iii. STRING INVERTER/PCU

The PCU required shall be of 1200 kW to convert DC power produced by SPV modules into AC power and adjust the voltage &frequency levels to meet the local grid conditions. The use of String Inverters of cumulative capacity 1200 kW must be preferred.

a) Common Technical Specification:

- Control Type: Voltage source, microprocessor assisted, output regulation.

  Output voltage: 3 phase, 11 KV AC (+12.5%, -20% V AC)
- Frequency: 50 Hz (+3 Hz, -3 Hz)
- Continuous rating: 1200 kW grid connected Normal Power: 1200 KW
- Total Harmonic Distortion: less than 3%Operating temperature Range :0 to55 deg C
- Humidity: 95 % Non-condensing
- Housing cabinet: PCU to be housed in suitable switch cabinet, IP-20 (Minimum) for indoor IP- 65(Minimum) for outdoor
- PCU efficiency: 98% and above at full load.
- PF: > 0.9

b) Other important Features/Protections of PCU

i. Mains (Grid) over-under voltage and frequency protection.
ii. Over load capacity (for 10 sec) should be 200% of continuous rating.
iii. The PCU shall be self-commuted and shall utilize a circuit topology and components suitable for meeting the specifications listed above at high conversion efficiency and with high reliability.
iv. The PCU shall be provided with MPPT (Maximum Power Point Tracing) features, so that maximum possible power can be obtained from the PV module.
v. The PCU shall be self-commuted and shall utilize a circuit topology/ DSP technology to meet the specifications listed above at high conversion efficiency and with high reliability. The PCU shall by String type and shall give the preference to feed the

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Loads from Solar Energy being produced and shall draw the additional power from mains to meet the load requirements in the case load is more than solar energy being produced. Conversely it should feed the solar power to the Grid if the load is less than the solar energy generated.

vi. Full proof protection against grid islanding which ensures that the PV power and the grid power get disconnected immediately in the event of grid failure.

vii. The power conditioning units / inverters should comply with applicable IEC/ equivalent BIS standard for efficiency measurements and environmental tests as per standard codes IEC 61683/IS 61683 and IEC 60068- 2 (1,2,14,30) /Equivalent BIS Std.

viii. The charge controller (if any) / MPPT units environmental testing should qualify IEC 60068-2(1, 2, 14, 30)/ Equivalent BIS std. The junction boxes/ enclosures should be IP 65(for outdoor)/ IP 54 (indoor) and as per IEC 529specifications.

ix. The PCU / inverters should be tested from the MNRE approved test centers / NABL / BIS / IEC accredited testing- calibration laboratories. In case of imported power conditioning units, these should be approved by international test houses.

x. The PCU shall be capable of operating in parallel with the grid utility service and shall be capable of interrupting line-to-line fault currents and line-to-ground fault currents.

xi. The PCU shall be able to withstand an unbalanced output load to the extent of 50%.

xii. The PCU shall go to the shutdown/standby mode with its contacts open under the following conditions before attempting and automatic restart after an appropriate time delay in insufficient solar power output.

xiii. **(a) Utility-Grid Over or Under Voltage-** The PCU shall restart after an over or under voltage shutdown when the utility grid voltage has returned to within limits for a minimum of two minutes.

(b) **Utility-Grid Over or Under Frequency-** The PCU shall restart after an over or under frequency shutdown when the utility grid voltage has returned to the within limits for minimum of two minutes. The permissible level of under/over voltage and under/over grid frequency is to be specified by ITI Ltd.

(c) The PCU shall not produce Electromagnetic interference (EMI) which may cause malfunctioning of electronic and electrical instruments including communication equipment, which are located within the facility in which the PCU is housed.

xiv. Communication Mod bus protocol with LAN / WAN options along with remote access facility and SCADA package with latest monitoring systems.

xv. The inverter with MPPT shall be used with the power plant.

xvi. The sine wave output of the inverter shall be suitable for connecting to 415V, 3 phase AC which can further be stepped up to 11 kV HT voltage grid.

xvii. The inverter shall incorporate transformer isolated output (transformer-less inverters shall be used with suitable external transformers), grid islanding protection disconnection of grid & PV power in case of failure of Grid supply suitable DC / AC fuses / circuit breakers and voltage surge protection. Fuses used in the DC circuit shall be DC rated.

xviii. The inverter shall have internal protection against any sustained faults and/or lightening in DC and mains AC grid circuits.

xix. The peak inverter efficiency inclusive of built-in isolation transformer shall exceed 94%. (Typical commercial inverter efficiency normally more than 97% and transformer efficiency is normally more than 97%)

xx. The kVA ratings of inverter should be chosen as per the PV system wattage.

xxi. The output power factor should be of suitable range to supply or sink reactive power.

xxii. Inverter shall provide panel for display of PV array DC voltage, current and power, AC output voltage and current (All 3 phases and lines), AC power (Active, Reactive 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.

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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 be foreit 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

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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 able 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.

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

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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 Rooftop. Conduits/ concealed cable trays shall be adequately secured onto the rooftop / wall.

vii. The AC cable type shall be PVC / XLPE insulated, suitably aluminum 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 ground 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.

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xv. DC distribution box shall incorporate DC disconnect switch, lightening 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 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,

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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 x450mm, and height does not exceed 300 mm.
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, 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

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