

and Apparent), Power Factor and AC energy (All 3 phases and cumulative) and frequency. Remote monitoring of inverter parameters should also be available.

xxiii. The inverter shall include adequate internal cooling arrangements (exhaust fan and ducting) for operation in a non-AC environment.

xxiv. The preferred brands of On-grid string Inverters are DELTA/Schneider/ABB/SMA. Bidder can quote any one make of the inverter.

c) **Factory Testing:**

i. The PCU shall be tested to demonstrate operation of its control system and the ability to be automatically synchronized and connected in parallel with a utility service, prior to its shipment.

ii. Operation of all controls, protective and instrumentation circuits shall be demonstrated by direct test if feasible or by simulation operation conditions for all parameters that cannot be directly tested.

iii. Special attention shall be given to demonstration of utility service interface protection circuits and functions, including calibration and functional trip tests of faults and isolation protection equipment.

iv. Operation of start-up, disconnect and shutdown controls shall also be tested and demonstrate. Stable operation of the PCU and response to control signals shall also be tested and demonstrated.

v. Factory testing shall not only be limited to measurement of phase currents, efficiencies, harmonic content and power factor, but shall also include all other necessary tests/ simulation required and requested by the Purchasers Engineers. Tests may be performed at 25%, 30%, 75% & 100% of the rated nominal power.

vi. A Factory Test Report (FTR) shall be supplied with the unit after all tests. The FTR shall include detailed description of all parameters tested qualified and warranted.

d) **PROTECTIONS:**

i. **Lightning protection (ECE Type)**

The SPV power plants shall be provided with lightning & over voltage protection. The

main aim in this protection shall be to reduce the over voltage 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 the entire space occupying the SPV array shall be suitably protected against Lightning by deploying required number of Lightning Arrestors. Lightning protection should be provided as per NFC 17- 102:2011 standard. The protection against induced high-voltages shall be provided by the use of metal oxide varistors (MOVs) and suitable earthing such that induced transients find an alternate route to earth.

**ii. Surge protection**

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

**e) Cables & wires**

**Cabling in the yard and control room:** Cabling in the yard shall be carried out as per IE Rules. All other cabling above ground should be suitably mounted on cable trays with proper covers.

- i. Wires: Only FRLS copper wires of appropriate size and of reputed make shall have to be used.
- ii. Cables Ends: All connections are to be made through suitable cable/lug/ terminals; crimped properly & with use of Cable Glands.
- iii. Cable Marking: All cable/wires are to be marked in proper manner by good quality ferule or by other means so that the cable can be easily identified. Any change in cabling schedule/sizes if desired by the bidder/supplier be got approved after citing appropriate reasons,
- iv. All cable schedules/layout drawings have to be got approved from the purchaser prior to installation. All cable tests and measurement methods should confirm to IEC 60189.

f) **Electrical Safety, Earthing Protection**

i. **Electrical Safety**

- Internal Faults: In built protection for internal faults including excess temperature, commutation failure and overload and cooling fan failure (if fitted) is obligatory.
- Over Voltage Protection: Over Voltage Protection against atmospheric lightning discharge to the PV array is required. Protection is to be provided against voltage fluctuations and internal faults in the power conditioner, operational errors and switching transients.
- Earth fault supervision: An integrated earth fault device shall have to be provided to detect eventual earth fault on DC side and shall send message to the supervisory system.
- Cabling practice: Cable connections must be made using PVC Cu cables, as per BIS standards. All cable connections must be made using suitable terminations for effective contact. The PVC Cu cables must be run in GL trays with covers for protection.
- Fast acting semiconductor type current limiting fuses at the main bus bar to protect from the grid short circuit contribution.
- The PCU shall include an easily accessible emergency OFF button located at an appropriate position on the unit.
- The PCU shall include ground lugs for equipment and PV array grounding.
- All exposed surfaces of ferrous parts shall be thoroughly cleaned, primed, and painted or otherwise suitably protected to survive a nominal 30 years design life of the unit. Weather proof and capable of surviving climatic changes and should keep the PCU intact under all conditions in the room where it will be housed. The INVERTER shall be located indoor and should be either wall / pad mounted. Moisture condensation and entry of rodents and insects shall be prevented in the PCU enclosure.
- Components and circuit boards mounted inside the enclosures shall be clearly identified with appropriate permanent designations, which shall also serve to identify the items on the supplied drawings.
- All doors, covers, panels and cable exits shall be gasket or otherwise designed to limit the entry of dust and moisture. All doors shall be equipped with locks. All openings shall be provided with grills or screens with openings no larger than 0.95 cm. (about

3x8 inch).

- In the design and fabrication of the PCU the site temperature (5° to 55°C), incident sunlight and the effect of ambient temperature on component life shall be considered carefully. Similar consideration shall be given to the heat sinking and thermal for blocking diodes and similar components.

## ii. Earthing Protection

### Earthing

1. PV array, DC equipment, Inverter, AC equipment and distribution wiring shall be earthed as per IS: 3043 - 1987.
2. Equipment grounding (Earthing) shall connect all non-current carrying metal receptacles, electrical boxes, appliance frames, chassis and PV panel mounting structures in one long run. The grounding wire should not be switched, fused or interrupted.

The complete earthing system shall be electrically connected to provide return to earth from all equipment independent of mechanical connection.

4. The equipment grounding wire shall be connected to PV power plant.
5. A separate grounding electrode shall be installed using earth pit per power plant. Test point shall be provided for each pit.
6. An earth bus and a test point shall be provided inside each control room.
7. Earthing system design should be as per the standard practices.

Each array structure of the PV yard should be grounded properly. In addition the lighting arrester/ masts should also be provided inside the array field. Provision should be kept be provided inside the array field. Provision should be kept for shorting and grounding of the PV array at the time of maintenance work. All metal casing/ shielding of the plant should be thoroughly grounded in accordance with Indian electricity Act/ IE Rules. Earth resistance should be tested in presence of the representative of ITI after earthing by calibrated earth tester. PCU ACDB & DCDB should be earthed properly.

Danger boards should be provided as and where necessary as per IE Act/ IE rules as amended up to date. Three signage shall be provided one each at control room, solar array area and main entry from administrative block.

**iii. Balance of Systems (BoS)**

- i. String / Array combiner boxes shall incorporate DC string circuit breakers, DC array disconnect switch, lightning and over voltage protectors, any other protection equipment, screw type terminal strips and strain-relief cable glands.
- ii. All DC and AC cables shall be terminated using suitable crimped cable lugs/sockets and screw type terminal strips. No soldered cable termination shall be accepted.
- iii. Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted.
- iv. Suitable Ground Fault Detector Interrupter (GFDI) shall be incorporated either with the inverter or with the array combiner box.
- v. String/Array combiner boxes shall be secured onto walls or metal structures erected separately in the terrace.
- vi. Conduits / concealed cable trays shall be provided for all DC cabling on the Roof top. Conduits/ concealed cable trays shall be adequately secured onto the roof top / wall.
- vii. The AC cable type shall be PVC / XLPE insulated, suitably aluminium armored, 1100V grade multi- stranded copper conductor. Appropriate colour coding shall be used.
- viii. For the DC cabling, XLPE or, XLPO insulated and sheathed, UV-stabilized single core multi- stranded flexible copper cables shall be used; Multi-core cables shall not be used.
- ix. The DC and AC cables of adequate electrical voltage and current ratings shall be also rated for in conduit wet and outdoor use.
- x. The total DC cable losses shall be maximum of 2% of the plant rated DC capacity over the specified ambient temperature range.
- xi. The DC and AC cable size shall be selected to maintain losses within specified limits over the entire lengths of the cables.
- xii. DC cables from array combiner box on the rooftop to DC distribution box in the control room
- xiii. DC/ AC cabling between inverter and distribution boxes shall be laid inside cable duct where available or secured with conduits/concealed cable trays where duct is not available.

- xiv. The DC and AC distribution boxes shall be wall mounted inside control room/open space.
- xv. DC distribution box shall incorporate DC disconnect switch, lightning surge protectors, any other protection equipment, screw type terminal strips and strain-relief cable glands.
- xvi. AC distribution box shall incorporate AC circuit breaker, surge voltage protectors, any other protection equipment, plant energy meter, screw type terminal strips and strain-relief cable glands.
- xvii. The total AC cable losses shall be maximum of 1% of the plant AC output over the specified ambient temperature range.
- xviii. All cable conduits shall be GI/HDPE type.
- xix. All cable trays shall be powder coated steel or GI or equivalent.

## **2. Civil**

1. For structural purpose, the panels plus support system that works as a distortion-free integral structural unit.
2. The panel assembly should at most 5m x 5m in plan area. The max height of panel above roof surface does not exceed 1.2 m.
3. The vertical projection area of the longer side of the panels does not exceed  $W/100$  in sq m where  $W$  is the gross load of the panel assembly in kg (weight of panels, connections, frames, bracings, pedestals, wiring, circuitry etc.).
4. PV array shall be installed in the space free from any obstruction and / or shadow.
5. Drainage and roof treatment should not be affected by the installation.
6. PV array shall be installed utilizing maximum space to minimize effects of shadows due to adjacent PV panel rows. The gross weight of the panel assembly should at most 45 kg/sq m ( $W$  divided by the plan area).
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. There is at least 1m clear spacing all around the panel assembly (panel edge to panel edge between assemblies, and panel edge to parapet wall / room on sides).

8. The column spacing shall be appropriate and shall be easily accessible for maintenance point of view. The pedestal is placed directly on the roof, over existing roof treatment, without making any structural connection to the roof surface.
9. The panel assembly should have at least 4 pedestal supports. The minimum spacing between pedestals is 2.0 m c/c in any direction. Each pedestal is made of cement concrete. Each pedestal can transmit at most 200 kg load on roof. The plan dimension of pedestal does not exceed 450mm x 450 mm, and height does not exceed 300mm.
10. Ample clearance shall be provided in the layout of the inverter and DC / AC distribution boxes for adequate cooling and ease of maintenance.
11. The Supplier will supply and install required size of Water Tank, Water pump, pipe etc. for cleaning the PV modules.
12. The supplier shall specify installation details of the PV Panel assembly 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;
  - b) Interconnection details inside the junction/terminal boxes;
  - c) Structure installation details and drawings;
  - d) Electrical grounding (earthing);
  - e) Inter-panel / Inter-row distances with allowed tolerances; and
  - f) Safety precautions to be taken.

The array structure shall support SPV modules at a given orientation and absorb and transfer the mechanical loads to the roof top columns properly. All nuts and bolts shall be of very good quality stainless steel. The panel support and panel-to-support connection both must be designed by vendor to withstand adequately high wind forces. Civil Works permission does not guarantee safety against flying/falling panels in the event of a storm or any other accident.

### **3. Mechanical**

1. PV panel assembly may consist of different number of modules with maximum of 10 PV modules.
2. Each panel assembly shall incorporated one bird repellent spike at a level higher than the panel upper edge. The location of the spike should be selected for minimum shadow effect.
3. Support structure of panel assembly shall be fabricated using corrosion resistant GI or anodized aluminium or equivalent metal sections.
4. Array support structure welded joints and fasteners shall be adequately treated to resist corrosion.
5. The support structure shall be free from corrosion when installed.
6. PV modules shall be secured to support structure using screw fasteners and/or metal clamps. Screw fasteners shall use existing mounting holes provided by module manufacturer. No additional holes shall be drilled on module frames. Module fasteners / clamps shall be adequately treated to resist corrosion.
7. The support structure shall withstand wind loading of up to 150 km/hr. Bidder shall provide the test Certificate complying the requirement.
8. Adequate spacing shall be provided between any two modules secured on panel assembly for improved wind resistance.
9. The structure shall be designed to withstand operating environmental conditions for a period of minimum 25 years.
10. It is required to design the grid structure (on which PV module will be installed) in such a way that all loads are transferred to the existing columns of the buildings. Such grid design should be presented to ITI, which will be certified by structural engineers.
11. The panel assembly structure should be installed in a manner to leave sufficient space for repair and maintenance aspects of the roof tops, particularly for leakages.
12. Installation of panel assembly should not tamper with the water proofing of roofs.

#### **Arraystructure**

1. Hot dip galvanized (minimum of 80 Microns) MS mounting structures may be

used for mounting the modules / panels / arrays. Each structure should have angle of inclination as per the site conditions to take maximum isolation. However to accommodate more capacity the angle inclination may be reduced until the plant meets the specified performance ratio requirements.

2. The Mounting structure shall be so designed to withstand the speed for the wind zone of the location where a PV system is proposed to be installed. Suitable fastening arrangement such as grouting and calming should be provided to secure the installation against the specific wind speed.
3. The mounting structure steel shall be as per latest IS 2062: 1992 and galvanization of the mounting structure shall be in compliance of latest IS 4759.
4. Structural material shall be corrosion resistant and electrolytically compatible with the materials used in the module frame, its fasteners, and nuts and bolts. Aluminium structures also can be used which can withstand the wind speed of respective wind zone.
5. Necessary protection towards rusting need to be provided either by coating or anodization.
6. The fasteners used should be made up of stainless steel. The structures shall be designed to allow easy replacement of any module. The array structure shall be so designed that it will occupy minimum space without sacrificing the output from the SPV panels
7. The bidder need to supply suitable structures based on the quality of roof and considering the load bearing capacity of the roof / civil structures of the proposed building.

#### **4. Electrical:**

1. LT distribution grid specifications 230 +/- 5%, 50Hz and frequency variation as per IE rules.
2. The output of the inverter shall be shall be fed into 415V, 3phase AC LT grid supplied via LT Air circuit Breaker.
3. The inverter output shall be connected to LT line prior to the LT/DG changeover switch. The mandatory islanding protection provided by inverter shall isolate the Solar PV power plant.
4. The time of day (TOD) 3 phase, digital AC load energy meter shall be installed in