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Technical specification

for

Supply, installation and commissioning of

1250kW 3-phase Grid-connected Power conditioning units

R00 dated 7.05.2019

R01 dated 22.05.2019 – Clauses 4.4.1, 4.9.2 and 4.9.3 modified

Approved: Prachi Rao V

Prepared	*Issued*	*Date*
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INTRODUCTION:

This technical specification provides details of supply of 1250kW 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.

1.0 Scope of supply

SL No	Item Description	Qty
1.1	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	Quantity shall be as per BHEL Tender requirement
1.2	Supply of External ducts or heat exchangers (to meet the thermal / exhaust / air-flow requirement of the panel)	
1.3	**Supply of Spares** for 1250kW power conditioning units. List of items with quantity is as follows: 1) Control Cards for PCU Quantity = 1 sets of each type 2) Fuses Quantity = 1 sets of each type and rating 3) Surge Protection Device Quantity = 1 sets of each type and rating 4) IGBT Stack assembly with drivers Quantity = 1 set 5) SMPS Power Supply Quantity = 1 set 6) Cooling Fan Quantity = 1 sets of each type and rating 7) DC Switch Disconnector, AC Contactor, MCB, MCCB Quantity = 1 sets of each type and rating **Notes:** (a) **1 SET = Total Quantity of items used in 1 PCU** (b) The above spare quantities are for contingency purposes over and above the warranty requirements. (c) Item-wise quantity and break-up prices shall be provided in the offer.	
1.4	**Commissioning of PCUs along with Training at site.** 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 etc) provided by the vendor.	

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	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) 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. (3) 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. (4) Training: Vendor shall provide training at site to BHEL and customer's engineers during commissioning. Training shall cover various technical aspects such as functional/ operational features, trouble-shooting procedures, maintenance schedules, requirements, safety, emergency precautions etc. Both the theory and practical (hands on) training shall be covered. 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.	
1.5	**Installation and commissioning of external ducts or heat exchangers** - Scope shall include installation of external ducts in case of air cooling or heat exchangers in case of liquid cooling. All fixing brackets, other support structures, hardware, piping etc. required for fixing of the exhaust duct to the roof of the Inverter Room or for connecting heat exchanger shall be in the PCU vendor's scope. Any drgs for the Inverter Room required for this purpose shall be provided by BHEL to vendor. BHEL will provide the cut-outs on the room walls for fixing the duct / exhaust fans as per dimensions provided by the vendor.	Quantity shall be as per BHEL Tender requirement

2.0 Warranty

Vendor shall provide comprehensive warranty for 60 months from date of commissioning or 66 months from date of supply, whichever is earlier. Vendor shall enclose, along with technical bid, the complete scope, terms and conditions of the warranty.

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.

3.0 Technical Documents to be submitted along with offer

1. Vendor has to enclose the deviation sheet clause wise separately in case any deviations are sought by the vendor. Absence of any deviation sheet shall be taken as compliance of BHEL specification in total without any deviation.
2. Product datasheet of the offered PCU model.
3. Overall General Arrangement of PCU including DC and AC Combiner Panels.
4. List of spares offered (with quantity) and without prices.

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5. List of type tests /IEC certifications available along with test certificates. Supporting test reports shall be provided by vendor during detailed engineering.
6. Filled in format-A enclosed with this specification regarding manufacturing capacity and orders under execution.

4.0 Technical specification of Power Conditioning Units

4.1 Basic requirements (PCU type, Standards, Technology, Interconnections, Interfaces etc)

#	Parameter	BHEL specification
4.1.1	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/customer approval. **Low Voltage mode:** The Inverter shall be capable of operating under reduced power mode and shall not trip when the PV array output is below MPPT range under high temperature conditions.
4.1.2	Compliance with standards	

Sl.	Standard	Description
1	IEC 61683 Ed 1	Photovoltaic systems - Power conditioners – Procedure for measuring efficiency
2	IEC 62109-1 Ed. 1	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements

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		3 IEC 62109-2 Ed. 1 — Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters 4 IEC 61000-6-2 Ed. 2 — Electromagnetic compatibility (EMC) - Part 6-2: Generic standards-Immunity Standard for industrial environments 5 IEC 61000-6-4 Ed.2.1 — Electromagnetic compatibility (EMC) - Part 6-4: Generic standards- Emission standard for industrial environments 6 IEC 62116 Ed. 2 — Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures 7 IEC 61727:2004 Ed. 2 — Photovoltaic (PV) systems - Characteristics of the utility interface 8 IEC 60068-2-1:2007 — Environmental testing - Part 2-1: Tests - Test A: Cold 9 IEC 60068-2-2:2007 — Environmental testing - Part 2-2: Tests - Test B: Dry heat 10 IEC 60068-2-14:2009 — Environmental testing - Part 2-14: Tests - Test N: Change of temperature 11 IEC 60068-2-30:2005 — Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic(12 h +12 h cycle) 12 CEA Technical Standards for Connectivity to the Grid Regulations 2007 with 2013 Amendment including LVRT requirement 13 As per the Solar Photovoltaics, Systems, Devices and components Goods (Requirements for Compulsory Registration) Order, 2017, Inverters used in the grid connected solar power projects shall be registered with BIS and bear the Standard Mark as notified by the Bureau of Indian Standards.
	All the type test certificates as per the standards mentioned above shall be submitted for approval. The tests should have been conducted at a test laboratory compliant with ISO 17025 for testing and calibration and accredited by an ILAC/IECEE member signatory. Laboratory accreditation certificate or weblink along with scope of accreditation shall also be submitted. It is the responsibility of the VENDOR to substantiate the compliance for CEA Regulations using test reports.	
4.1.3	Output transformer	PCU shall be of 'transformer-less' design.
4.1.4	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.
4.1.5	AC-DC conversion	3-phase Inverter stack

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4.1.6	Built-in support systems	PCU shall be provided with protection circuits, monitoring circuits, data logging & storage system, provisions to download data to PC/Laptop, MODBUS communication outputs for SCADA interface etc as per Cl. 4.7 of this specification.
4.1.7	External ducts or heat exchangers	PCUs shall be provided with external cooling ducts, design of which shall suit the control room layout of BHEL. Details of layout of the control rooms shall be as per Cl. 4.11 of this specification. Alternatively, if liquid cooling system is recommended, vendor shall supply and install all the required accessories such as pipes, fittings, heat exchangers, coolant etc.
4.1.8	DC input and AC output terminations	Input and output terminations together with cable glands, lugs, hardware shall be provided to match the connections using BHEL cables as specified under related clauses of this specification. Terminals should be shrouded.
4.1.9	Environment protection	All PCB cards shall be provided with suitable coating (epoxy etc) for protection.

4.2 Technical parameters

#	Technical parameter	BHEL specification
4.2.1	Output power rating	1250 kW minimum (at 50 deg C ambient) without any derating upto 50 deg C
4.2.2	AC grid connection	3-phase
4.2.3	Output frequency	50 Hz +/- 5%
4.2.4	Nominal output voltage	Value to be indicated by vendor
4.2.5	Maximum DC input voltage (Max open circuit PV voltage)	1000 V DC
4.2.6	MPPT Range of control system	Range to be indicated by vendor.
4.2.7	DC side peak power	Vendor shall confirm that PCU is suitable for overloading of DC input power upto 30%.
4.2.8	Max DC operating current	Value to be indicated by vendor.
4.2.9	Max AC output current	Value to be indicated by vendor corresponding to the rated output power of the PCU.
4.2.10	Power factor	Designed operation close to unity PF. Adjustable window 0.9 lead to 0.9 lag
4.2.11	Ambient temperature	0 to 50 deg C.
4.2.12	Relative Humidity	Upto 95% non-condensing
4.2.13	Ingress Protection	IP 20 (Indoor).

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4.2.14	Grid Frequency tolerance	+/- 3 Hz
4.2.15	Grid Voltage tolerance	- 10% and + 10%
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%.
4.2.27	Voltage Ride Through	The PCU shall remain connected to the grid during temporary dip or rise in grid voltage as per the LVRT and HVRT requirements of CEA Technical Standards for Connectivity to the Grid Regulations. The PCU shall also be able to inject reactive power during the period of voltage dip.

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4.2.28	Active power regulation	The PCU shall be able to limit the active power exported to the grid based on the set point provided through PCU front control panel. The PCU shall also be able to automatically the limit the active power after an increase in grid frequency above a pre-set value. The ramp rate shall be adjustable during operation and start-up after fault. The applicability of the requirement shall be as per CEA regulation and compliance.
4.2.29	Reactive power control	The PCU shall be able to inject /absorb reactive power to/ from the grid based on the set point provided through PCU front control panel. The same shall be performed automatically with adjustable ramp rate based on dynamic changes in grid voltage or reactive power reference

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. Type-II surge protective device (SPD) conforming to IEC 61643-11 shall be connected between positive/ negative bus and earth.
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.

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		(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.

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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.
4.8.2	Fuses on DC input side	Fuses of min. **400A** rating shall be provided on each positive DC input terminal
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. 1Cx400 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.

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		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 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. **Additionally, AC Cable (3C x 95 sq.mm) for connection to Auxiliary Transformer shall be terminated on the AC side busbars. Gland Plate and busbars in AC Combiner Panel shall be suitable sized for this termination and additional holes shall be provided for the same.**
4.9.3	Gland plates	Drilled Gland plates shall be provided with holes to accommodate the cable glands. **Also refer Cl. 4.9.2 for additional holes for cables for Auxiliary transformer.**
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

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		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	Busbars shall be of 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.

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4.10.6	Fixing of PCU	PCU shall be suitable for fixing on the cable trench channels by the means of tack welding.
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 including CFD analysis for ventilation. - 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:

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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. Type test reports
5. Spares List
6. 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
7. HVAC calculations
8. 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.