV generator junction boxes shall be Protection Class 2 & shall conform the IEC 60364-7-712 clause 712.413.2. A conformity can be provided by submitting relevant IEC 61439 Part 2 certificate and test report.
- iii. The PV Generator Junction boxes( AJB / Combiner Boxes / String Monitoring Boxes) are to be provided in the PV yard for termination of connecting cables. The JB's shall be made of Thermoplastic Polycarbonate with full dust, water & vermin proof arrangement. All the incoming String wires/cables must be terminated through Suitable MC4 compatible connectors. Copper bus bars/terminal blocks housed in the junction box with suitable termination threads. The terminals shall be rated for 1000Vdc.
- iv. Following are general requirements of JB's and DBS
  - Resistance to Ultra Violet radiation : The junction boxes should be verified in accordance with table 10.2.4 of IEC 61439 for resistance to UV radiation.
  - Degree of Pollution for Junction Boxes : 3 ( Verification Needed)
  - Degree of Protection shall be minimum IP 65 as per IEC 60529 and a type test report shall be submitted from TUV or equivalent certifying labs.
  - Clearance & Creepage Distances : Minimum creepage distance should be 16mm as per Table no.7 of IEC 61439-2
  - Fault Protection of Assembly : The complete assembly should be tested for fault protection in accordance with IEC 60364 – 4 – 41 ( verified by IEC 61439 )
  - Impulse withstand Voltage of Main circuits : Shall comply to 4.8KV in accordance to table 10.9.3.3 or 10.9.3.4 of IEC61439
  - Temperature Rise Limits : Tested and verified as per IEC 61439 -2, Table no.10.10 & with a diversity factor 0.8
  - Verification of Thermal Stability of Enclosures : As per IEC 60068 – 2-2 ( 70 deg C Temperature with manual air circulation duration of 168 hours& with recovery 96hours)
  - Mechanical Impacts : Compliance to IEC 62208 : 2002
  - Verification by testing with current : According to table 10.10.2.2. of IEC 61439-2. The entire assembly shall be designed and tested for elevated temperatures and shall be suitable for a minimum of 50 degrees or above Ambient temperatures suitable for the location of site.
  - Verification of Complete Assembly : As per table 10.10.2.3.5 considering rated diversity factor of 0.8
  - If the assembly for combiner Box is made with modular enclosures, class II insulation shall be verified and no metal screws shall be used for combining enclosures for the assembly.
  - The Assembly shall not use any metal gland to ensure Protection class II and cable entries shall be made through String connectors for incoming strings and IP 68 Polyamide cable glands shall be used for the outgoing cables.
  - TUV or equivalent Type Test report shall be mandatory and the certificate should not be older than Dec 2014

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- All junction/ combiner boxes including the module junction box, string junction box, array junction box and main junction box should be equipped with appropriate functionality, safety (including fuses, grounding, etc.), string monitoring capabilities, and protection.
- The terminals will be connected to copper bus-bar arrangement of proper sizes. The junction boxes will have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables. Suitable markings shall be provided on the bus-bars for easy identification and cable ferrules will be fitted at the cable termination points for identification.
- Vendor shall provide sufficient no. of Junction Boxes (JB), PV Combiner Boxes(CB), DC Distribution Board (DCDB), AC Distribution Box (ACDB), Instrumentation Junction boxes (IJB – for signal / communication) to ensure safe and convenient AC and DC distribution and monitoring.
- Reverse blocking diodes shall be used only if the Modules selected demand the protection against reverse currents. If Diodes are used, suitable heat sinks shall be used and a separate junction box shall be provided before the strings enter the Array Junction Boxes/ Combiner Boxes. The Junction box used for Diodes can be made of Sheet steel to ensure proper heat dissipation is maintained. Surge protection devices of appropriate 1000VDC rating shall be provided inside the Array Junction Boxes. Adequate capacity solar DC fuse, SPDs & DC Disconnect Switches should be provided in Array Junction Boxes / Combiner Boxes and String Monitoring Boxes wherever required.
- The Junction Boxes shall have suitable arrangement for combining groups of modules into independent charging sub-arrays that will be wired into the controller. Arrangement to be provided for disconnection for each of the groups and group array isolation. A test point to be provided for each sub-group for quick fault location.
- The current carrying rating of the Junction Boxes shall be suitable (with adequate safety factor) to inter connect the SPV array / local grid.
- The bypass & reverse blocking diodes, wherever necessary should work for temperature extremes and should have efficiency of 99.98%, confirmed by appropriate IEC standards.
- All ACDBs ( Distribution Boards) shall be provided with adequately rated copper bus-bar, incoming control, outgoing control etc. as a separate compartment inside the panel to meet the requirements of the Chief Electrical Inspectorate division of Central Electricity Authority (CEA). All live terminals and bus bars shall be shrouded. The outgoing terminals shall be suitable to receive suitable runs and size of cables required for the Inverter/Transformer rating.
- Make, model, specifications, data sheet and details of offered JB and DB shall be provided in the Bid. All the JBs and DBs offered should be of same make/manufacturer.
- Approved Makes for PV generator Junction boxes : Hensel, Ujjwal Systems, Gantner, Weidmuller or equivalent.

### v. **Monitoring System :**

- Monitoring of various parameters at string level should be made possible in the Power Transmission Sub Station (PTSS) by installing a string monitoring system of suitable type in line with other conversion / control systems offered by the Bidder. Any fault at string level could be recognizable by that system and shall be communicated to PCU / SCADA at PCSS/PTSS for control. String Monitoring System theoretical design, calculations and detailed explanations along with drawing shall be provided which shall be approved by Numaligarh Refinery
- The string monitoring Box (SMB) shall be of Hall Sensing technology / Shunt based or equivalent.
- The parameters to monitor will be (a) Individual String Currents (B) Overall Bus Voltage (C) SPD status (d) DC Disconnect Switch status (e) KWH for entire SMB (f) Temperature inside the SMB, outside SMB and temperature near the modules.
- The SMB manufacturer should have a TUV type test report in accordance with IEC 61439 for a design temperature of minimum 50 degC.

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SMB Approved Makes : Hensel / Ujjwal Systems /Gantner / Weidmuller. Alternative makes meeting the above specifications shall also be acceptable provided the product has been used for similar application in India for atleast 3 years satisfactorily (PTR to be submitted).

### 5.14. TECHNICAL SPECIFICATION OF FEEDER PILLAR

- i. The board/panel shall be made out of modular POLYCARBONATE THERMOPLASTIC ENCLOSURES. The enclosure shall be environment friendly, recyclable, UV resistant, halogen & silicon free, anti acid& anti corrosive.
- ii. The manufacturer of board/panel shall submit a copy of CPRI TEST REPORT OF DEGREE OF INGRESS PROTECTION IP 65 in ACCORDANCE WITH IEC 60529. The gasket material shall be Polyurethane; while the gasket shall be internally embedded.
- iii. The manufacturer of board / panel SHALL submit a copy of TYPE TEST REPORT of a board made out of Polycarbonate thermoplastic panel in accordance with IEC 60439-1and manufactures routine test certificate should be provided. The CPRI report shall have mention of following tests performed and passed out satisfactorily:
  - a) Temperature Rise.
  - b) Dielectric Properties.
  - c) Short circuit withstand current – Rated peak & short time withstand current and Rated Conditional Short Circuit Current.
  - d) Effectiveness of Protective Circuits.
  - e) Clearance & Creepage Distance.
  - f) Mechanical Operation
- iv. Power switchgear and controlgear assembly in accordance with IEC 61439 Part 1 and Part 2.As standard mainbusbar system EMC-complaint,with N/PEN conductor in the area of phase conductors and with the same current carrying capacity as the phase conductors.
- v. For better safety the Polycarbonate enclosure shall be fire retardant & self-extinguishing in accordance with IEC 60 695-2-1, DIN VDE 0304 Part 3, UL Subject 94 for Flammability V-2. It should be tested at Glow Wire test for 960 deg. Cent.
- vi. The impact strength of polycarbonate enclosures / boards i.e. the Degree of Protection against mechanical load IK 08(5 Joule)in accordance with IEC 62262.
- vii. The lid closing and opening shall be done by quick fastening spring mechanism latches.
- viii. Compactness of the boards is main criteria due to space constraints. The board / panel should be made compact meeting the technical requirements in accordance with relevant standards and also keeping adequate space for technicians to work. The MCB/ RCCB switching operations / accessing the MCB dolly should be preferably by opening of a window flap.
- ix. Technical Features of POLYCARBONATE Feeder Pillar:

Materials	Thermoplastic Polycarbonate (PC)
Gasket	Internally embedded made of Polyurethane

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Degree Of Protection	IP 65
Fire Protection in the event of internal faults	Minimum requirements: -Glow wire test in accordance with IEC 60 695-2-11- UL Subject 94 - 650°C for boxes & cable glands - 850°C for conducting components
Burning behaviour	- Glow wire test in accordance with IEC 60 695-2-11-960°C -UL Subject 94- V2 flame retardant & self-extinguishing.
Impact Protection	IK 08 (Protected against 5 joules mechanical impact as per IEC 62262)
Toxic behavior	Halogen, Silicon free , conform to RoHS directive 2002/95/EC
Temperature resistant	-40°C to +120°C
Chemical resistant	Acid, Lye, Petrol, Mineral Oil & partially resistant from Benzene
Rated Insulated Voltage	AC/DC 690V
Cable entries	Shall have option for cable plate
Protection Class	Class II, totally insulated
Type test certificate	Should hold type test certificate with switchgear assemblies (TTA), according to IEC 60 439-1 (IS 8623), AND CPRI
Mounting Type	Floor Mounting/Wall Mounting
Protection	SPD Must Be used in system ; For switchgears fixing should be maintain proper space in between two different switchgear for Heat Dissipation.

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### 5.15. LIGHTENING PROTECTION FOR PV ARRAY

- i. Earthing: The array structure of the PV yard shall be grounded properly using adequate number of earth strips to be connected to separate Earth Pits. All metal casing or shielding of the power plants shall be thoroughly grounded to ensure safety of the solar power plants.
- ii. Lightning: Lightning protection coil in each sub-array line shall be provided to prevent the high current transients from entering into the DC bus. There shall be the required number of suitable lightning arrestors installed in the array field. Lightning protection shall be provided by the use of metal oxide resistors and suitable earthing such that induced transients find an alternate route to earth. Protection shall meet the safety rules as per Indian Electricity Act. Over voltage protection against atmospheric lightning discharge to the PV array is required. The source of over voltage can be lightning or other atmospheric disturbance. 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 as per IEC 60099 / IS:2309 – 1989 (Reaffirmed – 2005), Edition 3.1 (2006-01). The lightning conductor shall be earthed through flats and connected to the earth mats as per applicable Indian Standards with earth pits. Two earth pits shall be provided for each lightning arrestor. 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.
- iii. Fast acting semiconductor type current limiting fuses shall be provided at the main bus bar to protect from the grid short circuit condition.
- iv. Necessary concrete foundation / anchoring 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.
- v. If necessary more numbers of lightning conductors may be provided. Bidder is also free to provide franklin rod type of lightning arrestors on the MMS structure designed in such a way not to cast shadow on the next row of SPV modules.
- vi. The Bidder shall submit the drawings and detailed specifications of the PV array lightning protection equipment to NRL for approval before installation of system.



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## 6. ANCILLARY WORKS AND FACILITIES

### 6.1. SPV MODULE CLEANING SYSTEM

- i. Vendor shall keep the provision for washing the panels periodically with clean water. The source of clean water will be shown from which a line shall be drawn up to the plant to create a facility for cleaning of all the panels. Vendor shall estimate the water requirements for cleaning the photovoltaic modules at a frequency of least once every week in order to operate the plant at its guaranteed plant performance. Irrespective of design consideration, the following shall be the minimum requirements:
  - $\frac{3}{4}$  inch GI piping. Piping to be given on each side of the array i.e. one line nearer to the existing road and one line along the boundary wall.
  - Suitable bib cock / stop cock to be provided at regular intervals. Such stopping arrangement be designed suitably but shall not exceed 30Meters interval.
  - Flexible piping shall be provided such that each PV panel of the area is easily accessible for washing without any supplementary arrangement. Flexible piping shall be suitable for regular outdoor use.
  - Piping shall end with suitable nozzle arrangement for directing the flow.
  - All necessary arrangement for wet cleaning of the solar panels shall be in the scope of the bidders and accordingly the agency has to provide all the necessary equipments, accessories, tool & tackles and piping arrangement which are required for the same.
  - Supply and installation 4 nos of  $\frac{1}{2}$  HP water centrifugal pumps (including piping) for pumping nearby water pond (as an alternative to the existing source shown by NRL).

### 6.2. STORM WATER DRAINAGE SYSTEM

- i. The storm water collected in the plant area shall have to be drained away from the plant with no residual water logging or accumulation in the plant area. Scope includes design and construction of adequate drainage to redirect the storm water and water used for module cleaning to a suitable location. Irrespective of design consideration, the following shall be the minimum requirements:
  - Area pavement shall have minimum 1:100 slope and sloped towards peripheral drain.
  - Atleast one peripheral brick drain shall be built along the full length of the plot i.e. parallel to the boundary wall.
  - Peripheral brick drain shall be as per site requirements, of minimum 300mm width and 500mm depth and inner-side paltered. Connecting drains, if required, shall be atleast 250mmX 250mm.
  - RCC hume pipes are to be provided at the crossing of road and drains and at required locations as per design.
  - Drain which connects the peripheral drain with the existing Storm water drain shall be designed for suitable evacuation.

### 6.3. RAIN WATER HARVESTING

- i. Provision of rain water harvesting shall be incorporated complementing the drainage system. The provision shall include, atleast two ponds/pits of sizes not lesser than 5MX5M and 1.5M depth and with suitable fencing. NRL may consider better alternatives in storing water proposed by Vendor. NRL may like to incorporating a filter/filtration system and ground-water recharging at a future date and vendor shall explore to incorporate suitable provision accordingly. To the extent feasible,

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“Cleaning System”, “Drainage System” and “Rain water Harvesting” will be harmoniously integrated to a single water system, such that power and water consumption is minimized.

### 6.4. ROADS

- i. Vendor shall build approach roads, internal roads, pavements, pathways, etc. internal roads, approach roads, pathways, etc. of asphalt/bitumen, WBM or concrete with adequate plinth protection.
- ii. Vendor has to design and construct such roads and pavements as per IS code.
- iii. Pathways shall be leveled and compacted. Brick should be class II or better class. The width of the internal pathways shall be 1.25 m minimum and shall be provided between each row. Peripheral pathways other than approach road shall be of 2.5m width and designed to facilitate movements to carry out daily maintenance. Approach road from nearest main road to control room shall be flexible type Bituminous of width at least 3.75 m with one meter shoulder each side as per IRC.

### 6.5. CABLE TRENCHES AND ROUTES

- i. Scope includes Construction of RCC cable trenches, Electrical Road Crossings (ERC), cable trays and covers wherever required. Bidder has to consider all the Road crossings as per the Plot Plan. There shall be no buried cables within the periphery of the plant i.e. cabling shall be over-ground and laid in conduit, in trays or saddled.

### 6.6. AREA PAVING

- i. Site earmarked for the solar plant is almost flat. Being located in the high rain fall area, the earmarked area is covered with small shrubs, bushes and wild vegetation at present. As such, the vendor shall carry out a topographical survey and thereafter carry out land development, site clearing, site grading, etc and level the area prior to construction.
- ii. The finished ground level (FGL) and slopes must be maintained as per approved design.
- iii. The Vendor shall pave the entire stretch of ground beneath Ground Mounted panels and immediately around it, with **150 mm thick PCC** to avoid growth of wild vegetations. Bidder shall take reasonable care to ensure that the plant is aesthetically designed.

### 6.7. PLANT PERIPHERY FENCING

- i. Chain Link Fencing:
  - Plant shall be protected by chain link fencing as per IS 2721 : 2003.
  - The minimum height of the fencing shall be 1.5m.
  - The chain link of 50mm x 50mm diamond mesh of 8 gauge galvanised steel wire with 10 gauge barbed wires at top ( 2 numbers) is to be provided.
  - Supply, Fabrication and fixing vertical post of 75mm x75mm x 6mm with cross bracing both side of ISA 45mm x 45mm x 5mm and 40mm x 60mm GI flat.
  - Chain link fencing shall be fixed in ground by sufficient foundation.
  - Vendor has to strictly follow the approved drawing for implementation.

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ii. Barb Wire:

- The barb wire shall conform to conforming to IS: 278.
- The spacing shall of barbed wires shall be maximum 12.5cm center to center.
- Also line wire at top and bottom of chain link mesh of 8 gauges is to be provided.

### 6.8. SIGN BOARDS

- i. 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 atleast 4 locations of the power plant.
- ii. The Signboard shall be made of steel plate of not less than 3 mm. The signs shall be luminescent/retro-reflective for easy visibility in low light conditions. Size of signboard shall be minimum 2 square meters. Minimum clearance from ground shall be 1 meter. NRL logo shall be imprinted on signages.
- iii. The Vendor shall submit detailed specifications and content of the sign boards for approval.

### 6.9. AUXILIARY POWER DB

- i. Auxiliary DB shall be provided inside the plant area. The reference lines drawn from respective substation can also be used as source of the auxiliary DB. Atleast two DBs are envisaged i.e. one each for each 500kWp.
- ii. Area lighting, pump motors, etc. shall be drawn from the auxiliary DB.
- iii. It shall provision for drawing power connections required for operation and maintenance.
- iv. The DB shall have suitable locking arrangement as well as padlock arrangement for preventing unauthorized drawing of power.
- v. Specification of DBs is provided in respective paragraph of this tender.

### 6.10. AREA LIGHTING

- i. Area lighting arrangement shall be made to illuminate the solar plant area at an appropriate lux level for night hours. Area lighting arrangement shall have adequate numbers of lights poles on the sides of roads, periphery, etc. Lighting fixtures shall be installed close to fencing.
- ii. LED lighting fixtures shall be mounted on tubular poles of approved height and mounting arrangement.
- iii. The connector box is to be recessed at the base of each Lighting pole. The connector box shall have suitable brass or copper made connector terminal. Other specifications shall be similar to JB.
- iv. Lighting poles and fixtures shall be effectively grounded using adequate size of GI earthing wires / GI earthing strips.
- v. PVC insulated armored Cu/Al cables of adequate size shall be used for interconnection and supply of power to Yard lighting systems.

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- vi. Cable terminations shall be made with suitable cable lugs & sockets etc, crimped properly and passed through brass compression type cable glands at the entry & exit point of the connector box and at the entry point to MCB distribution Box for controlling the lighting system.
- vii. The lighting poles shall be concreted with 600 mm coping above ground level for pole protection.
- viii. Timer shall be provided alongwith the lighting contactor for automatic switching without manual intervention. Timer shall be Astronomical type.

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## 7. GENERAL TECHNICAL CONDITIONS

### 7.1. STATUTORY REQUIREMENTS

- i. All construction, operation and maintenance procedures shall be carried out through appropriate relevant standards, regulations laid by NRL/MNRE / SECI / NVVN and / or any other agency as and when applicable.
- ii. The tender manual of NRL is provided in its website [www.nrl.co.in](http://www.nrl.co.in) under the section “Current Tenders”. General Conditions of Contract (GCC), General Purchase Conditions(GPC), Circulars for Minimum wages, Tender Conditions for Safety and Security, Formats for Contract agreement and Bank Guarantee and other details of NRL provided in this section, shall be applicable for this contract.
- iii. Further, the bidder and his offered services shall comply with the applicable laws and rules by statutory, regulatory and government agencies. The Bidder should be aware of such requirements and shall not solely depend on NRL to avail information required for the work.
- iv. Entry and exit of materials supplied by vendor will be governed by NRL gate pass system and shall be through material gate. Returnable and Non-returnable Materials are to be segregated. Likewise, entry of workers is governed by gate pass system including police verification. Work inside refinery is governed by Cold work permit and Hot work permit system and safety manuals. Normal working hours are 8 hours to be scheduled within 8am to 5:30pm excluding weekly off days on Sundays and 1<sup>st</sup> and 3<sup>rd</sup> Saturdays. Vendor to apprise himself of such procedures prior to proceeding with the bidding process.

### 7.2. GENERAL CONDITIONS OF CIVIL WORK

- i. **DESIGN** : All material, installations, fixtures, accessories etc. to be provided shall be as per the relevant I.S. codes and specifications. These shall be of best quality and of standard manufacturer as approved by the EIC, when there are no standard specifications. The agency has to provide best workmanship with skilled manpower for all the civil items as per the standard specifications/ best practice as approved by the EIC. The CPWD Standard Specifications for Civil Works will be applicable wherever there is dispute in the items of civil works. The design of all civil foundations, R.C.C structures, buildings etc. (if any) will be carried out considering appropriate seismic zone of the area. All appropriate loads, wind velocity, seismic factors, safe bearing capacity (SBC) of soil etc. will be considered as per the relevant I.S Specifications while designing any civil structure. Also the environmental conditions, soil characteristics, atmospheric effect, ground water table level, rain water data, land profile etc. will be considered as per site condition and accordingly appropriate precautions, preventive measures will be taken while designing the structures. RCC of appropriate grade will be adopted considering surrounding weather and soil effect of site and as per the relevant I.S standard specifications. The concrete mix design of required strength shall be carried out in Govt. approved laboratory. NRL may approve minor deviations in the same which are meant for increasing plant performance without sacrificing quality / workmanship norms. NRL reserves right to modify the specifications at any state as per local site conditions / requirements.
- ii. **Materials** : Fresh OPC cement Grade 43 and TMT steel reinforcement bars **Fe 500** shall be used confirming to relevant I.S specifications from the approved manufacturers of NRL. This is the minimum requirement. The agency has to keep the full proof of records of purchase, consumption, gate entry and exit along with original purchase bills of Cement and Steel as per NRL procedures and rules. NRL does not plan to supply any material for this work.

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- iii. **Site Survey:** Site survey shall have to be done by the Vendor of the proposed site. The ground level and plinth level of structures shall be fixed taking into consideration the highest flood level and surrounding ground profiles.
- iv. **Soil Test Report :** NRL will provide access to data of the last available soil test report of nearest location inside NRL site. All RCC works shall be provided of required grade of concrete as per relevant IS specifications as well as soil data considering appropriate earthquake seismic zone, wind velocity, whether effect, soil characteristics etc.
- v. **Foundation :** The foundations should be designed considering the weight and distribution of the structure and assembly, and a maximum wind speed of 140 km per hour. Seismic factors for the site have to be considered while making the design of the foundation. Vendor shall provide certificate of foundation design from competent chartered structural engineer in support of the foundation design proposed by him. M30 grade concrete shall be the minimum requirement for foundation works. Wherever grouting is to be done, suitable grouting material to be used as per standard process.
- vi. **Structural :** Vendor shall obtain and study earthquake and wind velocity data for design of module mounting structure, and after considering all parameters related to the weathers conditions like temperature, humidity, flood, rainfall, ambient air etc. The bidder has to arrange for certification of Module Mounting Structure design by a chartered structural engineer.
- vii. **Shadow Analysis :** The Vendor shall carry out Shadow Analysis at the site and accordingly design strings and arrays layout considering optimal use of space, material and man-power and submit all the details / design to NRL for its review / suggestions / approval. All design shall be to compact the plant in minimum possible area and also minimize shading losses because of SPV module structures. The spacing shall be sufficient for safe and convenient access of personnel during maintenance and cleaning.
- viii. **Site facilities:** Vendor shall plan for transportation and safe storage of materials at site. NRL shall not be obliged to provide and housing, office or storage space for the job. NRL shall provide free construction power. Vendor has to arrange its own temporary power installation at site and draw cable from the nearest available power source allocated by NRL. The electrical worthiness of power cable, installation and construction equipment shall have to be certified by registered electrical supervisor prior to applying for temporary power connection in standard format. The supply, installation, maintenance and testing of the installation will be in vendor's scope. Likewise, Vendor can avail Construction water from NRL at free of cost.

### 7.3. APPROVAL OF DESIGNS / DRAWINGS

- i. All designs, specifications, reports, etc. submitted or used by the Vendor at any point in time shall first be approved by "EIC" and shall be revised by Vendor as per instructions given by " EIC" if required prior to execution.
- ii. The Bidder shall submit in the Bid a comprehensive project management schedule in the form of a Gantt chart CPM/PERT chart and shall be liable for abiding by the schedule.
- iii. The Bidder shall submit in the Bid general engineering drawings of all civil work, including but not limited to, layout of the power plant indicating rows of photovoltaic modules, SLD, location of control panels, DC and AC Distribution Boxes, MMS design, civil foundations and anchoring design /details, shading analysis and generation estimation report etc.

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- iv. The drawings submitted shall be in hard copies (prints) of 3sets each. Soft copies of drawings(editable) shall be submitted in CD in versions of Autocad (alternative software if approved by EIC).
- v. The bidder shall submit in the Bid technical specifications / Drawings / Designs and datasheets for all electrical work including but not limited to electrical component of the power plant including photovoltaic modules, cables, connectors, junction boxes, inverters, transformers, monitoring and auxiliary systems, etc.
- vi. All construction, operation and maintenance procedures shall be carried out through appropriate relevant standards, regulations and labour laws and non-compliance detected at any stage shall be grounds of penal action by NRL and may include recoveries and withholding of payment. Approval of documents and drawing accorded by EIC shall not be cited as grounds for non-compliance.
- vii. The design / drawing / QA documents related to following items shall be submitted by vendor to EIC for approval of prior to start of respective work. NRL shall take 7 days maximum for approving or commenting such drawings. Bidder to consider this time as inclusive in the contract period. The following list is the minimum general requirement and final list shall be as per subsequent correspondence up to the finalization of order. The list of drawings and documents requiring approval shall be submitted to NRL within 1 week of site handover. List of documents and drawings which are prepared for information and record of NRL i.e. not requiring approval shall also be submitted together. Actual documents may follow in due course.
  - Overall general Layout
  - MMS and Array Structure- Structural/Mechanical design, Civil Foundation, etc.
  - SLD (Single Line Diagram)- including coordination and sizing calculations
  - Earthing layout
  - PV array lightning protection
  - Formats for FAT , SAT, QAP, Electrical commissioning, Final acceptance
  - Component sourcing plan
  - Monitoring and recording scheme
- viii. All the Solar Charge Controllers (MPPT), SPV modules, Dual Axis Trackers (and Tracking system), & Grid Tie Inverters shall be of reputed make with proven track record (PTR). These equipments shall be duly approved by NRL. NRL reserves the right for factory inspection of any one or all of the items. Vendor should inform NRL for inspection before dispatch of materials.

### 7.4. TESTING AND INSPECTION

- i. **Factory Acceptance Test (FAT)** : Vendor shall inform EIC whenever Solar Power Generation System, charge controller, dual axis trackers, grid tie inverters and all other equipments/ accessories, are ready for FAT. FAT shall be witnessed by NRL or its representative and vendor shall submit all the test certificates / calibration certificates for meters, etc. / test reports for all equipments during FAT. Depending on the success of FAT, vendor can dispatch the system to NRL site. Cost of testing and arrangement to display the same to visiting inspection representative shall be deemed to be inclusive in the quoted price.
- ii. **Site Acceptance Test (SAT)** : For items / sub-package where NRL is reasonably satisfied that FAT is not feasible, SAT shall be carried out for those items.



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- iii. **Test Conditions:** Module shall be tested as per IEC 61215 & IEC 61730. Module manufacturers shall be MNRE approved vendors or IEC certified modules with RFID shall be supplied. The inverters must be tested and approved by one of the IEC authorized test centers. Test certificates can be from any of the authorized laboratories viz. Electronics Regional Test Laboratory (ERTL (East)), CPRI (Bangalore), ERTL (West) and ERTL (North) or any international certified agency. All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions. Formats of FAT, SAT and Quality Assurance Plan (QAP) shall comply with respective standards and codes and shall be submitted to NRL atleast one month prior to the scheduled event.
- iv. **Third Party Inspection Agency (TPIA) :** Vendor to quote for TPIA charges separately. NRL may insist of inspection of FAT through TPIA and NRLs personnel may or may not be present during such inspection. In case no inspection agency is advised to be engaged by NRL, TPIA charges shall not be payable. The following are the Approved TPIA for the tender. Alternative TPIA agencies shall be considered provided the same is requested in pre-bid meeting or prior to it. Once, an agency is selected by vendor, subsequent change for rest of items shall only be with the consent of EIC. NRL shall be kept updated by vendor on the dates of such inspection, comments and inspection release note. Indian Register Of Shipping
- International Certification Services Pvt. Ltd
  - Lloyds Register Indl Service
  - Bureau Veritas Indl Services
  - Det Norske Veritas
  - TUV India Pvt Ltd
  - Certification Engineers International Ltd
  - RITES Ltd,
  - Projects & Development India Ltd.
  - SGS India Ltd
- v. **Goods acceptance at site:** Acceptance of material at site (or NRL store) shall be based on FAT and joint inspection by vendor & NRL at NRL site (or after SAT). Respective documents shall be submitted for acceptance.

### 7.5. FINAL ACCEPTANCE

Final commissioning and plant acceptance shall be subject to fulfillment of the following requirements :

- i. **Electrical Commissioning :** Inspection and successful electrical commissioning certificate from NRL (prior to commencement of guarantee period). The commissioning procedure shall be developed as per Solar Energy Corporation of India (SECI) guidelines. Electrical commissioning shall be certified by EIC upon evacuation of power to the respective substation successfully. In case of any hindrance in feeder allocation, suitable alternative feeder shall be provided on test basis by NRL.
- ii. **Comprehensive Commissioning :** The checklist points developed during electrical commissioning including all balance electrical and non-electrical jobs shall be completed and commissioned within one month. Failure to commission facilities which hinder evacuation of power within this period, shall be considered as grounds for extending the commencement of guarantee run as well as coverage of CMC period. Final Documents submission, training and site clearance shall also be completed within this period. Comprehensively commissioning shall be certified by EIC upon being satisfied with the completion of all major jobs.

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- iii. **Guarantee Run** : Vendor shall maintain the facility and shall demonstrate the Monthly and Annual plant performance as derived at metering point as plant acceptance guarantee run. For the purpose of evaluation of the plant performance, it shall offer access to the electrical parameters and weather data through remote monitoring system. The period of evaluation shall be 12 months after achieving completion of all works mentioned. EIC may authorize Electrical Maintenance department to certify the completion of successful guarantee run. Measure of energy at substation end shall be the basis of evaluation of guaranteed generation. Alternative schedules and procedures of evaluation / guarantee run submitted with bid may be considered.
- iv. **Final Job Completion** : Satisfactory Final job completion certificate shall be issued by EIC upon completion of all other contractual obligations by the Vendor as per scope of the order (and after goods acceptance of all items at site, Electrical Commissioning, Comprehensive commissioning and Guarantee Run).

### 7.6. BILL OF MATERIALS (BOM)

- i. A complete Bill of Materials inclusive of Solar PV Modules, array Junction box, main junction box, cables, , LT interface panel, dual axis trackers, grid tie inverter, DATA logger etc shall be provided along with the offer (without item rates). The bill of materials associated with PCU's should be clearly indicated while delivering the equipment. The numbers of each component proposed for supply shall be clearly specified. Vendor must submit proposed make of equipments and its rating and datasheet, technical specification etc. with bid for technical evaluation. Offers not complying above requirements will not be technically evaluated. Any material not mentioned specifically but required for successful completion of the Solar Power Generation System safely as per scope of work is in contractor's scope. Bidder should take care while preparing the BOM as it shall form the basis of any subsequent BILLING BREAK UP (BBU) if same is approved by EIC. The BOM updated with item rates as per BBU shall be submitted prior to despatch of materials. All items shall be labeled to clearly identify with BOM. Responsibility for ensuring clarity in BOM for releasing proportionate payments against phase-wise despatch rests on vendor.
- ii. Transportation, shifting and storage of the supplied materials at site shall be in responsibility of the vendor during the project execution period. Vendor to ensure adequate on-site supervision, safe-keeping and security to prevent loss or damage during the period.
- iii. Bidder shall quote only as per the (SOR) Schedule of Rates (refer Annexure 2) attached with the scope of work of tender and shall confirm the same in technical bid. Separate quote showing the BOM/BBU shall not be considered for evaluation.

### 7.7. SPARE PARTS

- i. **Mandatory Spares** : Mandatory spares shall be supplied along with the main equipment. These spares include only those spares, which are critical for equipment like PV modules, tracker and PCU electrical items / sub-packages. Spares and consumables required for Commissioning and rectification of guarantee period defects are considered in vendor's scope and shall not be consumed from mandatory spares (and refurbished if consumed). The mandatory spares are to be maintained in custody of client to meet any sudden failures.
- ii. **O&M Spares** : The spares required for 5 years Operation and Maintenance (O&M) during CMC period shall be considered inclusive in the quoted price for CMC.

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- iii. **Price list of spares** : Vendor shall provide NRL with a price list of spares which shall be valid during the Guarantee and CMC period. Escalation during the period, if any, shall be clearly mentioned in the offer and shall be reasonable.
- iv. **Tools and Tackles** : One set of all tools and tackles required for regular operation and maintenance shall be provided to NRL. Any of the tools used by the vendor during the contract period shall be returned to NRL in good condition (or refurbished). Any specialized tools and tackles which is mandatorily required for regular operation and maintenance shall be included.
- v. **Installed spares** : Adequate number of spare switches, fuses, protections, accessories, etc shall be installed in the supplied JB's and DB's items to minimise using the stock from warehouse.

### 7.8. DOCUMENTATION

- i. A complete comprehensive operation and maintenance manual complete for end-user shall be supplied (Four sets of prints and one editable soft copy) along with the each solar power plant along with as built drawings in English. The manual shall include complete system details of all the equipments catalogue/manuals, working principle, installation detail, etc. and is to be submitted prior to commencement of Guarantee period. **Following are the minimum requirements of the manual:**
  - About Photo Voltaic & PV Module.
  - Clear instructions about mounting of PV module.
  - About electronics used.
  - DO's and DON'T's.
  - Comprehensive maintenance schedule for operation and maintenance of the SPV plant along with checklists which will be applicable during Guarantee, CMC and post CMC period.
  - Clear and Step by step instruction on regular maintenance and trouble-shooting procedures of the power plants.
  - Name and address of the person or vendor to be contacted in case of failure

### 7.9. GENERAL REQUIREMENTS

- i. The offered equipments shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
- ii. Vendor shall ensure availability of spare parts and maintenance support services for the offered equipments for at least 10 years from the date of supply.
- iii. Vendor shall give a notice of at least three years of equipment before phasing out the product/spares to enable for placement of order for spares and services.
- iv. Vendor shall visit the site to take necessary detailed measurements of the cable requirement, verify & confirm space adequacy for installation of total 1 MWp solar systems at Numaligarh Refinery site, Golaghat, Assam.
- v. Vendor shall confirm to compliance to scope of work completely (Clause wise). Deviation from this "Technical Conditions of Tender", if any, shall be mentioned in a separate "**Technical Deviation Statement**" as per following format along with the technical offer. Deviations mentioned elsewhere, may be summarily ignored without further correspondence. NRL shall not be responsible for

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overlooking deviations mentioned in vendors offer documents when these are not specifically mentioned in the "Technical Deviation Statement".

**(1)SL No (2)Page/ Para no. (3)Tender text (4)Deviations sought/ offered**

vi. Training shall be provided to NRL personnel on operation and maintenance of the plant.

### 7.10. HEALTH, SAFETY & ENVIRONMENT

- i. Hazardous materials are manufactured and stored at NRL. The list of NRL products are available in its website [www.nrl.co.in](http://www.nrl.co.in) . All works carried out inside the premises shall be done with adequate protection from the hazards. Moreover, adequate protection shall be taken to avoid environmental degradation.
- ii. The installation shall meet all applicable statutory requirements for health, safety & environment and construction period activities shall be duly compliant.
- iii. The bidder shall submit the following before starting the installation of the power plant in accordance with NRL policies available in its website.
  - Safety and Environment policy of the Company
  - HSE Manuals for Installation
  - Emergency Management Plan

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### 8. GENERAL CONTRACTUAL CONDITIONS

#### 8.1. GUARANTEE / WARRANTY

- i. Guarantee period shall commence from the date of “Job completion” certified by EIC or from the date of successful “Performance Guarantee Test Run” certified by EIC, whichever is earlier.
- ii. Guarantee and Warranty shall be valid for 1 (ONE) YEAR of “Guarantee Period” and shall be comprehensive i.e. include all the supplied equipment and materials as well as the works carried out for developing the facilities. Although Guarantee and Warranty coverage shall be comprehensive, any deviation i.e. specific exclusion should be declared by bidder upfront during the pre-bid discussion through pre-bid queries for consideration of NRL. The decision for allowing such exclusion rests with NRL.
- iii. Grid tie inverter shall be warranted for 5 (FIVE) YEARS.
- iv. All repair and maintenance including replacement of the solar plant and accessories shall be in scope of vendor during the Guarantee period. Vendor shall visit quarterly during the guarantee period for preventive maintenance of the Solar Power System. Vendor shall attend breakdown calls within 48 hours of reporting and replace the faulty/damaged equipments at no extra cost to NRL.
- v. At the end of “Guarantee Period”, prior to commencement of Comprehensive Maintenance Contract (CMC) period, a status report will be provided by the vendor that all equipments are in order and offer the same for joint site inspection. Any pending repair/replacement shall be considered as non-completion of guarantee clause. CMC period shall be allowed to commence but the and Security/Retention/Bank Guarantee(BG) linked with Guarantee Period shall not be released till completion of the repair/replacement of failure or non-performance which has occurred during the pendency of the Guarantee Period. Accordingly, BG has to be extended as per advice of NRL.

#### 8.2. COMPLETION PERIOD

- i. Supply: All items are to be supplied to be within 5 (FIVE) months from the date of LOI/PO. All drawings, approvals, testing, inspection , supplies, installation , commissioning and acceptance shall be included in this period.
- ii. Service: The complete period of installation, testing including Electrical & Comprehensive Commissioning at site shall be 3 (THREE) month from the date of intimation from the site readiness or from the contractual delivery day of supply items, whichever is later.
- iii. Extension : 2 (TWO) months extension shall be considered for balance works i.e. Service part (not applicable for supply part) subject to following conditions:
  - Electrical commissioning is completed during the contractual completion period
  - Plant operates during the subsequent extension period uninterrupted.

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### 8.3. PAYMENT TERMS

- i. SCHEDULE : The following billing schedule shall be admissible for payment on completion of respective scope of work of Supply, Installation, Testing and Commissioning (SITC).
  - 30 % on receipt and acceptance of materials at site.
  - 30 % on Electrical commissioning.
  - 20 % on Comprehensive commissioning.
  - 10 % on Guarantee run completion certificate.
  - 10% on issue of Final Job Completion Certificate.
- ii. BILLING BREAK UP (BBU): Unless otherwise stated, payments shall be released against completion of the whole activity i.e. payments shall not be released against part delivery or part installation. However, EIC may allow for further phasing of payments upon being reasonably satisfied with vendor's mobilization and progress. Vendor shall request for such phased payments by submitting a BBU within one month of placement of order. The Billing Break Up (BBU) shall be based on the Bill of Materials (BOM) submitted along with tender. The authority to decide the extent of phased payments rests with EIC.
- iii. PERFORMANCE BANK GUARANTEE (PBG) : PBG of 10% of the order value (of SITC) shall be submitted immediately upon receipt of order as per NRL format. Equivalent retention money shall be withheld till submission and confirmation of PBG. The PBG or the equivalent withheld amount shall be released after issue of "Final Job Completion Certificate"
- iv. Price reduction for delayed delivery of materials: In case of delay in execution of the order, NRL may at its option, recover from the vendor price reduction of 0.5% of the value of delayed goods per week of delay or part thereof subject to a maximum of 5% of the total order value of goods.
- v. Liquated Damage(LD) for delayed job completion: Liquidated damage for delay in completion shall be charged equal to 1 % or part thereof on the amount of the "service part of the contract value" for every week subject to maximum of 10% of the contract value.
- vi. CMC retentions: In the event the total quoted price of 5 years CMC of the successful bidder is less than 5 % of the quoted price for SITC, differential amount shall be retained for the CMC period. This differential amount shall be released proportionately as per CMC payment terms upon satisfactory completion of CMC event. This shall be done to desist from under quoting and retain vendor's interest in CMC in a financially viable manner. The offer for CMC shall be part of evaluation to arrive at the successful bidder.

### 8.4. PRE QUALIFICATION CRITERIA (PQC)

- i. Bidder should have supplied and commission similar automatic dual axis tracking Solar Power Generation System of **1.0 MWp** capacity or more at single location in India and it should be operational for atleast one year and available for inspection by NRL. Copy of the Work Order (mentioning technical specification and scope), Job Completion Certificate and contact details of client (phone and email of engineering/maintenance section) are to be submitted with offer for verification of PQC.
- ii. Bidder should be manufacturer of the offered make and model of "SPV modules" and "Dual axis tracking system" and its manufacturing facility (factory) of these items should be in India. The factory shall be at least one year old. The relevant documents and details shall be furnished to NRL to

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facilitate documentary verification. NRL may insist on a factory visit where bidder shall demonstrate its manufacturing capability. Bidder may be allowed to outsource "Dual axis tracking system" from any other manufacturer in India meeting the conditions of this sub-clause.

- iii. Bidder should be MNRE approved. Bidder should be registered under MNRE for at least one audited year having moderate to high track record in supply & commissioning of Solar PV power plant.

### **8.5. PRE-BID MEETING**

- i. A pre-bid meeting will be held at NRL Site and the interested vendors should visit and participate in the pre-bid meeting for first hand information & data collection and full understanding of the system.
- ii. During the pre-bid meeting, vendor may propose alternate specifications or design, deviations, exclusions, additional detailing. Bidder is advised to mail the queries and deviations prior to attending the meeting. The final acceptance of such changes same rests with NRL. Such correspondence may be published and made known to other bidders through NRL website or through tender portal.
- iii. NRL reserves the right to ignore queries raised by any participant of the pre-bid meeting subsequently unless same is linked to the earlier pre-queries & responses or is linked to any resultant corrigendum to the tender.
- iv. NRL further reserves the right to ignore queries as well as any deviations sought by interested bidders who have not participated in the pre-bid meeting process.

### **8.6. EVALUATION**

- i. Evaluation of shall be done on the combined landed cost of the following items:
  - 1. SITC of 1MWp Solar Power Plant
  - 2. SITC of incremental 100 KWp Solar Power Plant
  - 3. CMC for Five(5) years for Solar Power Plant (*quoted for each year separately*)

### **8.7. COMPREHENSIVE MAINTENANCE CONTRACT (CMC)**

- i. Comprehensive Annual Maintenance for a period of five (05) years is included in the scope of the contract. It is required to have a minimum of one visit every three months by competent service personnel during the CMC period. Bidders shall separately quote for Maintenance of the power plant for Five (05) years after the first year, wherein the plant should perform at a minimum annual guaranteed performance derated every year by not more than 1% referring to the installed DC capacity of the plant indicated by the Bidder.
- ii. Vendor shall submit "Comprehensive Maintenance Contract" (CMC ) offer for next 5 years (with year wise price breakup) which will be evaluated during price bid. Separate purchase order shall be awarded for CMC job with effect from expiry of warranty period.
- iii. All spares shall be in the scope of vendor. All faulty/damaged parts shall be replaced by vendor with new one at no extra cost to NRL.

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- iv. Vendor shall visit the sites quarterly for preventive maintenance and carry out all the necessary checks/tests for smooth and satisfactory performance of the system. Vendor shall attend any breakdown call within 48 hrs of reporting the failure. Transportation /accommodation of service engineer/technicians for carrying out maintenance should be the responsibility of the vendor.
  
- v. For any incremental increase in capacity carried out under the same contract, the quoted price for CMC shall be deemed to include the additions/extensions. Detailed scope of work for CMC for 1MWp solar plant of NRL is as per Annexure-1

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### **9. ANNEXURE- 1 : COMPREHENSIVE MAINTENANCE CONTRACT (CMC)**

#### **of 1 MWp SOLAR POWER PLANTS AT NRL For 5 YEARS**

##### **9.1. SCOPE OF WORK**

- i. Checking & cleaning of solar modules externally: Solar modules will be cleaned of foreign materials, dust, etc.
- ii. Recording of solar generation parameters: Parameters like voltages, currents, frequency, KWH and all other readings on data logger shall be recorded & analyze with design data.
- iii. Checking of grid tied inverter, data logger & LT power inter phase panel:
  - Checking proper functioning of grid tied inverter, data logger & LT power inter phase panel & taking necessary corrective action to ensure smooth functioning of the system.
  - Cleaning of the ventilation & fans, if applicable (once in three months).
  - Ensuring all cables and terminations are tight.
- iv. Maintenance of Dual Axis Trackers: Trackers will be inspected for dust, rust or any foreign material & cleaned properly. The movement of trackers will be checked properly for proper operation & any discrepancy if found, shall be attended on urgent basis.
- v. Maintenance of Module Mounting Structures: Module mounting structure will be inspected for rusting and possible touch up using paint.
- vi. Checking earthing connections: Checking of all earth connections for solar system and tightening /rectifying the same.
- vii. All systems will have a service history card in which date of visit, job description, remarks by the technician & customer signature along with the details of CMC will be entered during each visit.

##### **9.2. SPECIAL CONDITIONS**

- i. Interval between two consecutive preventive maintenance visits should not be less than 80 days and should not be more than 100 days.
- ii. Quarterly program for maintenance shall be intimated to NRL at least 2 weeks in advance.
- iii. Vendor should submit 3 copies of original invoice along with service report after carrying out the visit.

##### **9.3. SCOPE OF SUPPLY**

- i. All spares / materials shall be in the scope of vendor. All faulty/damaged equipments shall be replaced by vendor with new one/ repair the same at no extra cost to NRL. Scope of supply for NRL is NIL.

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- ii. Vendor shall visit the sites quarterly for preventive maintenance and carries out all the necessary tests for smooth & satisfactory performance of the system.
- iii. All materials required for ensuring the system healthiness including manpower shall be the responsibility of the vendor.
- iv. Transportation / accommodation for carrying out maintenance should be the responsibility of the vendor.
- v. Breakdown Maintenance calls shall be attended when intimated by NRL officer within 48 hrs of intimation without any commercial implications (as offered CMC cost shall be inclusive of any breakdowns).

### 9.4. PAYMENT TERMS

- i. Payment shall be made on quarterly basis after due certification by NRL engineer in charge after affecting necessary deductions as applicable at the time of release of payment.

### 9.5. PENALTY CLAUSE

- i. In the event of vendor not carrying out the preventive maintenance visit in the stipulated time of 80-100 days on any two occasions in one year, NRL reserves the right to terminate the contract and evoke the PBG of vendor.

### 9.6. SCHEDULE OF RATES

	<u>Description</u>	<u>Amount (Rs)</u>
10	Supply, Installation, Testing and Commissioning of 1MWp Solar Power Plant	
20	Supply, Installation, Testing and Commissioning of incremental 100 KWp Solar Power Plant	
30	Comprehensive Maintenance Contract (CMC) Five(5) years for Solar Power Plant ( <i>Payment shall be made quarterly on pro-rata basis</i> )	<b>Rates (Rs per year)</b>
	a) CMC for Year 1	
	b) CMC for Year 2	
	c) CMC for Year 3	
	d) CMC for Year 4	
	e) CMC for Year 5	

**Note: Vendor to confirm SUPPLY COMPONENT in the UNPRICED BID in terms of %age of the quoted basic price (excluding price of CMC).**