	Design, Engineering, Supply, Construction, Erection, Testing, Commissioning, Grid synchronization of Hybrid Roof-Top 100 kW(AC) Solar PV Power Plant at NIWE, Chennai, Tamil Nadu with 5 years of Comprehensive O&M, Warranty and Insurance.

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1 Brief Scope of Works

Design, Engineering, Supply, Construction, Erection, Testing, Commissioning, Grid synchronization of Hybrid Roof-Top 100 kW (AC) Solar PV Power Plant at NIWE, Chennai, Tamil Nadu with 5 years of Comprehensive O&M, Warranty and Insurance. Scope includes dismantling the existing structures, concrete construction and panels at their own cost and detailed load assessment of roof certified by a licensed structural engineer. After dismantling NIWE will provide the area for storage of dismantled materials.

2 Project Particulars:

Particulars	Description
Design and Engineering	
Project AC Capacity	100 kW
Min. DC Capacity	120 kWp
Transformer	Existing 500 kVA Transformer at NIWE Substation (**Note:** Supply not in the scope of the Bidder)
Module Mounting Structure Type	South Facing, Fixed Tilt
Design life of power plant	25 Years
O&M period	5 Years
Site Location and Land Details	
Location	National Institute of Wind Energy, Pallikarnai, Chennai, Tamil Nadu
District	Chennai District
State/UT	Tamil Nadu
Latitude & Longitude	12.956°N and 80.214°E
Altitude	5 m
Available Area	Refer to Annexure B1: Roof Top Area
Type	Roof Top
Project Ownership	NATIONAL INSTITUTE OF WIND ENERGY
Power Evacuation	
Point of Interconnection (POI)	Existing LT Panel at NIWE substation **Note:** The Contractor shall be responsible for obtaining all necessary approvals, permissions, technical feasibility, net metering agreement, synchronization clearance and commissioning approval from TNEB/TANGEDCO. This includes preparation & submission of all drawings, documents, and coordination till successful grid synchronization and energization. Any delays or costs on this account shall be to the Contractor's account.
Evacuation at POI	100 kW

Metering Point	Energy Meter at NIWE substation
Design Parameters	
Design Ambient Temperature	50°C
Basic Wind Speed (IS 875-3)	50 m/s Cyclone Risk Hazard: **High Risk**
Seismic Zone (IS 1893-1)	Zone III
Corrosion Class	C3
Functional Guarantee (at 11 kV Solar Termination Point)	
At Operational Acceptance	PR= 78%
During O&M Period	CUF=19%
Other Details	
Water and Power for Construction	Power required during construction and operational maintenance will be provided by M/s. NIWE

2.1 The projects shall be commissioned as per the technical specifications given below. The Roof Top System (RTS) shall consist of the following:

1. Solar Photo Voltaic (SPV) modules
2. Inverter/PCU
3. Module Mounting structures
4. Net Meter/Smart Meter
5. Array Junction Boxes
6. DC Distribution Box
7. AC Distribution Box
8. Protections – Earthing, Lightning, Surge
9. Cables
10. Drawing & Manuals
11. Miscellaneous

2.2 **Components/Package of Grid Connected Rooftop Solar PV System**: The components of a Grid Connected Rooftop Solar PV System shall essentially comprise but not be limited to solar PV Panels/modules of required number, Inverters/PCU, module mounting structures of minimum 600mm ground clearance at the lowest point from the roof surface, total Cable/wiring of suitable length, cable conduits, required array junction boxes, DC distribution box, AC distribution box, various connectors, nut- bolts, civil and mechanical works, Protection- Earthing, lightning, surges, drawling & manual, 05 years of comprehensive operation & maintenance of grid-connected rooftop solar PV plant and other miscellaneous works.

3 Solar PV modules

3.1 Domestic Manufactured Solar PV modules using domestically manufactured Solar cells shall be used in the Scheme.

Note: *The Contractor shall submit DCR certificate for the PV Modules from the NISE DCR Verification portal along with the invoices for release of payment.*

3.2 The PV modules used must qualify to the latest edition of IEC standards or equivalent BIS standards, i.e. IEC 61215/IS 14286, IEC 61853-Part I or IS 16170-Part I, IS/IEC 61730 Part-1 & Part 2 and IS 17210(part 1) or IEC 62804-1 (PID). For the PV modules to be used in a highly corrosive atmosphere throughout their lifetime, they must qualify to IEC 61701/IS 61701. Thin - Film terrestrial photovoltaic (PV) modules must qualify to IS 16077: 2013 / IEC 61646: 2008

3.3 The rated power of solar PV module shall have maximum tolerance up to +3%.

3.4 The peak-power point current (Imp) of each module within a series-connected string shall not deviate by more than ±1% from the arithmetic mean Imp of all modules in that string. PV module procurement and grouping shall incorporate current binning to ensure compliance with this tolerance.

3.5 The temperature co-efficient power of the PV module shall be equal to or better than -0.4%/°C for crystalline modules and -0.3 %/°C for thin films modules.

3.6 Solar PV modules capacity to be used should adhere to the Approved List of Models and Manufacturers (ALMM) of Solar Photovoltaic Modules (Requirement for Compulsory Registration) Order 2019 - Implementation issued vide OM NO. 283/54/2018-GRID SOLAR -Part (I) Dated 10th March 2021 and subsequent amendments. The modules shall be manufactured using Solar Cells enlisted in ALMM List – II, as notified by MNRE.

3.7 All PV modules should have a nominal power output of >90% at STC during the first 10 years, and >80% during the next 15 years. Further, module shall have nominal power output of >99% during the first year of installation.

3.8 The manufacturer should warrant the Solar Module(s) to be free from the defects and/or failures specified below for a period not less than five (5) years from the date of commissioning.

3.9 Defects and/or failures due to manufacturing.

3.10 Defects and/or failures due to quality of materials.

3.11 Nonconformity to specifications due to faulty manufacturing and/or inspection processes. If the solar Module(s) fails to conform to this warranty, the manufacturer will repair or replace the solar module(s), at the Owners sole option. The PV modules shall be replaced by manufacturers, without charging any cost to the end consumer during the specified period of warranty.

3.12 Modules deployed must use an RF identification tag laminated inside the glass. The following information must be mentioned in the RFID used on each module:

i. Name of the manufacturer of the PV module
ii. Name of the manufacturer of Solar Cells.
iii. Month & year of the manufacture (separate for solar cells and modules)
iv. Country of origin (separately for solar cells and module)
v. I-V curve for the module Wattage, Im, Vm and FF for the module
vi. Unique Serial No and Model No of the module
vii. Date and year of obtaining IEC PV module qualification certificate.
viii. Name of the test lab issuing IEC certificate.
ix. Other relevant information on traceability of solar cells and module as per ISO 9001 and ISO 14001.
x. Nominal wattage +3%.

xi. Name, if applicable.

3.13 Other details as per IS/IEC 61730-1 clause 11 should be provided at appropriate place. In addition to the above, the following information should also be provided:

i. The actual Power Output Pmax shall be mentioned on the label pasted on the back side of PV Module.

ii. The Maximum system voltage for which the module is suitable to be provided on the back sheet of the module.

iii. Polarity of terminals or leads (colour coding is permissible) on junction Box housing near cable entry or cable and connector.

3.14 Unique Serial No, Model No, Name of Manufacturer, Manufacturing year, Make in India logo and module wattage details should be displayed inside the laminated glass.

4 Inverter/PCU

4.1 The Bidder shall comply with the technical requirements.

Parameters	Specifications
Inverter Type	**Hybrid (capable of both off-grid and On-grid mode) with seamless transfer (<10 ms) between grid and off-grid mode**
Nameplate AC power rating	**120 KVA @ 50° C**
Maximum input voltage	1000 V DC
Output voltage range	3 phase 4 wire (415 AC)
Rated frequency	50Hz Grid Frequency Tolerance range: as per CEA/State regulations
Operating frequency range	As per CEA guidelines
Power factor control range	0.9 lag to 0.9 lead
Inverter efficiency	Minimum 97%
Total Harmonic Distortion	Less than 3% at 100 % load
Degree of Protection	IP 54 for Indoor, IP 65 for outdoor
CEA Technical standards for connectivity to the grid regulations 2007 with subsequent amendments	

4.2 Solar Photovoltaic Inverters must comply with the Quality Control Order dated 30.08.2017 for Solar Photovoltaic Inverters and its amendments thereof.

4.3 Inverters/PCU should comply with applicable IEC/equivalent BIS standard for efficiency measurements and environmental tests as per standard codes IEC 61683/IS 61683, IS 16221 (Part 2), IS 16169 and IEC 60068-2(1,2,14,30)/Equivalent BIS Std.

4.4 Maximum Power Point Tracker (MPPT) shall be integrated into the inverter/PCU to maximize energy drawn from the array. Charge controller (if any) / MPPT units environmental testing should qualify IEC 60068-2(1, 2, 14, 30)/Equivalent BIS standard. The junction boxes/enclosures should be IP 65 or better (for outdoor)/ IP 54 or better (indoor) and as per IEC 529 Specifications.

4.5 All inverters/PCUs shall be IEC 61000 compliant for electromagnetic compatibility, harmonics, Surge, etc.

4.6 All the Inverters should contain the following clear and indelible Marking Label & Warning Label as per IS16221 Part II, clause 5. The equipment shall, as a minimum, be permanently

marked with:

i. The name or trademark of the manufacturer or supplier;
ii. A model number, name or other means to identify the equipment,
iii. A serial number, code or other marking allowing identification of manufacturing location and the manufacturing batch or date within a twelve- month time period.
iv. Input voltage, type of voltage (a.c or d.c), frequency, and maximum continuous current for each input.
v. The Ingress Protection (IP) rating

4.7 Inverter/PCU shall be capable of complete automatic operation including wake-up, synchronization & shutdown.

4.8 String Level Monitoring - The inverter shall provide minimum string-level current monitoring for all connected PV strings, with real-time data visibility, fault/alarm generation, and communication compatibility with SCADA/remote monitoring systems via RS485/Ethernet/Modbus protocol.

4.9 All the conducting parts of the PCU that are not intended to carry current shall be bonded together and connected to dedicated earth pits through the protective conductor of appropriate size.

4.10 Dedicated communication interfaces shall be provided to monitor the PCU from SCADA.

4.11 PCU front panel shall be provided with LCD/LED to display all the relevant parameters related to PCU operation and fault conditions. it shall include, but not be limited to, the following parameters.

i. DC Input Power
ii. DC Input Voltage
iii. DC Input Current
iv. AC Output Power
v. AC Output Voltage (All The 3 Phases and Line)
vi. AC Output Current (All The 3 Phases and Line)
vii. Frequency
viii. Power Factor

4.12 The PCU shall include appropriate self-protective and self-diagnostic feature to protect itself and the PV array from damage in the event of PCU component failure or from parameters beyond the PCU's safe operating range due to internal or external causes. The self-protective features shall not allow signals from the PCU front panel to cause the PCU to be operated in a manner which may be unsafe or damaging. Faults due to malfunctioning within the PCU, including commutation failure, shall be cleared by the PCU protective devices. The PCU shall provide protection against the following type of faults, among others.

i. DC/AC Over Current
ii. DC/AC Over Voltage
iii. DC Reverse Polarity
iv. DC Earth Fault
v. AC Under Voltage
vi. AC Under Frequency/Over Frequency
vii. Islanding
viii. Over Temperature
ix. Lightning Surges

x. Cooling Fan Failure
xi. Auxiliary Supply Failure

4.13 The PCU must be able to provide grid support functions, including active power regulation, reactive power control, and voltage ride through (VRT), as per the CEA guidelines

4.14 In case of an external auxiliary power supply is required, standalone UPS along with a minimum backup storage capacity of 2 hours shall be used to meet the auxiliary power requirement of PCU.

4.15 Integration of PV Power with Grid & Grid Islanding:

The Rooftop PV system shall be equipped with islanding protection as per IS 16169: 2019. In addition to disconnection from the grid (due to islanding protection) disconnection due to under and over voltage conditions shall also be provided, if not available in inverter. The inverter shall comply with the latest CEA Grid Code & Tamil Nadu regulations, as applicable.

5 DC Cables

5.1 Technical requirements

All DC cables shall comply with the latest/relevant IS/IEC standards. The following technical requirements general specifications standards and codes are given as general guidelines to follow:

Cable	Standard	Insulation & Conductor	Voltage Rating
DC Cable	IS 7098 Part I	XLPE cable with copper conductor	1.1 kV DC

5.2 General specifications

5.2.1 The outer sheath covering solar cable shall be flame retardant, UV resistant, and black in color, with positive polarity having red line marking on the black outer sheath. DC cables shall be single-core, armored, Flame Retardant Low Smoke (FRLS), PVC outer sheath conforming to IS 7098-I. DC cable with positive polarity should have marking of the red line on the black outer sheath. In addition to the manufacturer's identification on cables as per relevant standard, following marking shall also be provided over the outer sheath.

(i) Cable size and voltage grade.
(ii) Word' FRNC/ FRLS' (as applicable) at every meter.
(iii) Sequential marking of length of the cable in meters at every meter.

5.3 Cables shall be sized based on the following considerations:

(i) Rated and short circuit current of modules and array.
(ii) The average voltage drop in the cables (Modules to Inverter) shall be limited to 1.5 % of the rated voltage. Contractor shall provide voltage drop calculations in excel sheet.
(iii) Short circuit withstands capability.
(iv) De-rating factors according to laying pattern.

5.4 Cables shall be installed considering the following:

(i) Cable installation shall be as per IS 1255.
(ii) DC cables shall be provided with punched/ embossed aluminum tags. The marking shall be done with good quality letters and numbers of proper size so that the cables can be identified easily.
(iii) Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted.

(iv) Cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles. Bimetallic lugs shall be used for connecting Cu bus bar and Al cables or vice-versa.

(v) Solar cables or group of solar cables combined through branch connector may be laid over GI or FRP cable trays / through Double Wall Corrugated (DWC) HDPE conduits from PV String (Series connection of PV Modules) to SMB/String Inverter. The size of the conduit or pipe shall be selected on the basis of 40% fill criteria. Solar cable terminations shall be made with connectors complying IS 16781 / IEC 62852. The connectors shall have degree of protection of IP 68.

(vi) Solar cables, wherever exposed to direct sunlight, shall be laid through Double Wall Corrugated (DWC) HDPE conduits with GI Cable tray.

(vii) Solar cables shall be aesthetically tied to Module Mounting Structure using UV resistant cable-ties suitable for outdoor application.

6 AC Cables

All AC cables shall comply with the latest/relevant IS/IEC standards. The following technical requirements, general specifications, standards and codes are given as general guidelines to follow:

6.1 Technical requirements

AC Cables shall be of the following material types:

LT Cables (from the inverter to LT NIWE Substation)	XLPE insulated PVC sheathed cables

6.2 General Specifications

6.2.1 All AC 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.

6.2.2 Only terminal cable joints shall be accepted. No other cable joint to join two cable ends shall be accepted. However, cable joints may be allowed if the route length is more than the maximum available drum length, subject to NIWE approval.

6.2.3 In addition to the manufacturer's identification of cables as per relevant standards, the following marking shall also be provided over the outer sheath.

(i) Cable size and voltage grade

(ii) Word 'FRLS' at every meter

(iii) Sequential marking of the length of the cable in meters at every meter

6.2.4 Cables shall be sized based on the following considerations:

(i) Rated current of the equipment

(ii) Maximum voltage drop in LT cable (from the inverter to LT NIWE Substation) shall be limited to 0.5% of the rated voltage. Contractor shall provide voltage drop calculations in an excel sheet.

(iii) Short circuit withstands capability as per design for Is.

(iv) De-rating factors according to laying pattern.

6.2.5 Cable installation shall be as per IS 1255.

6.2.6 LT cable (*from the inverter to LT NIWE Substation*) shall be laid through the GI Tray with supports. The output of invertor LT cables shall be connected to NIWE substation LT panel

with required MCCB and Automatic changeover switch and other necessary equipment (panels, controls, indication lamps and measurement instruments etc.,)

6.2.7 Cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles. Bimetallic lugs shall be used for connecting Cu bus bar and Al cables or vice-versa.

6.2.8 All AC cables shall be provided with punched/embossed aluminum tags. The marking shall be done with good quality letters and numbers of proper size so that the cables can be identified easily.

6.3 **Standard And Certifications:**

6.3.1 Relevant standards and codes:

Is 7098-1	Cross-Linked Polyethylene Insulated PVC sheathed cables, Part 1: for working voltage up to and including 1100 V

7 Distribution Switchgear

Technical Specifications of distribution switchgear shall comply with the latest/relevant IS/IEC Standards. The following technical requirements, general specifications, standards, and codes are given as general guidelines to follow:

7.1 Technical Requirements

System Details	Specifications
Rated System Voltage	415V, 3 Phase, 50Hz 4 Wire, Neutral Solidly Earthed (As Per CEA Standards)
Digital Multifunctional Meter (MFM)	
Accuracy Class	0.2S Class for Main Distribution Board At Main Control Room And 0.2 Class For DB
Communication With SCADA	RS485 Communication with Modbus RTU
Current Transformer (CT) As Per Standards	
Voltage Transformer (VT) As Per Standards	
Moulded Case Circuit Breaker (MCCB)	
Rated Voltage	415V
Release	Thermal-Magnetic/Microprocessor
Rated Current	As Per System Requirement
Poles	4 Poles
Rated Insulation Level	690V
Rated Ultimate And Service Short Circuit Breaking Capacity	As Per System Requirement
Rated Making Capacity (As Per System Requirement)	2.1 X Short Circuit Breaking Capacity
Utilization Category	A

7.2 General Specifications

7.2.1 The panel shall be metal-enclosed, free-standing, floor-mounted, and modular type with Compartmentalized construction having the degree of protection of IP 54 as per IS 2147

or better & all outdoor protection of IP 65 or better. All Doors and covers shall be provided with neoprene gaskets to prevent the entry of vermin and dust.

7.2.2 All switches, pushbuttons, etc., shall be operated front and shall be flush/semi-flush Mounted.

7.2.3 The panel shall be fabricated from 2 mm CRCA sheet steel for frame & load-bearing Surfaces. Partitions may be fabricated from 1.6 mm CRCA if no components are mounted on them.

7.2.4 Cable entries shall be from the bottom. The opening of the cable entry shall be covered by 3mm thick gland plates with proper sealing to avoid water and rodent entry.

7.2.5 Earthing bus bar of a suitable cross-section shall be provided throughout the length of the panel.

7.2.6 The panel shall be duly wired with a suitable size of 11 kV, PVC insulated cable, and terminals shall be brought out for cable connections.

7.2.7 10% spare terminals subjected to a minimum of one of each rating shall be provided on each distribution switchgear. All wires shall have ferrules as per the wiring diagram.

7.2.8 The panel shall be painted with 2 coats of primer after pre-treatment and 2 coats of Polyurethane/epoxy paint.

7.2.9 The panel shall be of dead front construction suitable for front operated and back maintained functioning.

7.2.10 240 V, 15 A, 3 pins industrial socket-outlet with ON/OFF switch shall be provided in each panel.

7.2.11 Each panel shall be provided with an LED lamp rated for 240 V, 50 Hz, single- phase AC supply for interior illumination controlled by a door switch.

7.2.12 Suitable lifting hooks shall be provided for each panel.

7.3 Standards and Certification

7.3.1 All equipment provided under distribution switchgear shall comply with the latest revision and amendments of the relevant IEC standard and IS codes. Relevant standards and codes are given below:

Standard/code	Description
IEC 61439-1	Low-voltage switchgear and control gear assemblies- part 1: general rules
IEC 61439-2	Low–voltage switchgear and control gear assemblies- part 2: power switchgear assemblies
IEC 60947-1	Low voltage switchgear and control gear – part1: general rules
IEC 60947-2	low- voltage switchgear and control gear: circuit breakers
IEC 60947-3	Low-voltage switchgear and control gear – part-3 switches, disconnectors, switch, disconnectors, and fuse combination units
IEC 60947-4-1	Low-voltage switchgear and control gear- part 4-1: contactors and motor starters- electromechanical contactors and motor-starters

IEC 60947-5-1	Low-voltage switchgear and control gear – part 5-1: control circuit devices and switching elements electromechanical control circuit devices
IEC 60947-11	Electricity metering equipment(ac)- general requirements, tests, and test conditions-Part 11: Metering Equipment
IS 694	Polyvinyl chloride insulated unsheathed- and sheathed cables/cords with rigid and –flexible conductor for rated voltages—up to and including 450/750V
IEC 61869	Instrument Transformers
IS 3043	Code of practice for Earthing
IEC 60255	Measuring relays and protection equipment-Part 1: Common Requirements

8 Uninterrupted Power Supply (UPS)

8.1 The uninterrupted Power Supply (UPS) system shall be designed to supply power to the following loads (but not limited to)

i. Data logger/SCADA
ii. HMI of SCADA
iii. Emergency Lighting
iv. Inverter's Auxiliary supply (if applicable)

8.2 UPS should have a battery backup system for minimum 2 hours

8.3 Contractor shall provide the Operation & Maintenance Manual and Mandatory spare parts list along with the equipment.

8.4 On completion of installation and commissioning of the equipment on site tests shall be carried out with the max. available load, which does not exceed the rated continuous load. An on-site test procedure shall be submitted by Contractor include a check of controls and indicators after installation of the equipment.

9 Module Mounting Structure (MMS):

9.1 Supply, installation, erection and acceptance of module mounting structure (MMS) with all necessary accessories, auxiliaries and spare part shall be in the scope of the work.

9.2 The MMS structure shall be hot-dip galvanized with a minimum thickness of 120 microns coating provided on each side. The support structure shall be designed as per relevant Indian standard(s) against prevailing loads considering the appropriate factor of safety. The connection between foundation to structures and other marks should be designed as per Indian standards.

9.3 All bolts, nuts, fasteners shall be of stainless steel of grade SS 304 or hot dip galvanized, panel mounting clamps shall be of aluminum and must sustain the adverse climatic conditions. Structural material shall be corrosion resistant and electrolytically compatible with the materials used in the module frame, its fasteners, nuts and bolts.

9.4 The module mounting structures should have angle of inclination as per the site conditions to take maximum insolation.

9.5 The Mounting structure shall be so designed to withstand the speed for the wind zone of the location (Refer Clause 2. Project Parameters).

9.6 Suitable fastening arrangements such as grouting and calming should be provided to secure the installation against the specific wind speed.

9.7 Adequate spacing shall be provided between two panel frames and rows of panels to facilitate personnel protection, ease of installation, replacement, cleaning of panels and electrical maintenance.

9.8 The structure shall be designed to withstand operating environmental conditions for a period of minimum 25 years.

9.9 The design calculations of the Module Mounting Structure (MMS) and rooftop structural adequacy assessment shall be duly certified by a qualified Structural Chartered Engineer registered with the Institution of Engineers (India) having min. 15 years' experience in cyclone-prone areas. The MMS shall be designed in accordance with the latest applicable IS Codes, considering site-specific wind loads, seismic loads, dead loads, live loads, gust factor, terrain category, and importance factor. The bidder shall submit detailed structural design calculations and stability analysis for approval prior to installation.

9.10 The Contractor shall assess the load-carrying capacity of the existing roof (through a licensed Structural Engineer) and certify that the proposed solar installation, including modules, MMS, walkways, and associated equipment, can be safely accommodated without adversely affecting the structural integrity of the building.

9.11 Foundation - Foundations shall use chemical anchoring or non-penetrating ballast systems suitable for rooftop (with structural adequacy certificate).

9.12 Material standards:

9.12.1 Design of foundation for mounting the structure should be as per defined standards which clearly states the Load Bearing Capacity & other relevant parameters for foundation design (As per IS 6403 / 456 / 4091 / 875).

9.12.2 Grade of raw material to be used for mounting the structures so that it complies the defined wind loading conditions (As per IS 875 - III) should be referred as follows (IS 2062 – for angles and channels, IS 1079 – for sheet, IS 1161 & 1239 for round pipes, IS 4923 for rectangular and square hollow section)

9.12.3 Test reports for the raw material should be as per IS 1852 / 808 / 2062 / 1079 / 811.

9.12.4 In process inspection report as per approved drawing & tolerance should be as per IS 7215.

9.12.5 For ascertaining proper welding of structure part following should be referred:

(i) D.P. Test (Pin Hole / Crack) (IS 822)

(ii) Weld wire grade should be of grade (ER 70 S - 6)

(iii) For ascertaining hot dip galvanizing of fabricated structure following should be referred:-

(a) Min coating required should be as per IS 4759 & EN 1461.

(b) Testing of galvanized material

(c) Pierce Test (IS 2633)

(d) Mass of Zinc (IS 6745)

(e) Adhesion Test (IS 2629)

(f) CuSO4 Test (IS 2633)

(g) Superior High-Grade Zinc Ingot should be of 99.999% purity (IS 209)

10 Array Junction Boxes

10.1 The junction boxes are to be provided in the PV array for termination of connecting cables. The Junction Boxes (JBs) shall be made of GRP/FRP/Powder Coated aluminum /cast aluminum alloy with full dust, water & vermin proof arrangement. All wires/cables must

be terminated through cable lugs. The JBs shall be such that input & output termination can be made through suitable cable glands. 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.

10.2 Copper bus bars/terminal blocks housed in the junction box with suitable termination threads Conforming to IP 65 or better standard and IEC 62208 Hinged door with EPDM rubber gasket to prevent water entry, Single /double compression cable glands should be provided.

10.3 Polyamide glands and MC4 Connectors may also be provided. The rating of the junction box shall be suitable with adequate safety factor to interconnect the Solar PV array.

10.4 Suitable markings shall be provided on the bus bar for easy identification and the cable ferrules must be fitted at the cable termination points for identification.

10.5 Junction boxes shall be mounted on the MMS such that they are easily accessible and are protected from direct sunlight and harsh weather.

11 DC Distribution Box

11.1 DC Distribution Box are to be provided to receive the DC output from the PV array field.

11.2 DCDBs shall be dust & vermin proof conform having IP 65 or better protection, as per site conditions.

11.3 The bus bars are made of EC grade copper of required size. Suitable capacity MCBs/MCCB shall be provided for controlling the DC power output to the inverter along with necessary surge arrestors. MCB shall be used for currents up to 63 Amperes, and MCCB shall be used for currents greater than 63 Amperes.

12 Protections

The system should be provided with all necessary protections like earthing, Lightning, and Surge Protection, as described below:

12.1 Earthing

12.1.1 Codes and Standards

Earthing system shall comply with the latest revisions and amendments of the relevant IEC standards and IS codes. In particular, the earthing system shall comply with the following standards and codes.

Standard/code	Description
IS 3043	Code of practice for earthing
IEEE 80	IEEE Guide for Safety in AC Substation Grounding
IEEE 142	IEEE Recommended Practice for Grounding of Industrial and Commercial power systems

12.1.2 Earthing system shall be designed based on system fault current and soil resistivity value obtained from the geo-technical investigation report. Earth grid shall be formed consisting of a number of earth electrodes sufficient enough to dissipate the system fault current interconnected by earthing conductors

12.1.3 The earth electrode shall be made of a high tensile low carbon steel rod with high conductivity copper on the outer surface with coating thickness not less than 250 microns as per relevant standards. Suitable earth-enhancing material shall be filled around the

electrode to lower the resistance to earth. Inspection chamber and lid shall be provided as per IS 3043.

12.1.4 Earth conductors shall be made of copper bonded steel or galvanized steel of sufficient cross-section to carry the fault current and withstand corrosion.

12.1.5 Earth conductors buried in the ground shall be laid a minimum of 600 mm below ground level unless otherwise indicated in the drawing. Backfilling material to be placed over buried conductors shall be free from stones and harmful mixtures. Earthing conductor shall be buried at least 2000 mm outside the fence of electrical installations.

12.1.6 Earth electrodes shall not be situated within 1.5m from any building whose installation system is being earthed. Minimum distance between earth electrodes shall be driven from the depth of the electrode.

12.1.7 Every alternate post of the transformer yard and switchyard fence shall be connected to the earth grid by one GS flat and gates by flexible lead to the earthed post.

12.1.8 All welded connections shall be made by electric arc welding. For rust protection, the welds should be treated with a red lead compound and afterward thickly coated with bitumen compound.

12.2 Earthing of PV Array Field

12.2.1 All PV Modules, module mounting structures, and string monitoring unit structures in the PV array field shall be bonded to the earthing system by two distinct connections.

12.2.2 Each PV module frame shall be earthed using copper wire of sufficient cross-section. The copper wire shall be connected to the earth hole provided in the module frame using suitable arrangement in line with the manufacturer's recommendation. The earthing arrangement shall use stainless washers to prevent galvanic corrosion between the aluminum frame and copper wire. In order to achieve effective earthing, serrated washers shall be employed to penetrate the anodization layer of the module frame.

12.2.3 Continuous copper earthing wire shall be run to connect a group of modules, and both ends of the loop shall be bolted to the DC earth grid using bimetallic lugs and a stainless-steel fastener. The copper earthing wire shall be routed in such a way to avoid physical contact with the module aluminum frame.

12.2.4 The connection between MMS and DC earth grid shall be bolted or welded. The portion of the MMS which undergoes welding at the site shall be coated with two coats of cold galvanizing and anti-corrosion paint afterward.

12.2.5 Earth electrodes of the DC earth grid shall be uniformly distributed throughout the PV array field so that optimum earth resistance is offered to leakage current flowing from any module frame or MMS.

12.2.6 SMU equipment earthing point shall be connected to the DC earth grid using a flexible copper cable of sufficient cross-section as recommended by the manufacturer. The connection with the DC earth grid shall be made using suitable bimetallic lugs and stainless-steel fasteners.

12.3 PCU Earthing

12.3.1 DC negative bus bar of the PCU shall be earthed to avoid potential induced degradation. DC negative bus bar and PCU equipment earth shall be bonded to the PCU earth bus and connected to earth electrodes through the flexible copper cable of sufficient cross-section as mentioned by the manufacturer. The interconnection of PCU earth electrodes with DC earth shall be as per PCU manufacturer recommendation.

12.4 Tests

12.4.1 On completion of installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded.

12.5 Lightning Protection

12.5.1 The SPV power plants shall be provided with lightning & over voltage protection, if required. The main aim in this protection shall be to reduce the overvoltage to a tolerable value before it reaches the PV or other sub system components. The source of over voltage can be lightning, atmosphere disturbances etc. Lightning arrestor shall not be installed on the mounting structure.

12.5.2 The entire space occupying the SPV array shall be suitably protected against Lightning by deploying required number of Lightning Arrestors (LAs). Lightning protection should be provided as per NFC17-102:2011/IEC 62305 standard.

12.5.3 The protection against induced high-voltages shall be provided by the use of Metal Oxide Varistors (MOVs)/Franklin Rod type LA/Early streamer type LA.

12.5.4 The current carrying cable from lightning arrestor to the earth pit should have sufficient current carrying capacity according to IEC 62305. According to standard, the minimum requirement for a lightning protection system designed for class of LPS III is a 6 mm2 copper/ 16 mm2 aluminum or GI strip bearing size 25*3 mm thick). Separate pipe for running earth wires of Lightning Arrestor shall be used.

12.6 Surge Protection

12.6.1 Internal surge protection, wherever required, shall be provided. It will consist of three SPD type-II/MOV type surge arrestors connected from +ve and –ve terminals to earth.

13 SCADA

13.1 General Requirements

13.1.1 The Contractor shall provide complete SCADA system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation and monitoring of entire solar plant and its auxiliary systems suitable for industrial application.

13.1.2 The Contractor shall provide all the components including, but not limited to, Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cables, firewall etc. needed for the completeness.

13.1.3 SCADA System shall have the provision to perform the following features and/or functions:

(i) Web enabled Operator Dashboards: Showing key information on Generation, Performance and Current Status of various equipment in Single Line Diagram (SLD) format with capability to monitor PV array String level (Inverter DC Input) parameters.

(ii) Real time Data Logging with Integrated Analytics & Reporting: Logging of all parameters - AC, DC, Weather, System Run Hours, Equipment Status and Alarms as well as derived/ calculated/ integrated values. The SCADA User interface shall

be customizable and enable Report Generation and Graphical Analysis.

(iii) Fault and System Diagnostics with time stamped event logging.

13.1.4 The SCADA system shall perform the following operations, which include the measurement and continuous recording at an interval of 1 minute

(i) DC input of Inverter

(ii) Inverter output power, energy, voltage, current, and pf.

(iii) AC and DC side power of the inverter.

(iv) Energy delivered to the grid in kW

(v) System frequency

(vi) Current and voltage of each sub-array/string

(vii) Any other parameters considered necessary by supplier based on current prudent practice.

13.2 System Spare Capacity

13.2.1 Over and above the equipment and accessories required to meet the fully implemented system as per specification requirements, Control System shall have spare capacity and necessary hardware/ equipment/ accessories to meet following requirement for future expansion at site:

(i) 10 % spare channels in input/output modules fully wired up to cabinets TB.

(ii) Wired-in "usable" space for 10% modules in each of the system cabinets for mounting electronic modules wired up to corresponding spare terminals in system cabinets.

(iii) Empty slots between individual modules/group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice of Contractor shall not be considered as wired-in "usable" space for I/O modules.

(iv) Terminal assemblies (if any in the offered system), corresponding to the I/O modules shall be provided for above mentioned 10 % blank space.

(v) Each processor / controller shall have 20% spare functional capacity to implement additional function blocks, over and above implemented logic/ loops. Further, each processor / controller shall have spare capacity to handle minimum 20% additional inputs/ outputs of each type including above specified spare requirements, over and above implemented capacity. Each of the corresponding communication controllers shall also have same spare capacity as that of processor/controller.

(vi) The Data communication system shall have the capacity to handle the additions mentioned above.

(vii) Ten (10) percent spare relays of each type and rating mounted and wired in cabinets TB. All contacts of relays shall be terminated in terminal blocks of cabinets.

(viii) It shall be possible to remove/replace redundant controller or various modules from its slot for maintenance purposes without switching off the power supply to the corresponding rack without releasing any spurious signal to the controller and causing disturbance or loss of controller functions for another controller.

13.2.2 **Reports -** SCADA shall provide 1 minute and 10-minute interval daily, monthly and annual reports (downloadable in Excel/PDF, configurable for equipment parameters across the plant.). System should have a minimum storage capacity of 15 days.

13.2.3 SCADA should be compatible with transmitting the data to the NIWE server or any other institution as directed by NIWE as per their requirement which can be remotely accessed.

13.2.4 PLC Processor

The processor unit shall be capable of executing the following functions.

(i) Receiving binary and analog signals from the field to server

(ii) Implementing all logic functions for protection and annunciation of the equipment and systems.

(iii) Providing supervisory information for alarm, various types of displays, status information, trending, historical storage of data, etc.

13.3 Human Machine Interface System (HMIS)

13.3.1 Graphical interface unit/ Operator work station shall perform monitoring and operation of all devices interacting with PLC-based system.

13.3.2 The system shall have built-in safety features that will allow/ disallow certain functions and entry fields within a function to be under password control to protect against inadvertent and unauthorized use of these functions. The system security shall contain various user levels with specific rights as finalized by NIWE during detailed engineering. However, no. of user levels, no. of users in a level, and rights for each level shall be changeable by the programmer.

13.3.3 Contractor has to provide suitable hardware and software-based firewall for network security to restrict unauthorized access to HMI/Solar SCADA PCs and systems.

13.4 Software Requirements

13.4.1 All necessary software required for the implementation of control logic, operator station displays/ logs, storage and retrieval and another functional requirement shall be provided.

13.4.2 Industry standard operating systems like WINDOWS etc., to ensure openness and connectivity with other systems in the industry shall be provided. SCADA system shall support the following standard protocols to communicate with different subsystem/devices:

(i) MODBUS (TCP/IP, RTU, ASCII)

(ii) IEC 60870- 5 – 101/104

(iii) Any other protocol on which the offered equipment will communicate with SCADA

13.4.3 The Contractor shall provide software locks and passwords to NIWE for all operating and application software. Also, the Contractor shall provide sufficient documentation and program listing so that it is possible for NIWE to carry out modification at a later date.

13.4.4 The Contractor shall provide a software License for all software being used in Contractor systems. The software licenses shall be provided for the project and shall not be hardware/machine-specific.

13.5 Operator Interface Displays/Logs/Reports

13.5.1 Suitable operator interface displays/logs/reports for control operation and monitoring shall be provided. The details shall be furnished and finalized during detailed engineering.

13.6 Control And Power Supply Scheme

13.6.1 The Contractor shall provide the UPS/DC power supply of suitable rating to cater to all

the load requirements of the SCADA system and its auxiliaries. The power backup for the entire system should be at least for 2 hrs.

13.7 Communication Cables

13.7.1 Optical Fiber Cables

13.7.2 Optic Fiber cable shall be 8 core galvanized corrugated steel taped armoured, fully water blocked with the dielectric central member for outdoor/ indoor application.

13.7.3 The cable shall have multiple single-mode or multimode fibers on a required basis so as to avoid the usage of any repeaters.

13.7.4 The outer sheath shall have Flame Retardant, UV resistant properties and are to be identified with the manufacturer's name, year of manufacturing, progressive automatic sequential online marking of length in meters at every meter on the outer sheath.

13.7.5 All testing of the optic fiber cable being supplied shall be as per the relevant IEC/IS standards.

13.7.6 The Contractor shall ensure that a minimum of 10% cores is kept as spare in all types of optical fiber cables.

13.7.7 Cables shall be suitable for laying in conduits, ducts, trenches, racks.

13.7.8 Spliced/ Repaired cables are not acceptable. Penetration of water resistance and impact resistance shall be as per IEC standards.

13.8 Communication Cable (MODBUS)

13.8.1 Data (Modbus) Cable to be used shall be shielded type with stranded copper conductor. The cable shall have minimum 2 pair each with conductor size of 0.5 Sq.mm. Cable shall be flame retardant according to IEC 60332-1-2

14 Functional Guarantee Test

14.1 **Performance Ratio Test**: Functional Guarantee Test shall comprise of Performance Ratio Test in accordance with IEC/IS 61724.

14.1.1 The contractor shall maintain a minimum PR (as specified in Clause 1: Project Particulars) at the time of Operational Acceptance of the Project.

14.1.2 The "Plane of Array irradiance" for PR Test shall be the measured value from the weather monitoring station (WMS) installed at NIWE site. In case if this data is not available, the same shall be obtained from the nearest SRRA stations.

14.1.3 For every 1% shortfall in PR below the specified PR value, liquidated damages of 1% of the EPC Contract Value shall be levied. In case the Plant PR shortfall is more than 5% below the specified PR value, then the total plant will be accepted on "as-is basis" & 10% of the EPC Contract Value shall be deducted from the Operational Acceptance Milestone payment. However, any other earlier pending/running payments as may be applicable, will be paid to the contractor as usual.

14.2 **CUF:**

14.2.1 Capacity Utilization Factor (CUF) for Solar Plant shall be calculated as per the following formula.

$$\mathrm{CUF} = \frac{\mathrm{E_{ac}}}{8760 \times \mathrm{P_{ac}} \times [1 - \mathrm{DF} \times (\mathrm{N} - 1)] \times \mathrm{RCF}}$$

where,

E_{ac} , is the Net Energy Exported from the Plant, kWh

= (Energy export recorded in the Metering (LT) Panel at NIWE Substation*) - (Energy import recorded in the Metering (LT) Panel at NIWE Substation*), kWh

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

P_{ac} is the plant AC capacity, kW

DF is module degradation factor, (as per PV Module Datasheet)

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

RCF is the Radiation Correction Factor:

$$\text{RCF} = \frac{Measured\ Irradiation}{Reference\ Irradiation},$$

Reference Irradiation for the site = 1855 kWh/m^2/year

14.2.2 **Limitation of Contractor's Liability under this Guarantee**: In the event the CUF is less than the Guaranteed CUF, the Contractor shall immediately, upon demand, indemnify the Owner, as liquidated damages and not as penalty, amounts equivalent to remuneration of the equivalent shortfall Energy, subject to a maximum of ten (10%) percent of the Total Annual O&M Price.

15 Equipment Inspection Category

15.1 All equipment is classified into two categories namely, Category – A and Category – B on the basis of pre-dispatch inspection requirement by SECI and Contractor.

Category	Stake holder	Pre-dispatch inspection
Category – A	SECI/Employer	No
	Contractor	Yes
Category – B	SECI	No
	Contractor	No

15.2 However, SECI reserves the right to conduct pre-dispatch inspection for Category A and Category-B.

S. No.	Equipment Code	Equipment
Category – A		
1	PCU	Inverter
2	PV	PV Module
3	DSP	Distribution Switchgear Panel
4	SCADA	SCADA
5	MMS	Module Mounting Structure
6	DCD	DC Distribution Box

7	ABT	Metering Set
Category – B		
1	UPS	Uninterrupted Power Supply
2	DCC	DC Cables
3	ACC	AC Cables
4	AJB	Array Junction Box
5	EES	Earth Electrode and Accessories
6	LPS	Lightning Protection System
7	CMC	Communication Cable
8	TI	Testing instruments
9	CTK	Cable Termination Kits
10	FST	Fasteners

15.3 **Category – A**

For Category – A equipment, the Contractor shall intimate SECI/Employer about the proposed inspection at least 3 working days before the scheduled start date of pre-dispatch inspection. SECI/Employer will participate in the predispatch inspection, if required.

If SECI/Employer participates in the pre-dispatch inspection, based on the inspection report and compliance report (if any), Material Dispatch Clearance Certificate (MDCC) will issued by SECI. In case SECI does not participate in the pre-dispatch inspection, the Contractor shall submit the Inspection Report signed by Contactor and Manufacturer/Supplier Representatives to SECI for issuance of Material Dispatch Clearance Certificate (MDCC).

15.4 **Category – B**

For Category – B equipment, the Contractor shall submit internal routine test reports performed by the Manufacturer/Supplier. The methodology proposed for conduct inspection and issuance of MDCC is as under:

Category	Inspection done by	MDCC issued by	
A	Contractor (SECI/Employer optional)	SECI	Contractor shall submit all the test report / material certificates to SECI. SECI shall review these documents and if found satisfactory, shall issue MDCC.
B	Certificate of Compliance (CoC) by Manufacture / Supplier	SECI	Contractor will verify the CoC and issue the MDCC which will be verified by SECI.

Project Inspection Report under RfS document No: **Dated:**			
Date of Inspection:			
A	Name of the Contractor:		
B	Address of SPV power plant**:**		
C	Meter Consumer Number: ……. (Electricity bill copy to be attached)		
S. No	**Component**	**Details**	**Page No.**
1	Installed Project capacity in (kWp)		
2	Whether the system is installed in shadow free area or not? If not mention the details.	YES /NO	
3	PV modules	Attach Invoice copy of modules Attach Delivery challan of modules	
4	Type, Make and year of manufacturing of Modules		
5	Flash Test Report for all modules (rated output power of any supplied module shall have positive tolerance in range of 5 watt)	YES/NO (Documents attached)	
6	PV module qualification test standard (IEC 61215/IS14286 / IEC 61730 / IEC 61701/IS 61701 (for highly corrosive atmosphere)	Certificate Number: Certificate issued by: Certificate issued on: Certificate valid up to:	
7	Wattage of each module and Total No. of modules		
8	Integrated bypass diodes	YES/NO	
9	Representative I-V curve of modules @STC	Documents attached	
10	Module RF identification tag (Inside /outside lamination)	YES/NO	
11	Whether the modules contain information about company name, serial no and year manufacturing	YES/NO (RFID information attached)	

	etc.		
12	Warranty Certificates (Material Warranty/ Performance Warranty) signed and stamped by Contractor	Signed and Stamped copy by Contractor (Documents attached)	
13	Protection class of Junction box of modules (IP- 65)	YES/NO	
ARRAY STRUCTURE			
14	Material of structure	Hot dip galvanized MS / Steel (IS 2062: 1992) / Aluminum (Check Material test report as per IS)	
15	Galvanization of mounting structure as per IS 4759	YES/NO (check test report as per IS)	
16	Galvanization thickness of mounting structure	1. _____ mm 2. Galvanization test report as per IS – YES/NO	
17	Wind load calculation sheet for wind zone of the location	Designed to sustain wind speed up to _____ kmph	
18	MMS Design certified by a recognized Lab/ Institution	1. YES/NO 2. Attach Document	
19	Material of fasteners (Stainless steel)	YES/NO	
20	Load bearing capacity of the Crash Barrier & Sound Barrier	OK / Not OK (visual observation)	
21	Minimum clearance of the structure from the Crash Barrier	……mm	
PCU/ INVERTER			
22	Guaranteed Technical Particulars for PCU/ Inverter as per RfS document	YES/NO	
23	Make, rating of each inverter & No. of Inverters (AC capacity of		

	inverter)		
24	Combined Rated wattage of all inverters in Plant (Total AC rating)		
25	MPPT is integrated in the PCU/inverter	YES/NO	
26	Year(s) of manufacturing of inverters		
27	Switching devices, inverter data sheet as per RfS document	YES/NO	
28	Protection of Enclosure (IP) and Location of Inverters (outdoor/indoor)		
29	Phase of inverter	3 phase / 1 phase	
30	Whether solar PV plant is synchronized with grid	YES/NO	
31	Inverter standard codes IEC 61683/IS 61683, IEC 60068-2(1, 2, 14, 30) /Equivalent BIS Std.	Certificate Number: Certificate issued by: Certificate issued on: Certificate valid up to:	
32	Anti- Islanding (IEEE 1547/UL1741/IEC 62116)	Certificate Number: Certificate issued by: Certificate issued on: Certificate valid up to:	
33	Serial Numbers of installed inverters		
DCDB /JUNCTION BOXES (IF REQUIRED)			
34	GTP of JB as per RfS document (duly signed by Contractor and manufacturer)	YES/NO	
35	IP protection level	IP - (Check Test report as per IS)	
36	Bus bar material of DCDB	Copper, YES/NO,	
37	MCB/MCCB installed	YES/NO, Rating, Data	

		sheet attached	
38	Surge arrester, SPDS	YES/NO, Rating, Data sheet attached	
39	Material of sheet and thickness	GRP/FRP/Power coated aluminum /Cast Aluminum alloy	
40	Test report of DCDB	Attached (As per IS)	
41	Height of junction box	5 feet or more (YES/NO)	
42	Glands type	Single / Double compression gland	
43	JB Earthing provision	YES/NO	
AC DISTRIBUTION PANEL BOARD/ LT Panel			
44	All switches and the circuit breakers, connectors standards IEC 60947, part I, II and III/ IS60947 part I, II and III)	YES/NO, (check Rating, Data sheet)	
45	IP protection (Minimum 54 or better)	YES/No	
46	Material of LT panel and its details		
47	Change over switch	YES/NO,	
48	Proper Earthing of ACDB (As per IS 3043-1987)	YES/NO	
49	Surge protections	YES/NO (check Rating, Data sheet)	
50	Height of LT panel form ground	……Meters	
51	Test report of ACDB as per IE Rules	YES/NO	
LIGHTENING ARRESTER			
52	Proper Lighting arrester installed (As per NFC 17-102:2011/ IEC 62561)	YES /NO	
CABLES			
53	Meets IEC 60227/IS 694, IEC 60502/IS1554 standards (or other	YES/NO,	

	as applicable)	Certificate Number: Certificate issued by: Certificate issued on: Certificate valid up to:	
54	Cable dimension and Material 1- Modules to inverters, Inverter to LT panels,	1-……. sqmm Material - 2-……. sqmm, Material -	
55	Voltage drop in DC cable (Modules to inverters)	_____%__,	
56	Voltage drop in AC cable (inverter to LT panel or T/F)	_____%,	
57	Cable Routing/ Marking (GI cable tray and suitably tagged and marked with proper manner by good quality ferrule)	YES/NO	
SOLAR PLANT MONITORING			
58	Solar Irradiance sensor mounted on Plane of the array.	YES/NO	
59	Irradiance Sensor calibration certificate	Certificate Number: Certificate issued by: Certificate issued on: Certificate valid up to:	
60	Temperature sensor	YES/NO	
61	Online Monitoring mechanism for the installed system	YES/NO	
TRANSFORMER (IF REQUIRED)			
62	Transformer rating, Type etc.		
MISCELLANEOUS			
63	Earthing and protections (Array Structure, PCU, ACDB and DCDB) IS:3043-1987	OK/Not OK	

64	Earthing Resistance less than 5 ohms	YES/NO, values……. ohms	
65	NOC from the Concerned DISCOM for the connectivity, technical feasibility, and synchronization of SPV plant	YES/NO, attached (not mandatory)	
66	Bidirectional meters installed (for net metering)	YES/NO, Rating, Data sheet	
67	Accuracy and burden of Meters		
68	Danger boards and signages	YES/NO	
69	Fire extinguishers & Sand Buckets	YES/NO	
70	Tools & Tackles and **spares**	OK/Not OK	
71	O&M manual available at site	YES/NO	
72	Display Board	YES/NO	
DRAWINGS AT SITE			
73	Layout of solar Power Array As built drawing **(A3 Sheet)**	Check and Attach	
74	Shadow analysis of the Installation Area	Check and Attach	
75	Single line diagram of plant (SLD) **A 3 sheet)**	Check and Attach	
76	Structural drawing along with Installation details for the structure **(A3 Sheet)**	Check and Attach	
77	Itemised bill of material for complete SPV plant covering all the components and associated accessories. The country of manufacturing needs to be mentioned for all major components like modules, inverters, cables, mounting structure, switchgear, SCADA system etc.	Check and Attach	
78	Soft copy in CD of final drawing	Check and Attach	

79	Photo Graphs of sites	Check and Attach	
80	Any specific problem(s)		
81	Recommendations		

Format for Performance Ratio (PR)

"Performance Ratio" (PR) means the ratio of plant output versus installed plant capacity at any instance with respect to the radiation measured.

$$PR = \frac{Measured\ Output\ in\ kW}{Installed\ capacity\ in\ kW \times Measured\ radiation\ intensity\ in\ kW/m^2} \times 100$$

Parameters	**Input value**	**Remarks, if any**
Date and Time for PR measurement		
A) Installed Plant Capacity in kW		
B) Measured output in kW		
C) Measured radiation intensity in W/m^2		
Performance Ratio (%) $(\frac{B*1000}{A\times C} \times 100)$		
Date of Installation/ Completion of the Solar PV Project		

Declaration:

It is to certify that all the information given above is true and correct to best of our knowledge. The plant is found to be installed as per the technical specifications mentioned in SECI's RfS document No.: _____

Signature of Representative of Contractor, Date & Seal