4.2.17	AC output THD limits	Less than 3% at rated power
4.2.18	Maximum noise level	Value to be indicated by vendor
4.2.19	DC injection (as % of nominal load current)	DC injection shall be limited to 1% of the rated current of the inverter as per IEC 61727.
4.2.20	Flicker	Shall be as per IEC 61000
4.2.21	Set point pre-selection for active power and VAR control	PCU shall be provided with all necessary features that will enable set point selection through SCADA. For this PCU vendor shall furnish the Modbus mapping for the set points or suggest the possible method for selecting VAR control. Operator shall be able to limit the total power (Active and Reactive) injected in the grid through manual intervention as and when required in view of grid security.
4.2.22	Auxiliary power requirement for PCU Controls / Cubicle Fans **/ heat exchanger fans**	a) Vendor shall confirm (Yes or No) if any external auxiliary power supply such as 230VAC, 1Ph etc) is required for PCU controls. If required, rating shall be indicated by vendor on a per PCU basis.
		b) If external aux power is required for PCU as per point 4.2.22 (a), the same shall be provided through UPS which is in BHEL Scope. c) UPS shall be fed from ACDB panel located in the control room. Vendor to indicate the feeder rating required per PCU. d) Interconnection scope (including supply of cables, cable accessories, hardware etc) from ACDB Panel to UPS/battery to PCU shall be in the scope of BHEL.
		f) 415VAC, 3-Ph for PCU Cubicle Fans, if required, shall be in vendor's scope and shall be generated within the PCU.
4.2.23	Re-synchronization time	In case of grid failure, the PCU shall be re-synchronized with grid after revival of power supply. Vendor shall indicate the time taken by PCU to be re-synchronized after restoration of grid supply.
4.2.24	Efficiency	Minimum Euro Efficiency shall be 98% load as per IEC 61683 Std
4.2.25	PCU availability	The up-time of Inverters should be of 99% in a year, in case of failing to achieve this due to failure of any component of inverter the vendor shall either replace the inverter or the component at their own cost
4.2.26	No load loss	No load loss shall be < 1% of rated power and maximum loss in sleep mode shall be less than 0.05%.

4.3 Protection systems

4.3.1	Protection systems for current, voltage, temperature, surges, ground faults, fan failure etc.	AC & DC over current`
4.3.2		AC & DC short circuit
4.3.3		DC reverse polarity
4.3.4		Over temperature protection: Heat sink, Cabinet
4.3.5		Synchronization loss

4.3.6		Anti-islanding protection
4.3.7		EMI and RFI
4.3.8		Grid monitoring Protection against any sustained fault (lightning effect etc) in grid / feeder line.
4.3.9		Ground fault protection
4.3.10		Power regulation in the event of thermal overloading
4.3.11		SPD-based overvoltage protection on both DC and AC sides. SPD shall consist of MOV type arrestors. It shall have thermal disconnectors to interrupt surge current arising from internal / external faults. The SPDs shall be Type I+II.
4.3.13		Fan failure – Alarm contact shall be provided for air flow loss / rise of temperature of cooling fan

4.4 DC, AC side load break disconnecting switch / breaker provisions

4.4.1	DC side	Load break disconnecting mechanism required on DC side – motorized type.
4.4.2	AC side	(a) Aux contacts (ON/OFF) from both ACB and DC Switch Disconnector shall be made available at TB terminals to enable external wiring for SCADA purpose.
		(b) Surge protection device (3P) with suitable rating shall be provided at the input of the ACB.
		(c) Indication for grid side supply ON / OFF status shall be available on the Door Interface.
		(d) ACBs shall be provided on the AC output side
		(e) Interconnection between the ACB Panel and PCU supply/provision of cables / busbars as applicable shall be in the scope of the vendor.

4.5 Front panel display and control

4.5.1	Front panel screen (LCD display, etc) with browsing / navigation provisions to 1) select display parameters 2) provide settings for various parameters	Instantaneous DC power input DC input voltage DC Current
4.5.2		Instantaneous active AC power output Instantaneous reactive AC power output AC voltage (all the 3 phases and line) AC current (all the 3 phases and line) Frequency Power Factor Energy (kWh) produced during entire day

		Total Energy (kWh) produced during its life
4.5.3		Faults
4.5.4		Other event logs
4.5.5		Other features as may be necessary for supervisory control and operation of the PCUs shall be provided.

4.6 Data logging, storage, retrieval, downloading, uploading

4.6.1	Provision of built-in systems for data logging, storage, retrieval, downloading, uploading etc.	Date-cum-time stamped logging of DC and AC side parameters (current, voltage, frequency, phase, power factor, power, export energy etc), faults and other events.
4.6.2		Data storage with retrieval features.
4.6.3		Provision of all necessary built-in systems, ports etc for downloading the data into a PC / Laptop etc that will be required for reporting, data analysis and trouble-shooting purposes.
4.6.4		Provision of all necessary built-in systems, ports etc for uploading of software etc that will be required for replacing, revising, upgrading the system.

4.7 Provisions for SCADA interface

4.7.1	SCADA interface requirement	Solar PV power plant will have an integrated SCADA, which is within BHEL scope, whereby all the PCUs will be integrated with other data systems such as solar array string monitoring, weather monitoring, HT side transformers / breakers monitoring, etc. Accordingly, PCU shall have necessary communication protocol and output ports to facilitate SCADA interface. SCADA shall be OPC server based.
4.7.2	Communication protocol	Dedicated MODBUS / Ethernet for networking with SCADA.
4.7.3	Daisy-chain looping	PCU shall have provisions for daisy-chain looping of one another for SCADA purposes.
4.7.4	Parameters for SCADA	All DC and AC parameters (current, voltage, frequency, phase, power factor, power, export energy etc), grid data, temperature, faults, other event logs, date/time logs etc from each PCU will be required at SCADA control desk. PCU shall provide for this requirement.
4.7.5	Remote monitoring features	PCU shall have features to facilitate remote monitoring via telephone modem or mini web server.

4.8 DC Inputs and termination details

Vendor shall supply the PCU with the termination features on DC side as tabulated below. Detailed drawings of termination arrangements with bus bar particulars such as positions, dimensions, hole sizes, spacing between holes, support to bus bar, etc shall be submitted for BHEL approval.

4.8.1	DC input terminals	**10 inputs + 1 spare** Hence, a minimum of **11 DC input** terminals (each for DC +ve and –ve) shall be provided ~~with fuse and fuse holder.~~
4.8.2	Fuses on DC input side	Fuses of min. **378A** rating shall be provided on each **positive** DC input terminal. ~~both positive and negative.~~

4.8.3	Max DC input current rating of PCU	Vendor shall indicate the rating. In addition, max rating of each individual DC input shall be indicated
4.8.4	DC cable entry into panel	Bottom entry. Cable supply is within BHEL scope. 2Cx300 / 2Cx400 sq-mm Aluminium, multi-strand, armoured, XLPE insulation, PVC sheath cable will be used for each DC input. Exact size shall be provided during detailed engg. DC termination shall be suitable for the above cable.
4.8.5	Gland plates	Drilled Gland plates shall be provided with holes to accommodate the cable glands.
4.8.6	Cable glands	Nickel plated brass, double compression type cable glands of reputed make (Make: Comet or any other reputed make) shall be provided by the vendor. To enable right selection of glands, final cable O.D will be provided by BHEL at the time of manufacturing. Approval of make and type/size shall be taken from BHEL before procurement of glands. Part no. and qty shall be indicated in the BOM. PCUs shall be supplied with all the glands fixed on the gland plates.
4.8.7	Cable lugs, plain washers, spring washers, bolts and nuts	Similarly, cable lugs, bolts, nuts & plain washers, Zinc coated spring washers shall be provided by the vendor. Make for lugs: Dowells or any other reputed make with CE/VDE/UL/CSA/BIS. Approval of make and type/size shall be taken from BHEL before procurement of lugs. Part no. and qty shall be indicated in the BOM. PCUs shall be supplied with all these items fixed on the bus bars at their respective positions. Cable Lugs shall be Aluminium type. Bi-metallic strip or washer shall also be supplied for connection to Cu busbar **if applicable**.
4.8.8	Bus bar design	Tinned Copper **or Aluminium** Busbars shall be provided.
4.8.9	In case of separate DC termination panel	(a) In case the DC terminations are not within the main PCU panel with the vendor design featuring a separate panel, the add-on panel shall also be included in the offer. (b) General arrangement showing views and details of termination panel, with cable entry particulars, shall be submitted as part of technical bid. (c) Interconnecting the add-on DC termination panel with the main panel, including supply of cables for this purpose, shall be within the scope of vendor.
4.8.10	DC Side Negative Grounding	DC side negative grounding system shall be provided for the PCU. The same shall be indicated in the GA/SLD/Schematics and BOM.

4.9 AC Output and termination details

Vendor shall supply the PCU with the termination requirements on AC side as tabulated below. General arrangement showing views of termination shall be submitted as part of technical bid. Detailed drawings of termination arrangements with bus bar particulars such as positions, dimensions, hole sizes, spacing between holes, support to bus bar, etc shall be submitted within seven days after receipt of purchase order for BHEL approval.

4.9.1	Number of AC outputs	Three phases: R, Y, B terminals
4.9.2	AC cable entry into panel	Bottom entry. Cable supply is within BHEL scope. For each phase, 4 runs of 1Cx630 sq.mm or 8 runs of 1CX300 sqmm, aluminium, multi-strand, armoured, XLPE insulation, PVC sheath cable will be used. Final cable selected and cable O.D shall be informed to vendor during detailed engineering for selecting suitable cable lugs, glands and termination.
4.9.3	Gland plates	Drilled Gland plates shall be provided with holes to accommodate the cable glands.
4.9.4	Cable glands	Nickel plated brass, double compression type cable glands of reputed make (Make: Comet or any other reputed make) shall be provided by the vendor. Approval of make and type shall be taken from BHEL before procurement of glands. PCUs shall be supplied with all glands fixed on the gland plates.
4.9.5	Cable lugs, plain washers, spring washers, bolts and nuts	Similarly, cable lugs, bolts, nuts & plain washers, Zinc coated spring washers shall be provided by the vendor. Cable Lugs shall be Aluminium type. Bi-metallic strip or washer shall also be supplied for connection to Cu busbar **if applicable**. Make for lugs: Dowells or any other reputed make with CE/VDE/UL/CSA/BIS. Approval of make and type shall be taken from BHEL before procurement of these items. Part no. and qty shall be indicated in the BOM. PCUs shall be supplied with all these items fixed on the bus bars at their respective positions.
4.9.6	Bus bar design	Tinned Copper **or Aluminium** busbars shall be provided.
4.9.7	In case of separate AC termination panel	In case the AC output terminations are not within the main PCU panel with the vendor design featuring a separate panel, the add-on panel shall also be included in the offer. General arrangement showing views and details of termination panel, with cable entry particulars, shall be submitted as part of technical bid. Interconnecting the add-on AC termination panel with the main panel, including supply of cables for this purpose, shall be within the scope of vendor.

4.10 Panel related parameters

4.10.1	Structure sheets	Doors and frames - Type of enclosure and size/thickness details of the doors and frames shall be indicated by vendor Gland plate: Minimum 3mm thk min sheet steel or 4 mm thk non-magnetic material
4.10.2	Bus bars	Tinned copper with appropriate size to match current rating, based on vertical / horizontal layouts and bus bar orientations. Insulation sleeves (PVC etc.) shall be used wherever necessary. Bus bars (both AC and DC) shall be suitably colour coded.
4.10.3	Internal power cables	Insulated (PVC etc.) copper cable with appropriate cross section to match current rating.
4.10.4	Control wiring	Insulated (PVC etc.) copper cable of appropriate cross-section.
4.10.5	Base channel	ISMC channel of appropriate size to withstand the weight of the panel; suitable anti-corrosive finish (powder coated finish etc). Single rectangular ISMC base frame shall be provided for the complete panel.
4.10.6	Provisions for grouting	Base channel shall have suitable provisions (holes, etc) for grouting the panel on floor.
4.10.7	Earthing terminals as per relevant standards	Earthing terminals shall be provided using tinned copper / aluminium bars of suitable cross section. Terminals shall be brought out to facilitate external connections.
4.10.8	Insulation clearances	AC side: Phase to Phase / neutral: 25 mm min. DC side: As per relevant standards.
4.10.9	Painting	Epoxy based powder coating. Powder coating shall meet the requirement of IS 13871 Paint shade shall be informed during detailed engineering.
4.10.10	Overall dimensions	Width x Depth x Height in mm shall be indicated in the offer.
4.10.11	Weight	Panel weight shall be indicated in the offer.
4.10.12	Air Flow Requirement (m3/hr)	To be indicated by vendor for each PCU. - HVAC calculations shall be provided by vendor during detailed engg. - For this purpose, BHEL shall provide the final room layout drg during detailed engg. - **Alternatively, if liquid cooling is recommended, vendor shall provide all the details along with thermal design calculations.**

4.11 External ducts for air cooling system if applicable

4.11.1	External ducts	External ducts shall be designed suitably in accordance with the layout of the Inverter Rooms.
4.11.2		The Solar PV Plant will have distributed Inverter Rooms to house the PCU Panels. Approximate distance from the rear side of PCU to the Inverter Room wall will be approximately **1.0 metre**. Air duct design shall be

		suitable for the same. Exact layout of PCUs in the control rooms will be provided by BHEL during detailed engineering to facilitate design of external duct profiles.

5.0 Testing and inspection

5.1	Routine tests, as per relevant standards (IEC etc), shall be carried out on the PCUs and shall be witnessed by BHEL & Customer/ Customer authorized third party inspection agency). Vendor shall submit Manufacturing Quality Plan (MQP) and detailed Test Procedure along with drawings for formal approval by customer prior to inspection. Routine tests shall be carried out by vendor on all the PCUs as per customer approved MQP. Following are the minimum tests to be conducted but not limited to: (a) HV and IR tests on 100% PCUs. (b) Functional tests (c) Load testing of inverter on 1No. PCU: - Verification of inverter performance in its stand alone operational mode with a defined power (up to 100% rated full load power) and DC input voltage (up to max value). All parameters: DC voltage, current, power, grid voltage / current of R,Y,B lines, line frequency, ac output power, ac output energy, power factor, line current, efficiency, THD, etc. to be measured at 25%, 50%, 75% and 100% of the rated nominal power and checked against specified acceptance norms. (d) Heat Run Test at rated full load on 1 no. panel (e) Protection tests (by direct method or simulation method) - Verification of automatic disconnecting and reconnecting of Inverter to the grid, based on rise and fall of heat sink and cabinet temperature with reference to set points. - DC Reverse Polarity protection test - DC Ground Fault - AC and DC Overvoltage - Abnormal voltage and frequency Test reports shall be submitted prior to dispatch of the system to the site.

6.0 Documents to be submitted after receipt of purchase order

6.1	Following documents shall be submitted for approval within seven days from date of purchase order. 1. GTP/Datasheet 2. General Arrangement of PCU 3. BOM for complete PCU including all major components of PCU, AC and DC Combiner Panels 4. Spares List 5. Exhaust Duct Drg including placement and complete mounting arrangement drg inside control room for which final control room layout drg shall be provided to vendor 6. HVAC calculations 7. Manufacturing Quality Plan (MQP) Vendor shall proceed with Manufacturing only after final approval of all the listed documents.

7.0 Documents to be submitted along with consignment

7.1	Following documents shall be submitted at the time of dispatch: a. Test reports on individual PCUs b. Technical manual with system specifications, installation guidelines, commissioning guidelines, schematic drawings, circuit board overlays, system set points, calibration settings, hardware settings, cable schedule, general arrangement drawings, panel details. c. Operation and Maintenance manual including final As Built and tested drgs and datasheet, test reports, catalogs of individual components, schematic drgs shall be provided (segregated section wise) in both hard copy and soft copy.