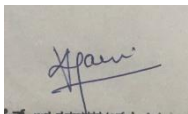


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Technical specification
for
Supply of Balance of System items, Installation and Commissioning
And Operation & Maintenance of
50MW (AC) Solar Photovoltaic Grid-connected Power plant
at
Kaudgaon, Maharashtra

Revision details: R01 dtd -15-10-2019	Prepared  Varun Jain	Approved  Prachi Rao V	Date: 15.10.2019
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1.0 Introduction

1.1 Overall project outline of 50MW (AC) solar photovoltaic power plant

Bharat Heavy Electricals Limited (BHEL), Electronics Division, Bangalore is setting up 50MW (AC) solar photovoltaic (SPV) power plant for MAHAGENCO Kaudgaon, Maharashtra.

Solar PV modules employed at the plant generates DC electricity that in turn shall be inverted to AC at 600V-700V range Output of each solar block (5MW) with independent Inverter station (IR) / transformer yards shall be stepped up to 33kV. Solar plant comprises of 10 no of Inverter stations with associated 5 MW PV array and 1 no. of Main Control Room (MCR/ CR). Output of Inverter station is combined at 33KV pooling yard near control room in the block of 25 MW. MMS structures are fixed type.

Power generated at the above SPV plant shall be transmitted to substation by connecting to 33KV double circuit transmission line being installed by MAHAGENCO.

The plant is envisaged to have several other infrastructural support systems such as module cleaning system for SPV modules, plant illumination system, fire alarm system, boundary fencing, approach roads, pathways, drainage system etc.

1.2 Scope of this tender specification

Vendor scope includes supply, installation, testing and commissioning of certain identified activities of the solar photovoltaic power plant as detailed in this specification.

This scope includes activities but not limited to obtaining approval from BHEL/ MAHAGENCO/ MAHAGENCO/ TRANSCO/ CEIG for the datasheets/ drawings/ MQP, manufacture/ testing/ inspection at manufacturer's works, packing, supply, transportation, transit insurance, delivery to site, unloading, storage, installation and commissioning of certain AC and DC side activities of power plant identified under this specification.

Note: The above is only a broad outline of vendor scope for the sake of introduction. The detailed vendor scope is elaborated under various other sections of this specification.

1.3 Enclosures to this tender specification (Tender purpose only)

1	Tentative AC single line diagram of overall Solar PV power plant
2	Tentative SPV plant layout with solar array, control/ inverter rooms, switchyards

2.0 Location/ address of power plant:

50MW (AC) Solar Photovoltaic Power Plant, Kaudgaon, Dist-Osmanabad, Maharashtra.

3.0 Vendor scope of supply, Installation and Commissioning

The table below indicates the scope of work for the vendor, as briefly outlined. Vendor shall submit the offer as per this list and quantity.

#	Scope of work (as briefly outlined)	Qty
1	Supply of MC4 connectors, cable ties, HDPE conduits, cable lugs, hardware etc	1 set

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2	Supply of LT control / instrumentation cables with cable installation accessories, hardware, termination kits etc	1 set
3	Supply of UPS panels, FCBC, ACDB, UPS DB Batteries etc with all related accessories and hardware etc	1 set
4	Supply of electrical utility items such as LED luminaires, fans, exhaust fan etc for Inverter station, PEB rom, security room, pooling yard, transformer yard, watch tower etc	1 set
5	Supply of 33kV interconnection yard equipments such as surge arrestors, GOS isolators, structures etc.	1 set
6	Supply of items of earthing system for solar array field, inverter/CMCS room panels, transformer yard / metering yard equipment etc including earthing electrodes, Copper flats, earthing cables, GI wires, MS rods (earth mat), earth chamber lids and all related miscellaneous hardware etc	1 set
7	Supply of lightning arrestors along with poles/masts, down conductors, all related accessories and hardware for the complete solar power plant	1 set
8	Supply of items for plant lighting system such as electric poles, bend pipes, luminaires/lamps, ballasts, junction boxes, cable conduits, fittings/clamps, other related accessories and hardware etc	1 set
9	Supply of miscellaneous items such as SMB mounting structures, ABT meters, metering panel metering panels, weather monitoring system, LED display for SCADA system, cable route markers, cable tags, danger boards, hoarding boards, sign boards, display boards, electrical insulation mat, checkered plates, air conditioners, tool kits, measuring instruments, SCADA office furniture etc	1 set
10	Supply of CCTV System	
11	Supply of safety related items including fire alarm systems for inverter station /CMCS rooms, fire extinguishers, safety gadgets etc	1 set
12	Supply of spare items	1 set
13	I&C: Electrical works in Inverter station, PEB rom, security room, pooling yard, transformer yard, watch tower etc	1 AU
14	I&C: Interconnection of SPV modules, erection of SMB mounting structures, installation of string monitoring boxes including power cable terminations etc.	1 AU
15	I&C: Underground cable trenches & laying of cables for LT AC/DC power cables, HT (33kV) cables, data communication / control / SCADA / OFC cables etc.	1 AU
16	I&C: Erection of indoor / outdoor electrical panels (PCU containers, VCB breaker panels, ACDB/DCDB panels, UPS panels etc) at the inverter station laying & fixing of cable trays, routing and terminations of DC/AC cables (HT, LT, data / control) at the electrical panels up to LV side of inverter/auxiliary transformers, laying of earth grids (external underground / internal within the rooms), earthing connections etc.	1 AU

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17	I&C: Erection of indoor outdoor electrical panels (VCB breaker panels, ACDB/DCDB panels, UPS panels etc) in the main CMCS control room, 33KV pooling yard laying & fixing of cable trays, routing and terminations of DC/AC cables (HT, LT, data/control) at the electrical panels up to LV side of inverter/auxiliary transformers, laying of earth grids (external underground / internal within the rooms), earthing connections etc	1 AU
18	I&C: Erection of 33kV transformer yards (attached to the 10 inverter stations) with necessary land leveling within the yards, laying of underground earth mat grid, erection of inverter transformers, underground cable trenches, routing and terminations of 33kV/LT/ data/ control cables at inverter transformers etc	1 AU
19	I&C: Erection of 33kV interconnection yard (evacuation point near plant boundary) including foundation/erection of pole structures, installation of yard equipments viz LA/ GOS isolator/ cable support structure etc, cable trenches, laying of 33kV/ LT / data / control / SCADA cables between metering yard and control room panels, laying of earthing electrodes / earthing strips for the yard equipments, earthing connections etc	1 AU
20	I&C: Installation works of Weather monitoring station and SCADA system – laying and terminations of OFC/ instrumentation/ data cables etc at SCADA panels of inverter station and CMCS room a	1 AU
21	I&C: Earthing system for solar array field including laying of underground earth mat grids and interconnection to the module mounting structures, I&C of lightning protection system (lightning arrestors) with earthing provisions as per clause 5.28, 5.30.	1 AU
22	I&C of lighting system for illumination of the complete power plant including cable terminations at the yard lighting poles as well as ACDB panels of inverter station / main control room etc as.	1 AU
23	I&C: CCTV System	
24	I&C of miscellaneous and safety items such as ABT metering panel, cable tags, danger boards, cable markers, hoarding board, sign boards, display boards, electrical insulation mat, checkered plates, air conditioners, SCADA office furniture, fire extinguishers, fire alarm system, fire-fighting system, LED display for SCADA system, landscaping works for the power plant, grouting of electrical panels in inverter station/CMCS rooms etc	1 AU
25	I&C: Pre-commissioning inspections / checks / tests, MRT tests and coordination with state / central departments / CEA/ CEIG etc for necessary approvals / clearances for commissioning, synchronization with grid and post-commissioning operation of the plant	1 AU
26	Operations and Maintenance per month (one Year)	12 Mon

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4.0 BHEL scope of supplies and works

For clarity to the vendor, other items and activities within BHEL scope of solar PV plant end of the project are listed below:

1	Supply of 1C x 4 sqmm Solar Cable	~700 KM
2	Supply of DC cable, 1C x 185 sqmm, Cu, XLPE, armoured as per IS: 7098 (from SMB to PCU)	~100 KM
3	Supply of LT cable, 1C x 630 sqmm, Al, XLPE, armoured as per IS: 7098 (from PCUs to Inverter transformers)	~5 KM
4	Supply of 33kV cable, 1C x 300, Al, XLPE, armoured as per IS: 7098 (for all 33kV connections within solar plant including Aux transformer HV side)	~30KM
5	Supply of OFC cables along with termination kits. Also, termination of the cables at both ends (SCADA panels of inverter station SCADA panels of main control room)	As required
6	Supply of containerized power conditioning units (PCUs) of 2 x 2.5 or 1 x 5 MW	10 Sets
7	Supply of String Monitoring Box	260 Sets
8	Supply of inverter transformer 5MVA, 33kV/xxx-xxx V, ONAN	10 Nos
9	Supply of 33kV breaker panels	12Sets (26 Nos)
10	Supply of SCADA system including PLC panels, computers, software systems and related peripherals & accessories	1 set
11	Supply of GI earthing strips for PV array, Inverter station, 33Kv pooling yard, control room, interconnection yard	1 Set
12	Supply and Installation of Module cleaning system	1 Set
13	Supply and Installation of Module mounting structure including module mounting	~5810 Sets
14	Construction of Inverter and aux transformer foundations including fencing	1 Set
15	Construction of foundation for Inverter station, 33KV pooling yard	1 Set
16	Unloading/ storage/ security for BHEL supplied items.	-
17	Construction of RCC main control room except those vendor scope supply/I&C activities defined under this specification.	1 + 1 rooms
18	Construction of civil works such as approach roads, pathways, drains, overall plant boundary fencing, soak pit, septic tank.	-

5.0 Technical specification for supply, installation and commissioning

#	BHEL specification
5.1	Temporary site office for vendor use Vendor shall make necessary office arrangements such as porta cabin, furniture, electrical points/ fittings etc. on their own for their use/ occupation at site during the period of project execution. Note: Site offices for BHEL and MAHAGENCO shall be arranged by BHEL.
5.2	Electrical power / water for construction Vendor shall organize, on their own, necessary electrical power supply such as DG sets and water supply etc. required for construction activities.
5.3	Construction of temporary yards for safe storage of vendor supplied items Vendor shall, at a suitable location at the site, as decided based on discussions with BHEL site engineer, construct temporary yards for safe storage of vendor supplied items.

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5.4	Unloading, safe storage and movement of supply items received at site: A. Items supplied by vendor (1) Vendor shall organize all necessary resources such as labour, machinery and tools (cranes, hydra, forklifts, transportation trucks/ trolleys, lifting accessories etc.) for unloading the items (supplied by the vendor) received at site and subsequent movement to storage yards. (2) Similar arrangements shall also be made by vendor for movement of the stored items from storage yards to the exact construction locations within the project site. (3) Vendor shall maintain proper documentation / compilation of all the records related to shipping (invoices, LRs, delivery challans, material receipt certificates etc.) and shall take approval from BHEL site engineer for every consignment. The documents shall be suitably preserved for further handing over to BHEL. (4) Registers shall be maintained for the yard to keep track of incoming/outgoing items. (5) Safety of items shall be in vendor scope. Accordingly, suitable watch and ward shall be deployed on round-the-clock basis. B. All other items (supplies from BHEL and other vendors) (1) Receipt, unloading, storage, security guards shall be in scope of BHEL/ other vendors. (2) However, movement of these items from their respective storage locations to the points of construction is in scope of vendor (excluding modules and MMS). Accordingly, vendor shall organize all necessary resources such as labour, machinery and tools (cranes, hydra, forklifts, transportation trucks/ trolleys, lifting accessories etc.) for this purpose. (3) Vendor shall maintain proper documentation / compilation of all the records related to shipping (invoices, LRs, delivery challans, material receipt certificates etc.) and shall take approval from BHEL site engineer for every consignment. The documents shall be suitably preserved for further handing over to BHEL
5.5	Series interconnection of SPV modules to form strings Supply of SPV modules is in BHEL scope. Type of module: L24270 (~330Wp). Total quantity = ~1,74,240 Nos Vendor shall interconnect the SPV modules as follows: (a) Each module is fitted integrally with a junction box having positive and negative polarity cables (4 sq-mm). (b) Positive cable of one module shall be connected to the negative cable of adjacent module. The cables have MC4 type of connectors. One polarity cable has male type connector, while the other has female type connector. (c) This way, 30 modules shall be connected in series. Each set of connections is called as a sub string. (1) (d) Each Module mounting structure (MMS) contains 30 nos of SPV modules. Thus from each MMS, one sets strings The output of string will be connected to 4 sqmm solar grade cable through MC4 connector. Supply of MC4 connectors is in scope of vendor. This 4 sqmm cable will be terminated at the input side of SMB as a single input. After placing the purchase order on vendor, BHEL will provide layout drawings that will describe the exact way in which the strings are formed after placement of purchase order. Vendor shall implement the interconnection as per these drawings.
5.6	Routing of 1Cx 4 cable below the SPV modules (1) 1Cx4 sq-mm cables connecting the SPV module strings to SMBs suitably routed below the SPV modules and along the horizontal C-lip purlin member of MMS structure. These cables shall be dressed properly and fastened to the purlin using UV resistant cable ties of suitable length. (2) Cable ties shall be in vendor scope of supply. (3) Cable ties, nylon polyamide 6.6 UV stabilized black, UL94 flammability rating V2, operating temperature up to 85 deg C, shall be used to arrest any possibility of movement

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	or sagging. Cable ties shall be of make: 3M, Phoenix contact, Weidmuller, Hellermannntyton, Panduit or other reputed equivalent subject to approval of BHEL/MAHAGENCO. Width and Length shall be so appropriate as to ensure that the bunched cables are held firmly to the mounting structure. Spacing between two adjacent cable ties shall be so appropriate as to ensure that there is no loose hanging of cables. During detailed engineering, BHEL/MAHAGENCO approval shall be obtained for the selected brand and sizes of cable tie. (4) Spacing between two adjacent cable ties shall be so appropriate as to ensure that there is no loose hanging of cables. (5) Solar cables, wherever exposed to direct sunlight (including gaps between tables) and buried underground, shall be laid through Double Wall Corrugated (DWC) HDPE conduits.
5.7	Interconnection of SPV module strings to 1Cx4 cable and Supply MC4 connectors (1) Vendor shall connect strings (each of 30 SPV modules) to 1Cx4 cable (copper, XLPO insulation cable) using MC4 connectors. (2) Vendor shall supply 5810 sets (1 set = 1 male + 1 Female connector) MC4 connectors. These quantities are excluding spares requirement. (3) Extra quantity shall be procured for any damages / pilferage during the installation by vendor at site. Such additional quantities will not be paid for. Vendor shall ensure that there shall not be any shortage during execution time. (4) Four sets of tool kits shall be supplied. This shall include crimping plier MC4, open end spanner set MC4, stripping plier MC4, socket wrench insert to tighten, socket wrench insert to secure, inserts for 4 sq-mm. (5) MC4 connectors shall have rating of 1500VDC (IEC), rated current of 30A (min), type approved by TUV Rheinland for product safety. (6) Approved make: Multicontact, Bizlink, Sunlont, Elmex or other reputed equivalent subject to BHEL/ MAHAGENCO approval during detailed engineering. (7) In addition, any other required tools and tackles for crimping of cable etc. shall be arranged by vendor.
5.8	Installation of string monitoring boxes including supply/erection of mounting structures (1) Supply of string monitoring boxes (SMB), 260 sets, is in BHEL scope. These are 24-in/ 1- out type. This way, on input side of SMB. (2) SMB shall be mounted on the Module Mounting structures. Provision will be provided in the Module mounting structure to mount the SMB. However, necessary hardwares like nuts, bolts, washers etc and canopy of SMB shall be in the vendor scope of supply. (3) Vendor shall install the SMBs on the module mounting structures. (4) All necessary labour, tools, machinery etc for erection work shall be in vendor scope.
5.9	Routing of 1Cx4cable in DWC HDPE pipes underground between the rows of solar array (1) One SMB is connected to 23 strings. SMBs are located in center of a string block. Where 1Cx4 cables run vertically along MMS leg or between two rows of structure (or) where the cables cross over the pathway separation between two adjacent solar array blocks, HDPE double walled corrugated (DWC) pipe shall be provided to route the cables underground from one row/ block to the other. HDPE DWC pipe together with necessary HDPE couplers/ joints (T-joints, elbows, bends etc.) shall be within scope of vendor supply. Where cables run vertically along MMS leg, HDPE pipes shall be routed properly and tied/ clamped to leg. For this, necessary UV protective cable ties of suitable length or clamps shall be in vendor's scope of supply. (2) Specification of HDPE DWC pipe: As per relevant IS; ID shall be selected to accommodate the number of 1Cx4 cables to be guided. A maximum of 7 circuits can be run through single HDPE pipe. Fill ratio will be considered max 50%. However, exact ID shall be selected to ensure that only a maximum of 50% of the ID space is occupied by the

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	cables. Make, part number, sizes/ dimensions shall be submitted for BHEL/MAHAGENCO approval during detailed engineering. (3) Cables with HDPE pipe (and couplers/joints etc.) shall be directly buried underground as per IS: 1255. Continuous trenches shall be excavated on either side of the SMB. In addition, for each SMB, there shall be minimum one pathway crossing, for which trench shall be excavated. a. Trench depth = 400 mm minimum b. Trench width = As per conduit size and number of conduits c. Trench shall, then, be filled with refill soil and compacted. Excavation, laying of pipes, routing of 4 sqmm cables through HDPE pipe, fixing of couplers, sealing end of the HDPE pipes, trench backfilling shall be vendor's scope. Trenches shall be backfilled, compacted and the area shall be neatly levelled. (4) Total length of HDPE DWC pipe and quantity of couplers/joints shall be as required. (5) Bending radii for cables shall be as per IS: 1255. (6) At road crossings, cables shall be routed through Hume pipe of class NP3 of appropriate size that shall be in vendor scope of supply and technical details/ brand etc. shall be submitted for BHEL/ MAHAGENCO approval during detailed engineering. (7) All cable entry openings of conduit pipes, after laying/ termination of the cables, shall be sealed using appropriate sealant (single component thermoplastic insulating compound) to ensure water proof tightness. The sealant supply will be vendor's scope of supply. (8) Solar cables, wherever exposed to direct sunlight and buried underground, shall be laid through Double Wall Corrugated (DWC) HDPE conduits.
5.10	Termination of 1Cx4 cables on input side of SMBs 1Cx4 sqmm cables of positive and negative polarities originating from SPV module strings shall be terminated at the input side of SMBs. (2) Vendor scope includes removal of sleeve at the cable end, crimping with suitable cable lug of appropriate type/size and connecting the lugged end to the terminal block (connector) within the SMB. Cables shall enter the SMB through the cable glands that are provided as part of the SMBs supplied by BHEL. (3) Cable lug shall be in vendor scope of supply. Type of lug (pin type etc) shall be in accordance with the termination arrangement within the SMB. Quantity required shall be appropriately selected by the vendor (cable lug + any other hardware if required). (4) Any other hardware, if necessary for fulfilling the connection, such as bolts, nuts, screws, washers etc shall be in vendor scope of supply. All hardware shall be of SS304. (5) All necessary tools such as pliers, strippers, crimping tool etc shall be within vendor scope
5.11	Ferruling for 1Cx4 cable 1) For 1Cx4 sqmm DC solar array cable, vendor shall supply and provide UV resistant ferrules printed with source/destination identification of cable. Printing details shall be given by BHEL after placement of order. Printing shall be of appropriate size to ensure readability. 2) Supply of ferrule shall be in vendor scope. 3) Ferrules shall be provided on all termination ends: module end and SMB ends for all 4 sqmm cables.
5.12	Underground cable trenches and laying of 1Cx185 sqmm in solar array field (1) DC power cable 1Cx185 sqmm, Cu conductor, XLPE, armoured (from SMB to PCU) shall be laid underground by way of direct burying as per IS:1255. Supply of above the cables shall be in BHEL scope. Cable laying shall be carried out as per "Cable installation methodology" defined in this specification. (2) Typical trench details/dimensions are below only for tender purpose. (a) Total trench depth = 850 mm minimum (b) Trench width = As per number of cables laid.

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	(c) Trench shall have layers one over the other as below (from bottom to top): 1. Bottom layer shall be sand of IS: 383 with 75mm minimum thickness 2. 1Cx185 sqmm cable shall be laid over the sand layer 3. Another layer of sand of 75 mm minimum thickness. 4. Single layer of brick as protective cover covering all cables 5. Trench shall, then, be filled with refill soil and compacted (3) Communication from SMB to SCADA shall be through wireless medium. (4) Bending radii for cables shall be as per IS:1255. At road crossings, cables shall be routed through Hume pipe (Class NP3, 300 dia) of appropriate size that shall be in vendor scope of supply. At Nallah crossings, cables shall be routed through Covered cable trays/ structures. Hume pipe and cable trays/ structures of appropriate size shall be in vendor scope of supply, fabrication, grouting and erection. Vendor shall take utmost care in laying the cables in order to prevent wastages and damages on outer sheath and inner insulation. Cable shall be drawn with rollers only to ensure no damage to cable during laying. In case cables found to be damaged/ cut after the laying in trenches, vendor shall implement suitable corrective action such as cable jointing, or re-lay a new cable in consultation with BHEL.
5.13	Laying of 1Cx185 in inverters rooms and terminations at PCU (1) 1Cx185 cables (Cu conductor, XLPE insulation, armoured: BHEL scope of supply) running from SMBs (through outdoor cable trenches) shall be routed into the Containers at Inverter stations. (2) Vendor shall carry out drilling of holes in cable gland plates of the PCUs for the 13 positive and 13 negative DC inputs of 1Cx185 cable. Gas cutting method is strictly not allowed. Vendor shall organize hole-saw cutters of appropriate size for this purpose. All necessary drilling machines / tools etc. shall be made available at site. (3) Prior to termination, each cable shall be checked for continuity and megger. In case any cable found defective, vendor shall implement suitable corrective action such as cable jointing, replacement/re-laying of cable etc. as applicable. (4) Vendor shall carry out glanding of the cables following which the glands shall be fitted to the respective holes of gland plates. (5) Vendor shall carry out the 1Cx185 cable terminations for the 13 positive and 13 negative inputs that include tasks such as unsleeving, crimping, connecting to the tinned copper bus bars, tightening using torque wrench etc for all PCUs (7) Vendor shall arrange torque wrench of appropriate range. Torque setting shall be as per the bolt size and property class. For the setting, approval shall be obtained from BHEL site engineer. (5) (8) All tools/accessories such as crimping tools etc. required to carry out the termination shall be within scope of vendor.
5.14	Termination of 1Cx185 DC power cables at SMBs (1) Cables of 1Cx185 (Cu conductor, XLPE insulation, armoured) shall be terminated at the output side of SMBs (positive, negative terminals). Supply of this cable is in BHEL scope. (2) Vendor scope includes removal of sleeve at the cable end, crimping with suitable cable lug of appropriate type/size and connecting the lugged end to the tinned copper bus bar within the SMB. Cables shall enter the SMB through the metallic cable glands that are also supplied by BHEL along with SMBs. (3) Copper Cable lug shall be in vendor scope of supply. Make shall be Dowell, or equivalent subject to approval of BHEL/MAHAGENCO Lug shall match the cable conductor material /size and also the tin plated copper bus bar of SMB. (4) Quantity of lug and hardware shall also include contingency requirements arising out of shortage due to various reasons (damage, theft etc) during installation. (5) All necessary tools such as pliers, strippers, crimping tool etc shall be within vendor scope.

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5.15	Laying and Termination of 1Cx630 LT AC power cables at PCU and Inverter Transformer (1) LT Cables 6 runs of 1C x 630 sqmm Al conductor, XLPE, armoured per phase shall be laid between AC side of the PCU and the LT side of the Inverter transformer over the cable trays. Supply of these cable treys along with the cable support structure shall be in vendor's scopes. Cables shall be laid in trefoil arrangement. Trefoil clamps supply and fixing in in vendor's scope. (2) Vendor scope includes removal of sleeve at the cable end, crimping with suitable Bimetallic Lug or Aluminium Lug with Bimetallic washer/ strip. Cables shall enter the PCU and Transformer through the metallic cable glands. Supply of Lugs and Glands required for Inverter Transformer side termination shall be in vendor's scope. (3) Cable lug make shall be Dowell, or equivalent subject to approval of BHEL/MAHAGENCO. (4) Cable gland metallic type shall be of COMET make or equivalent subject to approval of BHEL/MAHAGENCO. (5) Quantity of lug and hardware shall also include contingency requirements arising out of shortage due to various reasons (damage, theft etc.) during installation. (6) All necessary tools such as pliers, strippers, crimping tool etc. shall be within vendor scope.
5.16	Identification marking of cables using cable tags 1) Cable tags shall be provided on all power cables at both ends just before entering the equipment enclosure and every 20 m on cable tray or trench run. 2) Cable tags shall be of rectangular shape. 3) Cable tag shall be of 2mm thick aluminum with number punched (embossed) on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. 4) ID numbering scheme shall be provided to vendor after Purchase order placement. Vendor shall submit the technical details of cable tags for BHEL/MAHAGENCO approval during detailed engineering.
5.17	Installation of electrical panels / Container at Inverter Station, main control room and 33KV Pooling yard I. Out door Panel installation at Inverter Station Vendor shall organize necessary resources such as labour, cranes, hydra, forklifts, transportation trucks / trolleys and other accessories for movements and positioning of the panels as below (Quantities mentioned are per inverter room): (a) 2x 2.5 MW or 1 x 5 MW PCU Container consisting of PCU, aux transformer, AC distribution board: 1 sets (This shall be installed on the RCC foundation. Construction of foundation is in BHEL scope) (b) 33kV outdoor VCB panels: 1 No. (This shall be installed on the RCC foundation. Construction of foundation is in BHEL scope) II. Indoor Panel installation at Inverter Station These panels shall be installed inside small room adjacent to inverter station (a) Distribution boards: UPSDB, AC, DCDB and any extra boards as required (b) SCADA panel: 1 No (c) UPS with battery bank: 1 No (d) FCBC battery charger with Battery bank– 1 No Panel installation within main control room: (a) ACDB main panel: 1 set

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	(b) Distribution boards (wall mounted): DCDB, UPS DB, CR DB (room utilities), LDB (plant lighting), PDB (power DB): 1 No each + any extra boards as required (c) SCADA panel: 2 Nos (d) HMI SCADA control desk with PCs and accessories: 1 set (e) UPS with battery bank – 2 Nos (f) FCBC battery charger with battery bank – 1 No Outdoor Panel installation in 33KV pooling yard near Control room: (a) 33kV outdoor VCB Switchboard: 2 sets. (Each set shall consist of 8 nos 33KV VCB panels. These shall be installed on the RCC foundation. Construction of foundation is in BHEL scope) (1) Panels shall be moved to the respective positions and placed over the cable trenches in control room, in the exact sequence and locations as per drawings. Drawing shall be provided after placement of purchase order. (3) Panels / Container shall be suitably grouted using welding/ bolting methods as per relevant standards and recommendation of OEMs. BHEL approval shall be obtained for the grouting arrangement. All necessary hardware for the same shall be within vendor scope of supply.
5.18	Supply and Installation of UPS: Vendor shall supply, install and commission UPS, UPS battery and UPS DB panels – one for each Inverter station and one for main CMCS room. Thus, there shall be a total of 11 UPS panels. Indicative capacity of UPS shall be 3kVA for Inverter station and 5kVA for main CMCS room. The UPS shall have back up of 4 hours. Vendor shall, however, submit exact sizing calculations considering (but not limited to) the loads as below: • Data logger / SCADA • Fire Detection/ Alarm Panel • HMI of SCADA • Emergency Lighting Battery for UPS shall be VRLA type.
5.19	Supply and Installation of Float cum boost charger and Battery Bank: Battery bank shall be VRLA/MF stationery, sealed type, 110V DC, at 8 hours rate of discharge, IS 1651-1979, performance as per IS:8702, nominal cell voltage 2V/12 V cells, plastic resin/ ABS/ PP container, epoxy coated exhaust fans to remove the gas emissions, suitable battery rack/stand with painted steel sections. Details of Battery shall be as follows: Minimum rating of the battery shall be 1. For Inverter station : 20 AH, 110V 2. For 33KV Polling yard : 150 AH, 110 V 2. Float-cum-boost-charger with boost current (45A) and boost voltage (135V): Minimum Rating of Float-cum-boost-charger shall be (i) boost current (50A) and boost voltage (135V) for 33KV pooling yard.

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	(ii) boost current (10A) and boost voltage (135V) for each inverter room Each FCBC shall have in build DCDB with following output feeders: 1. For Inverter station : 3 nos of 10 A feeder 2. For 33KV pooling yard: 5 nos of 16 A feeder Battery charger as well as their automatic regulators shall be of static type. Battery chargers shall be capable of continuous operation at the respective rated load in Trickle mode i.e. Trickle charging the associated DC Batteries while supplying the DC loads. The chargers shall be designed to operate, as mentioned above, at an ambient air temperature of 50°C. Battery chargers shall have a selector switch for selecting the battery charging mode i.e. whether Trickle or Boost charging. During automatic boost charging, the Battery chargers shall operate on constant current mode. Charger shall have load limiters which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the DC load current exceeds the load limiter setting of the Charger. LED indications with alarm annunciation on the panel for Mains ON, Float charger AC ON, Float charger DC ON, Boost charger AC ON, Boost charger DC ON, AC Mains Fail, Float charger DC fail, Boost charger DC fail, DC earth fault, SCR fuse fail, Filter fuse fail, Blocking diode fail, Battery under-voltage, Battery over-voltage, Charger DC overload. LED indications for various parameters: 3-ph AC input voltage, boost/float/trickle currents, charge/discharge currents, DC output voltage/current, Battery leakage current etc. Selector switches for Float Auto/Manual, Boost Auto/Manual, Float/Boost/ Autoboot selector switches. Also, Voltmeter / Ammeter selector switches as applicable.
5.20.	Laying, termination of LT/HT/aux supply cables/ inverter station/ main control rooms and in associated 33KV yards (1) For all electrical panels viz. PCUs/ VCB panels/ ACDB panel/ UPS/ FCBC battery charger/ battery bank /DB boards/ aux transformer and inverter transformers of the inverter rooms, laying and termination of LT/HT/Aux power cables shall be in vendor scope. (2) For all electrical panels viz. PCUs/ VCB panels/ ACDB panel/ UPS/ FCBC battery charger/ Battery bank / DB boards / aux transformers/ inverter transformers/ GOS/ Metering panel/ Metering CT/ Metering PT of the control room, laying and termination of LT/HT/Aux power cables/, switchyard structure & equipment erection shall be in vendor scope. (3) 630sqmm AC cables in transformer yards in inverter room and control room yard shall be routed on ladder type cable tray 600mm above the ground. Support structure required for cable tray shall be in vendor scope. (4) Cable glands, cable lugs, 33kV HT cable termination kits (indoor/ outdoor types as applicable), Cable jointing kits, lugs, clamp & connectors, cable support structure for termination of 33KV cable at the evacuation point , bolts, nuts, washers etc. shall be in vendor scope of supply. (5) It is the responsibility of the vendor to assess the actual length requirements duly considering all applicable clearances as per relevant standards, Indian electricity rules, CEA/CEIG requirements etc. For this purpose, tentative (indicative) locations of inverter/Control rooms, internal layouts of inverter/Control rooms are enclosed along with tender. (6) For marshalling box of transformer/ UPS/ SCADA/ DB boards, single compression nickel plated brass glands shall be provided by vendor. Make shall be COMET or reputed equivalent subject to approval of BHEL/MAHAGENCO.

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	(7) HT termination kits (indoor/ outdoor as applicable) shall be of Raychem make as shall be approved by BHEL/MAHAGENCO. HT termination shall be carried out by certified jointers. Credentials / certification of experience from Raychem for the proposed jointers shall be submitted for BHEL/MAHAGENCO approval during detailed engineering. (8) Quantity of 33KV End termination and straight through jointing kits shall be supplied by vendor as follow : a. Indoor 33KV End termination kit for 1Cx300 sqmm (E) cable = 144 Nos b. Outdoor 33KV End termination kit for 1Cx300 sqmm (E) cable = 12 Nos c. Straight through jointing kit for for 1Cx300 sqmm (E) cable = as per site requirement These quantities are excluding spares requirement. (9) The scope of HT cable laying and termination at Control room incomer panels for the cables coming from Inverter room shall be in the scope of the vendor. (10) All trench excavations, cable laying, sand and brick layer, backfilling etc as per IS 1255 shall be in vendor's scope. (11) Vendor shall make appropriate holes in the gland plates of PCUs, HT VCB panels, ACDBs, SCADA panels, Inverter transformers, Marshaling boxes, Auxiliary transformer, Battery chargers, Distribution boards etc. for fixing the cable glands. Gas cutting is strictly prohibited. Hole-saw cutters of appropriate sizes with suitable drilling machines shall be made available at site for this purpose. (12) Bimetallic lugs or aluminium lugs with bimetallic strip/washer shall be used for connecting Cu bus bar and Al cables or vice-versa wherever applicable. (13) Terminations with M10 and above shall be tightened using torque wrench. Torque setting shall be as per size, property class of bolt. BHEL approval shall be obtained for the settings prior to tightening. (14) Approximate (indicative) specifications of certain power cables are as follows. Exact specification shall be based on design calculations that shall be submitted for BHEL/MAHAGENCO approval during detailed engineering. Quantity shall be appropriately selected. (a) PCU to 5MVA transformers: Cable supply in BHEL scope 3-phase 3-wire system, 6Rx1Cx630 sqmm per phase, 1.1kV grade, aluminium conductor, XLPE insulation, unarmoured, PVC sheathed as per IS: 7098. (Note: cables from inverter tp stransformer shall be laid on ladder type cable tray in trefoil arrangement). (b) HV (33kV) side connections in VCB panels, 5MVA transformer, 33KV pooling yard near control room auxiliary transformer: Cable supply in BHEL scope 3-phase 3-wire system, 3Rx1Cx300 sqmm, 33kV, aluminium conductor, XLPE insulation, armoured, PVC sheathed as per IS: 7098. (d) ONAN Auxiliary transformers to ACDB panel in 33KV pooling yard near CMCS room: Cable supply in vendor scope (e) Metering CTs, PTs, GOS, LA connections in control room: ACSR Conductor & termination accessories supply in vendor scope (f) LT AC aux power supply cables from ACDB panels in Inverter/control room to the related utility loads such as battery charger, UPS, 33KV Motorised isolator, metering yard kiosks, MCB DB boxes for room appliances, PCU, ABT meters, transformers aux supply, SCADA, VCB panels aux supply, fire alarm system, panel illumination lamps, space heaters of VCB panels etc. Cable supply in vendor scope (g) LT DC aux power supply cables from DCDB panels in inverter /CMCS rooms to the utility loads such as DCDB panels, VCB panel tripping/closing circuits, SCADA, VCB panel spring charge motors in 33kV metering yard etc. Cable supply in vendor scope
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	(15) Supply of all cable accessories (for the above requirements) such as cable trays, cable glands, cable lugs, ferrules, nuts/bolts/washers, cable dressing ties etc shall be in vendor scope. (16) Laying of above cables, fixing of cable glands, cable termination at the respective terminal bus bars shall be in the scope of vendor (17) All resources such as labour, machinery, tools and accessories to carry out the above electrical works shall be in vendor scope. (18) All applicable/relevant clauses under “General specification of LT cables” and “Cable installation methodology” sections of this specification shall be adopted for all aspects of these cables.
5.21	Laying and installation of Control / data / instrumentation / OFC cables (1) Vendor shall supply all the control/ data/ instrumentation / communication cables except OFC and Ethernet LAN cables for SCADA. (2) All the cable installation accessories such as cable trays, cable conduits, cable glands, cable lugs, ferrules, cable ties, bolts, nuts, washers etc. shall be in vendor scope of supply. Cable laying and cable terminations shall be in vendor scope. All necessary resources such as labour, tools and accessories required to carry out laying and termination works etc. shall be in vendor scope. (3) OFC cable termination kits shall be in BHEL scope of supply. Vendor scope includes laying of the OFC cable underground in the conduit from inverter station SCADA panels to main control room SCADA panel. Termination of the OFC cables at both the ends shall be in BHEL scope. (4) Vendor shall lay and terminate the RS485 cables to SCADA from all plant equipment e.g. HT panels, ACDBs, transformers, FCBC, UPS etc. These cables shall be laid between the panels of respective inverter station/ main control rooms. (5) Vendor shall lay and terminate the Ethernet cables to SCADA from (a) PCUs, (b) numerical relays of VCB panels. These cables shall be laid between the panels of respective inverter station/ main control rooms. (6) Vendor shall lay and terminate control and instrumentation cables from inverter transformers to SCADA and from HT breakers to SCADA. (7) Laying and termination of cables in 33KV pooling yard e.g. from 33 KV motorized isolator, metering CTs, Metering PTs to SCADA/ ABT meters/ HT breakers etc. Distance of Metering yard from control room is 100 m approximately. (8) Electrical Interconnections of HT breaker panels e.g. outgoer, incomers, Bus PT panels for 3Kv pooling yard HT breakers. (9) Suitable size ferrules with details shall be provided on either side on either side of each control/ data/ instrumentation cable. (10) Vendor shall submit cable schedules for approval of BHEL/MAHAGENCO. (11) All applicable/relevant clauses under “Cable installation methodology” sections of this specification shall be adopted for all aspects of these cables.
5.22	Erection of 33kV yard Equipments (1) Near each Inverter station there shall be one transformer yard having one 5 MVA inverter transformer. (2) Near control room there shall be 2 nos of 63 KVA, 33/415 aux transformer at 33KV pooling yard. (3) Construction of transformer RCC foundations, fencing and gates for these transformers yard and pooling yard near control room and inverter station is in BHEL scope.

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	Levelling, stone jelly, cable support structures fabrication & cable tray support foundation works, all earthing related works-excavation etc shall be in vendor's scope. TRANSFORMER ERECTION- (1) Vendor shall erect the inverter and auxiliary transformers on RCC foundation as per transformer GA details. Vendor scope of I&C of transformers shall include: - Movement of transformers and its accessory parts such as radiators, cable boxes, hardware etc from storage yard and placement on foundation pedestal. - Assembly of transformer parts. - Cable laying and terminations at LV/HV/Marshalling boxes of transformers. - All activities applicable to oil filling and filtration including measurement of oil BDV and PPM. Particularly for inverter transformers, filtration of oil shall be carried out to such an extent as to obtain the desired BDV (>60 kV) and PPM (< 15ppm) values. - Testing of transformers as per “pre-commissioning checks” section of this section. (2) After installation of transformers at the transformer yards of each inverter station/ pooling yard near control room, vendor shall level/ compact the ground with an appropriate magnitude and direction of slope to facilitate draining of rain water away from transformer yard. Accordingly, to prevent stagnation of water within transformer yard, vendor shall implement suitable civil works in and around the transformer yard. This shall include filling up the land (wherever necessary) with suitable soil and compact the filled-up portions either manually or with rollers, as applicable, as per site conditions, to achieve required compaction/slope. General Notes- Vendor shall provide the 100 mm layer of stone gravels in transformer yards as per relevant IS standards / CBIP/ CEIG requirements etc. Vendor shall provide applicable earthing connections to transformers, fencing / gates etc. in the yard as per relevant clauses under the “Earthing system” section of this specification. All other items (if any, other than the above) that are required to meet the technical requirements of transformer yard as per applicable standards / electricity rules shall be incorporated by the vendor.
5.23	Inter connection Point (1) MAHAGENCO will supply and install 33KV double circuit line from nearest substation to the plant boundary. Vendor shall lay and terminate the 2R x 1C 300 sqmm 33KV cable/ phase from each of 25 MW pooling switchgear to the interconnection pont. At the interconnection point vendor shall provide 33KV LA, motorized isolator, cable support structure etc. Supply of all necessary hardwares, structure/ pole for LA/Isolator etc shall be in vendor scope of supply. All other items (if any, other than the above) that are required to meet the technical requirements of interconnection point as per applicable standards / electricity rules shall be incorporated by the vendor.
5.24	Metering system: (2) Vendor shall supply and install 4 nos of ABT meters (1 Main and 1 Check for each 25 MW feeder) along with the metering panel. These meter shall be installed at 220 KV LILO substation as per the provisions of MSEDCL/MSETCL. Vendor shall comply with arranging for installation, sealing, inspection, calibration, maintenance and testing of Main Meter and Back-Up Meter as per the applicable Grid Code and recommendations and provisions of MSEDCL / MSETCL and shall also conform to

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	the Central Electricity Authority (Installation and Operation Meters) Regulation, 2006 as amended from time to time.																																																																
5.25	Supply, erection and commissioning of auxiliary transformer 63kVA, 33kV/415V, Dyn11, Outdoor, ONAN QTY REQUIRED- 2 NO Type test reports from NABL accredited lab will be submitted for Auxiliary transformer for approval of manufacturer. Vendor will be approved based on type test report and credential. 1.0 Technical parameters and specifications: <table border="1"> <thead> <tr> <th>#</th><th>Technical parameter</th><th>Specification</th></tr> </thead> <tbody> <tr><td>1</td><td>Transformer type</td><td>Outdoor, oil-immersion type</td></tr> <tr><td>2</td><td>IP class</td><td>Transformer, including cable box and marshalling box shall be of IP55</td></tr> <tr><td>3</td><td>Type of cooling</td><td>ONAN</td></tr> <tr><td>4</td><td>Governing Standard</td><td>IS: 1180</td></tr> <tr><td>5</td><td>Rating in KVA</td><td>63 kVA</td></tr> <tr><td>6</td><td>No. of phases</td><td>3</td></tr> <tr><td>7</td><td>Frequency</td><td>50 Hz, +/- 3%</td></tr> <tr><td>8</td><td>HV winding</td><td>33kV, 3-Ph, with Delta connection</td></tr> <tr><td>9</td><td>LV windings</td><td>415V, 3-Ph, with Star connection</td></tr> <tr><td>10</td><td>Winding material</td><td>Electrolytic grade copper for both HV and LV windings</td></tr> <tr><td>11</td><td>Winding Insulation</td><td>Class A</td></tr> <tr><td>12</td><td>Neutral on LV side</td><td>Neutral terminal shall be brought out separately to facilitate earthing connections.</td></tr> <tr><td>13</td><td>Vector Group</td><td>Dyn11</td></tr> <tr><td>14</td><td>Short circuit withstand time (thermal)</td><td>2 sec.</td></tr> <tr><td>15</td><td>% Impedance</td><td>As per IS: 2026</td></tr> <tr><td>16</td><td>Termination HV/LV/Orientation</td><td>Air insulated cable box with disconnecting chamber, for both HV and LV sides. Cable box / Cable box / 180°.</td></tr> <tr><td>17</td><td>Cable entry on HV side</td><td>Bottom entry of cables.</td></tr> <tr><td>18</td><td>Cable entry on LV side</td><td>Bottom entry of cables.</td></tr> <tr><td>19</td><td>Cables and accessories</td><td>HV & LV Cables, termination kits (for HV), cable lugs (Dowell make), (Comet make) and connecting hardware shall be in vendor scope of supply. Vendor shall provide hole on the bottom-side gland-plate of HV & LV side cable box for cable entry as per the final outer diameter of cable provided by BHEL during detailed Engg.</td></tr> <tr><td>20</td><td>Tapping on HV winding</td><td>Off circuit tap changer (OCTC) switch with five tap positions: +5%, +2.5%, 0, -2.5%, -5%.</td></tr> </tbody> </table>		#	Technical parameter	Specification	1	Transformer type	Outdoor, oil-immersion type	2	IP class	Transformer, including cable box and marshalling box shall be of IP55	3	Type of cooling	ONAN	4	Governing Standard	IS: 1180	5	Rating in KVA	63 kVA	6	No. of phases	3	7	Frequency	50 Hz, +/- 3%	8	HV winding	33kV, 3-Ph, with Delta connection	9	LV windings	415V, 3-Ph, with Star connection	10	Winding material	Electrolytic grade copper for both HV and LV windings	11	Winding Insulation	Class A	12	Neutral on LV side	Neutral terminal shall be brought out separately to facilitate earthing connections.	13	Vector Group	Dyn11	14	Short circuit withstand time (thermal)	2 sec.	15	% Impedance	As per IS: 2026	16	Termination HV/LV/Orientation	Air insulated cable box with disconnecting chamber, for both HV and LV sides. Cable box / Cable box / 180°.	17	Cable entry on HV side	Bottom entry of cables.	18	Cable entry on LV side	Bottom entry of cables.	19	Cables and accessories	HV & LV Cables, termination kits (for HV), cable lugs (Dowell make), (Comet make) and connecting hardware shall be in vendor scope of supply. Vendor shall provide hole on the bottom-side gland-plate of HV & LV side cable box for cable entry as per the final outer diameter of cable provided by BHEL during detailed Engg.	20	Tapping on HV winding	Off circuit tap changer (OCTC) switch with five tap positions: +5%, +2.5%, 0, -2.5%, -5%.
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21	Loading Capability	Continuous operation at rated KVA on any tap with voltage variation of +/-10%. Transformer shall be capable of being loaded in accordance with IS: 6600 / IEC 60076-7.
22	Ambient temperature	Max 50 deg C
23	Temperature rise	For top oil: Max. 50 deg C by thermometer method For winding: Max. 55 deg C by resistance method Both rises shall be over an ambient temperature of 50 deg C irrespective of tap position.
24	Flux density	Not to exceed 1.9 Wb/sq.m at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over-fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating b) 125% for at least one minute c) 140% for at least five seconds Vendor shall furnish over-fluxing characteristics up to 150%
25	Air Clearance	As per CBIP
26	Load loss principal tap at 75°C, with IS tolerance	This shall be provided by vendor.
27	No Load loss at rated voltage on principal tapping and at rated frequency, with IS tolerance	This shall be provided by vendor.
28	No load current at rated voltage and rated frequency	This shall be provided by vendor. To be indicated as percentage.
29	Efficiency at 75°C, UPF	As per IS 1180 and CBIP
30	Regulation at full load, 75 °C	< 2 % for UPF For 0.8 PF lagging, to be indicated by vendor.
31	Harmonics	Shall be designed to suppress harmonics especially 3 rd & 5 th .
32	Vibration & noise	Noise level shall be according to NEMA TR-1 standard
33	Highest system voltage	LV side: 1.1kV HV side: 36 kV
34	Insulation levels as per IS:2026 Rated Lightning Impulse withstand voltage / Short duration power frequency withstand voltage	LV side: -- kVp / 3 kV rms HV side: 170kVp / 70kV rms

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	35	Overall dimensions in mm Length x Breadth x Height	This shall be provided by vendor.
	36	Oil capacity (in Litres)	This shall be provided by vendor.
	37	Weight of transformer in Kg	This shall be provided by vendor.
	38	Constructional features	As per relevant clause of this specification
	39	Fittings and accessories	As per relevant clause of this specification
	40	Painting	RAL 7032
2.0 Tests on auxiliary transformer will be witnessed by BHEL/MAHAGENCO prior to dispatch clearance.			
5.26	Auxiliary AC/DC power supply system 1. Each PCU container shall have 1 no aux transformer for aux supply requirement. Vendor shall provide a small Ac distribution board to cater the aux supply requirement like lighting, UPS, FCBC, transformer aux supply, module washing pump etc. 2. For Control room vendor shall supply the ACDB which shall be fed from 2 nos of 63, KVA Aux transformer. There shall be a changeover switch of suitable rating for selection of the transformer. Installation, testing and commissioning is in vendor's scope. Following DB boards for application in main control room shall be in vendor scope of supply, installation and commissioning: UPS DB for 230V AC UPS supply to SCADA, weather monitoring system, fire alarm system, emergency loads, CCTV system - 1Nos i. Following DB boards for inverter rooms shall be in vendor scope of supply, installation and commissioning: UPSDB 230V UPS supply for PCUs (control circuits), fire alarm system panel, emergency loads, CCTV system etc – 1 No ii. SLD will be shared after PO placement. iii. Above DBs shall be wall-mounted board, of reputed make such as Legrand, Siemens, Schneider or any other reputed make as approved by BHEL/MAHAGENCO. iv. Installation of all the above items including all necessary cable terminations/ installation shall be in vendor scope.		
5.27	Supply and Installation of Weather monitoring system As part of weather monitoring system (WMS), vendor shall supply, install and commission Pyranometers, Anemometer, Temperature sensors and data logger with all necessary software and hardware such as power supply/ control/ data/ communication cables, support structures etc. required to integrate with SCADA. Scope of vendor shall also include supply and erection of all the mounting arrangements including all necessary civil works/ foundations, clamps arrangement etc. as recommended by manufacturer and required at site. Communication cables shall be laid and terminated at both SCADA station at main control room and data logger at weather monitoring station end. Similarly, power supply cables shall be laid between WMS and DB boards in main control room.		



Exact location of the weather monitoring station shall be decided during detailed engineering.

Detailed specification of WMS items is as below-

Pyranometer (2 Nos)

Vendor shall supply and erect 2 Nos pyranometers secondary standard pyranometers (ISO 9060 classification) for measuring the incidental solar radiation at horizontal and inclined plane of array. One shall be mounted horizontally and one shall be mounted in tilt position. Specification of the pyranometer shall be as follows-

Parameter	Specification
Spectral Response	0.31 to 2.8 micron
Time response (95%)	Maximum 15s
Nonlinearity	±0.5%
Temperature Response	±2%
Tilt error	<±0.5%
Zero offset thermal radiation	±7 W/m ₂
Zero offset temperature change	±2 W/m ₂
Operating temperature range	0°C to +80°C
Non-stability	Maximum ±0.8%
Resolution	Minimum +/- 1W/m ₂
Output	Analog output: 4 – 20 mA, Serial output: RS485

Calibration certificate with calibration traceability to World Radiation Reference (WRR) or World Radiation Centre (WRC) shall be furnished along with the equipment. The signal cable length shall not exceed 20m. The Contractor shall provide instrument manual in hard and soft form.

Temperature Sensors

Vendor shall supply and install two thermometers (one for ambient temperature measurement with shielding case and other for module temperature measurement). The thermometers shall be RTD/ semiconductor type measuring instrument with measurement range of 0°C to 80°C. The instrument shall have valid calibration certificate.

Ultrasonic Anemometer and wind vane (wind speed and direction)

Vendor shall supply and install one no. ultrasonic wind sensor (no moving parts) for wind speed and direction monitoring.

Specification of the Anemometer shall be as follows-

Parameter	Specification
Velocity range with accuracy limit	0-60m/s with +/-2% accuracy @12 m/s; Resolution: 0.01m/s
Wind direction range with accuracy limit	0 to 360° (No dead band) with +/-2° accuracy @12 m/s; Resolution: 1°
Mounting Bracket	Anodized Aluminium bracket to reduce corrosion, all mounting bolts of SS
Protection Class	IP66
Output	RS232 and RS485

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	<u>Data logger and Data Acquisition System</u> Vendor shall supply and install data logger for weather monitoring system. Data logger for the weather monitoring station should have the following features: Provision for analog, digital and counter type inputs for interfacing with various type of sensors (i) Analog Input • Adequate nos. for all analog sensors with redundancy • Provision for operation in different current and voltage ranges as per connected sensors • Accuracy of +/-0.1% of FS (ii) Digital Inputs • Adequate no. of Digital inputs and outputs for the application (iii) Provision for RS232 and RS485 serial outputs (iv) Built-in battery backup (v) Connectivity and Data transmission: • Built-in GSM/ GPRS modem for wireless data transmission to SCADA/ cloud server (procurement of GPRS enabled SIM Card and connection subscription to be the responsibility of Contractor). It should be possible to remotely communicate with the device for configuration settings. • RS485 MODBUS interface for data collection and storage on SCADA • Web interface with provision for user login to enable viewing and downloading of weather data in XLS/ CSV format • Communication protocol should support fast data transmission rates, enable operation in different Frequency bands and have an encryption-based data security layer for secure data transmission (vi) Display Settings: Graphic LCD screen which should be easily accessible and should display relevant details like all sensor values, battery strength, network strength etc. (vii) Provision of Time synchronization from telecom time or server time (viii) Data Storage: Provision for at least 2 MB internal Flash Memory and at least 8 GB Micro SD card (expandable) (ix) Protection level: IP65 or better
5.28	Installation and commissioning of SCADA integration systems (1) SCADA system, supply of which shall be in BHEL scope, comprises of data station panels and PC based control desks with software to collect, store, process and report the data parameters of power plant and also to control the operations of the power plant by integrating the various equipment at the segments as follows: (a) String monitoring boxes (260 Nos) in solar array field (b) Weather monitoring equipment: Pyranometers for solar irradiation (2 Nos), thermometer for ambient temperature (1 No), thermometer for module surface temperature (1 No), anemometer for wind speed and direction with datalogger. (c) Power conditioning units (20Nos): DC input / AC output parameters of inverters, grid data, fault status and events logged, etc. (d) Inverter transformers (10 Nos): Alarm/Trip signals, WTI/OTI temperature values. (e) 33kV VCB breaker panels (as per SLD): status of VCB breakers, status of protection relays of transformers, oil / winding temperatures, AC parameters at every 5MW level of the plant. (f) ACDB multifunction meters (2 Nos): AC auxiliary utility consumption parameters

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	(g) Fire alarm system (all inverter station/ main control rooms): status signals (h) CCTV system (2) BHEL scope of SCADA: (a) Supply of Data station panels with necessary data loggers / PLCs and other accessories such as power supply etc to integrate the data signals as listed below. This includes main panel at main control room and intermediate (linking) panels at inverter room. (b) Supply of Desktop PCs (HMI control desks) provided with necessary software packages and remote monitoring features. (c) Supply of OFC and LAN cables for SCADA. (d) Termination of OFC cable at SCADA panels. (3) Vendor scope of supply and installation of SCADA system: (a) Vendor shall install the BHEL supplied SCADA system in the SCADA room in main control room. Vendor shall also install SCADA panels in the inverter rooms. (b) Cable laying/ terminations of all SCADA cables at respective rooms/ panels / equipments including cable trench works shall be in vendor scope. BHEL will provide the necessary cabling schedule during detailed engineering. (c) Supply of all SCADA related control / communication cables except OFC and LAN cables shall be in vendor scope. (d) INTERNET CONNECTION: (Internet/Intranet at Plant with Static IP: Public or private network access shall be provided at the plant through any broadband/VSAT connectivity of 2Mbps or higher bandwidth. SCADA system shall be capable of sending all plant data in real time to the Remote Server.) All required hardware items such as Modem / Router / Wifi facility etc. shall be in vendor scope. (e) Data Communication to SLDC: Vendor shall provide required interface to integrate plant SCADA with TRANSCO-SLDC, in compliance with grid code, to send any parameters specified by SLDC. Note: The methodology and specification of SLDC interface will be provided separately by SLDC/TRANSCO and it shall be the responsibility of the vendor to obtain and implement the same as per SLDC/ TRANSCO requirements.
5.29	Supply and installation of lightning protection system (ESE type lightning arrestors) to protect the electrical equipment of SPV power plant and Buildings from lightning. 1. The Complete Solar PV Power plant shall be provided with Lightning and over voltage protection. The "Lightning Protection System" must be completed prior to start-up of commissioning activities of the project. The main aim of over voltage protection is to reduce the over voltage to a tolerable level before it reaches the PV or other sub-system components. The source of over voltage can be lightning or other atmospheric disturbance. 2 The Lightning Conductors shall be made to protect the entire Array Yard from Lightning stroke. Necessary concrete foundation for holding the lightning conductor in position to be made after giving due consideration to maximum wind speed and maintenance requirement at site in future. 3 The lightning conductor shall be earthed through flats and connected to the Earth mats as per applicable Indian Standards with earth pits. Each Lightning Conductor shall be fitted with individual earth pit as per required Standards including accessories, and providing

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	masonry enclosure with cast iron cover plate having locking arrangement, watering pipe using charcoal or coke and salt as required as per provisions of IS. 1.8.4 Direct Stroke lightning protection shall be used. The system shall have following features: a. Active Lightning Rod OLP-214 shall based on Early Streamer Emission principle, complying NFC 17-102 and UNE 21186 Standards. The Device shall create an upward propagating streamer into the air 60 microseconds earlier than conventional air terminals or other objects on the earth, The device selected shall gives 107 meter radius of protection in level III when mounted on 5 meter effective height mast. Along with Mast (G.I. pipe of suitable height) for mounting The device & adaptor along with supporting stray wires, etc. The device shall be in compliance to CE. The device shall be tested & cer1ified by CPRI (Central Power Research Institute- Bangalore) Govt. of India. The device shall be tested from International lab I University in compliance with NFC17-102 standard for Lightning catching head (ESE) impulse voltage streamer time Lag. Gain measurement. The ESE device shall have Warranty of 30 years. b. High voltage insulated (HVI) cable shall be used as a down conductor to overcome the separation distance which is essential to avoid creep age flashovers. The HVI shall have high voltage resistant of the inner Cu conductor. Safe injection of lightning voltage at the entry thus preventing creeping flashovers (voltage flashovers) along the surface between the first Earthing point and the entry. The diameter of cable shall be 27mm, inner conductor size 25sqmm. And Separation distance :S 90 cm in air or :Sl.8 meter in solid c. Tripod C- Bar Maintenance Free Chemical Earthing for Lightning Protection consists of 3 Nos. of Copper bonded rod of 5/8"dia 10' length (The electrode shall be a solid steel rod made of high tensile low carbon steel and coated with molecularly bonded copper on the outside as per UL 467. The thickness of the copper coating shall be at least 250 microns. The electrode shall carry UL marking.) With two clamps (Clamp shall be suitable to terminate the earth rod and strip. The clamp shall be of Brass/Gunmetal), supported with 3 bags of 22.6 Kg Ground Enhancement Material (GEM) {The GEM shall have a low resistivity for faster transient/fault current dissipation. The GEM shall be Performed in all soil conditions even during dry periods. The GEM shall maintain constant resistance for the life of the system, temperature variation effects less than 1.0%. The GEM shall be non-toxic, environment friendly and does not adversely affect soil or ground water. The GEM shall lowers the contact resistance to earth by up to 63%.The GEM shall have a resistivity of less than 0.2 ohmmeter. The GEM shall be CE & ROHS certified.} Joined by using 25x3mm copper flexible strip of 3 mtr length each (total 9 mtr.) and one number of poly plastic pit cover no meson work needed. d. The Contractor shall ensure adequate lightning protection to provide an acceptable degree of protection as per IS for the array yard. If necessary more numbers of Lightning conductors may be provided. Theoretical design calculations and detailed explanations along with drawings shall be provided and approved by BHEL/MAHAGENCO.
5.30	Earthing for solar array structures and SMBs

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	Vendor shall supply and install the earthing system for solar array, MMS structures, SMBs and various other electrical equipments in line with IS 3043 latest amendment. Vendor shall supply 40 nos of Earth electrode of 17mm dia, 3 m length along with back fill chemical compound for array earthing. Electrode connection shall be brought out upto ground level. Earthing cables all necessary hardwares like nut, bolts, bimetallic lugs etc. shall be in vendor's scope of supply. Supply of 25x3 and 25x6 GI earth strip shall be in BHEL scope. Vendor has to supply and fix the earth chamber precast/prefab type for each earth electrode with following details. (a) Minimum Inner diameter shall be 300mm. Exact size shall be chosen to ensure ease of maintenance operation using spanners etc. (b) Projection of chamber above FGL = 150mm minimum (c) Cover plate with suitable lifting hooks and padlocking arrangement. Supply and installation of all materials related to Earth chambers shall be in vendor scope. Array Earth mat grid shall have following dimensions: (1) Earth mat grid (25X6 mm GI flat) shall be buried 600mm minimum below ground level. Where it crosses trenches, pipes, ducts, channels etc, it shall be at least 300mm below them. Back filling soil to be placed over buried conductors shall be free from stones and harmful mixtures. Back filling shall be placed in layers of 150 mm. Backfilled surface shall be well compacted. (2) Inner branches (along the solar array rows) shall be with GI flat 25x6mm (Supply of GI strip by BHEL). Inner branches shall be connected to outer grid. All excavations related to earthing in each row shall be in scope of vendor. Earthing of MMS structures shall be as follows: (1) Solar array MMS structure shall be connected to earth mat using GI flat 25x6 mm minimum; Bolting on structure (M10 minimum), Welding on earth mat end. (2) Adjacent structures shall be connected to one another using GI flat 25x3 mm minimum. Both ends shall be bolted (M10 minimum). (3) Wherever the clear distance between the adjacent structure is 2m, 25x6 GI strip shall be laid below the ground at a depth of 600mm from GL. (4) Earth strips shall be bend properly and taken along the support structure. Earthing of SMBs shall be as follows: (1) SPD earth point shall be earthed using 1Cx16 flexible copper (unarmoured) green cable from SPD to SMB structure. Both ends of cable shall be suitably lugged and connected using matching hardware. (2) Data card of the SMB shall be earthed using 1Cx2.5 flexible copper (unarmoured) green cable from Data card to SMB structure. Both ends of cable shall be suitably lugged and connected using matching hardware. (3) Above earthing cables along with Lugs shall be in vendor's scope of supply. (4) SMB structure shall be connected from structure legs (2 independent connections) to MMS leg using 25X6 GI strip for earth continuity. Earth strips shall be bend properly and taken along the support structure. General points:
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	(a) Stainless steel, nuts, plain washers shall be used. Spring washers shall be zinc/epoxy coated. (b) All connections to equipments and earth electrodes shall be bolted connections. (c) Weldings shall be allowed only in case of inner earth grid to outer earth grid connections. Welding for GI flats shall be using electric arc welding. Both the flats shall be overlapped for the full width where they are in perpendicular direction in same plane. Where the connection is along same line, both flats shall be overlapped for a minimum of 50mm. L-bend with weld length of 50mm minimum shall be adopted wherever overlap length to be ensured. (d) Resistance of welded joint shall not be more than that of GI flat. (e) All Welds shall be treated with red lead for rust protection and then coated with bitumen compound for corrosion protection. (f) Bimetallic lugs/ washers shall be used wherever copper to GI earthing is made. Supply of bimetallic lug/ washer is in vendor's scope. (g) While laying earthing electrodes, adding/mixing of chemical compound and water around the electrode in the dug hole shall be as per instructions of OEM. (h) In compliance to Rule 11 and 61 of Indian Electricity Rules, 1956 (as amended up to date), all non-current carrying metal parts shall be earthed with two separate and distinct earth continuity conductors to an efficient earth electrode.
5.31	Earthing system for inverter rooms, main control room, 33kV transformer yards and metering Yards Vendor shall supply and install minimum following no of earth electrode: Inverter station transformer yard: 15 nos for each Inverter station Control room: 5 nos 33KV pooling yard: 15 nos Interconnection point : 12 nos (1) Vendor shall install and commission earthing system for protection against faults as guided by IEC 60364 for the inverter station main control room, 33kV transformer yards, 33kV pooling yard and interconnection point. (2) Vendor shall prepare and submit the earthing system Layout for Inverter station, Control Room, 33kV pooling yard, interconnection point and Transformer yards and submit for BHEL/ MAHAGENCO approval during detailed Engg. (3) Earthing electrodes of 3m minimum long, 17.2 mm minimum diameter, copper bonded MS, chemical compound filled shall be in vendor scope of supply (4) Bore holes of appropriate diameter shall be made by vendor on the earth for insertion of such chemical earthing electrodes with filling of mix of chemical compound and water around. Inverter rooms and main control room shall be provided with separate earth grids. (5) Earthing connections to electrical panels within the inverter room/ main control room: Flats GI 65x8 (BHEL scope of supply) shall be provided for double earthing of 33kV VCB panels, UPS/ FCBC/ Battery banks, ABT metering panels, cable trays. The earthing for PCU shall be done through 1Cx 70 flexible copper cable and for SCADA through 1Cx 16 sqmm copper cable. Supply of 1CX70 sqmm cable, 1CX16 sqmm cable, cable lugs and hardware is in scope of vendor. (6) Earthing of inverter transformers in the transformer yards of inverter/control room, Aux transformer, GOS and LA in 33kV switchyard at interconnection point: (a) Flats GI 65x8 minimum shall be provided for interconnecting various parts of the inverter transformer (for body earthing) viz tank, conservator, disconnecting chambers, cable boxes, marshaling box, radiators etc. (b) Such interconnected local grid shall be double earthed to the main earth mat grid running underground through GI flats 65x8 outside 2 m from yard fence.

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	(c) Flats shall be bolted on transformer side and overlap welded to earth mat grid. Two earth pits shall be located close to each transformer for body earthing. (d) Shield earthing of inverter transformers shall be separate and connected to two earth pits (connected together, isolated from earth grid) using copper flat 50x6mm (e) Neutral of Inverter transformer shall be connected to two earth pits (connected together, isolated from earth grid) using copper flat 50X6 mm. (f) Neutral of aux transformer shall be connected to two earth pits (connected together, isolated from earth grid) using copper flat 50X6 mm. (7) Transformer yard fencing shall be earthed at every alternate post using GI flats 25x6 mm minimum to the earth grid. Gate shall be looped to the fencing mesh by way of GI wire of suitable size. (8) Switchyard/ metering yard structure and equipments shall be earthed using GI flats 65x8 minimum. (9) The metallic frame work of all switchyard equipment, cable trays and support structures shall be connected to the earth grid by means of two separate and distinct connections (10) Earth grid shall be buried underground up to a depth of 600mm minimum from NGL. Back filling soil to be placed over buried conductors shall be free from stones and harmful mixtures. Back filling shall be placed in layers of 150 mm. Backfilled surface shall be well compacted. (11) Vendor has to provide the brick earth chamber each earth electrode with following details - Minimum Inner diameter shall be 300mm. Exact size shall be chosen to ensure ease of maintenance operation using spanners etc. - Projection of chamber above FGL = 150mm minimum - Cover plate cast iron cover plate with suitable lifting hooks and padlocking arrangement. (12) Supply and installation of all materials related to Earth chambers shall be in vendor scope. (13) Earth electrode shall be bolted to a horizontal GI flat 65x8 minimum that in turn bolted (M10 minimum) to two GI flat 65x8 minimum raisers on either side of horizontal flat. Raisers shall be connected to earth mat grid by way of overlap welding. General points: - All earthing electrodes, GI flats is in BHEL scope of supply - All earthing cables, 50X6 mm copper strip, lugs, hardware etc shall be in vendor scope of supply. Stainless steel bolts, nuts, plain washers shall be used. Spring washers shall be zinc/epoxy coated. - Welding for GI flats shall be using electric arc welding. Both the flats shall be overlapped for the full width where they are in perpendicular direction in same plane. Where the connection is along same line, both flats shall be overlapped for a minimum of 50mm. L-bend with weld length of 50mm minimum shall be adopted wherever overlap length to be ensured. - Resistance of welded joint shall not be more than that of GI flat. - Welds shall be treated with red lead for rust protection and then coated with bitumen compound for corrosion protection. - While laying earthing electrodes, adding/mixing of chemical compound and water around the electrode in the dug hole shall be as per instructions of OEM.
5.32	Design, supply and installation of CCTV System Surveillance CCTV system is required to ensure effective surveillance of solar power plant area (array yard, 5MW Inverter station, transformer yards etc.) as well as create

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a tamperproof record for post event analysis. The System shall provide an online display of video images on Large LCD/LED monitors located in Main Control Room as well as at main security cabin in the site. System shall facilitate viewing of live and recorded images and controlling of all cameras by the authorized users present in the LAN. System shall provide interoperability of hardware, OS, software, networking, printing, database connectivity, reporting, and communication protocols. System expansion shall be possible through off-the-shelf available hardware.

There shall be cameras installed inside and outside the Inverter room/Inverter station control rooms, main gate, security cabin, switch yard, all weather stations and all watch tower, providing round the clock surveillance. The location and type of cameras are mentioned as here

Location of Surveillance Cameras:

1. Following table states location wise types of cameras to be used in CCTV system.

Sr. No	Location	Type of Cameras
1	Inside each Inverter room	Dome Type
2	Outside each Inverter Station	Bullet Type
3	Transformer Yard	Bullet Type
4	Inside Control room	Dome Type
5	Outside Main control room	Bullet Type
6	Main Gate	Bullet Type
7	Inside Security Cabin	Dome Type
8	Outside Security Cabin	Bullet Type
9	Each Weather station	Bullet Type
10	Each Watch tower	PTZ

Cameras shall cover the entire inside & outside area of all inverter & main control rooms, main gates, security cabin, switch yards, all weather stations and all watch towers, providing round the clock surveillance considering the safety point of view. No. of cameras will depend on the design of Surveillance & vigilance CCTV system.

Design & drawing for the Surveillance & vigilance CCTV system shall be submitted for approval to BHEL/ MAHAGENCO

2. Equipment with better specifications shall be accepted.

a. CCTV Cameras shall have low lux so that the same can operate in minimum illumination also. Cameras shall have both auto/manual focus mode and control shall also be both manual/auto.

b. The system shall be based on Stand Alone Integrated DVR (Digital Video Recording). Specifications of Stand Alone Integrated DVR:

(i) Ability to connect Cameras as per requirement,

(ii) Facility to store 90 days of Video,

(iii) Capability to set the frame rate, contrast, brightness of each individual camera,

(iv) Shall have facility to view live video (with audio) images in a monitor, in a PC and web browser.

(v) Remote Administration: Shall be fully administrable/ programmable remotely through client software and web browser.

(vi) Recording rate per channel - NTSC/30 fps per channel, PAL/25 per channel.

(vii) Configurable/adjustable recording rate.

(viii) Full recording and playback facilities on remote machine.

(ix) Smart monitoring (Motion Detection).

(x) Adjustable motion detection (motion detection sensitivity shall be adjustable).

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	(xi) Ability to convert H.264 video into AVI files. (xii) Date and time stamping of video files. (xiii) Viewing for all cameras. (xiv) Shall support backup devices like USB drive, DVD writer DVR Software must be able to take backup in DVD writer, USB drive etc. (xv) Shall have live display, playback, record facilities. (xvi) Shall have minimum 1 USB port. c. System shall have the capability of increasing the storage capacity as and when required. d. It shall have low maintenance cost and shall be upgradeable to inputs for more cameras, as and when required, with minimum cost. e. It shall be compatible with alarm system. f. Cameras shall be C-mount type. g. The firm installing the system shall have adequate infrastructure for providing after sales/installation service. 3. PTZ Cameras • 36x optical zoom and 12x digital zoom, up to 432x total zoom • High resolution of 540TVL (color) and 570TVL (B/W) • Wide Dynamic Range (WDR) • True Day/Night (IR-cut filter) • IP66 rate and surge protector • Pan speed up to 300°/sec and tilt speed up to 120°/sec • High-performance memory with 128 preset positions, 24 privacy mask zones and 3 selflearning auto tracks Image Sensor : 1/4" Sony ExView HAD CCD or equivalent Effective Pixels: 752(H) x 582(V) Horizontal Resolution: 540TVL (Color), 570TVL (B/W) 1.0lx (30IRE): IR Cut Filter On 0.1lx (30IRE): IR Cut Filter Off 0.001lx: DSSx256-ON Minimum Illumination: 0.0001lx (30IRE): Night ON+DSS Focal Length: f=3.4mm - 122.4mm Aperture Range : F1.6 (wide) - F4.5 (tele) Angular Field of View: 57.8° (wide) - 1.7° (tele) Electronic Shutter: 1/50 - 1/10,000 Sec Synchronization: Internal/External (V-Lock) S/N Ratio : > 50dB White Balance: Manual / Auto / Indoor / Outdoor / ATW Day/Night: True Day/Night (IR-cut filter) WDR: ON/OFF BLC: ON/OFF Dome Size: 6" Power-off Real-time Memory: Yes Long-focus Speed-limited: ON/OFF Camera ID Range: 0 – 255 Video Output: (1.0Vp-p), 75ohm, BNC Pan Angle: 360° rotation capability Tilt Angle: 0° - 90° Pan Speed: 0.1° - 300°/Sec Tilt Speed: 0.1° - 120°/Sec Zoom: 36x Optical Zoom, 12x Digital Zoom
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	Auto Scan: ON/OFF PTZ Tours (Pattern): 3 Programmable, 120 Seconds Preset Speed: 360°/Sec Accuracy: 0.1° Turn Over: Digital Turn Over Preset Position: 128 Maximum Vector Scan Group: 6 PTZ Protocol: Pelco D/P, KD6, VCL, Maxpro Mode Power Supply: 24VAC 2A 60Hz/50Hz, Surge Protector Power Consumption: 35W Connector: RS-485 Protection Class: IP66 Operating Temperature: -20°C to 55°C Certification: CE, FCC,UL 4. Integrated IR Analog Bullet camera 700 TVL • Ultra high resolution: 700TVL • Min. illumination: 0 Lux (IR ON) • 2 IR LED array lights; 30 – 40m IR range • 5 - 50mm lens • True Day/Night (with IR-cut filter) • AES, BLC, White Balance, digital spot compensation, lens shaded control, horizontal mirror • Motion detection, privacy masking • Lens shaded control, horizontal mirror, OSD • Defog function • IP66, aluminium casing – vandal-proof, lightening-proof • UTC (Up-the-Coax) function optional • Operating Temperature -20°C to 50°C • Storage Temperature -30°C to 70°C • Operating Humidity 90%RH (non-condensing) • Casing Material Aluminium Alloy • Rating IP66, vandalproof, lightening proof 5. Analog Dome camera 700 TVL Ultra high resolution: 700TVL • 5 - 50mm lens • True Day/Night (with IR-cut filter) • White Balance, electronic Shutter adjustable, BLC • Lens shaded control, horizontal mirror • Defog function • Motion detection, privacy masking, OSD • Up-the-Coax (UTC) function (optional) for controlling OSD remotely • 24V AC / 12V DC • Video Cable: RG59U video cable (with heavy gauge PVC conduit) • Power Cable with heavy Gauge • Other technical requirements: • The DVR system shall have CE certification with certificates • All Cameras must be provided with suitable mounts/housings Wall, Dome etc.
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	• All cameras must be connected with DVR system with RG59 (with heavy gauge PVC conduits) cables and vendor must perform the necessary cabling to connect DVR with cameras. • The DVR system offered must be an integrated DVR system and shall not be a DVR system assembled using third party Personal Computers and DVR cards. • 16 channel DVR shall be able to support D1 resolution for all camera's with 16 TB HDD facility & they shall have a central management software & joystick keyboard shall be there for PTZ controlling. • Training Aspect • At the time of installation of equipment, the vendor shall offer free training specific to CCTV system. • CCTV vendor shall be reputed and have relevant experience of similar solutions in any of Private/ PSU/ State Govt . Supporting documents in form of customer completion letter shall be submitted at vendor approval stage to BHEL/ Mahagenco. • The CCTV system shall be warranted for 5 years from the date of commissioning. Circuit • diagram for the Surveillance & vigilance CCTV system shall be submitted for approval to MAHAGENCO All related supplies, installation including trench work, civil works etc for CCTV system shall be in scope of vendor. All necessary labour, machinery, tools, instruments shall be in vendor scope																																				
5.33	Design, supply and installation of Plant lighting System Illumination system within main control room (CMCS) shall be BHEL scope of supply and installation. Illumination system (lighting) at 10 Inverter Stations. PEB rooms, 33KV pooling yard, security cabin, watch tower and Transformer yards at inverter stations shall be in vendor scope of supply and installation. All fixtures shall be Led type. Minimum following LED lights shall be provided as per the details below <table><tr><th>Sl. No</th><th>Location</th><th>No of Lights</th><th>Type of Light</th></tr><tr><td>1</td><td>Inverter station (10)</td><td>4</td><td>70 W LED</td></tr><tr><td>2</td><td>Inverter Transformer yard (10)</td><td>2</td><td>70 W LED</td></tr><tr><td>3</td><td>33KV switchgear panel (10)</td><td>2</td><td>70 W LED</td></tr><tr><td>4</td><td>PEB room (10)</td><td>4</td><td>35 W LED</td></tr><tr><td>5</td><td>33KV pooling yard (1)</td><td>6</td><td>70 W LED</td></tr><tr><td>6</td><td>Interconnection point (1)</td><td>4</td><td>70 W LED</td></tr><tr><td>7</td><td>Security Room (2)</td><td>2</td><td>35 W LED</td></tr><tr><td>8</td><td>Watch Tower (8)</td><td>2</td><td>1 No search Light an 1 No Flood Light</td></tr></table>	Sl. No	Location	No of Lights	Type of Light	1	Inverter station (10)	4	70 W LED	2	Inverter Transformer yard (10)	2	70 W LED	3	33KV switchgear panel (10)	2	70 W LED	4	PEB room (10)	4	35 W LED	5	33KV pooling yard (1)	6	70 W LED	6	Interconnection point (1)	4	70 W LED	7	Security Room (2)	2	35 W LED	8	Watch Tower (8)	2	1 No search Light an 1 No Flood Light
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	In addition 1 No of Exhaust fan shall be supplied and installed in each PEB room and 1 no wall mounted fan in each security room. All necessary cable, switches, boards etc shall be in vendor scope of supply. Layout shall be submitted for BHEL/ MAHAGENCO approval during detailed Engg. Array / Peripheral Lighting Vendor shall design supply and install array/ peripheral lighting system to provide average lux10. Lights used shall be LED type. Lights shall be mounted on the GI poles. Vendor shall submit the detailed calculation for type of light/ height of pole, pole foundation, cable details to meet the lux calculation for BHEL/ MAHAGENCO approval during detailed Engg. All material like Light, Pole, cable JB, earthing for lighting pole etc shall be vendor scope of supply.
5.34	Fire Alarm and Firefighting systems Fire alarm system : Vendor shall supply and install intelligent microprocessor based main fire alarm panel of modular construction complete with central processing unit, input and output modules, power supply module , supervision control and isolator modules with 10% spare provisions. Fire detection alarm system shall include alarm initiating devices e.g. multisensor type smoke detectors and alarm notification Appliances (Audio device). Multisensor type smoke detectors shall be provided for areas of Inverter Room and Main Control Room. One(01) sensor shall be provided for each 25 sqm of area in Inverter & Main Control Room. Fire Alarm Control Panel: Alarm conditions shall be immediately displayed on the control panel of Main Control Room. Alarm LED shall flash on the control panel until the alarm has been acknowledged. Once acknowledged the LED shall remain lit. A subsequent alarm received from another zone after acknowledgement shall illuminate the alarm LED and the panel display shall show the new alarm information. During an alarm condition, an alarm tone shall sound within the control panel until the alarm is acknowledged. If the audible alarm signals are silenced for any reason, they shall automatically resound if another zone is activated. All alarm signals shall be automatically “locked in” at the control panel until the operated device is returned to its normal condition and the control panel is manually reset Firefighting systems: Fire extinguishers and sand buckets Vendor shall provide fire extinguishers/ sand buckets as follows for fighting fire of oils, solvents, gases, paints, varnishes, electrical wiring, live machinery fires and flammable liquid/ gas as per recommendation by relevant fire safety authority and as per relevant standards IS: 2171 and IS: 10658 marked. All buildings shall be installed with required no. of fire extinguishers as per relevant BIS standard and NBC. LiquefiedCO₂/ foam/ ABC type fire extinguisher shall be upright type of capacity 10kg conforming to IS: 2171, IS: 10658. ▪ DCP type (ABC) 10 Kg designed/tested IS 15683/ IS 2171 with safety release valve, NRV and CE approved valve. Dry powder IS 14609 with standard accessories.

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	- CO2 type 10 Kg with wheel. Designed/tested IS 2878/ IS 15683/ IS 8149 complete with hose, screw valve, CO2 gas IS 1522, cylinder IS 7285, valve IS 3224. Tested at 250 Kgf/cm2. - Sand bucket should be wall mounted made from at least 24 SWG sheet with bracket fixing on wall conforming to IS 2546 at strategic locations. Minimum Quantity requirements: <table><tr><th>Type of extinguisher</th><th>DCP type (ABC) 10 Kg</th><th>CO2 type Hand 10 Kg</th><th>Foam type Hand held 9 Kg</th><th>Sand bucket stand (4 sand bucket on one stand)</th></tr><tr><td>Main control room</td><td>3</td><td>3</td><td>3</td><td>2</td></tr><tr><td>Inverter room</td><td>2</td><td>2</td><td>2</td><td>2</td></tr><tr><td>Inverter room transformer yard</td><td>2</td><td>2</td><td>2</td><td>2</td></tr><tr><td>33KV Pooling yard</td><td>2</td><td>2</td><td>2</td><td>4</td></tr><tr><td>Metering Yard</td><td>1</td><td>1</td><td>1</td><td>2</td></tr><tr><td>Security rooms</td><td>-</td><td>1</td><td>-</td><td>1</td></tr></table>	Type of extinguisher	DCP type (ABC) 10 Kg	CO2 type Hand 10 Kg	Foam type Hand held 9 Kg	Sand bucket stand (4 sand bucket on one stand)	Main control room	3	3	3	2	Inverter room	2	2	2	2	Inverter room transformer yard	2	2	2	2	33KV Pooling yard	2	2	2	4	Metering Yard	1	1	1	2	Security rooms	-	1	-	1
Type of extinguisher	DCP type (ABC) 10 Kg	CO2 type Hand 10 Kg	Foam type Hand held 9 Kg	Sand bucket stand (4 sand bucket on one stand)																																
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33KV Pooling yard	2	2	2	4																																
Metering Yard	1	1	1	2																																
Security rooms	-	1	-	1																																
5.35	Identification marking using painting Following items shall be identified by way of artistic painting in black letters with yellow background. For danger symbol/text, white letters in red background. Identification number/ text to be painted shall be submitted for BHEL/MAHAGENCO approval during detailed engineering for the following. - Solar array structures: ~5810 Nos - String monitoring boxes: 260Nos - Size/ source/ destination of DC cable 1Cx185 with arrow mark (power flow direction) to be painted on SMBs and PCUs - PCUs front side: PCU ID number (1 to 20) with rating 2500kW, AC chamber/ DC chamber, Danger text/symbol. - PCUs DC chamber back side: SMB ID numbers, cable size (1Cx185 +,-) with upward arrow mark, danger text/symbol - PCUs AC chamber back side: Inv Trnfmr ID, cable size (6Rx1Cx630 / ph) with downward arrow mark, danger text/symbol - Same way as above, the corresponding panel ID with rating, cable destination with arrow mark in power flow direction, danger text/symbol shall be painted for all VCB panels, Inverter transformers (HV and LV sides), Aux transformer (HV and LV sides), ACDB panel. - For UPS/ FCBC/ SCADA/ ABT metering panels, C&R panel, all DB boards/ fire alarm panels ID number shall be painted. Cable size/ destination/ arrow marks not required to be painted as cable tags shall be adequate. - For earth chambers of inverter rooms, main control room, switchyard, array, ID number with resistance value and due date shall be painted. All switchboards shall be painted with ID number.																																			
5.36	Cable markers and cables tags Cable markers and joint markers for underground cables shall be provided along the route of the cables as per section “Cable installation methodology” of this specification.																																			

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	(2) Cable tags shall be provided at either of the cable (at the entry point to the panel / equipment to which it is connected / terminated) shall be provided as per section “Cable installation methodology” of this specification. (10) Cable tags details shall be provided by BHEL during detailed engineering.																																		
5.37	Display boards and sign boards <table border="1"> <thead> <tr> <th>Sl. No</th><th>Description</th><th>Qty for Inverter Station</th><th>Qty for Control room</th></tr> </thead> <tbody> <tr> <td>1</td><td>Board displaying instruction chart for restoration from Electric Shock</td><td>1 No</td><td>1 No</td></tr> <tr> <td>2</td><td>Board displaying instruction chart for artificial respiration</td><td>1 No</td><td>1 No</td></tr> <tr> <td>3</td><td>Board displaying dos and don'ts.</td><td>1 No</td><td>1 No</td></tr> <tr> <td>4</td><td>Board displaying fire extinguishers details and operations</td><td>1 No</td><td>1 No</td></tr> <tr> <td>5</td><td>“No smoking” board</td><td>2 Nos</td><td>5 Nos</td></tr> <tr> <td>6</td><td>Danger boards: 33000V with danger symbol in Hindi, Telugu, English</td><td>As required</td><td>As required</td></tr> <tr> <td>7</td><td>Identification boards, of suitable sizes, within and outside control room such as Inverter room, Main control room, Executive lounge, Store room, Gents toilet, Ladies toilet, SCADA room, Battery room, Pantry room etc. BHEL will provide list.</td><td>1 set</td><td>5 set</td></tr> </tbody> </table> (a) 5mm thick sun board with LG make vinyl sticker (computerized cutting and pasting) shall be used for Sl Nos 5, 6 and 7. (3) (b) For others, flex banner with design & printing shall be used.			Sl. No	Description	Qty for Inverter Station	Qty for Control room	1	Board displaying instruction chart for restoration from Electric Shock	1 No	1 No	2	Board displaying instruction chart for artificial respiration	1 No	1 No	3	Board displaying dos and don'ts.	1 No	1 No	4	Board displaying fire extinguishers details and operations	1 No	1 No	5	“No smoking” board	2 Nos	5 Nos	6	Danger boards: 33000V with danger symbol in Hindi, Telugu, English	As required	As required	7	Identification boards, of suitable sizes, within and outside control room such as Inverter room, Main control room, Executive lounge, Store room, Gents toilet, Ladies toilet, SCADA room, Battery room, Pantry room etc. BHEL will provide list.	1 set	5 set
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5.38	Electrical insulation mat (1) Vendor shall supply electrical insulating mats as follows: (a) Reputed make as shall be approved by BHEL/MAHAGENCO (b) As per IS: 15652:2006 (c) Class C (d) Thickness 3 mm minimum (e) Size = 2m x 1m minimum, exact size shall be as approved by BHEL/MAHAGENCO during detailed engineering. (f) Colour: to be approved by BHEL/MAHAGENCO (g) Max use voltage = 33 kV (h) Marking of IS standard on the mat (2) Test certificate shall be provided by vendor Vendor shall lay the mats in front of all the indoor electrical panels viz. PCUs, VCB panels, ACDB panels, SCADA panels, UPS panels, FCBC battery charger, battery banks etc.																																		

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5.39

Supply and Installation Miscellaneous Items

(1) Split Air conditioner of 1.5 tonne 5 star rating (4 Nos) of split type for SCADA room, conference room and office room of Voltas/ Hitachi/ Samsung/LG make.

(2) Furnitures for SCADA room as below

- Table with drawer for desktop PC – 5 Nos
- Chair, industry standard, revolving type, with wheels, arm rest, provisions for adjustment of height (hydraulic/ gas lift):5 Nos
- Storage almirah: 4 No
- Filing cabinet: 4 No
- Printer table: 1 No

(3) Furniture for Conference Room

- 1 number of LED TV of 52 inch of Sony/ Phillips / Samsung make,
- 1 no of conference table of 10 person equipped power sockets and 10 chairs revolving type with wheels.

(3) Furniture for security room and security cabins

- Table with drawers – 2Nos
- Chairs revolving type with arm rest – 10 Nos

(4) Note : Make of the above mentioned furniture shall be Godrej or equivalent.

5.40

Tool kits and instruments

A. Measuring instruments

1	Earth Resistance Tester	Reputed make	2 No
2	Array tester	Reputed Make	1 No
3	Insulation tester	Reputed make	2 No
4	Digital multimeter	Reputed make	2 No
5	Clamp meter	Reputed make	2 No
6	Infra-red thermal imaging camera	Reputed Make	1 No
7	Digital lux meter	Reputed Make	1 No

Note: Make / model number etc shall be approved by BHEL/MAHAGENCO prior to procurement.

All testing equipment shall possess valid calibration certificate issued from approved NABL labs.

B. Tool kits

1	Double ended spanner Set of sizes 10-11, 12-13, 14-15, 16-17, 17-18	1 No each
2	Screwdriver Set	1 Set
3	Crimping tool with Dye range 50-630sq-mm cable, mechanical gear power, hand operated	1 Set
4	Crimping tool up to 10 sq-mm cable	1 set
5	Drilling machine AC, hand operated, with bit size up to 20 mm	1 set
6	Measuring Tape, 5m	1 No
7	Measuring Tape, 50 m	1 No
8	Allen Key set	1 Set
9	Adjustable spanner 2-inch size	1 No
10	Hammer	1 No
11	Rough file kit	1 Set
12	Platform balance, 50Kg range	1 No
13	Cutting Pliers	1 No

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14	Nose Pliers	1 No
15	Vacuum cleaner, of industrial type, for control room sweeping / cleaning.	1 No
16	Blowers for cleaning the panels	1 No

Note: Prior to procurement, vendor shall obtain approval from BHEL for the make and specification of the items.

Detailed specification of the instruments are as below-

Earth resistance tester

Parameter	Specification
Display	Backlit LCD or LED display
Range	Earth Resistance: up to 2000 Ω Earth Voltage: 200 V
Accuracy	$\pm (2\% + 5)$
Safety Ratings	IP 56
Programmable Limits setting	Enabled

Accessories-

Earth Ground Stakes (4 Nos)
Three cable reels with cable length up to 20 m
Carry Case-1 (capable of handling tester along with accessories)
1 set of spare battery

Array tester

Parameter	Specification
Display	Backlit LCD or LED display
Functionality	All electrical tests required by IEC 62446-1:2016
Memory	Up to 200 records & USB downloadable to Computer

Accessories

A set of two, 4mm fused leads for extra protection during installation tests.
Leads which enable the array tester to connect directly to PV arrays
1 set of spare battery

Insulation tester

Parameter	Specification
Display	Backlit LCD or LED display
Insulation Test Range	0.1 M Ω to 10 G Ω
Test Voltage	250V, 500V, 1000V, 5000V
Test Voltage accuracy	+20% on positive side only no negative variation is allowed
Insulation Test Current	1 mA nominal
Auto Discharge	Discharge time < 0.5 Second for C = 1
Open Circuit test Voltage	>4 V, <8 V

Accessories

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Heavy duty Test Lead Set – 4 Nos.

Carry Case with sufficient space for accommodating accessories.

Digital Multimeter

Parameter	Specification
Display	Backlit LCD or LED display; Minimum resolution: 5 ¾ places for DC, 4 ¾ places for AC
Measuring Category	1000V CAT III as per IEC Standard 61010-1; wave shape independent RMS measurement (True RMS) suitable for operation in the site conditions.
Additional Functions	Resistance (Ω), Temperature ($^{\circ}\text{C}$), Continuity, Diode, Capacitance, Frequency, Duty cycle measurement

Accessories

Temperature Probe

Silicon Test Lead

Alligator Clip

Carry Case with sufficient space for accommodating accessories.

Clamp meter

Parameter	Specification
Display	Backlit LCD or LED display
Measuring Category	1000V CAT III as per IEC Standard 61010-1; wave shape independent RMS measurement (True RMS) suitable for operation in the site conditions.
Current Range	AC&DC Current up to 1000A/400 A
Voltage range	AC&DC Voltage upto 1000V
Additional Functions	Resistance, continuity, diode and non contact voltage detection, Active, Reactive and Apparent Power, THD, PF

Accessories

Test leads

Electrical test leads

Probe light & extender

Carry Case with sufficient space for accommodating accessories.

Infra-red thermal imaging camera

Parameter	Specification
Spectral response	8 μm to 14 μm (LW)

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	Temperature-sensitivity and calibration range	–20 °C to +120 °C
	Atmospheric air temperature	-10 °C to +40 °C
	Thermal sensitivity	NETD ≤ 0.1 K at 30 °C
	Geometric resolution	640 x 480 pixels
	Photo camera resolution	Approx. 30 times of IR camera resolution
	Absolute error of measurement	< ± 2 K
	Adjustable parameters	Emissivity, ambient temperature
	Adjustable functions	Focus, temperature level and span
	Measurement functions	Measuring spot, measuring area with average and maximum temperature
	Calibration	The measuring system (Camera, lens, aperture and filter): The camera has to be traceably calibrated at least every two years. The calibration has to be documented. If the camera is not compliant, it has to be readjusted by the manufacturer.
	Documentation	Storing of the infrared picture with the radiometric data
Digital lux meter		
	Parameter	Specification
	Range	0 – 1000 lux
	Accuracy	± (2% + 5)
	Resolution	1 lux
	Display	3½ digits, Backlit LCD/LED
All the tools and instruments are required for post-commissioning of the plant. Items shall be handed over to BHEL in new condition. Used tools and instruments will not be accepted. Any tools and instruments required by Vendor during I&C activities will be arranged separately by vendor.		
5.41	Cable installation Methodology	
	1. CODES AND STANDARDS	
	All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards/ codes as applicable.	
	IS:513	Cold rolled low carbon steel sheets and strips.
	IS:802	Code of practice for the use of Structural Steel in Overhead Transmission Line Towers.
	IS:1079	Hot Rolled carbon steel sheet & strips
	IS:1239	Mild steel tubes, tubulars and other wrought steel fittings
	IS:1255	Code of practice for installation and maintenance of power cables upto and including 33 KV rating

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IS:1367 Part-13	Technical supply conditions for threaded Steel fasteners. (Hot dip galvanized coatings on threaded fasteners).
IS:2147	Degree of protection provided by enclosures for low voltage switchgear and control gear
IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanizing of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles.
IS:3043	Code of practice for Earthing
IS:3063	Fasteners single coil rectangular section spring washers.
IS:6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
IS:8308	Compression type tubular in- line connectors for aluminium conductors of insulated cables
IS:8309	Compression type tubular terminal ends for aluminium conductors of insulated cables.
IS:9537	Conduits for electrical installation.
IS:9595	Metal - arc welding of carbon and carbon manganese steels - recommendations.
IS:13573	Joints and terminations for polymeric cables for working voltages from 6.6kv up to and including 33kv performance requirements and type tests.
BS:476	Fire tests on building materials and structures
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:142	Grounding of Industrial & commercial power systems
DIN 46267 (Part-II)	Non tension proof compression joints for Aluminium conductors.
DIN 46329	Cable lugs for compression connections, ring for Aluminium conductors
VDE 0278	Tests on cable terminations and straight through joints
BS:6121	Specification for mechanical Cable glands elastomers and plastic insulated cables.
	Indian Electricity Act
	Indian Electricity Rules.
Equipment complying with other internationally accepted standards such as IEC, BS, DIN, USA, VDE, NEMA etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official amendments and revisions in force as on date of opening of bid and shall clearly bring out the salient features for comparison.	
2. DESIGN AND CONSTRUCTIONAL FEATURE	
Inter Plant Cabling	
Interplant cabling for main routes shall be laid in Cable trenches/duct banks. Cables from main plant to control room shall be laid in Cable trenches/duct banks. In case of Duct banks, pull-pits shall be filled with sand and provided with a PCC covering. Directly buried cables, if essential ,shall not have concentration of more than 4 cables in one route. All buried cables shall be armoured.	
Trenches	
PCC flooring of built up trenches shall be sloped for effective drainage with sump pits and	

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	sump pumps. No subzero level cable vault/trenches shall be provided below control building/switchgear rooms in plant. General The cable slits to be used for motor/equipment power/control supply shall be sand filled & covered with PCC after cabling. Sizing criteria, derating factors for the cables shall be met as per respective chapters. However for the power cables, the minimum conductor size shall be 6 sq.mm. for aluminium conductor and 2.5 sq.mm. for copper conductor cable. Conscious exceptions to the above guidelines may be accepted under special conditions but suitable measures should be taken at such location to: • Meet all safety requirements • Safeguard against fire hazards, mechanical damage, flooding of water, oil accumulation, electrical faults/interferences, etc 3. Cable accessories 3.1 Cable trays, Fittings & Accessories a) Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables. b) Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized as per relevant IS. c) Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 metre. Thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be 3 mm. d) Cable troughs shall be required for branching out few cables from main cable route. These shall be U-shaped, fabricated of mild steel sheets of thickness 2 mm and shall be hot dip galvanized as per relevant IS. Troughs shall be standard width of 50 mm & 75 mm with depth of 25 mm. 3.2 Support System for Cable Trays (a) Cable tray support system shall be pre-fabricated similar or equivalent to "Unistrut make". (b) Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The main support channel shall be of two types: (i) C1:- having provision of supporting cable trays on one side and (ii) C2:-having provision of supporting cable trays on both sides. The support system shall be the type described hereunder: 1. Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardwares such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc. 2. The system shall be designed such that it allows easy assembly at site by using
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	bolting. All cable supporting steel work, hardware, fittings and accessories shall be prefabricated factory galvanised. 3. The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. to form various arrangements required to support the cable trays. Welding of the components shall not be allowed. However, welding of the bracket (to which the main support channel is bolted) to the overhead beams, structural steel, insert plates or reinforcement bars will be permitted. Any cutting or welding of the galvanised surface shall be brushed and red lead primer, oil primer & aluminium paint shall be applied. 4. All steel components, accessories, fittings and hardware shall be hot dip galvanised after completing welding, cutting, drilling and other machining operation. 5. Support system shall be able to withstand • weight of the cable trays • weight of the cables (75 Kg/ Metre run of each cable tray) • Concentrated load of 75 Kg between every support span. • Factor of safety of minimum 1.5 shall be considered. 3.3 Pipes, Fittings & Accessories a) Pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.) The size of the pipe shall be selected on the basis of maximum 40% fill criteria b) GI Pipes shall be of medium duty as per IS:1239 c) Duct banks shall be High Density PE pipes encased in PCC (10% spare of each size, subject to minimum one) with suitable water-proof manholes. d) Hume pipes shall be NP3 type as per IS 458. 3.4 Junction Boxes a) Junction Boxes with IP:55 degree of protection, shall comprise of a case with hinged door constructed from cold rolled sheet steel of thickness 2mm. Top of the boxes shall be arranged to slope towards rear of the box. Gland plate shall be 3mm thick sheet steel with neoprene/synthetic rubber gaskets. All junction boxes shall be of adequate strength and rigidity, hot dip galvanised as per relevant IS, and suitable for mounting on wall, columns, structures etc. The boxes shall include brackets, bolts, nuts, screws M8 earthing stud etc. required for installation. b) Terminal blocks shall be 1100V grade, 10Amps rated, made up of unbreakable polyamide 6.6 grade. The terminals shall be screw type or screw-less (spring loaded) / cage clamp type with lugs. Marking on terminal strips shall correspond to the terminal numbering in wiring diagrams. All metal parts shall be of non-ferrous material. In case of screw type terminals the screw shall be captive, preferably with screw locking design. All terminal blocks shall be suitable for terminating on each side two (2) nos. stranded copper conductors of size upto 2.5 sq mm each. All internal wiring shall be of minimum 1.5 sq. mm cu. Conductor PVC wire. 3.5 Terminations & Straight Through Joints a) Termination and jointing kits for 33kV, 11kV, 6.6 kV and 3.3 kV grade XLPE insulated cables shall be of proven design and make which have already been extensively used and type tested. Termination kits and jointing kits shall be pre-moulded type, taped type or heat shrinkable type. 33kV, 11kV and 6.6 kV grade joints and terminations shall be
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	type tested as per IS: 13573. 3.3kV grade joints and terminations shall be type tested as per VDE0278. Critical components used in cable accessories shall be of tested and proven quality as per relevant product specification/ESI specification. Kit contents shall be supplied from the same source as were used for type testing. The kit shall be complete with the aluminium solderless crimping type cable lugs & ferrule as per DIN standard. b) Straight through joint and termination shall be capable of withstanding the fault level for the system. c) 1.1 KV grade Straight Through Joint shall be of proven design and make shall be approved by BHEL. 3.6 Cable glands Cable shall be terminated using double compression type cable glands. Cable glands shall conform to BS: 6121 and be of robust construction capable of clamping cable and cable armour (for armoured cables) firmly without injury to insulation. Cable glands shall be made of heavy duty brass machine finished and nickel chrome plated. Thickness of plating shall not be less than 10 micron. All washers and hardware shall also be made of brass with nickel chrome plating Rubber components shall be of neoprene or better synthetic material and of tested quality. Cable glands shall be suitable for the sizes of cable supplied/erected. 3.7 Cable lugs/ferrules Cable lugs/ferrules for power cables shall be tinned copper solderless crimping type suitable for aluminium compacted conductor cables. Cable lugs and ferrules for control cables shall be tinned copper type. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of terminals provided on the equipments. Cable lugs and ferrule shall conform to relevant standard. 3.8 Trefoil clamps Trefoil clamps for single core cables shall be pressure die cast aluminum or fibre glass or nylon and shall include necessary fixing accessories like G.I. nuts, bolts, washers, etc. Trefoil clamps shall have adequate mechanical strength to withstand the forces generated by the peak value of maximum system short circuit current. 3.9 Cable Clamps & Straps The cable clamps required to clamp multicore cables on vertical run shall be made up of Aluminium strip of 25x3 mm size. For clamping the multicore cables, self-locking, de-interlocking type nylon clamps/straps shall be used. The clamps/straps shall have sufficient strength and shall not get affected by direct exposure to sun rays and outdoor environment. 3.10 Receptacles Receptacles boxes shall be fabricated out of MS shet of 2mm thickness and hot dipped galvanized or of die-cast aluminium alloy of thickness not less than 2.5 mm. The boxes shall be provided with two nos. earthing terminals, gasket to achieve IP55 degree of protection, terminal blocks for loop-in loop-out for cable of specified sizes, mounting brackets suitable for surface mounting on wall/column/structure, gland plate etc. The ON-OFF switch shall be rotary type heavy duty, double break, AC23 category, suitable for AC supply. Plug and Socket shall be shrouded Die-cast aluminium. Socket shall be provided with lid safety cover. Robust mechanical interlock shall be provided such that the switch can be put ON only when the plug is fully engaged and plug can be withdrawn only when the switch is in OFF position. Also cover can be opened only when the switch is in OFF position. Wiring shall be carried out with 1100 V grade PVC insulated stranded
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	aluminium/copper wire of adequate size. The Terminal blocks shall be of 1100 V grade. The Terminal blocks shall be of 1100 V grade made up of unbreakable polymide 6.6 grade with adequate current rating and size. The welding receptacles shall be provided with inbuilt ELCB rated for suitable mA sensitivity. 3.11 Galvanising - Galvanising of steel components and accessories shall conform to IS: 2629, IS: 4759 & IS: 2633. Additionally galvanising shall be uniform, clean smooth, continuous and free from acid spots. - The amount of zinc deposit over threaded portion of bolts, nuts, screws and washers shall be as per IS: 1367 . The removal of extra zinc on threaded portion of components shall be carefully done to ensure that the threads shall have the required zinc coating on them as specified. 3.12 Welding The welding shall be carried out in accordance with IS: 9595. All welding procedures and welders qualification shall also be followed strictly in line with IS: 9595. 4. CABLE INSTALLATION 4.1 Cable tray and Support System Installation - Cables shall run in cable trays mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures. - Horizontally running cable trays shall be clamped by bolting to cantilever arms and vertically running cable trays shall be bolted to main support channel by suitable bracket/clamps on both top and bottom side rails at an interval of 2000 mm in general. For vertical cable risers/shafts cable trays shall be supported at an interval of 1000mm in general. Fixing of cable trays to cantilever arms or main support channel by welding shall not be accepted. Cable tray installation shall generally be carried out as per the approved guidelines/ drawings. Vendor shall design the support system along with tray, spacing etc in line with relevant standard. - The cantilever arms shall be positioned on the main support channel with a minimum vertical spacing of 300 mm unless otherwise indicated. - The contractor shall fix the brackets/ clamps/ insert plates using anchor fasteners. Minimum size of anchor fasteners shall be M 8 X 50 and material shall be stainless steel grade 316 or better. Anchor fastener shall be fixed as recommended by manufacturer and as approved by site engineer. For brick wall suitable anchor fasteners shall be used as per the recommendations of manufacturer. Make of anchor fasteners subject to QA approval. - All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75 mm. For long lengths of trays, the identification shall be painted at every 10 meter. Risers shall additionally be painted/ stenciled with identification numbers at every floor. - In certain cases it may be necessary to site fabricate portions of trays, supports and other non- standard bends where the normal prefabricated trays, supports and
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accessories may not be suitable. Fabricated sections of trays, supports and accessories to make the installation complete at site shall be neat in appearance and shall match with the prefabricated sections in the dimensions. They shall be applied with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint.

4.2 Conduits/ Pipes/ Ducts Installation

- The Contractor shall ensure for properly embedding conduit pipe sleeves wherever necessary for cabling work. All openings in the floor/roof/wall / cable tunnel/cable trenches made for conduit installation shall be sealed and made water proof by the Contractor.
- GI pull wire of adequate size shall be laid in all conduits before installation. Metallic conduit runs at termination shall have two lock nuts wherever required for junction boxes etc.
- Conduit runs/sleeves shall be provided with PVC bushings having round edge at each end. All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed with Glass wool/Cement Mortar/Putty to prevent entrance of moisture and foreign material.
- Exposed conduit/pipe shall be adequately supported by racks, clamps, straps or by other approved means. Conduits /pipe support shall be installed square and true to line and grade with an average spacing between the supports as given below, unless specified otherwise

Conduit /pipe size (dia).	Spacing
Upto 40 mm	1 M
50 mm	2.0 M
65-85 mm	2.5 M
100 mm and above	3.0 M

- For bending of conduits, bending machine shall be arranged at site by the contractor to facilitate cold bending. The bends formed shall be smooth.

4.3 Junction Boxes Installation

Junction boxes shall be mounted at a height of 1200mm above floor level or as specified in the drawings and shall be adequately supported/mounted on masonry wall by means of anchor fasteners/ expandable bolts or shall be mounted on an angle, plate or other structural supports fixed to floor, wall, ceiling or equipment foundations.

4.4 Cable Installation

- Cable installation shall be carried out as per IS: 1255 and other applicable standards.
- For Cable unloading , pulling etc following guidelines shall be followed in general :
 - Cable drums shall be unloaded, handled and stored in an approved manner on hard and well drained surface so that they may not sink. In no case shall be drum be stored flat i.e. with flange horizontal. Rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In absence of any indication, the drums may be rolled in the same direction as it was rolled during taking up the cables. For unreeling the cable, the drum shall be mounted on suitable jacks or on cable wheels and shall be rolled slowly so that cable comes out over the drum and not from below. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends. Cable ends shall be provided with sealed plastic caps to prevent damage and ingress of moisture.

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	• While laying cable, ground rollers shall be used at every 2 meter interval to avoid cable touching ground. The cables shall be pushed over the rollers by a gang of people positioned in between the rollers. Cables shall not be pulled from the end without having intermediate pushing arrangements. Pulling tension shall not exceed the values recommended by cable manufacturer. Selection of cable drums for each run shall be so planned so as to avoid using straight through joints. Care should be taken while laying the cables so as to avoid damage to cables. If any particular cable is damaged, the same shall be repaired or changed to the satisfaction of Project Manager. c) Cables shall be laid on cable trays strictly in line with cable schedule d) Power and control cables shall be laid on separate tiers in line with approved guidelines/drawings. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. In horizontal tray stacks, HT cables shall be laid on topmost tier and cables of subsequent lower voltage grades on lower tiers of trays. Single core cable in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil center lines and clamped at every two meter. All multi core cables shall be laid in touching formation. Power and control cables shall be secured fixed to trays/support with self locking type nylon cable straps with de-interlocking facilities. For horizontal trays arrangements, multi core power cables and control cables shall be secured at every five meter interval. For vertical tray arrangement, individual multi core power cables and control cables shall be secured at every one meter by nylon cable strap. After completion of cable laying work in the particular vertical tray, all the control cables shall be binded to trays/supports by aluminium strips at every five meter interval and at every bend. e) Bending radii for cables shall be as per manufacturer's recommendations and IS: 1255. f) Where cables cross roads/rail tracks, the cables shall be laid in hume pipe/ HDPE pipe. g) No joints shall be allowed in trip circuits, protection circuits and CT/PT circuits. Also joints in critical equipment in main plant area shall not be permitted. Vendor shall identify and accordingly procure the cable drum length. h) In each cable run some extra length shall be kept at suitable point to enable one LT/two HT straight through joints to made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so that shifting of termination in terminal blocks can be done without requiring any splicing. i) Wherever few cables are branching out from main trunk route troughs shall be used. j) Wind loading shall be considered for designing support as well Cable trays wherever required. k) Where there is a considerable risk of steam, hot oil or mechanical damage cable routes shall be protected by barriers or enclosures. l) The installation work shall be carried out in a neat workman like manner & areas of work shall be cleaned of all scraps, water, etc. after the completion of work in each area every day. Contractor shall replace RCC/Steel trench covers after the Installation work in that particular area is completed or when further work is not likely to be taken up for some time.
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4.5 Separation

At least 300mm clearance shall be provided between :

- HT power & LT power cables,
- LT power & LT control/instrumentation cables,

4.6 Segregation

- Segregation means physical isolation to prevent fire jumping.
- All cables associated with the unit shall be segregated from cables of other units.
- Interplant cables of station auxiliaries and unit critical drives shall be segregated in such a way that not more than half of the drives are lost in case of single incident of fire. Power and control cables for AC drives and corresponding emergency AC or DC drives shall be laid in segregated routes. Cable routes for one set of auxiliaries of same unit shall be segregated from the other set.
- In switchyard, control cables of each bay shall be laid on separate racks/trays.

4.7 Minimum number of spare cores required to be left for interconnection in control cables shall be as follows:

No. of cores in cable	No. of spare cores
2C,3C	NIL
5C	1
7C-10C	2
14C and above	3

4.8 Directly Buried Cables

- Cable trenches shall be constructed for directly buried cables. Construction of cable trench for cables shall include excavation, preparation of sieved sand bedding, riddled soil cover, supply and installation of brick or concrete protective covers, back filling and compacting, supply and installation of route markers and joint markers. Laying of cables and providing protective covering shall be as per IS: 1255. Reference drawing for buried cables is included as a tender drawing and enclosed with this specification.
- RCC cable route and RCC joint markers shall be provided wherever required. The voltage grade of the higher voltage cables in route shall be engraved on the marker. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable Joint". The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road crossings and drain crossings. Top of cable marker/joint marker shall be sloped to avoid accumulation of water/dust on marker.

4.9 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, and at every 20 meters in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, motor control centers, control and relay panels etc. where a number of cables enter together through a gland plate. Cable tag shall be of rectangular shape for power cables and control cables. Cable tag shall be of 2 mm thick aluminum with number punched on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. Alternatively, the Contractor may also provide cable tags made of nylon, cable marking ties with cable number heat stamped on the cable tags.

4.10 While crossing the floors, unarmoured cables shall be protected in conduits upto a height of 500 mm from floor level if not laid in tray.

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	5. Cable Terminations & Connections a) The termination and connection of cables shall be done strictly in accordance with cable termination kit manufacturer" instructions, drawings and/or as directed by Project Manager. Cable jointer shall be qualified to carryout satisfactory cable jointing/termination. Contractor shall furnish for review documentary evidence/experience reports of the jointers to be deployed at site. b) Work shall include all clamps, fittings etc. and clamping, fitting, fixing, plumbing, soldering, drilling, cutting, taping, preparation of cable end, crimping of lug, insulated sleeving over control cable lugs, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job to the satisfaction of the Project Manager. c) The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for punching of gland plates, painting and touching up. Holes shall not be made by gas cutting. The holes shall be true in shape. All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively sealed by 2mm thick aluminium sheets. d) Control cable cores entering control panel/switchgear/MCC/miscellaneous panels shall be neatly bunched, clamped and tied with self-locking type nylon cable ties with de interlocking facility to keep them in position. e) All the cores of the control cable to be terminated shall have identification by providing ferrules at either end of the core, each ferrule shall be indelible, printed single tube ferrule and shall include the complete wire number and TB number as per the drawings. The ferrule shall fit tightly on the core. Spare cores shall have similar ferrules with suffix sp1, sp2, -etc along with cable numbers and coiled up after end sealing. Supply of ferrules is in Vendor's scope. f) All cable terminations shall be appropriately tightened to ensure secure and reliable connections. Cable Sealing: Vendor shall ensure for properly embedding conduit pipe sleeves wherever necessary for cabling work. All opening in floor/roof/wall/cable tunnel/cable tranches made for conduit installation shall be sealed and made water proof by the vendor with modular multi dimensional cable system consisting of frames, blocks, compression wedge and its accessories. The cable sealing system shall have been tested for fire insulation for minimum 2 hrs as per BS 476/UL 1479/EN 1364 and shall provide water sealing for continuous pressure of 0.3 bars the system shall be rodent proof and shall have valid enclosure protection as per IEC 60529.				
5.42	Pre-commissioning inspections/ checks/tests, MRT tests, coordination/liaison with state /central departments/CEIG etc. for necessary approvals/clearances for commissioning, synchronization with grid/ plant commissioning <table border="1" data-bbox="331 1697 1481 2042"> <thead> <tr> <th>#</th><th>Scope description</th></tr> </thead> <tbody> <tr> <td>1</td><td>Pre-commissioning inspections / checks / tests, MRT tests and coordination / liaison activities with state / central departments / Transco/ DISCOM/ CEIG/ CEA etc for necessary approvals / clearances for commissioning, synchronization with grid and post-commissioning operation of the plant. (Clearances shall include</td></tr> </tbody> </table>	#	Scope description	1	Pre-commissioning inspections / checks / tests, MRT tests and coordination / liaison activities with state / central departments / Transco/ DISCOM/ CEIG/ CEA etc for necessary approvals / clearances for commissioning, synchronization with grid and post-commissioning operation of the plant. (Clearances shall include
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		obtaining prior approvals for all applicable drawings/ documents etc from concerned state / central departments / Transco/ DISCOM/ CEIG/ CEA etc.)	
	A	Basic checks	
	A1	Tightness checks:	
		1) Terminations of AC/DC power cables at SMBs, PCUs, Inverter transformers, Aux transformer, ACDB panel, UPS/ FCBC/ Battery banks, Aux AC/DC DB boards, ABT metering panel, 33kV VCB panels, metering CT/PT, GOS, LA, LV side of Inverter transformer, SCADA panels etc. 2) Terminations of Control/ Instrumentation/ Data/ Communication cables wherever applicable. 3) Terminations of earthing at all electrical equipment/ panels of inverter rooms/ control room/metering yard/Transmission line/ Substation bay 4) Terminations of earthing of inverter transformers, aux transformer 5) Terminations of earth chambers of vendor scope. Note: For M10 and above, torque wrench settings shall be followed for reference.	
	A2	Electrical continuity checks	
	A3	Megger (5kV) checks for all HT (33kV) cables and Line	
	A4	Hi-pot testing for all HT (33kV) cables prior to connection to the panels/ transformers.	
	A5	Megger (1kV) checks for all 1.1kV grade cables	
	A6	AC/DC supply checks at TBs of all electrical panels/ DBs/ Transformers.	
	A7	Transmission line testing	
	B	Pre-commissioning electrical tests:	
	B1	Power conditioning units (with the support of PCU service engineer at site)	
		1) DC side open circuit voltage and verification with SMB side measurements 2) Vendor to provide technician support to PCU service engineer for all other pre-commissioning tests as per OEM checklist 3) Functioning of duct fans (operation, direction of rotation)	
	B2	Inverter transformers and Aux transformer	
		1) Oil filtration: Equipment of adequate evacuation/ heating/ oil circulation capacity shall be deployed at site for this purpose. Filtration shall be carried out adequately in order to achieve the BDV, ppm, tan delta values within the limits as per relevant standards and as measured by NABL accredited laboratory. The machine shall have built-in BDV measuring set up for in-situ checking of BDV during filtration process. DG if required for oil filtration shall be arranged by vendor. 2) IR tests LV-HV, HV-E, LV-E 3) Vector group 4) Voltage ratio 5) Magnetizing current 6) Magnetic balance	

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			7) Winding resistance at all taps 8) Fault simulation checks (at VCB breaker panels): Buchholz, OTI, WTI, PRV, LOLA etc 9) Alarm, trip settings (S1, S2) for WTI, OTI 10) Oil level at conservator (to be topped up, if required)		
	B3		CTs 33kV at plant and substation		
			1) IR tests (all cores): Pri-Sec, Sec-Sec, Pri-E, Sec-E 2) Ratio tests / primary injection		
	B4		PTs 33kV at plant and substation		
			1) IR tests (all cores): Pri-Sec, Sec-Sec, Pri-E, Sec-E 2) Voltage ratio test 3) Polarity test		
	B5		33KV breakers at plant and substation		
			IR tests Contact resistance measurement (CRM) Timing test: close/ open/ close-open Functional checks: breaker open/close, spring-charged motor Remote operation from SCADA panels: open/close, command/ status, lamp indications		
	B6		Numerical relays at 33KV breaker/C&R panels at plant & substation		
			1) Relay calibration using applicable kit/ software 2) IDMT, DT curves with timing/pickup settings in all relays based on gradation across from downstream to upstream taking into account settings at substation 3) Overcurrent/ earth fault pickup/ tripping time tests		
	B7		CT ratio / PT ratio to be set in meters/relays		
			i. All MFM meters ii. ABT meters iii. Protection relays		
	B8		ACB breaker settings (with the help of PCU service engineer)		
			1) Over load, Short time fault, ground fault		
	B9		Earth resistance measurements for all chambers of vendor scope		
			1) With electrode connected to grid 2) Without connecting electrode to grid		
	B10		UPS/ FCBC charger/ Battery banks		
			1) All functional checks: battery charging/ discharging, FCBC/ battery output parameters etc. as per OEM checklists		
	B11		Transmission line testing		
	B12		Tests on 30KV LA		
	B13		Tests on GOS Isolator		
	C		Testing agency		
			Credentials of testing agency shall be submitted to BHEL for approval prior to awarding of work.		
	D		Coordination and Liaison activities to be carried out by vendor:		
			1) Vendor shall lead in the process of obtaining approval from Transco/ DISCOM/ CEIG/ CEA etc as applicable for line charging/ grid synchronization/ plant commissioning.		

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			2) Liaison responsibility for getting the approvals rests with the vendor. Wherever technical clarifications are required by the approving agencies with regard to SPV portions (including solar array) up to metering yard, transmission line and substation bay, vendor shall suitably coordinate/liaison with the concerned state/central approving agencies to make the approval process successful. Accordingly, vendor shall participate in direct discussions with the approving agency whenever necessary. Also, all the necessary payments/expenditures to be incurred with ref to such coordination/ liaison in this regard shall be borne by the vendor. 3) Following are the areas of approval, as applicable (a) GTP/ datasheets/ GA drawings/ Bill of materials, MQP etc of all (BHEL's/vendor's) supply items. (b) Site test reports of transformers, transformer oil, VCB breakers, CTs, PTs, LAS, resistance of earth mat grids etc (c) Interaction with supervising/ inspection agency such as MRT departments, Transco, CEIG, CEA etc, as applicable, for applying to them/ inviting them for supervision/ inspection at site. (d) Interaction/ coordination with customer in the above process as and when required. (e) All necessary testing kits/ instruments shall be arranged as per the requirements of inspection agency. Basic instruments such as digital multimeter, 5kV digital megger with PI feature, earth resistance meter, VCB open/close timing test kit, clamp meters etc shall be organized at site at the time of inspection. Competent electrical technician shall also be made available at the site. (f) Subsequent to site inspection by the concerned agency, vendor shall obtain the clearance for grid synchronization after implementation of all the observations of CEIG. (g) Vendor shall also coordinate with DISCOM for obtaining approvals such as grid connectivity approval etc.		
		E	Commissioning of Substation bay equipment, Transmission line and Solar Power Plant		
			1) Vendor shall organize all necessary tools/ measuring instruments required to operate the various electrical equipment at the time of commissioning: Digital megger 5KV with PI feature, Earth resistance tester, Phase sequence meter, Clamp meters etc., discharge rods, PPE safety gadgets (helmets, shoes etc.). 2) It is the responsibility of the vendor to successful charge 33kV transmission line followed by charging of 33kV yard at SPV plant end and grid synchronization of inverters/ plant commissioning for full DC capacity. 3) Vendor shall participate actively in the commissioning until it is established that there is successful export of power from all the strings PCUs and through the 33kV transmission line/ switchyards/ substation bay.		
		F	Trial run and Performance Guarantee test		
			After commissioning and completion of all works including clearing of all punch points, trial run of the plant will be commenced for 7 consecutive days based on acceptance by MAHAGENCO. Immediately after trial Performance Guarantee test shall start for a period of 30 days. During trial run and PG		

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		test vendor shall deploy manpower, operate and maintain the plant and ensure that there are no breakdowns in any equipment, all required tools and spares are available. After successful completion of PG test, Operation and maintenance period will start. It is the responsibility of vendor to maintain the plant in all respects as per regular O&M procedures during PG test period.	
5.43	Spares required to be supplied along with main consignment: 1) Fuses of all types: 1 % of total population of respective items 2) MCB of all types: 1% of total population of respective items 3) Indicating lamp set of all types: 1% of total population of respective items 4) Surge protection devices/ MOV: 1% of total population of respective items 5) Lamps for peripheral lighting- 10 Nos 6) MC4 connectors: 500 sets (1 set = 2 nos) 7) 33KV, 1C, 300 sqmm (E) Indoor End termination kits- 4 Nos 8) 33KV, 1C, 300 sqmm (E) Outdoor End termination kits- 2 Nos 9) 33KV, 1C, 300 sqmm (E) Straight through jointing kits- 3 Nos 10) Spares of aux transformers: a) HV bushings with metal parts and gaskets: 1 set b) LV bushings with metal parts and gaskets: 1 set c) Neutral bushing with met metal parts an gaskets: 1 set d) Gaskets : 2 sets e) Silica gel breather with charge: 1 set f) Diaphragm of explosion vent: 1 set g) Prismatic oil level gauge: 1 set h) Valves: 1 set Notes: (a) 1 set refers to total quantity of the item used in one transformer. In case quantity arrived based on percentage is a decimal figure, it shall be rounded off to next higher integer.		

6 General conditions applicable during supply, installation, commissioning and O&M

6.1	As already mentioned in previous clauses, vendor shall organize power supply on their own. Accordingly, DG sets of suitable capacity shall be deployed by the vendor for construction works.
6.2	Similarly, water required for construction works shall be organized by vendor (tankers etc).
6.3	All machinery such as cranes, hydra, JCBs, forklifts, transport trucks, trolleys etc necessary for movement and installation of materials / panels / equipment etc shall be organized by the vendor.
6.4	All necessary tools and tackles such as crimping tool (including heavy duty tools for crimping copper/ aluminium cables up to 630 sq-mm), screw driver set, power screw drivers, cutting pliers, nose pliers, spanner sets, adjustable spanners, hole-saw cutter set, bending tools, torque wrenches, hack saw blades, pipe wrenches, flat / round files, HV termination tools, drilling machines, welding machines, concrete mixers, steel bar bending tools / templates/ shuttering materials for RCC works, spade, shovel, hammer etc shall be organized by the vendor.
6.5	All necessary measuring instruments such as digital multimeters, measuring tapes, vernier calipers, electrical testers, digital meggers (1kV, 2.5kV, 5kV), earth resistance meters, clamp

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	meters, transformer oil BDV kit, relay testing kit (secondary injection), primary injection kit, infrared thermal imaging handheld temperature meter etc. All these instruments shall possess valid calibration certificate issued from approved NABL laboratory.
6.6	Vendor shall make their own arrangements for necessary food, drinking water and accommodation for their labour and employees posted at the site. Similarly, food and drinking water required at the site, during the construction operations, shall also be in scope of vendor.
6.7	Vendor shall organize all necessary steps to meet statutory requirements such as labour license, PF, ESI etc and also ensure compliance with relevant acts such as minimum wages act, income tax act, employee insurance act etc for their labour deployed at site.
6.8	Vendor shall maintain updated labour register, with name, age, qualification, salary, attendance details etc. at the site.
6.9	Vendor shall use danger boards, wherever required, to ensure safety of the persons during the work at site.
6.10	Vendor shall adhere to all necessary safety norms such as use of helmet, goggles, hand gloves, gumboots, aprons etc. It is the ultimate responsibility of the vendor in all respect to prevent accidents at the site and safeguard their labour from accidents.
6.11	Vendor shall, at the completion of every work, clear off the debris, which resulted out of the work. In case of excavation work such as cable trench etc, vendor shall finish the land neatly with necessary leveling, rolling etc.
6.12	Vendor shall carry out the work without causing inconvenience to other contract groups at the site. In case of conflicts with other groups, vendor shall ensure that the matter is resolved at once amicably so that the progress of work is not affected.
6.13	Any damages on the building, structures etc. attributable to the acts of labour / employees of vendor shall be rectified and made good by the vendor at their own cost.
6.14	No child labour shall be employed for execution of the present contract.
6.15	Any miscellaneous materials, which are found essential for technical completion of the contract but not mentioned explicitly in this specification, shall be deemed to be included in the specification. Accordingly, such materials shall be included by the vendor as part of the offer.
6.16	Special instruction for earthing: In compliance with Rule 33 and 61 of Indian Electricity Rules, 1956 (as amended up to date), all non-current carrying metal parts shall be earthed with two separate and distinct earth continuity conductors to an efficient earth electrode. Accordingly, all cases such as cable support structures, cable ladders, cable trays (control room) etc. shall be earthed.
6.17	BHEL/MAHAGENCO shall witness routine/ acceptance/ type tests performed at manufacturer works for the items supplied by vendor. Vendor shall accordingly provide inspection call to BHEL with submission of quality assurance plan in advance. For the items bought out from dealers, test certificates, as per relevant IS / IEC standards, as issued by manufacturer shall be submitted to BHEL. However, prior approval shall be obtained from BHEL/MAHAGENCO for procurement of the item from dealers.
6.18	Field Quality Plan / Quality control system (if applicable) Vendor shall set up a field quality control laboratory with full set up to facilitate testing of all construction materials in accordance with FQP (Field quality control plan) as approved by BHEL/MAHAGENCO. Vendor shall deploy a well experienced quality control engineer to monitor all QC activities at site as per approved FQP. Specifically with reference to civil works, vendor shall submit all concrete mix designs and bituminous mix designs for BHEL/MAHAGENCO approval before starting of the work. All the third party testing should be conducted in NABL approved laboratories only. Vendor shall submit the FQP for the civil construction works before starting of the works for approval of BHEL/MAHAGENCO.

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6.19	Any deviations shall be discussed with BHEL/MAHAGENCO site engineers and implementation shall be taken up only after approval from BHEL /MAHAGENCO.
6.20	Vendor shall submit periodic status report, on daily as well as weekly consolidated basis, to BHEL on the progress of the contract.
6.21	Vendor shall, as and when required by BHEL/MAHAGENCO, participate in the review meetings conducted by BHEL/MAHAGENCO at project site, BHEL-EDN (Bangalore), BHEL-Corporate office (New Delhi), MAHAGENCO office, New Delhi etc
6.22	General Guidelines - Any civil or electrical work which is not mentioned or included in this tender document but necessary for functional requirements of the plant shall be carried out by vendor. - Vendor shall prepare all designs / drawings based on the specifications given in the tender and in light of relevant BIS/IS/ equivalent standard. - Vendor shall provide type test reports and datasheet/ GTP for all equipments covered under vendor scope of supply. - BHEL reserves right to modify the design at any stage to meet local site conditions / project requirements. - All work shall be carried out in accordance with the latest edition of the Indian Electricity Act and rules formed thereunder and as amended from time to time.
6.23	For all current carrying parts and earthing, S.S hardware shall be provided and all other places, G.I hardware shall be provided. M.S hardware shall not be used in any place.

7 Documents to be submitted for BHEL/MAHAGENCO approval during detailed engineering

7.1	BHEL/MAHAGENCO approval shall be obtained for the following technical documents, which shall be submitted to BHEL in phased manner based on priority sequence of activities during detailed engineering (after receipt of purchase order from BHEL).
7.2	Name of vendor/ make, model number/ part number, specification/ sizes/ dimensions/ drawings/ datasheets shall be submitted for all the vendor supplied items.
7.3	Design calculations/ general arrangement drawings/ single line diagrams/ GTP particulars/ datasheets/ schemes/ layouts/ bill of materials etc., as applicable.
7.4	Manufacturing Quality Plans for all the vendor supplied items
7.5	Field quality plan for the field work: civil works, electrical works
7.6	Detailed activity-time chart for project implementation
7.7	Detailed manpower deployment schedule

8.0 Operations and Maintenance

8.1	Date of commencement of operations and maintenance Zero date for O&M shall be the actual date on which the successful commissioning of the 50MWp solar photovoltaic power plant with synchronization / export of power to the grid.
8.2	O&M personnel 1. Vendor shall deploy following minimum personnel: (a) Technical / administrative / office personnel One technical-cum-administrative in-charge having graduation in electrical / electronics engineering and experience with overall responsibility for complete plant

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	operations. The in-charge shall have competence to deftly handle technical and operational / crisis problems. • Six working level staff with ITI / diploma level qualifications in engineering with competence for operating electrical / electronics / mechanical equipment, taking measurements, data logging / maintaining registers, preparation of reports in computer. • Six unskilled persons for regular house-keeping (cleaning / mopping etc) and water cleaning of SPV modules. • Note: At least one among the technical personnel shall essentially be a certified / licensed person for HT operations (33kV minimum). This is a mandatory requirement. (b) Security personnel • Minimum 6 security guards with competence to handle tough situations and safeguard the plant from miscreants. • Among these, two shall be deployed during night shift, two during morning shift and two during evening shift. 2. Vendor shall provide uniforms for the O&M staff. 3. Similarly, O&M personnel shall be provided with raincoats, toolsets, earthing rods, safety gloves, safety goggles, gumboots, helmets and all other personal protective equipment (PPE) that will be relevant to ensure human safety. 4. Names, qualification, work responsibility of personnel shall be listed on a display board within control room. 5. Attendance register shall be maintained for both the teams. 6. Vendor shall ensure statutory requirements such as ESI, PF and labour license for their O&M personnel posted at site. 7. BHEL / MAHAGENCO shall have right to disallow any O&M employee, if found unfit to perform. BHEL instructions issued in writing shall be binding on vendor who shall replace the person. 8. O&M personnel at site shall conform to general regulations in force at site and to any special instructions from local MAHAGENCO administration. 9. O&M personnel at site shall be deemed to be aware of damages and risks incidental to conditions of MAHAGENCO land & works from time to time and BHEL / MAHAGENCO shall not be responsible for any injury to personnel arising there from. 10. Training to O&M personnel It is the absolute responsibility of vendor to ensure imparting of necessary training to their O&M personnel to get them acquainted with the operations of various electrical and mechanical equipment of the power plant. For this purpose, vendor shall identify the O&M
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	personnel well in advance and involve them during installation and commissioning stages so that they become well versed with various functional aspects of the power plant. 11. Availability of O&M personnel at power plant (a) Vendor shall ensure that operating staff are present in the power plant during 7:30 AM – 6:30 PM every day. (b) Vendor shall ensure that certain minimum operating staffs are present at the power plant even on festivals, public holidays and any other unique occasions so that the plant is run under competent supervision on all days. 12. O&M personnel shall, strictly, not use any part of the power plant for their personal / residential purposes. Their presence at the plant shall, strictly, be meant only for the purpose of operation and maintenance of plant.
8.3	Responsibility of vendor during PG test Vendor shall, in addition to the O&M activities (as per this specification), carry out the Performance Guarantee test (PG test) that commences on a date (as mutually decided by BHEL/MAHAGENCO) after successful commissioning of 50 MW plant. PG test is the final acceptance test (conducted for a period of 90 days as decided by MAHAGENCO within the O&M period) to prove the performance of the power plant in respect of energy generation as contractually guaranteed by BHEL to MAHAGENCO. Vendor shall carry out the following activities during this period: 1. O&M activities as per this specification 2. Monitoring of power plant parameters as per SCADA reports 3. Reporting power plant parameters to BHEL/MAHAGENCO on daily basis
8.4	O&M operations – daily basis (1) Water cleaning of SPV modules (2) Inverter station / CMCS room cleaning – dry sweeping, wet mopping (3) Water wash cleaning of toilets, urinals (4) Gardening of landscaping areas: watering of plants, trimming of plants as applicable and necessary. (5) Logging of DC, AC, grid parameters (current, voltage, power, energy) at PCUs & VCB panels, transformer temperatures, equipment tripping/ breakdown, grid outage etc as per BHEL formats. (6) SCADA data station / PC operations for daily monitoring of weather parameters, trend graphs and urgent reporting to BHEL/MAHAGENCO in case of any problems / anomalies observed with any of the parameters. (7) Drinking water to be arranged for O&M personnel at site.

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8.5	O&M activities – weekly basis (1) Removal of garbage from solar array field, switchyard, roads, drains, pathways, sand buckets; logging in registers with signatures of operating persons and in-charge. (2) Monitoring and logging of fire extinguisher levels / pressures as per BHEL formats
8.6	O&M activities – monthly basis (1) Inspection of fire extinguishers (weight, pressure indication, physical status etc) followed by refilling actions, if necessary, based on indications. Report to be submitted as per BHEL approved recording formats. (2) Earthing resistance measurements for solar array structures, control room equipment, switchyard equipment, lightning arrestors: measured values shall be recorded in registers and reported to BHEL as per BHEL approved recording formats. (3) Submission of values / status of plant parameters and events for the corresponding month, as below, as per BHEL approved formats: a. Daily values of solar array strings (SMB parameters) b. Daily values of weather parameters (solar energy, wind speed, ambient temperature) c. Daily energy generation d. Events (with date, time) of faults / tripping / breakdown of equipment e. Events (with date, time) of grid outage f. Events (with date, time) of equipment damages, accidents and thefts g. Activities of module cleaning (4) Monthly reports shall be submitted to BHEL for all the above data. (5) Energy generation / meter reading report to be prepared and submitted to the concerned department. Signatures from MAHAGENCO representatives shall be obtained wherever required.
8.7	O&M activities - quarterly basis (1) Cleaning of PCUs, LT panels, VCB panels, UPS panels etc to remove accumulated dust. (2) Monitoring and status review, followed by rectification / calibration / replenishment / replacement actions as necessary and applicable for following: (a) Spare items of all electrical equipment (b) First aid box items - medicines and accessories (c) Safety gadgets (d) Tool kits and measuring instruments (e) Yard lights (f) Pumps, starters (g) Control room appliances: air conditioners, lights, fans, exhaust fans, switch boards etc (3) Pest control for control room (rats, snakes etc) – sprays, chemicals, medicines etc to be applied wherever required. (4) Submission of quarterly report on above activities to BHEL.
8.8	O&M activities – half yearly basis (1) Cleaning of water storage tanks.

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8.9	O&M activities – yearly basis (1) BDV measurements for oil samples from all the transformers and submission of report to BHEL / MAHAGENCO. (2) Filtration of oil to be arranged, if required, based on BDV measurement report. (3) Lubrication of moving contacts (VCBs etc) with appropriate grease etc (4) Cleaning of sewerage lines, septic tanks (if found necessary) (5) Painting of main gate, switchyard gate / fencing, earthing chambers, other steel structures within control room and switchyard if required based on conditions of rusting etc. (6) Checking tightness of hardware in solar array structures and tightening wherever required. (7) Checking tightness of power cable terminations in SPV modules (MC4), SMBs, electrical panels of control room and switchyard.
8.10	O&M activities - as and when required (contextual basis) (1) Monitoring and operation of plant electrical equipment as and when required: (a) VCB on/off: local operations from outdoor VCB panel and remote operations from SCADA system. (b) Settings of numerical relays in VCB panels: review and revision in consultation with BHEL. (c) ACB and MCCB on/off operations on LT side (d) PCU operations: emergency close, LCD displays (selection of settings, monitoring the DC/AC/event/fault status parameters), operation of duct fans (e) UPS panels and Battery bank operations (f) Bore well pump operations to fill the water storage tanks (2) Coordinating, on behalf of BHEL, and obtaining renewal of statutory licenses, clearances and approvals from state departments such as electricity boards, CEA/CEIG etc. (3) Repair and replacement of vendor supplied items, by vendor, with urgent action plans and implementation, when the items are found non-working / damaged. The same shall be reported to BHEL within 12 hours from time of observation. (4) Reporting, on an immediate basis (within max 2 hours) of functional problems / damages in BHEL supplied items to facilitate repair / replacement by BHEL. Further, vendor shall correspond / coordinate with respective equipment vendors / service centers, on behalf of BHEL, for getting the service engineers to the site. Later, coordinating with the service engineers during their visit to site, and assisting them in the trouble shooting process until the problem is resolved. Vendor shall report to BHEL (within max 2 hours) immediately after the problem is resolved. (5) Vendor shall keep updating the spares inventory at the site every time there is consumption of spare items towards replacement. In case of shortage of spares, the same shall be reported on an urgent basis (with max 2 hours) to BHEL. (6) Coordinating with sub-station upon grid failures, line problems etc and implementing the needful steps to restore the plant to normal operation. (7) Theft incidents: immediate reporting to BHEL, filing FIRs with police stations on behalf of BHEL, coordination for site inspection by insurance companies and clearance of insurance claims, logging of events (date, time) and maintaining records.

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	(8) Accidents: immediate reporting to BHEL, coordinating with hospitals, logging of events (data, time) and maintaining records.
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