Technical specification

Supply, installation and commissioning of

1250kW 3-phase Grid-connected Power conditioning units

for

2x10MW (AC) Solar Photovoltaic Power Plant

1.0 Introduction: Bharat Heavy Electricals Limited (BHEL), Electronics Division, Bangalore is setting up a 2x10 MWp(AC) Grid-connected SPV Power Plant at two places of West Bengal. **One site is at Chharrah in Purulia District and other one is at Mejia in Bankura District.**

This technical specification provides details of supply of 1250 kW 3-phase Grid-connected Power Conditioning Units (PCU). The scope also includes commissioning of the supplied units at the project site for synchronizing the generated ac power with LV side of a transformer that connects to 33kV grid on HV side.

2.0 Scope of supply

Sl. No.	Item Description	Qty
2.1	Supply of 1250kW (minimum), 3-phase, Grid-connected Power Conditioning Unit (PCU). **Note:** 1 no "PCU" includes Inverter Panel, DC Combiner Panel and AC Combiner Panel	16 nos (8 nos per site)
2.2	Supply of (a) External ducts (to meet the thermal / exhaust / air-flow requirement of the panel) (b) Exhaust fans – if applicable (wall-mounted for fixing on control room wall), starters for fans including cables for wiring, with all associated accessories and hardware required for the complete quantity of PCUs as per Sl. 2.1. (c) Note: Exhaust fans along with all associated accessories/hardware/ cables shall be provided if the same is required to be provided in line with HVAC calculations and heat dissipation requirements as per Cl. 5.10.12. Vendor to propose with supporting calculations. (d) In case of other method of cooling, same shall be proposed in lieu of a, b, c sub-clause mentioned above.	16 sets (8 nos per site)
2.3	**Supply of Mandatory Spares** for 1250kW power conditioning units. List of items with quantity is as follows, spares quantity to be dispatched to the two sites – Equal quantity 1) Control Cards, inclusive of power supply card for PCU 2) DC input Fuse 3) AC fuse 4) Surge Protection Device / MOV 5) IGBT Stack for PCU **Note:** (a) The above spare quantities are to be supplied over and above the warranty requirements. Any spares consumed during warranty period, shall be supplied by vendor in 6 week time to maintain spares at site. (b) Item-wise quantity and break-up prices shall be provided.	4sets per site 20nos per site 4sets per site 4nos per site 2nosper site **YES / NO** **YES / NO**

2.4	**Commissioning of PCUs at each of the two sites** BHEL scope of activities at site for installation and commissioning: (1) Movement and positioning of PCU panels at the earmarked position in the control room. (2) Crimping the incoming (DC side) and outgoing (AC side) cables (BHEL supply) using the cable lugs provided by the vendor. (3) Connecting at the respective termination ends of the panels using the cable glands and fastening hardware (nuts, bolts, washers) provided by the vendor. **Vendor scope of activities at site for commissioning:** (1) All the electrical checks that are required to confirm that solar DC parameters (current, voltage) are available at the DC input side of PCUs. (2) All the pre-commissioning checks such as mechanical checks (physical firmness of internal components), electrical tests up to the level of synchronization of the PCU output with the grid. (3) All the mechanical tools such as spanners, crimping tools required for above checks at site shall be in the scope of vendor. (4) All the electrical tools such as measuring instruments, meters required for above checks at site shall be in the scope of vendor. (5) Guidance and support to BHEL team in case of technical problems associated with AC grid side (synchronization-related) or DC side (Problems related to DC input parameters, Earth-faults in solar array). (6) Service engineers shall be present at site during commissioning of power plant, providing all necessary guidance and support to achieve successful synchronization of PCU output with grid and also to trouble-shoot / resolve the technical problems associated with PCU. Commissioning / Service Engineer shall be from OEM. (7) Guidance and support to BHEL team, at the time of installation and commissioning of SCADA, in respect of connection of communication cables to PCUs and technical problems related to receiving data signals at SCADA station from PCUs. **Note:** Supply and installation of integrated SCADA system for the overall power plant is within BHEL scope. A single lump-sum price on per-PCU basis shall be offered. The lump-sum price shall include all the costs that will be incurred by the vendor towards commissioning including travel, boarding, lodging and any other contingency expenses.	**16 sets (8 sets per site)**
2.5	**Installation and commissioning of external ducts** Scope shall include installation of external ducts, exhaust fans (if provided) with starters, with all associated accessory parts, including erection, fixing, mounting, wiring of starters. Interconnection (including supply of cables) from exhaust fans up to ACDB panel shall be in the scope of vendor. In case of any other method of cooling, this includes the installation and commissioning of the same, inclusive of civil works.	**2 set (1 set = 8 PCU ducts)**

	BHEL will provide the cut-outs on the control room walls for fixing the exhaust fans as per dimensions provided by the vendor. A single lump-sum price taking this as a single activity covering all the PCUs shall be offered.	
2.6	**Warranty:** Vendor shall provide on-site warranty for 60 months from date of commissioning or 63 months from date of supply, whichever is earlier. Vendor shall enclose, along with technical bid, the complete scope, terms and conditions of the warranty.	**Accepted Yes / No**

3.0 Instructions to vendors on bid submission

3.1	**First-part shall be Technical bid and following details shall be furnished, in the absence of which offer will not be accepted.** 1. Technical offer covering letter 2. Filled-up enclosures as per BHEL tender formats 3. Vendor signed & sealed BHEL specification with deviations, if any and fill up information, wherever asked for. 4. List of type test certifications available with copy of certificates 5. Type test reports shall be enclosed 6. Type test report for Heat Run Test 7. Enclosure as per PQC criteria 8. Product datasheet of the offered PCU model 9. Derating curve for AC power for a range of 30 to 60^0 C 10. BoM list with make, part no and quantity 11. Overall General Arrangement showing relevant views (plan, elevation, side views) with width, height and depth and overall weight. Such details of add-on DC / AC termination panels, if any, as applicable, shall also be provided. 12. Overall electrical schematic diagram of PCU showing details such as DC/AC side isolators / breakers, AC/DC side surge protection devices, inverter bridge, filters (EMC) 13. List of spares offered (with quantity) and without prices as per clause 2.3 14. Service centre nearest to site – address and details 15. Detailed dimensional DC cables entry drawing showing entry point of cables 16. Detailed dimensional AC cables exit drawing
3.2	Second-part shall be Price bid with filled up enclosures as per BHEL tender format.
3.3	In addition to the above instructions, tender document provides detailed instructions for bid submission. Vendor shall submit the bid based on such tender instructions.

4.0 Power plant configuration

The 2x10MWp solar photovoltaic power plant at WESTBENGAL employs 16 nos of PCUs (8 nos at Chharrah and another 8 nos at Mejia) of PCUs connected on the DC side to solar photovoltaic array that employs SPV modules. Each segment generates DC power of 1.25 MWp, which is then inverted by a 3-phase grid-connected power conditioning unit of 1.25 MWp rating. At the AC output level, every two PCUs are combined to form a 2.5MWp group using a three-winding transformer. Thus, at each 2.5MWp level, two PCUs are connected independently to the two LV windings of the transformer to get the combined 2.5MWp output on the HV side (33kV). Thus, each of the two power plants employs 8 PCUs and 4 transformers, whereby the transformers are combined on the HV side to achieve overall power output of 10MWp at two different location Chharrah & Mejia respectively.

5.0 Technical specification of Power Conditioning Units

5.1 Basic requirements (PCU type, Standards, Technology, Interconnections, Interfaces)

#	Parameter	BHEL specification
5.1.1	PCU type	Grid-interactive. PCU shall remain connected to the grid as per Central Electricity Authority Technical (standards for connectivity to the grid) regulation 2007 with all latest amendments and its components shall be designed accordingly. **Low power mode:** The control system that continuously monitors the output of the solar PV plant until pre-set value is exceeded and begins to export power provided there is sufficient solar energy and the grid voltage and frequency are in the specified range. Further, the inverter shall be capable of operation under reduced power mode and shall not trip when the PV array output voltage is below MPPT range under high temperature conditions. **Active MPPT mode (high power mode):** When solar radiation increases further, PCU shall enter maximum power point tracking (MPPT) mode and adjust the voltage of the SPV array to maximize solar energy fed into the grid. When the solar radiation falls below threshold level, the PCU shall enter lower power mode. **Sleep mode:** Automatic 'sleep' mode shall be provided so that unnecessary losses are minimized at night. Vendor shall provide threshold DC voltage level / power level of the PCU as to when it shall enter into the sleep mode and back to low power mode and MPPT mode during detailed engineering for BHEL approval. Inverter shall have the feature like Low voltage ride through (LVRT), High voltage ride through (HVRT) for grid support and connection.

5.1.2	Compliance with standards	**IEC 61727 Relevant CEA/ CERC regulation and grid code (amended up to date) -** Interfacing with utility grid **IEC 61683** - Photovoltaic systems - Power conditioners - Procedure for measuring efficiency **IEC 61000** - Emission/ Immunity requirements **IEEE 519** - Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems **IEC 60068** – Environmental Testing **IEC 62116 / IEEE 1547/ UL 1741 or equivalent international standard** - Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures **IEC 62109 or IEC 62103 or EN 50178 equivalent international standard** - Safety of power converters for use in photovoltaic power systems Compliance to requirement for the design and manufacture of PCU for protection against electric shock, energy, fire, mechanical and other hazards. **EN 50530** - Overall efficiency of grid connected photovoltaic Inverters **BDEW 2008** - Technical Guidelines for Generating plant connected to Medium voltage network **Note:** All standards, specifications and codes of practice referred to shall be the latest editions including all applicable official amendments and revisions as on date of RFQ. In case of conflict between the specification and those codes/standards (IEC, IS), the former shall prevail. Equipment complying with other internationally accepted standards such as BS, UL, DIN, VDE will also be considered if they ensure performance and constructional features equivalent or superior to standards listed in this specification. In such case, the bidder shall clearly indicate the standards adopted, furnish a copy in the English of the latest revisions in force as on date of RFQ and shall bring out salient features for comparison.
5.1.3	Output transformer	PCU shall be of 'transformer-less' design.
5.1.4	Maximum Power Point Tracking (MPPT)	MPPT shall be integrated in the power conditioning unit to maximize energy drawn from the solar PV array. The MPPT should be microprocessor based to minimize power losses. The details of working mechanism of MPPT shall be submitted during the detailed engineering. The operating voltage range of PCU and the MPPT shall be large enough such that it satisfactorily operates for PV modules exposed to the maximum ambient temperature of 50 deg C.
5.1.5	AC-DC conversion	3-phase Inverter stack
5.1.6	Built-in support	PCU shall be provided with protection circuits, monitoring circuits,

	systems	data logging & storage system, provisions to download data to PC/Laptop, MODBUS communication outputs for SCADA interface as per Cl. 5.7 of this specification.
5.1.7	DC negative earthing	The PCU shall have the DC negative pole earthing so that the negative inputs from the SMBs are earthed directly to the ground at PCU end. The negative earthing is to prevent the PID effects on the solar modules. Typical materials to be incorporated for Negative pole earthing kit are adequate rating CT, Fuse with fuse holder, special cables and accessories for earthing the Negative pole to earthing station. Suitably, software and the accessories at the control card level for operating with Negative pole grounded shall be provided. Any other material required for satisfactory operation of the PCU with Negative pole grounded shall be deemed to be included in the scope of supply / work.
5.1.8	External ducts and exhaust fans	PCUs shall be provided with external cooling ducts and exhaust fans (if applicable) design of which shall suit the inverter room layout of BHEL. Details of layout of the inverter rooms shall be as per Cl. 5.11 of this specification. Any other method of cooling other than ducting may be detailed.
5.1.9	DC input and AC output terminations	Input and output terminations together with cable glands, bimetallic lugs, hardware shall be provided to match the connections using BHEL cables as specified under related clauses of this specification.
5.1.10	Environment protection	All PCB cards shall be provided with suitable coating (epoxy).

5.2 Technical parameters

#	Technical parameter	BHEL specification
5.2.1	Output power rating	1250 kW minimum (at 50^0C ambient) without any derating up to 50^0C. (Vendor to furnish the output of the PCU in KW for a temperature range of 30 to 60^0 C)
5.2.2	AC grid connection	3-phase
5.2.3	Output frequency	50 Hz +/- 5%
5.2.4	Nominal output voltage	Value to be indicated by vendor
5.2.5	Maximum DC input voltage (Max open circuit PV voltage)	1000 V DC

5.2.6	MPPT Range of control system	Range to be indicated by vendor
5.2.7	DC side peak power	Maximum continuous DC input power to PCU to be 1250 kW + 10% Vendor to confirm the same and indicate otherwise.
5.2.8	Max DC operating current	Value to be indicated by vendor
5.2.9	Max AC output current	Value to be indicated by vendor corresponding to the rated output power of the PCU.
5.2.10	Efficiency	Minimum Euro Efficiency shall be 98% load as per IEC 61683
5.2.11	Power factor	Designed operation close to unity PF Adjustable window 0.9 lead to 0.9 lag
5.2.12	Ambient temperature	1250 kW from 0 to 50 deg C, derating curve with max allowed ambient temperature to be provided for above 50 deg C
5.2.13	Relative Humidity	Up to 95% non-condensing
5.2.14	Enclosure	IP 42
5.2.15	Grid Frequency tolerance	+/- 3 Hz
5.2.16	Grid Voltage tolerance	- 10% and + 10%
5.2.17	AC output THD limits	Less than 3% at rated power
5.2.18	Maximum noise level	Value to be indicated by vendor
5.2.19	DC injection (as % of nominal load current)	Value to be indicated by vendor
5.2.20	Flicker	Shall be as per IEC 61000
5.2.21	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.
5.2.22	Auxiliary power requirement for PCU Controls / Cubicle Fans / Wall Mounted Exhaust Fans (if applicable)	Vendor shall confirm (**Yes or No**) if any external auxiliary power supply is required for PCU controls/ fans etc. If required, rating of load shall be indicated per PCU basis.
5.2.23	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.

5.3 Protection systems

5.3.1	Protection systems for current, voltage, temperature, surges, ground faults, fan failure etc.	AC & DC over current
5.3.2		AC & DC short circuit
5.3.3		DC reverse polarity
5.3.4		Over temperature protection: Heat sink, Cabinet
5.3.5		Synchronization loss
5.3.6		Anti islanding protection
5.3.7		EMI and RFI
5.3.8		Grid monitoring Protection against any sustained fault (lightning effect) in grid / feeder line.
5.3.9		LVRT, HVRT
5.3.10		Ground fault protection
5.3.11		Insulation monitoring of the PV array with sequential fault location.
5.3.12		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 discharge capability of SPD shall be at least 10kA at 8/20 microsecond wave as per IEC 61643-12.
5.3.13		SPD for auxiliary power supply
5.3.14		Fan failure – Alarm contact shall be provided for air flow loss / rise of temperature of cooling fan

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

5.4.1	DC side	Load break disconnecting mechanism required on DC side – motorized type.
5.4.2	AC side	(a) ACB shall be provided either within the PCU cubicle or in a separate LT Panel attached to PCU depending on the design available with vendor. Vendor shall indicate the methodology followed.
		(b) 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.
		(c) Surge protection device (3P) with suitable rating shall be provided at the input of the ACB.

		(d) Indication for grid side supply ON / OFF status shall be available on the Door Interface.
		(e) Interconnection between the ACB Panel and PCU supply/provision of cables / busbars as applicable shall be in vendor's scope.
		Make and part no. of ACB being used shall be indicated in offer

5.5 Front panel display and control

5.5.1	Front panel screen (LCD display) with browsing / navigation provisions to 1) select display parameters 2) provide settings for various parameters	DC side voltage, current, power
5.5.2		AC side output voltage (all three lines), current (all three lines), frequency, phase, power factor, power, export energy
5.5.3		Cumulative energy exported
5.5.4		Energy generated data for a minimum of past 5-7 days
5.5.5		Grid side voltage, frequency, phase
5.5.6		Temperatures (ambient, heat sink, cabinet)
5.5.7		Faults record
5.5.8		Other event logs
5.5.9		Other features as may be necessary for supervisory control and operation of the PCUs shall be provided.

5.6 Data logging, storage, retrieval, downloading, uploading

5.6.1	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, others), faults and other events.
5.6.2	Data storage with retrieval features.
5.6.3	Provision of all necessary built-in systems, ports for downloading the data into a PC / Laptop that will be required for reporting, data analysis and trouble-shooting purposes.
5.6.4	Provision of all necessary built-in systems, ports for uploading of software that will be required for replacing, revising, upgrading the system.
5.6.5	Vendor should indicate the storage capacity for fault records.

5.7 Provisions for SCADA interface

5.7.1	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.
5.7.2	Communication protocol	Dedicated MODBUS RS485 / Ethernet for networking with SCADA.
5.7.3	Daisy-chain looping	PCU shall have provisions for daisy-chain looping of one another for SCADA purposes.
5.7.4	Parameters for SCADA	All DC and AC parameters (current, voltage, frequency, phase, power factor, power, export energy), grid data, temperature, faults, other event logs, date/time logs from each PCU will be required at SCADA control desk. PCU shall provide for this requirement.
5.7.5	Remote monitoring features	PCU shall have features to facilitate remote monitoring via telephone modem or mini web server.

5.8 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, shall be submitted for BHEL approval within seven days after receipt of purchase order.

5.8.1	DC input terminals	20 inputs + 2 spare = 22 input cable entries Hence, a minimum of 22 DC input terminals shall be provided. Spare terminal shall also be provided with fuse and fuse holder. Gland plate shall have total 22 holes with glands.
5.8.2	Fuses on DC input side	Fuses of suitable rating shall be provided on each DC input terminal - both positive and negative inputs.
5.8.3	Max DC input current rating of PCU	Vendor shall indicate the rating. In addition, max rating of each individual DC input shall be indicated.
5.8.4	DC cable entry into panel	Bottom entry: Cable entry shall be from bottom entry only. Cable gland plate for PCU shall be made suitable for the above and drawing for the same shall be made available by vendor during detailed engineering.

		Cable supply is within BHEL scope. 1-corex 300 mm^2 Aluminium, multi-strand, XLPE insulation, armoured, PVC sheath cable will be used for DC input. DC termination lugs, glands, bus-bars and cable supports inside the panel shall be suitable for the above mentioned cable, shall be in vendor's scope.
5.8.5	Gland plates	Drilled Gland plates shall be provided with holes to accommodate the cable glands. Spacing between holes shall be chosen to ensure that glands do not touch each other, duly taking into account the clearance required for placing the spanners used to tighten the glands.
5.8.6	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 outer diameter will be provided by BHEL at the time of manufacturing. Approval of make and type shall be taken from BHEL before procurement of glands. Part no. and quantity shall be indicated in the BOM. PCUs shall be supplied with all the glands fixed on the gland plates.
5.8.7	Cable lugs, plain washers, spring washers, bolts and nuts	Similarly, bimetallic cable lugs (Aluminium-Copper), bolts, nuts & plain washers, Zinc coated spring washers shall be provided by the vendor. Make for lugs: Dowells / Chetna / Billets Electro Werke (3D) or any other reputed make as shall be approved by BHEL. Part no. and quantity shall be indicated in the BOM. PCUs shall be supplied with all these items fixed on the bus bars at their respective positions
5.8.8	Bus bar design	Tinned Copper Bus-bars shall be provided. Width and length of the bus bars shall be so chosen as (1) to provide full electrical contact to the cable lugs, (2) to ensure that lugs and cables do not touch each other and (3) to provide adequate access to the tightening tools (spanners). Bus bars shall be positioned in such a way that the cables enter the panel vertically upwards from the cable trench below, without having to take any bends or turns after entering the panel.

5.8.9	In case of separate DC termination panel	(a) In case the DC terminations are not within the main PCU panel but in a separate panel, this add-on panel shall also be deemed part of PCU supply. (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.

5.9 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 shall be submitted within seven days after receipt of purchase order for BHEL approval.

5.9.1	Number of AC outputs	Three phases: R, Y, B busbars, 4 runs per phase
5.9.2	AC cable entry into panel	Bottom entry. Refer Cl. 5.8.4 for further details regarding cable entry. Cables are in BHEL scope. 4 runs of 1-corex 630 sq-mm Aluminium, multi-stranded, XLPE insulated, unarmoured, PVC sheath cable per phase will be used. (Total 12 AC terminations). Final cable selected and cable outer diameter shall be informed to vendor during detailed engineering for selecting suitable cable lugs, glands and termination. Cable supply is within BHEL scope. AC termination lugs, glands, bus-bars and cable supports inside the panel shall be suitable for the above mentioned cable.
5.9.3	Gland plates	Drilled Gland plates shall be provided with holes to accommodate the cable glands. Spacing between holes shall be chosen to ensure that glands do not touch each other, duly taking to account the clearance required for placing the spanners used to tighten the glands.
5.9.4	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.

5.9.5	Cable lugs, plain washers, spring washers, bolts and nuts	Similarly, bimetallic cable lugs (Aluminium-copper), bolts, nuts & plain washers, Zinc coated spring washers shall be provided by the vendor. Make for lugs: Dowells / Chetna / Billets Electro Werke (3D) or any other reputed make as shall be approved by BHEL. Part no. and quantity shall be indicated in the BOM. PCUs shall be supplied with all these items fixed on the bus bars at their respective positions.
5.9.6	Bus bar design	Tinned copper bus-bars shall be provided. Width and length of the bus bars shall be so chosen as (1) to provide full electrical contact to the cable lugs, (2) to ensure that lugs and cables do not touch each other and (3) to prove adequate access to the tightening tools (spanners). Bus bars shall be positioned in such a way that cable shall enter the panel vertically upwards from cable trench below, without any bends or turns after entering the panel.
5.9.7	In case of separate AC termination panel	In case the AC output terminations are not within the main PCU panel but in a separate panel, this 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.

5.10 Panel related parameters

5.10.1	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 thick min sheet steel or 4 mm thick non-magnetic material (preferred)
5.10.2	Bus bars	Tinned copper with appropriate size to match current rating, based on vertical / horizontal layouts and bus bar orientations. Insulation sleeves (PVC) shall be used wherever necessary. Bus bars (both AC and DC) shall be suitably colour coded.
5.10.3	Internal power cables	Insulated (PVC) copper cable with appropriate cross section to match current rating.
5.10.4	Control wiring	Insulated (PVC) copper cable of appropriate cross-section.

5.10.5	Base channel	ISMC channel of appropriate size to withstand the weight of the panel; suitable anti-corrosive finish (powder coated finish). Single rectangular ISMC base frame shall be provided for the complete panel.
5.10.6	Provisions for grouting	Base channel shall have suitable provisions (holes) for grouting the panel on floor.
5.10.7	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.
5.10.8	Insulation clearances	AC side: Phase to Phase / neutral: 25 mm min. DC side: As per relevant standards.
5.10.9	Painting	(i) Epoxy based powder coating. (ii) Paint thickness: 50 microns (minimum). (iii) Colour: Front and Rear Doors (Internal and external): RAL 9002 Grey. (iv)Powder coating shall meet the requirement of IS 13871.
5.10.10	Overall dimensions	Width x Depth x Height in mm shall be indicated in the offer.
5.10.11	Weight	Panel weight shall be indicated in the offer.
5.10.12	Air Flow Requirement (m^3/hr)	To be indicated by vendor for each PCU.
5.10.13	Rear Door	Rear doors for all panels shall be bolted type for opening. Bolting arrangement is mandatory since the panels will be placed at minimum distance from the wall and hence opening with hinged doors is not possible. Handles (2 nos) shall be provided on each door for easy removal of door during maintenance of panel.
5.10.14	Minimum clearance	Vendor should indicate the minimum clearance required on sides, front and rear side of PCU

5.11 External ducts & Exhaust Fans

5.11.1	External ducts	External ducts shall be designed suitably in accordance with the layout of the Inverter Rooms. Details are as per Cl. 5.11.2.
5.11.2		Approximate distance from the rear side of PCU to the Control Room wall will be approximately 600mm. Air duct design shall be suitable for the same. Exact layout of PCUs in the inverter rooms will be provided by BHEL during detailed engineering to facilitate design of external duct profiles.
5.11.3	Exhaust Fan (if applicable)	In case external exhaust fan (at the exit end of ducts) is additionally necessary to meet the thermal / exhaust / airflow requirement of the PCU, the same shall be provided for each PCU. In such a case, fan of wattage and size shall be fitted on cut-out on the inverter room wall. Also, starters for the fan along with

		other accessories including hardware shall be supplied, installed and commissioned at the site by the vendor. Scope shall also include wiring of starters to the AC distribution board in the control room. Cables for wiring and cable laying shall be within vendor scope. Cut-outs on the control room wall for exhaust system will be made by BHEL based on dimensions and positions provided by vendor.

6.0 Testing and inspection

6.1 Routine tests, as per relevant standards shall be carried out on the PCUs and shall be witnessed by BHEL. Vendor shall submit Manufacturing Quality Plan and detailed Test Procedure along with drawings for formal approval prior to inviting BHEL for inspection. Testing shall be carried out by vendor on all the PCUs supplied against Main Order and Initial spares Order.

Following shall be the minimum checks and shall be included by the vendor in the Manufacturing Quality Plan.

1. Visual inspection check
2. Raw material check as per the internal standards of manufacturer
3. In-process checks as per the internal standards of manufacturer
4. Dimensional check on enclosure
5. Degree of Protection Test
6. Complete Bill of materials check
7. HV / IR insulation tests on main and control circuits
8. Factory acceptance tests
   (a) Load testing of inverter:
   - Verification of inverter performance in its standalone 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.
   - Heat Run Test at rated full load on 1 no. panel
   - Synchronization to grid
   - Verification of responses of heat sink and cabinet cooling fans to heat sink and cabinet temperature rises.
   - Verification of inverter tripping response to simulated electrical shorts on ac output side.

	(b) Automatic mode testing (wake up and shut down) with simulated / actual grid and dc input supplies. - Verification of automatic waking up of inverter as the dc input supply picks up and rises beyond set point levels. - Verification of export of power to the grid in relation to functioning of MPPT. This functional test shall include demonstration of change in MPPT output with change in input DC voltage. - Verification of automatic shutdown of inverter as dc input supply falls below set point levels (c) 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. - Loss of Air Flow / rise of temperature alarm indication due to cooling fan failure - Verification of inverter tripping response to simulated failure of cooling fans. - Anti-Islanding Protection test - DC Reverse Polarity protection test - DC Ground Fault - AC and DC Overvoltage - Abnormal voltage and frequency - Insulation monitoring of each DC input of PV array with sequential fault location (d) Functional tests - System response to various set points for controls and protections - Emergency shutdown cases, Disconnector switch, breaker and contactor operations - Meters and displays - Data downloading from PCU Test reports shall be submitted prior to dispatch of the system to the site.
6.2	**Type Tests /IEC Certifications** (a) Valid type test reports and IEC certifications along with detailed IEC test report shall be submitted along with technical bid. (b) In addition, during detailed engineering, if any of these type tests are found to be not in technical compliance with standards requirements, the vendor shall conduct all such tests under this contract at no additional cost to BHEL either at third party lab or in presence of BHEL/customer representative and submit the reports for approval.

7.0 Service during warranty period

7.1	During the warranty period, whenever a technical problem is encountered with the PCU, BHEL will report the same to the vendor. Vendor shall ensure that the problem is attended to by their service engineer within two days from the date of reporting. Any spares consumed during warranty period, shall be supplied by vendor in 6 week time to maintain spares at site.

8.0 Documents to be submitted after receipt of purchase order

8.1	Following documents shall be submitted for approval within seven days from date of purchase order. 1. GTP/Datasheet 2. General Arrangement of PCU with LT output Switchgear (either integrated in PCU or in separate panel) (with overall dimensions, plan, elevation, side views, bill of materials of major functional components viz. Inverter stack, IGBTs, heat sinks, cooling fans, air filters, capacitors, inductors, power supplies, sensors, protection cards, fuses, MCBs, ACBs, Surge protection devices, isolator switches, breakers, contactors, displays, push buttons, data loggers, communication devices, ports, make / part number / rating / quantity of these components. 3. Panel details of doors, frames, gland plates, bus bars, cables, earth terminals, base channel, paint finish, IP class, applicable standards. 4. General arrangement of front panel with displays, push buttons, lamp indicators, etc. 5. General arrangement showing DC input termination details viz. bus bars with details of holes for cable connections, bus bar supports, fuses, etc. 6. General arrangement showing AC output termination details viz. bus bars with details of holes for cable connection, bus bar supports. 7. BOM for complete PCU including all major components of PCU, AC and DC Combiner Panels 8. Exhaust Duct Drg including placement and mounting arrangement drg inside control room for which final control room layout drg shall be provided to vendor 9. All the above documents shall be submitted to BHEL for final approval – GA and Layout Drawings, Foundation Drawings, Datasheet, Detailed BOM, Manufacturing Quality Plan (MQP) including Final Test Procedure. Vendor shall proceed with Manufacturing only after final approval of all the listed documents.

9.0 Documents to be submitted along with consignment:

9.1	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 drawings shall be provided (segregated section wise). - 4 sets bound hard-copy and 2 nos CD-ROM shall be despatched along with panel supply to site. - 1 set bound hard copy and 1 no. CD-ROM – soft copy shall be provided to BHEL-EDN, Bangalore d. Product catalogues / datasheets of disconnector switches, breakers, contactors, IGBTs, DC/AC capacitors, power supplies, protection devices, communication devices, sensors, meters.