ANNEXURE B

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I. SCOPE OF WORK

1. Project Particulars

Particulars	Description
Design and Engineering	
Project AC Capacity	600 MW
Cumulative Power Transformer Capacity	640 MVA
Cumulative Inverter Duty Transformer Capacity	Minimum 640 MVA
BESS minimum nameplate DC Capacity (Cumulative), (MWh)	1400 MWh with minimum container size of 5 MWh (Tendered separately; not in scope of the Contractor)
BESS minimum dispatchable Capacity at Point of Interconnection at the Beginning of Life	1200 MWh (*Tendered separately; not in scope of the Contractor*)
Supply of BESS	Supply of BESS System at the Project Site shall be in the Scope of the Employer. BESS shall comprise of the following components: i. Accumulation sub-system, comprising unit batteries/battery packs/racks with battery management system (BMS) ii. Conversion sub-system comprising of Bi-directional Power Conditioning System(s) iii. Auxiliary sub-systems such as HVAC and fire suppression systems iv. Data Acquisition and Communication sub-systems v. BESS Energy Management System (EMS) The Employer shall deliver BESS at the Project site.
Design life of power plant	15 Years
O&M period	15 Years 3 months
Site Location and Land Details	
Location	Kolimigundla Village
District	Nandiyal
State/UT	Andhra Pradesh
Latitude and Longitude	15°01'18"N 78°09'13"E
Altitude	285 m
Available Land Area	approx. 40 acres
Type of Land	Leased Govt. Land

<table>
<tr><td>Project Ownership</td><td>Solar Energy Corporation of India Limited</td></tr>
<tr><td colspan="2">Access</td></tr>
<tr><td>Nearest Urban Area</td><td>Kolimigundla</td></tr>
<tr><td>Nearest Highway</td><td>Thimannayunipeta – Ankireddy Palli Road (adjacent to location)</td></tr>
<tr><td>Nearest Railway Station</td><td>Tadipatri (31.9 kms)</td></tr>
<tr><td>Nearest Airport</td><td>Uyyalawada Narasimha Reddy Airport, Kurnool</td></tr>
<tr><td colspan="2">Power Evacuation</td></tr>
<tr><td>Plant End Substation Power Transformer (33/220 kV) Capacity</td><td>640 MVA</td></tr>
<tr><td>Plant End Substation Switching Scheme (220 kV)</td><td>Main and Transfer Bus</td></tr>
<tr><td>Point of Interconnection</td><td>220 kV Bay at Nandiyal, Kurnool -3 PGCIL Substation</td></tr>
<tr><td>Transmission Line from Pooling Substation to Interconnecting Substation</td><td>220KV DCSS line from project site up to 400/220KV S/s Kurnool (Approximate aerial distance 2 km)
Note: Construction of 220KV Underground Cable from Pooling Sub-Station (plant end) to 400/220KV S/s Kurnool including all clearances shall be in the scope of Contractor.</td></tr>
<tr><td colspan="2">Design Parameters</td></tr>
<tr><td>Design Ambient Temperature</td><td>50 °C</td></tr>
<tr><td>Basic Wind Speed (IS 875-3)</td><td>39 m/s</td></tr>
<tr><td>Seismic Zone (IS 1893-1)</td><td>Zone II</td></tr>
<tr><td>Corrosion Class</td><td>C4</td></tr>
<tr><td>Losses Consideration</td><td>AC Contractor shall consider the following losses as prescribed below for the components within its scope
<table>
<tr><td>LV Cable Efficiency (PCS to BESS Trafo)</td><td>0.75%</td></tr>
<tr><td>BESS Transformer Efficiency</td><td>98.50%</td></tr>
<tr><td>MV Cable Efficiency (Trafo to MV Transformer)</td><td>99.50%</td></tr>
<tr><td>Power Transformer</td><td>99.00%</td></tr>
<tr><td>HT Line Losses</td><td>0.25%</td></tr>
</table></td></tr>
<tr><td colspan="2">Functional Guarantee (FG)</td></tr>
</table>

<table>
<tr><td>Round trip Efficiency</td><td>Round Trip Efficiency (RTE) shall be measured at 220 kV Interconnection point and shall not fall below 82% incorporating auxiliary consumption.</td></tr>
<tr><td>Dispatchable Energy</td><td>Dispatchable Energy shall me measured at the 220 kV Interconnection point and shall not fall below following at the start of the respective year:
<table>
<tr><td>Year 1</td><td>1200 MWh</td></tr>
<tr><td>Year 2</td><td>1170 MWh</td></tr>
<tr><td>Year 3</td><td>1140 MWh</td></tr>
<tr><td>Year 4</td><td>1110 MWh</td></tr>
<tr><td>Year 5</td><td>1080 MWh</td></tr>
<tr><td>Year 6</td><td>1050 MWh</td></tr>
<tr><td>Year 7</td><td>1020 MWh</td></tr>
<tr><td>Year 8</td><td>990 MWh</td></tr>
<tr><td>Year 9</td><td>960 MWh</td></tr>
<tr><td>Year 10</td><td>930 MWh</td></tr>
<tr><td>Year 11</td><td>900 MWh</td></tr>
<tr><td>Year 12</td><td>870 MWh</td></tr>
<tr><td>Year 13</td><td>840 MWh</td></tr>
<tr><td>Year 14</td><td>840 MWh</td></tr>
<tr><td>Year 15</td><td>840 MWh</td></tr>
</table></td></tr>
<tr><td>For Operational Acceptance</td><td>The round-trip efficiency and dispatchable energy shall meet the minimum requirements as stipulated at the start of operation.</td></tr>
<tr><td colspan="2">During O&M Period</td></tr>
<tr><td>BESS Availability</td><td>98%</td></tr>
<tr><td colspan="2">Other Details</td></tr>
<tr><td>Water and Power for Construction</td><td>To be arranged by the Contractor</td></tr>
</table>

2. Brief Scope of Work

2.1. Scope of Supply & Work includes design & engineering, procurement & supply of equipment and materials (excluding BESS Containers, PCS, EMS and associated Cables), testing at manufacturers works, multi – level inspections, packing and forwarding, supply, receipt, unloading and storage at site, associated civil works, services, obtaining permits, licences, installation and incidentals, insurance at all stages, erection, testing and commissioning for 600 MW/1200 MWh Battery Energy Storage Project, and performance demonstration with associated equipment and materials on turnkey basis along with comprehensive operation and maintenance from the date of Operational Acceptance.

2.2. All works shall be executed as per Technical Specifications provided in this annexure's Electrical Systems (Section II) & Civil, Mechanical & Plumbing Works (Section III) along with General Annexures (Section IV, V, VI, VII, VIII, IX, X and XI) & Specific Annexure (Section-XII).

3. Responsibility Matrix

3.1. The following Responsibility Matrix is specified to delineate the Scope of Works of different Contracting parties engaged by the Employer (This document corresponds to the Scope of Work of AC Package).

S. No.	Activity / Scope Item	DC Package	AC Package	Remarks
1	Supply of BESS Battery Racks and Modules	✓		
2	Supply of Battery Enclosures / Containers with HVAC & Fire Protection System	✓		
3	Power Conditioning System (PCS) – Supply & Installation	✓		DC Package terminates at AC output of PCS
4	Battery Management System (BMS)	✓		Integrated with BESS
5	Energy Management System (EMS)	✓	Interface required with AC system	Interface with overall plant SCADA (scope of AC package)
6	Integration of BMS, EMS with PCS	✓		
7	Cabling from BESS to PCS (DC Cables)	✓		
8	Cabling from PCS AC Terminals to BESS Transformer Primary		✓	Coordination required with BESS Supplier for cable terminations
9	BESS Transformer (LV to HV) – Design, Supply, Installation		✓	
10	AC Cabling from BESS Transformer to 220 kV Plant Substation		✓	
11	220 kV Substation Bay Construction and Integration		✓	Includes protection system, metering, etc.

12	Civil Works – Foundations for BESS Containers & PCS		✓	AC Package Contractor must coordinate with DC Package Supplier for layout requirements
13	Cable Trenches, Trays, and Supports	✓ (up to PCS)	✓ (beyond PCS)	
14	Internal Roads, Drains, Water Supply, and Fencing		✓	
15	Fire Alarm System Integration with Plant Level SCADA	✓ (Local), Interface by AC	✓ (Plant-wide)	
16	Earthing of BESS Equipment and PCS	✓ (up to PCS)	✓ (plant grid)	Coordination required at Interface Points (Handover and Take over points)
17	Lightning Protection System		✓	
18	Aux Power for BESS (from AC side)	Interface only	✓	Power supply for HVAC, control, etc.
19	Testing and Commissioning of BESS (Battery, PCS, EMS)	✓	Witness and support	
20	Testing and Commissioning of BESS Transformer and Grid Interconnection		✓	
21	Grid Synchronization and Final Plant Commissioning	Support	✓	DC Package to support EMS tuning and validation
22	Plant Performance Demonstration and Trial Operation	✓ Shared	✓ Shared	Roles to be defined in commissioning protocol

Note: *In case of discrepancy between the Illustration for Scope of Works and the Matrix, the matrix shall prevail.*

3.2. With reference to above, following is the scope of Interfacing and co-ordination requirements:

Area	Interface Responsibility
Layout planning (Control room, BESS container placement)	AC Package (Lead), with inputs from DC Package
Cable routing and entry points	AC Package with terminal coordination with DC Package
EMS integration with grid SCADA	Joint Responsibility of AC and DC Packages
Aux supply routing and capacity	AC Package (Lead), DC Package to confirm loads
Civil works sequencing	AC Package to coordinate with DC Package delivery and erection timeline

3.3. The Contractor shall refer to the detailed Technical Specifications for specific handover points to the Employer's Balance of Plant (AC Package Contractor for AC Component).

3.4. Design & Installation Coordination: Supplier (DC Package) and Contractor (AC Package) shall jointly review interface points during detailed engineering. Any changes required to accommodate space, cable routing, or ventilation shall be mutually agreed. The Employer shall conduct coordination meetings periodically and final drawings shall be issued post integration.

3.5. Testing and Commissioning Interface: Functional testing of BESS, PCS, and EMS systems up to the AC terminals of PCS shall be undertaken by the Employer's DC Package Supplier. The AC Package Contractor shall perform testing from BESS transformer onward and overall plant synchronization. Joint testing protocols shall be developed and approved by the Employer.

4. Design and Engineering

4.1. The Contractor shall prepare the detailed design basis report (DBR), PERT Chart (up to at least 3 levels) and Master Drawing List (MDL). The Contractor shall submit a copy to Employer for review and approval prior to detail engineering.

4.2. All documents and drawings (soft copy) shall be submitted to the Employer for review and approval. Every drawing shall also be submitted in '*.dwg' format. In case of design calculations done in spread sheet, editable (working) soft copy of the spread sheet shall also be submitted along with 'pdf' copies during every submission. The Employer shall return the document / drawing to the Contractor with category of approval marked thereon. Two nos. of hard copies of approved documents and drawings shall be submitted to the Employer. The drawings/documents shall be approved in any one of the following categories based on nature of the comments/ type of drawing or document.

i. Category-I: Approved
ii. Category-II: Approved subject to incorporation of comments
iii. Category-III: Not approved. Re-submit for approval after incorporation of comments
iv. Category-IV: Kept for record/ reference
v. Category-IV (R): Re-submit for record/ reference after incorporation of comments

(*Note: Approval of document neither relieves the Contractor of its contractual*

obligations and responsibilities for correctness of design, drawings, dimensions, quality & specifications of materials, weights, quantities, assembly fits, systems/ performance requirement and conformity of supplies with Technical Specifications, Indian statutory laws as may be applicable, nor does it limit the Employer's rights under the contract)

4.3. The contractor shall submit basic design data, design documents, drawings and engineering information including GTP and test reports to Employer or its authorized representative for review and approval from time to time as per project schedule. The documents typically include, but not limited to, the following:

- Detailed technical specifications (GTP) of all the equipment
- General arrangement and assembly drawings of all major equipment
- Schematic diagram for entire electrical system (AC and auxiliary systems)
- GTP & G.A. drawings for all types of components, 220 kV, 132 kV, 66 kV or 33 kV switchgears (as applicable) & other interfacing panels
- Test reports (for type, routine and acceptance tests)
- Relay setting charts
- Design calculations and sheets (civil, mechanical, structural and electrical designs)
- Geotechnical investigation data and Topographical survey report including topographical survey data in digital format (Excel file) and Contour plan of the area.
- GA drawings of the entire project including equipment rooms/ inverter control rooms, office cum control room, roads, storm water drainage, sewage networks, security gate, fire protection system, perimeter fencing, transformer yard fencing etc.
- Transmission line drawings and erection plans as per DISCOM / STU / CTU guidelines
- Quality assurance plans for manufacturing (MQP), Standard Operating procedure (SOP) and field activities (FQP)
- Detailed site EHS plan, fire safety & evacuation plan and disaster management plan.
- Detailed risk assessment and mitigation plan.
- O&M Instruction's and maintenance manuals for major equipment
- As-built drawings / documents and deviation list from good for construction (GFC)

4.4. **Grid Compliance Study:**

i. Bidder shall also submit detailed Grid compliance study (steady state/Dynamic/Power Quality) with Power Plant Controller for BESS project (in PSS/E and PSCAD platform) as per CEA technical standard to grid connectivity/CTU requirement/ Report of the Working Group in respect of Data Submission Procedure And Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid and latest guideline of RLDC for first charging clearance. In this regard, Bidder shall submit the single inverter, aggregated and detailed RMS model of the plant in PSS/E along with PSCAD aggregated model in line with CEA Working Group report and/or applicable standard. In case any site testing is required for grid compliance as per RLDC, it shall also be conducted.

ii. Bidder shall submit preliminary CEA grid compliance study as per timeline mentioned for CON4 submission to CTU/RLDC in Report of the Working Group in respect of Data Submission Procedure and Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid by RE Generators. Based on the comments received on the submitted report, the study and Model shall be updated and resubmitted again within stipulated timeline, with latest parameters for final acceptance. Availability of required PSSE and PSCAD model of Inverter and PPC shall be ensured by Bidder during selection of respective Manufacturer.

iii. Bidder shall provide all data and applicable study/simulation reports as per 'Procedure for Integration of solar plant those are regional entities" for submission to RLDC/SLDC/STU for first time charging clearances (as required by regulatory/statutory body). Some information/documents from the above procedure and Report of the Working Group in respect of Data Submission Procedure and Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid by RE Generators July 2022 are mentioned below. However, bidder shall refer the applicable documents in detailed on their own for compliance.

Dynamic Model

i. Copy of dynamic model as per the connectivity

ii. Updated dynamic model at least three months ahead of the proposed date of first-time charging

iii. Following Reports also to be included along with the dynamic model:
   a) Parameters of Inverter in .dyr file to be validated with the test report results from the LVRT/HVRT certification and the validation report to be submitted.
   b) Simulation Report of plant model confirming CEA compliance for Dynamic reactive support /LVRT/ HVRT/Frequency control.
   c) Simulation Report of Reactive Capability Curve of Plant measured at POI to ISTS system for compliance of CEA technical standard (for Voltage 0.95/1/1.05 pu with pf ranging from 0.95 lag to 0.95 lead) and short circuit study/Load flow study/harmonics analysis results

iv. Inclusion of EMTP model of plant (in PSCAD platform), benchmarking report of model along with the dynamic model.

v. Harmonic study (Voltage and current harmonics) flicker study at Inverter level, Pooling Switchgear Level and POI. Impedance vs Frequency plot of the plant.

vi. Bidder shall provide the PSSE and PSCAD model and related study report at least 12 months before the schedule commissioning date of the project and Final Updated dynamic model after COD of the entire station (within one month of COD declaration) after site verification and site testing.

vii. Bidder has to ascertain that all the queries of SECI/CTU/RLDC with respect to submitted reports and models are answered to their satisfaction.

viii. Bidder shall update themselves latest requirement for technical data requirement/PSSE/PSCAD Model as per RLDC/CTU. The minimum data required is attached in General Annexure-A for IBR (Inverter Based Resources) to be submitted to SECI for Grid study. Bidder shall submit above documents within 3 months from LoA. However, the final requirement or any other requirement shall be as per RLDC. The simulation study has to be carried out as per POI data (like SCR, X/R etc.) shared by SECI/RLDC/CTU.

ix. Bidder shall install suitable reactive compensation equipment for compliance of dynamic reactive power compensation at rated capacity at POI under CEA technical standard of connectivity to Grid and Report of the Working Group in respect of Data Submission Procedure And Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid by RE Generators July 2022 and it's amendments/clarifications thereof.

x. Bidder shall measure harmonic content, DC injection and flicker at least once in a year in line with the provisions mentioned as per CEA Technical Standards for Connectivity to the Grid, 2007. Bidder shall ensure that the power quality values at POI are within the limit specified as per CEA Technical Standards for Connectivity to the Grid, 2007. This measurement shall be done every year till the completion of O&M and report shall be submitted to RLDC/SECI for verification to ensure compliance.

xi. All equipment, materials and services whether explicitly stated or Not in Technical Specifications or anywhere in the tender documents but that are necessary for the successful commissioning of BESS Plant as per latest statutory regulations/ procedures/ clarifications/ Advisories/ OMs/ Guidelines/ standard issued by bodies like CERC/ SERC/ CEA/ RLDC/ NLDC/ SLDC/ CTU/ STU/ MNRE, other Ministry etc.

4.5. Design of associated civil, structural, electrical & mechanical auxiliary systems includes preparation of single line diagrams and installation drawings, manuals, electrical layouts, erection key diagrams, electrical and physical clearance diagrams, design calculations for Earth- mat, Bus Bar & Spacers indoor and outdoor lighting/ illumination etc., GTP and GA drawings for the major equipment including transmission line, design basis & calculation sheets, and other relevant drawings and documents required for engineering of all facilities within the periphery to be provided under this contract.

4.6. All drawings shall be fully corrected to match with the actual "As – Built" site conditions and submitted to Employer after commissioning of the project for record purpose. All as-built drawings must include the Good for Construction deviation list.

4.7. The Contractor shall submit technical connection data, inter alia, dynamic simulation data, details of data & voice communication within one month of signing the LOA. In case, technical data is subjected to change during detailed engineering, the contractor shall furnish the tentative technical data within one month of signing the LOA & shall furnish the final technical data not later than six (6) months from award of work.

4.8. The technical connection data shall be submitted as per "Detailed Procedure for Connectivity and GNA" under Regulation 39.1" of the Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter-State Transmission System) Regulations, 2022.

4.9. The contractor shall ensure that Generating Plant comply with "Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007" & subsequent amendments. The plant shall be capable of reactive power support in line with regulations & its amendments/clarifications.

4.10. The contractor shall ensure that Generating Plant comply with "Central Electricity Authority (Grid Standards) Regulations, 2010" & subsequent amendments.

5. Procurement & Supply

The scope of procurement and supply including testing at manufacturer's works, packing, transportation, transit insurance, receipt, unloading, storage at site of equipment and materials for Battery Energy Storage System Plant with associated system shall be as follows::

5.1. AC Cables (LT & HT) of appropriate size and rating along with cable termination kits, ferrules / tags, conduits, cable ties and other materials required for cable laying and termination at PCU and Inverter Duty Transformer terminals.
Note: Inverter output shall be at 690 V.

5.2. Inverter duty transformers of appropriate rating including fire protection system, as applicable.

5.3. 33 kV Switchgear Panels including Vacuum / SF6 Circuit Breakers, Current Transformers, Voltage Transformers, Relays, and other accessories for complete protection at the inverter stations. The 33kV Switchgear panels shall be placed on elevated platform with overhead canopy.

5.4. 33 kV Cable including Cable Termination Kits and associated accessories from 33 kV Switchgear of inverter stations to 33/220 kV Pooling Substation.

5.5. 33/220 kV Pooling Substation with required no. of 33/220 kV transformers, 220 kV Bays including Substation Automation System. Busbars, Equipment of Line Bay and Bus Coupler Bay.

5.6. ABT meters with all necessary metering rated CTs and PTs at the plant take-off point as well as at the interconnecting substation as per CEA Metering Regulations 2006 as amended time to time and state metering code.

5.7. Any other equipment / system required to comply with the relevant Procedures / Regulations issued by CEA/ CERC/ any other statutory body for connectivity to the Grid.

5.8. 220 kV Over Head Transmission Line / Under Ground Cable (suitable for evacuation of 600 MVA) including Towers, Conductors, OPGW cable, Insulators, Cable Termination Kits and associated accessories from 33/220 kV Pooling Substation to

Interconnecting Substation as per CTU drawings/specifications including Right of Way, permits and approvals, CTU supervision and maintenance charges.

5.9. The Contractor shall provide provision to integrate Special Protection Scheme (SPS), if required, in case the RLDC requires the same. In that event, details of SPS and its setting shall be worked out in consultation with RLDC & RPC.

5.10. Fibre Optic based communication system comprising of OPGW cable (having minimum 12 fibres) and hardware fittings for the transmission line and FOTE (STM-16) terminal equipment, FODP, approach cables and other associated equipment/accessories at Pooling Substation and interconnecting substation as per CTU specifications. The communication system shall facilitate for telemetry data communication, voice communication and tele-protection.

5.11. Phasor Measurement Units (PMU), and other associated equipment/accessories at the Pooling Substation as per CEA (Technical standard for construction of Electrical Plants & Electric Lines), Regulations, 2022 & amendments thereof.

5.12. Auxiliary supply system including auxiliary transformers, distribution panels, cables, and related accessories for plant internal consumption.

5.13. Uninterrupted Power Supply (UPS) including Batteries, Distribution Boards, Cables, and associated equipment.

5.14. Battery Bank, Battery Charger, Distribution Boards, Cables and associated equipment.

5.15. LT Power and Control Cables including end terminations and other required accessories.

5.16. Communication cables including end terminations and other required accessories.

5.17. Supervisory Control and Data Acquisition (SCADA) and Power Plant Controller (PPC) for remote monitoring/control of plant facilities.

5.18. Data Acquisition System and communication infrastructure to transfer real time data to SLDC / RLDC.
Note: Next Generation Firewall (NGFW) shall be provided as per specifications mentioned in "Firewall Specifications for ISTS stations" at CTU website.

5.19. Earthing system including earth strip/cables, earth electrodes, earth enhancing compound and all other associated materials for complete earthing of the plant.

5.20. Lightning Protection System for entire plant area.

5.21. LED luminaries with diffuser for illumination, lighting poles, distribution boxes and power supply cables along with required conduits, fittings, etc.

5.22. Weather monitoring station shall include but not be limited to the following:

- Ultrasonic Anemometer (wind speed and direction) – 6 (six) nos.
- Ambient Temperature Sensor – 6 (six) nos.
- Sensors required for measurement of following parameters
  i. Rainfall (mm) – 6 (six) nos.

ii. Relative humidity (%) – 6 (six) nos.

- Power source to the all sensors wherever required
- Data Logger

5.23. CCTV cameras with monitoring station along with mounting poles, power supply cables, communication cables, network switches, conduits, fittings, etc.

5.24. Fire detection and fire protection system in buildings/containers, inverter / transformer yard and switchyard.

5.25. Testing instruments as specified.

5.26. Mandatory spares as specified in General Annexure-C.

5.27. Supply of site office (Portable Cabin type) for SECI during construction.

5.28. Any other equipment / material, not mentioned but required to complete the BESS Power Plant facilities in all respect.

6. Installation, Testing and Commissioning

The takeover point of the Contractor shall be the terminals of the PCS supplied by the Employer's DC Package Supplier (under Employer's separate DC Package Contract). The scope of installation, testing and commissioning for the plant facilities shall include, but not limited, to the following:

6.1. Laying of AC LT cables along cable trays from Power Conditioning System to Inverter transformer along with termination at both the ends.

6.2. Installation, Testing and Commissioning of Inverter transformers including fire protection system.

6.3. Installation, Testing and Commissioning of 33 kV Switchgear panels in BESS yard.

6.4. Laying of AC cables from Inverter transformer to 33 kV Switchgear panels in BESS yard along with termination at both the ends.

6.5. Installation, Testing and Commissioning of 33 kV Cable from 33 kV Switchgear panels in BESS Yard to 33 kV Outdoor bays in 33/220 kV Substation along with termination at both the ends including Right of Way, permits and approvals.

6.6. Installation, Testing and Commissioning of 33/220 kV Substation with required number of 33 kV outdoor bays, 33/220 kV transformers and 220 kV Bays.

6.7. Installation, Testing and Commissioning of ABT meters with all necessary metering rated CTs and PTs at Plant take-off point as well as at Interconnecting Substation as per CEA Metering Regulations 2006 as amended time to time and state metering code.

6.8. Installation, Testing and Commissioning of 220 kV Over Head Transmission Line / Underground Cable from 33/220 kV Pooling Substation to Interconnecting Substation as per CTU drawings/specifications including Right of Way, permits and approvals, CTU supervision and maintenance charges.

6.9. Installation, Testing and Commissioning of 220 kV bay and associated accessories for

integration of BESS Plant at the interconnecting substation as per CTU drawings/specifications including shifting or replacement of substation equipment / materials, permits and approvals, CTU supervision and maintenance charges.

6.10. Installation, Testing and Commissioning of Fibre Optic based communication system comprising of OPGW cable (having minimum 12 fibers) and hardware fittings for the transmission line and FOTE (STM-16) terminal equipment, FODP, approach cables and other associated equipment/accessories at Pooling Substation and interconnecting substation as per CTU specifications. The communication system shall facilitate for telemetry data communication, voice communication and tele-protection.

6.11. Installation, Testing and Commissioning of Phasor Measurement Units (PMU) and other associated equipment/accessories at the Pooling Substation as per CEA (Technical standard for construction of Electrical Plants & Electric Lines), Regulations, 2022 & amendments thereof.

6.12. Installation, Testing and Commissioning of auxiliary power supply system consisting of auxiliary transformers, AC distribution boards, AC LT cables and related accessories.

6.13. Installation, Testing and Commissioning of Uninterrupted Power Supply (UPS), Distribution boards, Cables, and related accessories.

6.14. Installation, Testing and Commissioning of Battery Bank, Battery Charger, Distribution boards, Cables, and related accessories.

6.15. Laying of LT Power and Control Cables along with termination at both the ends.

6.16. Installation, Testing and Commissioning of SCADA, Power Plant Controller along with suitable communication system for interfacing Energy Management System and Field devices like Inverter Transformers, 33 kV Switchgear Panels, Power Transformers, Control and Relay Panel, UPS, Fire alarm panel, WMS and other equipment with SCADA, remote monitoring capabilities and internet facility equipped with functionality as per Central Electricity Authority (Technical Standards for Connectivity to the Grid) (Amendment) Regulations, 2019. The testing and commissioning of EMS and SCADA shall take place jointly with the DC Package Contractor (refer Responsibility Matrix).

6.17. Installation, Testing and Commissioning of Telemetry System for communication of Plant Data to SLDC / RLDC.

6.18. Earthing of Switchgear panels, Transformers, and all other electrical equipment.

6.19. Installation of lightning protection system for entire plant facilities.

6.20. Installation of illumination system including all required accessories and laying of power supply cables.

6.21. Installation, Testing and Commissioning of Weather Monitoring Station along with laying of required power supply and communication cables.

6.22. Installation of CCTV cameras on strategic locations including all required accessories, laying of power/communication cables and installation of monitoring station.

6.23. Installation of fire detection and fire protection system for buildings/containers, transformer yard and switchyard.

6.24. Pre-commissioning checks and tests for all equipment.

6.25. Synchronization and Commissioning of plant.

6.26. Any other works related to installation, testing and commissioning not mentioned but required to complete the BESS Plant facilities in all respect.

7. Civil Works

The scope of civil works for the plant facilities shall include, but not limited, to the following.

7.1. Conducting topographical survey of the plant area is in the scope of the Contractor. Contour map attached in Specific Annexure – A is only for reference and general information of the bidder. No warranty is expressed or implied that such information, given in good faith, will represent a complete or accurate picture of the whole of the site. The Employer shall not be responsible for any variation in topography, if observed, during detailed topographical survey to be carried out by the Contractor during contract execution and there shall be no compensation what so ever in the contract price on this account.

7.2. Conducting geotechnical investigation of the plant area

7.3. Clearing plant site and transmission line corridor by cutting of trees, bushes and shrubs including disposal of waste material.

7.4. Earthwork for site grading, cutting, filling, levelling and compaction of land.

7.5. Construction of chain link fence around the entire designated plant site, including one entry gate (Refer Annexure).

7.6. Construction of foundation and / or mounting structure for LT Switchgear panel, Inverter Transformer, Auxiliary Transformer, 33 kV Switchgear panel, Power Transformer, Substation / Switchyard Equipment, lighting mast, watch tower, lightening arrestor and other electrical equipment. Mounting structure of 220 kV substation equipment and gantry shall be as per CTU drawings.

7.7. Construction of Main Control Room.

7.8. Construction of outdoor storage shed of area sufficient enough to store spares.

7.9. Contractor shall provide storage areas within the plant area to receive and store BESS Containers and PCS. The storage areas shall be levelled hard ground free from water logging.

7.10. Construction of one security room at main gate and watch towers at every land parcel / one for every 200 acres of land parcel inside the boundary of the plant.

7.11. Construction of fence for transformer yard, and 33/220 kV Pooling Substation.

7.12. Construction of foundation and / or mounting structure for Weather Monitoring Station

and associated civil works.

7.13. Construction of foundation for Lighting poles, CCTV poles and other equipment.

7.14. Construction of foundation for 220 kV Underground Cables from 33/220 kV BESS Substation to Interconnecting Substation and associated civil works.

7.15. Construction of foundation and / or mounting structure for 220 kV Switchgear Bay and associated accessories for integration of BESS Plant at the Interconnecting Substation as per CTU drawings/specifications.

7.16. Construction of approach roads, access roads, internal roads, and peripheral roads, as applicable.

7.17. Construction of storm water drainage network for smooth disposal of storm water from the plant to the nearest available drainage outlet.

7.18. Suitable arrangement of water shall be ensured to cater to day-to-day requirement of drinking water and permanent water supply during entire O&M period.

7.19. Erection of site office (portable cabin type) for SECI during construction.

7.20. Any other civil works not mentioned but required to complete the BESS Power Plant facilities in all respect.

8. Statutory Approvals

8.1. Obtaining statutory approvals /clearances/ compliances on behalf of the Employer from various Government Departments, not limited to, the following:

- Pollution control board clearance, if required
- Mining Department, if required
- Forest Department, if required
- All other approval as and when, as necessary for setting up of the BESS power plant including CEIG/ CEA, power evacuation, etc. as per the suggested guidelines.

8.2. All statutory approvals / permissions and/or No Objection Certificates (NoC) etc. from DISCOM / STU / CTU for interconnection of BESS plant at the substation.

8.3. All royalties and taxes as required to be paid for excavation of earth / rocks / sand shall be borne by the Contractor.

8.4. The Contractor shall comply all provisions of the following regulations and amendments thereof.

Central Electricity Authority (CEA) Regulations:

- CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007
- CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022
- CEA (Grid Standards) Regulations, 2010
- CEA (Safety Requirements for Construction, Operation, and Maintenance of Electrical Plants and Electric Lines) Regulations, 2011

- CEA (Measures Relating to Safety and Electric Supply) Regulations, 2010
- CEA (Installation and Operation of Meters) Regulations, 2006
- CEA (Technical Standards for Communication System in Power System Operations) Regulations, 2020
- CEA (Cyber Security in Power Sector) Guidelines, 2021
- CEA (Manual of Communication Planning in Power System Operations), 2022

Central Electricity Regulatory Commission (CERC) Regulations:

- CERC (Communication System for Inter-State Transmission of Electricity) Regulations, 2017
- CERC (Indian Electricity Grid Code) Regulations, 2023
- CERC (Connectivity and General Network Access to the Inter-State Transmission System) Regulations, 2022
- CERC 'Detailed Procedure for Connectivity and General Network Access' under the Connectivity and General Network Access Regulations, 2022
- CERC (Grant of Connectivity, Long-Term Access, and Medium-Term Access in Inter-State Transmission and Related Matters) Regulations, 2009 (as applicable under extant procedures)
- CERC's Revised Procedure for Grant of Connectivity to Projects Based on Renewable Sources to Inter-State Transmission System (as applicable under extant procedures)

Ministry of Power (MoP) Orders:

- MoP Order dated 02.07.2020 on measures to protect the security, integrity, and reliability of the critical power supply system and network.

Miscellaneous Guidelines and Reports:

- Report of the Working Group on Data Submission Procedure and Verification of Compliance with CEA Regulations on Technical Standards for Connectivity to the Grid by Renewable Energy Generators, July 2022
- MNRE/CEA/MoP Guidelines, Office Memorandums (OMs), Advisories, or Clarifications (as applicable).
- Any Other Applicable Standards, Regulations, Guidelines, Clarifications, OMs, Advisories, or Procedures.

8.5. The Contractor shall comply with Section-2 (Procedure for Integration of Solar, Wind or Hybrid Power Plant/Wind or Solar Power Parks, WPD/SPD/HPD those are regional entities) of NLDC's Procedure for First Time Charging/Energization (FTC) and Integration of New or Modified Power System Element dated 3rd June, 2020 and amendments thereof.

8.6. The Contractor shall comply with 'Report of the Working Group in respect of Data Submission Procedure and Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid by RE Generators' and amendments thereof.

8.7. All other statutory approvals and permissions and their respective compliances, not mentioned specifically but are required to carry out hassle free Construction and O&M of the plant.

8.8. Adequate and seamless insurance coverage during EPC and O&M period to mitigate all risks related to construction and O&M of the plant to indemnify the Employer.

8.9. The Contractor shall comply with the provision of all relevant acts of Central or State Governments including payment of Wages Act 1936, Minimum Wages Act 1948, Employer's Liability Act 1938, Workmen's Compensation Act 1923, Industrial Dispute Act 1947, Maturity Benefit Act 1961, Mines Act 1952, Employees State Insurance Act 1948, Contract Labour (Regulations & Abolishment) Act 1970, Electricity Act 2003, Grid Code, Metering Code, MNRE guidelines or any modification thereof or any other law relating whereto and rules made there under or amended from time to time.

9. Operation and Maintenance

9.1. Total Operation & Maintenance of the BESS Plant shall be with the AC Contractor under an O&M Contract as per the terms and conditions of O&M Agreement (Section – XIII Operation & Maintenance Agreement), after commissioning of the plant till culmination of the O&M period and shall include deployment of engineering personnel, technicians and security personnel.

9.2. To provide a detailed training plan for all O&M procedures to Employer's nominated staff, which shall have prior approval from the Employer.

9.3. Employ and coordinate the training of contractors' personnel who will be qualified and experienced to operate and monitor the facility and to coordinate operations of the facility with the grid system.

9.4. Discharge obligations relating to retirement/ Superannuating benefits to employees or any other benefit accruing to them in the nature of compensation, profit in lieu / in addition to salary, etc. for the period of service with the contractor, irrespective continuance of employees with the project as employees of Contractor, after conclusion of O&M period.

9.5. To maintain accurate and up-to-date operating logs, records and monthly Operation & Maintenance reports at the facility. Contractor shall keep the measured daily data at regular intervals and provide the same to Employer in electronic form, compatible in CSV format. The right to use the data shall remain with the Employer.

9.6. The Contractor shall establish forecasting tools for submitting schedule and comply with respective CERC/SERC Regulations on Forecasting, Scheduling and Deviation settlement of generation. The scope under this Clause shall also include establishing and maintaining forecasting tools and appointment of QCA/Aggregator, if required. % Error

(Deviation) shall be calculated as per the said regulations and DSM Charges in case of deviation beyond the permissible limits shall be borne by the Contractor.

9.7. Procurement of spare parts, overhaul parts, tools & tackles, equipment, consumables, etc. required for smooth operation and maintenance of the plant as per prudent/ standard utility practices, OEM recommendations and warranty clauses for the entire O&M period.

9.8. To upkeep all administrative offices, roads, tool room, stores room, equipment in clean, green and workable conditions.

9.9. To carry out periodic overhauls or maintenance required as per the recommendations of the original equipment manufacturer (OEM) and to furnish all such periodic maintenance schedules at the time of plant commissioning/ start of O&M contract.

9.10. Handover the system to maintain an inventory of spare parts, tools, equipment, consumables and supplies for the facility's operation along-with required details of recommended spares list with all associated information regarding replacement records, supplier details, tentative cost, storage details, specifications on the basis of replacement frequency and mean time between failures and mean time to restore at the culmination of penultimate year under O&M period.

9.11. The contractor shall be responsible for all the required activities for the successful running, committed energy generation & maintenance of the BESS Plant covering:

- Deputation of qualified and experienced engineers and technicians at the facility.
- Deputation of Security personnel for the complete security of plant.
- Successful running of BESS Plant for committed performance.
- Co-ordination with CTU/other statutory organizations as per the requirement on behalf of Employer for Joint Metering Report (JMR), furnishing generations schedules as per requirement, revising schedules as necessary and complying with grid requirements.
- Monitoring, controlling, troubleshooting maintaining of logs & records, registers.
- Furnishing generation data monthly to Employer by 1st week of every month for the previous month to enable Employer raise commercial bills on consumers.
- Replacement of Battery Modules, Inverters/PCS and other equipment as and when required during the O&M period without additional cost to Employer

9.12. Continuous monitoring the performance of the BESS Plant and regular maintenance of the whole system including Battery Modules, PCSs, transformers, overhead line, outdoor/indoor panels/ kiosks etc. are necessary for extracting and maintaining the performance of the BESS Plant.

9.13. Preventive and corrective O&M of the BESS Plant including supply of spares, consumables, wear and tear, overhauling, replacement of damaged modules, inverters/PCSs and insurance covering all risks (Fire & allied perils, earth quake, terrorists, burglary and others) as required.

9.14. The period of Operation and Maintenance will be deemed to commence from the date

of commissioning and successively the complete BESS Plant to be handed over to the O&M contractor for operation and maintenance of the same. O&M contract shall further be extended on the mutually agreed terms and conditions for the mutually agreed period.

9.15. All the equipment required for Testing, Commissioning and O&M for the healthy operation of the Plant must be calibrated, time to time, from the NABL accredited labs and the certificate of calibration must be provided prior to its deployment.

9.16. The Contractor shall ensure that all safety measures are taken at the site to avoid accidents to his or his sub-contractor or Employer's Workmen. This will include procurement of all safety gadgets during Construction and O&M period including but not limited to, rubber mats of appropriate grade, PPE, rubber gloves and suitable shoes etc.

10. Operation and Performance Monitoring

10.1. Operation part consists of deputing necessary manpower necessary to operate the BESS Plant at the full capacity. Operation procedures such as preparation to starting, running, routine operations with safety precautions, monitoring etc., shall be carried out as per the manufacturer's instructions to have trouble free operation of the complete system. The Contractor shall ensure continuous, un-uninterrupted Plant Operation and Monitoring as per this Clause (Clause 10) and sub-clauses therein, for the period commencing from Plant Commissioning to the signing of the O&M Agreement.
Note: The Employer shall enter into an O&M Agreement with the Contractor as per Section-XIII: Operation & Maintenance Agreement subsequent to Plant Operational Acceptance.

10.2. Daily work of the operation and maintenance in the BESS Plant involves regular checking of container temperature, humidity, HVAC status, and fire suppression system functionality, periodic automatic/manual check of key performance indicators (KPIs) like SoC and SoH, review of SCADA and/or EMS dashboards for alarms, energy throughput, charge-discharge events, ensuring seamless communication between BESS Containers, PCS, SCADA etc., ensuring system area cleanliness, no obstructions and safe access to equipment. The operator shall record monthly energy output, down time, etc. DC Package Supplier shall enter into a Service Level Agreement (SLA) with SECI. The AC Package Contractor shall enforce the SLA on behalf of SECI.

10.3. Earth resistance of Plant as well as individual earth pit is to be measured and recorded every month. If the earth resistance is high (compared to standards) suitable action is to be taken to bring down the same.

10.4. A maintenance record is to be maintained by the operator/ O&M-in-charge to record the regular maintenance work carried out as well as any breakdown maintenance along with the reasons for the breakdowns and steps taken to attend the breakdown, duration of the breakdown etc.

10.5. The Preventive Maintenance Schedules will be drawn such that some of the jobs other than breakdown, which may require comparatively long stoppage of the Power Plant, shall be carried out preferably during the non-sunny days or evenings. Prior information

shall be provided to the Employer for such preventive maintenance prior to start.

10.6. The Contractor will attend to any breakdown jobs immediately for repair/ replacement/ adjustments and complete at the earliest working round the clock. During breakdowns (not attributable to normal wear and tear) in O&M period, the Contractor shall immediately report the accidents, if any, to the Employer showing the circumstances under which it happened and the extent of damage and/or injury caused.

10.7. The contractor shall at his own expense provide all amenities to his workmen as per applicable laws and rules.

10.8. If negligence / mal operation of the contractor's operator results in failure of equipment, such equipment should be repaired/replaced by the contractor free of cost.

11. Security Services

11.1. The contractor has to arrange proper security system including deputation of security personnel at his own cost for the check vigil for the BESS Power Plant for the complete scope of works including comprehensive O&M period.

11.2. The security staff may be organized to work on suitable shift system; proper checking & recording of all incoming & outgoing materials vehicles shall be maintained. Any occurrence of unlawful activities shall be informed to Employer immediately. A monthly report shall be sent to Employer on the security aspects.

11.3. Any other activities required for completion of project, but not specified in the above shall be in the scope of contractor. The Contractor must provide the BOM of the plant as per the design during the time of submission of design basis report. The detailed technical specifications of major equipment to be followed strictly and are described in the technical specification section.

II. TECHNICAL SPECIFICATIONS (TS) – ELECTRICAL SYSTEM

1. Inverter duty and Auxiliary Transformer

Takeover Point: The takeover point of this AC Package (Balance of Plant) Contract shall be the **AC output terminals of the Power Conditioning System (PCS)** which is supplied under the Employer's separate DC Package Contract. All cabling from these terminals to the **BESS Inverter Duty transformer** shall be under the scope of AC Package. The DC Package Supplier shall terminate the PCS output cables inside the PCS cabinet and provide terminal drawings, cable schedules, and load data in advance to the Contractor of this AC Package Contract.

1.1. Standards and Codes

Inverter transformer and auxiliary transformer, wherever applicable, shall comply with the latest edition of the following standards and codes including amendments.

Standard	Description
IS 2026, IEC 60076	Specification of Power Transformers
IS 11171, IEC 60076	Dry-Type Power Transformers
IS 2099, IEC 60137	Bushings for alternate voltage above 1000 V
IS 335, IEC 60296	Insulating oil
IS 3639	Fittings and Accessories for Power Transformers
IS 12063	Degree of protection provided by enclosures
CBIP publication no. 317	
CEA regulations and other statutory regulations	

1.2. Technical Requirements

Parameters	Inverter Transformer	Auxiliary Transformer
VA Rating	As per system design requirement	
Voltage Ratio	33 kV / Inverter output voltage	As per system design
Duty, Service & Application	Converter Duty (Outdoor)	Continuous application (Outdoor/Indoor)
Winding	As per system design requirement	2
Frequency	50 Hz	50Hz
Nos. of Phase	3	3
Vector Group & Neutral earthing	As per system/inverter manufacturer requirement	Dyn11
Cooling	ONAN	ONAN / AN
Tap Changer	OCTC, No. of steps shall be as per system requirement	

Impedance at 75°C	As per Inverter Manufacturer requirement	As per system requirement
Permissible Temperature rise over an ambient of 50°C (irrespective of tap)		
Top Oil	50°C	As per IS/IEC
Winding	55°C	As per IS/IEC
SC withstand time (thermal)	2 second	2 second
Short Circuit Apparent power	As per system requirement	
Termination	As per system requirement	
Bushing rating, Insulation class (Winding & bushing)	36 kV – porcelain bushings 1.1 kV – epoxy bushings	As per the system requirement
Noise level	As per NEMA TR-1	
Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-3%, also transformer shall be capable of being loaded in accordance with IEC 60076-7	
Flux density	Not to exceed 1.9 Wb/sq.m. at any tap position with combined frequency and voltage variation from rated V/f ratio by 10% 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. Bidder shall furnish over fluxing characteristic up to 150%	
Air Clearance	As per IS/IEC	

1.3. Construction

1.3.1. The transformer shall be provided with conventional single compartment conservator with prismatic toughened glass oil gauge. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather with transparent enclosure. Silica gel shall be isolated from atmosphere by an oil seal. Inverter transformers shall be provided with Magnetic Oil Gauge (MOG) with low oil level alarm contact.

1.3.2. It is the responsibility of the Contractor to ensure that the inverter transformer comply with all the requirements of inverter provided by the inverter manufacturer.

1.3.3. Inverter Transformer shall be designed for at least 5% total harmonic distortion (THD) to withstand distortion generated by the inverter as well as possible outside harmonics from the network.

1.3.4. The transformer shall be suitable for continuous operation with a frequency variation of ± 2.5% from nominal frequency of 50 Hz without exceeding the specified temperature rise.

1.3.5. Inverter Transformer shall have shield winding between LV & HV windings. Each LV winding must be capable of handling non-sinusoidal voltage with voltage gradient as specified by the inverter manufacturer. Also, shield winding shall be taken out from tank through shield bushing and the same shall be brought down to the bottom of the tank using copper flat and support insulator for independent grounding.

1.3.6. Neutral earthing of inverter transformer shall be as per the recommendations of inverter manufacturer. Even if neutral earthing is not required, neutral bushing shall be brought outside the tank for the testing purpose. It shall be covered with MS sheet and a sticker "For testing purpose only. Do not earth". Neutral bushing of auxiliary transformer shall be brought outside the tank for earthing.

1.3.7. Transformer shall have 150 mm dial type Oil Temperature Indicator (OTI) and Winding Temperature Indicator (WTI) with alarm and trip contacts. All indicators shall have accuracy of 1.5%. For inverter transformers, WTI shall be provided for all the windings.

1.3.8. The radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/ valve at the bottom and air release plug at the top.

1.3.9. Marshalling Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 10% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Wiring scheme (TB details) shall be engraved in a stainless-steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

1.3.10. Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement shall be provided.

1.3.11. Inverter transformer shall be provided with spring operated Pressure Relief Device (with trip contacts) with suitable discharge arrangement for oil. For Auxiliary transformers, diaphragm type explosion vent shall be provided.

1.3.12. Filter valve at top the tank and drain cum sampling valve at bottom of the tank shall be provided.

1.3.13. All external surface of the transformer shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. Internal surface of cable boxes and marshalling box shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 microns.

1.3.14. LV and HV cable box shall be provided with disconnecting chamber to facilitate the movement of transformer without disturbing cable box and termination.

1.3.15. Air release plug, bi-directional wheel/skids, cover lifting eyes, transformer lifting lugs, jacking pads, towing holes, core and winding lifting lugs, inspection cover, rating plate, valve schedule plate, accessories and terminal marking plates, two nos. of earthing terminals shall be provided.

1.3.16. Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.

1.3.17. The accessories listed above are indicative only. Accessories which are not mentioned above but required for satisfactory operation of the transformers are deemed to be included in the contract without extra charges.

1.3.18. Fire-protection for inverter transformer shall be provided in accordance with relevant CEA regulations as amended time to time.

1.4. Dry Type Auxiliary Transformer

1.4.1. Transformer shall be cast resin encapsulated dry type transformer, made of cold rolled grain-oriented silicon steel laminations of M4 grade or better. Winding conductor shall be electrolytic grade Copper/Aluminium and insulation shall be Class F or better.

1.4.2. The transformers shall be housed in a metal protective housing, having a degree of protection of IP 23 suitable for indoor installation. The enclosure shall be provided with suitable hardware and accessories required for satisfactory operation of the transformer per the relevant standard.

1.5. Warranty

The transformer shall be warranted against all material/ manufacturing defects and workmanship for minimum of 5 (five) years from the date of supply.

1.6. Testing and Inspection

1.6.1. Type Tests and Special Tests

The following type test and special test reports shall be submitted during detailed engineering. The tests should have been conducted on the similar transformer by NABL accredited laboratory within last five years from the last date of bid submission.

1.6.1.1. Type Tests

i. Lightning impulse (Full & Chopped Wave) test on windings as per IEC 60076-3
ii. Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076-2
iii. Tank vacuum test & pressure test as per CBIP manual

1.6.1.2. Special Tests

i. Measurement of zero-sequence impedance as per IEC 60076-1
ii. Measurement of harmonics of no-load current as per IEC 60076-1
iii. Measurement of acoustic noise level as per NEMA TR-1
iv. Short-circuit withstand test as per IEC 60076-5

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by Employer.

1.6.1.3. Type tests mentioned in Clause 1.6.1.1(ii) & (iii) shall be performed for auxiliary transformers. Special tests are not required.

1.6.2. Routine Tests

Each completed transformer shall be subjected to following routine tests as per the latest edition of IEC 60076 unless specified otherwise.

i. Measurement of winding resistance at each tap
ii. Measurement of voltage ratio between HV and LV windings at each tap
iii. Check of vector group
iv. Measurement of no-load loss and no-load current
v. Measurement of short-circuit impedance and load loss
vi. Magnetic balance test as per CBIP manual publication no. 295
vii. Separate source voltage withstand test
viii. Induced over voltage withstand test
ix. Measurement of insulation resistance
x. Marshalling box functional test
xi. IR Measurement on wiring of marshalling box
xii. Breakdown voltage test on transformer oil as per IS 335
xiii. Oil leakage test on completely assembled transformer (along with radiators on at least one equipment of each type and rating)

1.6.3. Tests at Site

After erection at site all transformer(s) shall be subjected to the following tests.

i. Measurement of voltage ratio
ii. Check of vector group
iii. Magnetic balance test
iv. Measurement of insulation resistance
v. Breakdown voltage test on transformer oil

In case the equipment is not found as per the requirements of the Technical Specifications of NIT, all expenses incurred during site testing will be to the Contractor's account and the equipment shall be replaced by him at free of cost.

2. 33 kV Switchgear Panel

2.1. Standards and Codes

All equipment provided under HT switchgear shall comply with latest editions and amendments of the relevant IEC standards and IS codes. In particular, the switchgear shall comply with the following standards and codes.

Standard/Code	Description
IS/IEC 62271-1	High Voltage Switchgear and Control gear - Part 1: Common Specifications
IS/IEC 62271-100	High Voltage Switchgear and Control gear - Part 100: AC Circuit Breakers
IS/IEC 62271-102	High Voltage Switchgear and Control gear - Part 102: AC Disconnectors and Earthing Switches
IS/IEC 62271-200	High Voltage Switchgear and Control gear - Part 200: AC Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
IEC 62271-206	High-voltage Switchgear and Control gear - Part 206: Voltage presence indicating systems for rated voltages above 1 kV and up to and including 52 kV
IEC 61869 / IS 16227	Instrument Transformers
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment
IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV
IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 15086-4	Surge Arresters, Part 4: Metal-Oxide Surge Arresters Without Gaps for A.C. systems
IEC 62052-11	Electricity metering equipment (A.C.) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) - Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

2.2. Technical Parameters

Parameter	Specification
System Parameters	
Highest system voltage	36 kV
Rated system voltage	33 kV
Rated frequency	50 Hz
Number of phases	3
Power frequency withstand voltage	70 kV (r.m.s.)
Lightning impulse withstand voltage	170 kV (peak)
System fault current	25 kA / 1s
Internal Arc Classification	IAC-A, FLR, System Fault Current for 1s
RMU Requirement: 3 VCBs, 1 Metering PT((2 cores, 50 VA), 1 Cast Resin Power VT (250 VA)	
Circuit Breaker	
Type	Vacuum type
Operating duty cycle	O – 0.3 sec – CO – 3 min – CO
Short circuit breaking current	As per system requirement
Short circuit making current	2.5 times S.C. breaking current
Re-strike performance class	C1
Mechanical endurance class	M1
Current Transformer	
Accuracy class	0.2 for metering (0.2S for metering at outgoing feeder), 5P20 for protection
Rated VA burden	As per requirement
Insulation class	Class E or better
Voltage Transformer	
Accuracy class	0.2 for metering, 3P for protection
Rated VA burden	As per requirement
Insulation class	Class E or better

2.3. Switchgear Panel

2.3.1. The switchgear panel shall be free standing, floor mounted, single front, single tier fully compartmentalized, metal enclosed construction. Each panel shall have separate compartments for circuit breaker, bus bars, cable termination and auxiliary circuit.

2.3.2. The circuit breakers shall be mounted on horizontally withdrawable trucks with locking facility in SERVICE and TEST positions.

2.3.3. The panel enclosure shall be constructed with CRCA steel/Aluzinc sheet. The thickness of load bearing members shall be minimum 3 mm and that of non-load bearing members shall be minimum 2 mm.

2.3.4. All surfaces shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. The minimum dry film thickness (DFT) shall be 100 micron.

2.3.5. The circuit breaker and auxiliary circuit compartments provided on the front side shall have separate concealed hinged doors. Cable and bus bar compartments provided on the rear side shall have separate bolted covers. All doors and covers shall be provided with neoprene/synthetic rubber gaskets to prevent entry of vermin and dust.

2.3.6. Pressure relief device shall be provided in each high voltage compartment of a panel to safely vent the gases in the event of internal arc. Seal-off bushing arrangement shall be provided between the breaker compartment and bus bar/cable compartments to prevent transfer of arc from one compartment to other.

2.3.7. Automatic safety shutters shall be provided to cover up the fixed high voltage contacts on bus bar and cable sides when the truck is moved to TEST position.

2.3.8. Degree of protection shall not be less than IP 5X for auxiliary circuit compartment. However, for remaining compartments it shall not be less than IP 4X. For outdoor panels, degree of protection shall not be less than IP 55.

2.3.9. Mechanical /Electrical interlocks shall be provided to prevent mal-operation and in particular to ensure the following.

i. The breaker shall be operated only if it is in SERVICE or TEST position.
ii. Movement of the breaker truck between SERVICE and TEST positions shall be possible only if the breaker is OFF.
iii. It shall be possible to open the door only when the breaker is in TEST position.

2.3.10. Each switchgear panel shall be provided with thermostatically controlled space heaters, separately for breaker, cable and bus bar compartments, to prevent condensation within the compartment. The space heater shall be connected to 240 V, 50 Hz, single phase AC supply through suitable switch and fuse.

2.3.11. 240 V, 5 A, SPN industrial socket-outlet with ON/OFF switch shall be provided in each panel.

2.3.12. Each panel shall be provided with LED lamp rated for 240 V, 50 Hz, single phase AC supply for interior illumination controlled by door switch.

2.3.13. Gapless, metal-oxide surge arrestors shall be provided between line and earth in cable compartment of the switchgear panel.

2.3.14. Suitable lifting hooks shall be provided for each panel.

2.4. Circuit Breakers

2.4.1. Circuit breakers shall be of vacuum type. It shall comprise of three separate identical single pole units operated through the common shaft and shall be fully interchangeable both electrically and mechanically.

2.4.2. The circuit breaker operating mechanism shall be based on motor operated spring charging and it shall be re-strike free, trip free both electrically and mechanically, with anti-pumping feature.

2.4.3. The rated control voltage shall be 110 VDC/220 VDC. The closing coil and spring charging motor shall operate at all values of control voltage between 85% and 110% of rated voltage. The shunt trip coil shall operate correctly under all operating conditions of the circuit breaker up to the rated short-circuit breaking capacity and at all values of control voltage between 70% and 110% of rated voltage.

2.4.4. Each circuit breaker shall be provided with two tripping coils operated through two independent DC supplies. Each trip coil shall have its own actuating contacts.

2.4.5. The spring charging motor shall have adequate thermal rating such that continuous sequence of the closing and opening operations is possible as long as power supply is available to the motor. It shall also be possible to charge the spring manually and close the breaker in the event of failure of motor / control supply to motor. Operating handle shall be provided for charging the operating mechanism. After failure of control supply to the motor, one open-close-open operation shall be possible with the energy contained in the operating mechanism.

2.4.6. The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring. Closing action of the circuit breaker shall compress the opening spring ready for tripping. When closing springs are discharged after closing the breaker, they shall be automatically charged for the next operation.

2.4.7. Mechanical indicators shall be provided to indicate OPEN/CLOSED positions of the circuit breaker and CHARGED/ DISCHARGED positions of the closing spring. An operation counter shall also be provided. These indicators and counter shall be visible from the panel front door without opening it.

2.5. Relays

2.5.1. All relays shall be microprocessor based numerical type. However, auxiliary relays can be static or electromechanical type. The relays shall be flush mounted on panel front with connections from the inside.

2.5.2. Auxiliary voltage of the relays shall be 110 VDC / 220 VDC and the relays shall be capable of operating continuously between 80 – 120% of auxiliary voltage.

2.5.3. All numerical relays shall have adequate number of freely configurable, optically

isolated, Binary Inputs (BI) and potential free Binary Outputs (BO).

2.5.4. All numerical relays shall have minimum four no. of current inputs, three for phase current and one for earth current, suitable for CT secondary current of 1A. The current inputs shall be compatible with both residual connected CT and Core Balance CT (CBCT). In addition, numerical relay in main outgoing feeder shall have three no. of voltage inputs for Under Voltage/Over Voltage protection.

2.5.5. All I/O's shall have galvanic isolation. Analog inputs shall be protected against switching surges and harmonics.

2.5.6. Making, breaking and continuous capacity of the relay contacts shall be adequate enough for the circuits in which they are used.

2.5.7. The numerical relay shall have the following protection functions with at least two independent protection setting groups. The protection functions shall be selectable from any of the IEC characteristic curves.

i. Definite time (DT) phase over current protection
ii. Inverse Definite Minimum Time (IDMT) phase over current protection
iii. Definite time (DT) earth fault current protection
iv. Inverse Definite Minimum Time (IDMT) earth fault current protection
v. Under Voltage protection
vi. Over Voltage protection

2.5.8. Transformer feeder protection relay shall have provision for the following protection functions.

i. Buchholz alarm & trip
ii. Oil Temperature Indicator (OTI) alarm & trip
iii. Winding Temperature Indicator (WTI) alarm & trip
iv. Pressure Relief Valve (PRV) trip
v. Magnetic Oil Gauge (MOG) alarm

2.5.9. All numerical relays shall have provision for measurement and storage of electrical parameters such as voltage, current, frequency, active power, reactive power etc.

2.5.10. The numerical relay shall be able to record faults and events in non-volatile memory.

i. Fault record – At least 5 recent faults including the protection function operated, operating phase(s), voltages and currents along with date and time stamp.
ii. Event record – At least 200 events with date and time stamp.

2.5.11. The numerical relay shall have trip circuit supervision facility to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions. The relay shall also be able to provide circuit breaker monitoring, CT and VT supervision.

2.5.12. The numerical relay shall have self-diagnostic feature with separate output contact for indication of any internal relay failure.

2.5.13. The numerical relay shall have feature for time synchronization through the SCADA System / networking.

2.5.14. The numerical relay shall be provided with backlit alphanumeric LCD to access protection settings, measurement parameters, fault and event records. Read and write access to protection settings shall be password protected.

2.6. Instrument Transformers

2.6.1. Instrument transformers shall be completely encapsulated cast resin type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchgear is operating at its rated load and the outside ambient temperature is 50°C.

2.6.2. Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

2.6.3. Voltage transformers shall be single phase units. Bus voltage transformers shall be housed in a separate panel on withdrawable truck.

2.6.4. HRC fuses of suitable rating shall be provided on primary side of voltage transformers. For secondary side, four pole Miniature Circuit Breakers (MCB) shall be provided.

2.7. Earthing

2.7.1. An earth bus made of copper shall be provided throughout the length of the panel. It shall be bolted to the framework of each panel and brazed to each breaker earthing contact bar.

2.7.2. The earth bus shall have sufficient cross section to carry maximum fault current without exceeding the allowable temperature rise.

2.7.3. All non-current carrying conductors of the panel shall be connected to the earth bus. All joints to the earth bus shall be made through at least two bolts. Hinged doors shall be earthed through flexible earthing braid of adequate cross section. Suitable provision shall be provided at each end of the earth bus for connection with Employer's Earth conductor.

2.7.4. Positive earthing of the breaker truck and frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

2.7.5. All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth bus by independent copper wires of size not less than 2.5 sq. mm with green colour insulation.

2.7.6. Instrument transformer secondary neutral point shall be earthed at one place only on the terminal block. Such earthing shall be made through links so that earthing of one circuit may be removed without disturbing the earthing of other circuits.

2.7.7. Separate earthing trucks shall be provided for earthing of busbars and incoming/outgoing feeders. The trucks shall have voltage transformer to indicate presence of voltage prior to earthing. An audible alarm shall also be provided in case of voltage on the earthing terminal. Integral earth switches may also be considered

instead of earthing trucks. The earthing truck/switch shall have short circuit withstand capability equal to that of the associated switchgear panel.

2.7.8. The interlocks shall be provided to ensure the following.

2.7.9. It is not possible to rack-in the earthing truck/close the earthing switch when the breaker truck is in SERVICE position.

2.7.10. It is not possible to rack-in the breaker truck into SERVICE position when earthing truck is connected/earthing switch is in closed position.

2.8. Bus bar

2.8.1. Bus bar shall be made of copper or aluminium with uniform cross section throughout their length. They shall be adequately supported on insulators to withstand electrical and mechanical stresses due to specified short circuit current.

2.8.2. All bus bars joints shall be thoroughly cleaned and anti-oxide grease shall be applied. Plain and spring washers shall be provided to ensure good contacts at the joints and taps. Wherever aluminium to copper connections are required, suitable bimetallic connectors or clamps shall be used.

2.8.3. Bus bars shall be provided with heat shrinkable sleeves of suitable insulation class throughout their length with proper colour coding. All bus bar joints and taps shall be shrouded.

2.8.4. Bus bar support insulators shall be made of non-hygroscopic, arc and track resistant, high strength material suitable to withstand stresses due to over voltage and short circuit current.

2.8.5. The Contractor shall submit busbar sizing calculation for specified continuous and short time current ratings during detailed engineering.

2.9. Measuring Instruments

2.9.1. All the measuring instruments shall be digital, flush mounting type with communication facility.

2.9.2. All feeders except main outgoing feeder shall be provided with digital Multi-Function Meter (MFM). Tri Vector Meter (TVM) shall be provided for the main outgoing feeder (in the HT Panel). Accuracy class of MFM shall be 0.2 and that of TVM shall be 0.2S.

2.9.3. Measuring instruments shall have provision to display the following parameters.

i. Line and phase voltages
ii. Line and phase currents
iii. Active power, Reactive power, Apparent power
iv. Frequency
v. Power factor
vi. Total Harmonic Distortion (THD)

2.10. Wiring and Terminal blocks

2.10.1. All internal wiring shall be done with 650 V grade, 1.5 sq.mm. PVC insulated stranded flexible copper wire. For CT secondary circuits, 2.5 sq.mm copper wire shall be used.

2.10.2. Wire terminations shall be made with solderless crimping type tinned copper lugs, which shall firmly grip the conductor. Insulation sleeves shall be provided at all the wire terminations.

2.10.3. Printed identification ferrules, marked to correspond with panel wiring diagram shall be provided at both ends of each wire. The ferrules shall be firmly located on each wire so that they cannot move or turn freely on the wire. Wire identification shall be done in accordance with IS 11353.

2.10.4. The Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

2.10.5. All internal wiring to be connected to the external equipment shall terminate on terminal blocks. Terminal blocks shall be rated for 650 V, 10 A and made of non-inflammable material.

2.10.6. CT and VT secondary circuits shall be terminated on stud type, disconnecting terminal blocks.

2.10.7. At least 10% spare terminals shall be provided on each panel and these spare terminals shall be distributed on all terminal blocks.

2.11. Warranty

2.11.1. The HT panel unit shall be warranted against all material/ manufacturing defects and workmanship for minimum of 2 (Two) years from the date of supply.

2.12. Testing and Inspection

2.12.1. Type Tests

The switchgear panel shall be of type tested design. The following type test reports shall be submitted during detailed engineering. The tests should have been conducted on the similar equipment by NABL accredited laboratory. Validity period of type tests conducted on the equipment shall be as per 'CEA Guidelines for the Validity Period of Type Test(s) conducted on Major Electrical Equipment in Power Transmission'.

Test	Standard	Relevant IEC Clause
Switchgear Panel		
Dielectric tests		
Power frequency voltage test	IEC 62271-200	6.2.6.1
Lightning impulse voltage test	IEC 62271-200	6.2.6.2

Dielectric tests on auxiliary and control circuits	IEC 62271-200	6.2.10
Measurement of the resistance of the main circuit	IEC 62271-200	6.4.1
Temperature-rise tests	IEC 62271-200	6.5
Short-time withstand current and peak withstand current tests	IEC 62271-200	6.6
Verification of the IP coding	IEC 62271-200	6.7.1
Verification of making and breaking capacities	IEC 62271-200	6.101
Mechanical operation test	IEC 62271-200	6.102
Internal arc test	IEC 62271-200	6.106
Circuit Breaker		
Mechanical operation test at ambient air temperature (M1 Class)	IEC 62271-100	6.101.2
Basic short-circuit test-duties	IEC 62271-100	6.106
Relays		
Vibration tests	IEC 60255-21-1	
Shock and bump tests	IEC 60255-21-2	
Seismic tests	IEC 60255-21-3	
Electromagnetic compatibility requirements	IEC 60255-26	
Product safety requirements	IEC 60255-27	
Common requirements	IEC 60255-1	
Communication requirements	IEC 61850	
Current Transformers		
Temperature-rise test	IEC 61869-2	7.2.2
Impulse voltage withstand test on primary terminals	IEC 61869-2	7.2.3
Tests for accuracy	IEC 61869-2	7.2.6
Short-time current tests	IEC 61869-2	7.2.201
Voltage Transformer		
Temperature-rise test	IEC 61869-3	7.2.2
Impulse voltage withstand test on primary terminals	IEC 61869-3	7.2.3
Test for accuracy	IEC 61869-3	7.2.6
Short-circuit withstand capability test	IEC 61869-3	7.2.301

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by Employer.

2.12.2. Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

3. AC Cables

3.1. Standards and Codes

All AC Cables shall conform to the following standards and codes.

IS 7098-I	Cross linked Polyethylene Insulated Thermoplastic Sheathed Cables, Part 1: For Working Voltages up to and including 1100 V
IS 7098-II	Cross linked Polyethylene Insulated Thermoplastics Sheathed Cables Part 2: For Working Voltages from 3.3 kV up to and including 33 kV

3.2. All AC cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses develop under steady state and transient operating conditions.

3.3. Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted. However, cable joints may be allowed if the route length is more than maximum available drum length subject to Employer's approval.

3.4. In addition to manufacturer's identification on cables as per relevant standard, following marking shall also be provided over outer sheath.

i. Cable size and voltage grade
ii. Word 'FRLS' at every metre
iii. Sequential marking of length of the cable in metres at every metre

3.5. Cables shall be sized based on the following considerations:

i. Rated current the equipment
ii. Average voltage drop in LT cable (from PCS to inverter transformer) shall be limited to 0.5% of the rated voltage. For HT cables (from inverter transformer to Pooling Panel/Substation), average voltage drop shall be limited to 1% of the rated voltage. The Contactor shall provide voltage drop calculations in excel sheet.
iii. Short circuit withstand capability as per design
iv. De-rating factors according to laying pattern

3.6. Warranty

All cables shall be warranted for minimum of 1 (one) year against all material/ manufacturing defects and workmanship from the date of supply.

3.7. Testing

Type, routine and acceptance tests requirements shall be as per relevant standards for all cable sizes.

3.8. Installation

3.8.1. Cable installation shall be as per IS 1255.

3.8.2. IAC cables from PCS to inverter transformer shall be laid above ground on horizontal GI cable trays of required width. The cable trays shall be supported on concrete foundations. Minimum clear height of the cable tray shall be 350 mm above FGL.

3.8.3. Cables within plant pooling substation shall be laid through RCC cable trench with supports.

3.8.4. AC Cables from Inverter Transformer to 33 kV Switchgear Panel in Local Control Room shall be laid directly buried underground. AC cables from 33 kV Switchgear Panel in Local Control Room to 33 kV Switchgear Panel/33 kV outdoor Switchyard in Plant Pooling Substation may be laid over ground on GI cable trays / directly buried underground / on over ground transmission lines.

3.8.5. Cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles. Bimetallic lugs shall be used for connecting Cu bus bar and Al cables or vice-versa.

3.8.6. All AC cables shall be provided with punched/embossed aluminum tags. The marking shall be done with good quality letter and numbers of proper size so that the cables can be identified easily.

4. Auxiliary Supply System

4.1. Scheme for auxiliary supply system shall be submitted by contractor during detailed engineering for the approval by Employer.

4.2. It shall mainly comprise of auxiliary transformer, AC distribution board(s) (ACDB), Battery & battery charger system, emergency lighting network, Uninterrupted power supply (UPS), distribution cables and metering & protective devices.

4.3. Auxiliary AC power for BESS auxiliary sub-system shall feed BESS container HVAC, fire protection, lighting, and control systems etc. **Contractor shall consider the auxiliary power load list provided by the Employer's DC Package Supplier**. The necessary interface for BESS Auxiliary Power shall be supplied by the Employer's BESS Supplier, which shall be metered. The Balance of Plant Contractor shall route power up to the defined terminals in the said interface.

4.4. Auxiliary system of Pooling Substation shall incorporate redundant source of power supply for increased reliability.

4.5. Following consideration shall be taken into account while sizing the auxiliary transformer:

i. 20% future load margin

ii. Total connected load at 0.8 power factor

5. LT Switchgear

5.1. Standards and Codes

All equipment provided under LT switchgear shall comply with latest revisions and amendments of the relevant IEC standards and IS codes. In particular, the switchgear shall comply with the following standards and codes.

Standard/Code	Description
IEC 61439-1	Low-voltage switchgear and control gear assemblies - Part 1: General rules
IEC 61439-2	Low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies
IEC 60947-1	Low-voltage switchgear and control gear - Part 1: General rules
IEC 60947-2	Low-Voltage Switchgear and Control gear: Circuit Breakers
IEC 60947-3	Low voltage switchgear and control gear: Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IEC 60947-4-1	Low-voltage switchgear and control gear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
IEC 60947-5-1	Low-voltage switchgear and control gear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
IEC 62052-11	Electricity metering equipment (a.c.) - General requirements, tests and test conditions - Part 11: Metering equipment
IS 694	Polyvinyl chloride insulated unsheathed-and sheathed cables/ cords with rigid and flexible conductor for rated voltages - up to and including 450/750V
IEC 61869	Instrument Transformers
IS 3043	Code of practice for earthing
IEC 60255	Measuring relays and protection equipment - Part 1: Common requirements

5.2. Technical Parameters

System Details	
Rated system voltage	415 V ± 10%, 3 Phase, 50Hz, 4 wire, Neutral Solidly Earthed
Rated frequency	50 Hz ± 5%
System fault current	As per system requirement

Moulded case circuit breaker (MCCB)	
Rated voltage	415 V
Rated current	As per system requirement
Rated insulation level	690 V
Rated ultimate short-circuit breaking capacity and Rated service short-circuit breaking capacity	As per system fault current
Rated short-circuit making capacity	2.1 × Rated ultimate short-circuit breaking capacity
Rated short-time withstand current duration	1 s
Utilization category	A
Current transformer (CT)	
Type	Cast Resin Bar Primary
Voltage class and frequency	650 V, 50 Hz
CT Secondary Current	1 A
Class of insulation	Class E or better
Accuracy class & burden	
a) For Protection	5P20, 5VA
b) For Metering	Class 0.5, 5VA (min)
Instrument Security Factor for metering CT	5
Voltage transformer (VT)	
Type	Cast Resin
Accuracy class	0.5
Rated Voltage factor	1.1 continuous, 1.5 for 30 seconds
Class of insulation	E or better
Digital Multifunctional Meter (MFM)	
Accuracy class	0.5
Communication with SCADA	RS485 communication with Modbus RTU

5.3. Constructional Details

5.3.1. The panel shall be metal enclosed, free standing, floor mounted, modular type with compartmentalized construction having degree of protection of IP 5X (Indoor) and IP 55 (Outdoor) as per IS/IEC 60529. All doors and covers shall be provided with neoprene gaskets to prevent entry of vermin and dust.

5.3.2. All switches, push buttons etc. shall be operated front and shall be flush/semi-flush mounted.

5.3.3. The panel shall be fabricated from 2 mm CRCA sheet steel for frame & load bearing surfaces. Partitions may be fabricated from 1.6 mm CRCA if no components are mounted on them.

5.3.4. Cable entries shall be from bottom. The opening of cable entry shall be covered by 3mm thick gland plates with proper sealing to avoid water and rodent entry.

5.3.5. Earthing bus bar of suitable cross section shall be provided throughout the length of panel.

5.3.6. The panel shall be duly wired with suitable size of 1.1kV, PVC insulated cable and terminals shall be brought out for cable connections. 10% spare terminals subjected to minimum one of each rating shall be provided on each distribution switchgear. All wire shall have ferrules as per wiring diagram.

5.3.7. The panel shall be painted with 2 coats of primer after pre-treatment and 2 coats of Polyurethane / epoxy paint with shade as decided by the Employer.

5.3.8. The panel shall be of dead front construction suitable for front operated and back maintained functioning.

5.3.9. 240 V, 5 A, 3 pin industrial socket-outlet with ON/OFF switch shall be provided in each panel.

5.3.10. Each panel shall be provided with LED lamp rated for 240 V, 50 Hz, single phase AC supply for interior illumination controlled by door switch.

5.3.11. Suitable lifting hooks shall be provided for each panel.

5.3.12. Each switchgear panel shall be provided with thermostatically controlled space heaters to prevent condensation within the enclosure. The space heater shall be connected to 240 V, 50 Hz, single phase AC supply through suitable switch and fuse.

5.3.13. Earth leakage relay with Core balance CTs (CBCT) shall be provided on main incoming feeders having phase CT ratio more than 50/1A. CBCT's shall be circular window type with window size based on the overall diameter of the cables, to be finalized during detailed engineering.

5.4. Warranty

LT switchgear shall be warranted against all material/ manufacturing defects and workmanship for minimum of 1 (one) year from the date of supply.

5.5. Testing

Routine test and acceptance tests requirements shall be as per relevant standards for all cable sizes.

6. Uninterrupted Power Supply

6.1. Standards and Codes

Standard/Code	Description
IEC 62040-1	Uninterruptible power systems (UPS) - Part 1: General and safety requirements for UPS
IEC 62040-2	Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements
IEC 62040-3	Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements

6.2. General Requirements

6.2.1. The Uninterrupted Power Supply (UPS) system shall be designed to supply power to following loads (but not limited to).

i. Data logger / SCADA
ii. Fire Detection/ Alarm Panel
iii. HMI of SCADA
iv. Emergency Lighting
v. PCS's Auxiliary supply (if applicable)
vi. HT panel auxiliary
vii. CCTV

6.2.2. Pooling Substation UPS system shall comprise of two nos. of UPS of 100% capacity, i.e., two inverters, batteries and UPSDB connected by bus coupler.

6.2.3. Sizing of UPS shall be done considering the above-mentioned load at power factor of 0.8 lagging inclusive of 10% design margin at 50 ˚C.

6.2.4. The battery sizing shall account for suitable temperature correction factors, ageing factors of 1.25, design margin of 1.1 & depth of discharge of 80%.

6.3. System Description

6.3.1. The UPS shall automatically provide continuous, regulated AC power to critical loads under normal and abnormal conditions, including loss of input AC power. The UPS system shall consist of the following major equipment.

i. UPS Module
   a) Insulated Gate Bipolar Transistor (IGBT) Converter
   b) Insulated Gate Bipolar Transistor (IGBT) Inverter
   c) Digital Signal Processor (DSP) using Pulse Width Modulation (PWM) for Direct Digital Control (DDC) of all UPS control and monitoring functions
   d) Static bypass switch
ii. Battery system for 2 hours
iii. Battery protective and disconnect device
iv. Maintenance bypass switch

v. LCD display panel and LED indications

vi. Integrated UPS Communications Protocols capable of communicating with SCADA system

6.3.2. The UPS shall meet the following minimum specifications.

Parameter	Specification
Topology	Online double conversion UPS
Overall efficiency	> 90%
Input	
Voltage	230 V ± 10% AC for UPS rating of less than 5 kVA 415 V ± 10% AC for UPS rating of 5 kVA and above
Frequency	50 ± 5%
Power factor	0.95
Output	
Voltage	230V ± 1% AC
Frequency	50 Hz
Power factor	0.8
Battery	
Type	Sealed, Maintenance-Free (AGM) battery
Capacity	100% UPS load for 2 hours
Monitoring and communication	
LED Indication	Yes
Local Display	LCD / LED
SCADA communication	RS-485 Interface Port

6.3.3. The UPS shall be forced air cooled by internally mounted fans. The fans shall be redundant in nature to ensure maximum reliability. The fans shall be easily replaceable without the use of special tools.

6.3.4. The Contractor shall provide the Operation & Maintenance Manual and mandatory spare parts list along with the equipment.

6.4. Warranty

UPS shall be warranted for minimum of 5 (five) years and batteries shall be warranted for a minimum of 2 (two) years against all material/ manufacturing defects and workmanship from the date of supply.

6.5. Tests

6.5.1. Routine tests and acceptance tests on final product shall be done as per QAP approved by the Employer.

6.5.2. On completion of installation and commissioning of the equipment on site tests shall be carried out with the max. available load, which does not exceed the rated continuous load. An on-site test procedure shall be submitted by contractor include a check of controls and indicators after installation of the equipment.

7. Battery and Battery Charger

7.1. Standards and Codes

Standard/Code	Description
IEC 60896-21:2004	Stationary lead-acid batteries - Part 21: Valve regulated types - Methods of test
IEC 60896-22:2004	Stationary lead-acid batteries - Part 22: Valve regulated types - Requirements
IS 15549	Stationary Regulated Lead Acid Batteries

7.2. General

7.2.1. 110 V / 220 V DC system (Battery, Battery Charger & DCDB) in accordance with this specification and standards stated herein, shall comprise of the following.

i. Sealed Maintenance Free VRLA battery complete with racks & accessories.
ii. Float cum Boost Charger (FCBC)
iii. DC Distribution Board (DCDB)

7.2.2. Pooling Substation DC system shall comprise of two nos. of battery, battery charger and DCDB connected by bus coupler.

7.2.3. Battery shall be used to supply the following loads with back up of two hours in case of complete power failure:

i. Trip and closing coil of 33 kV circuit breaker
ii. Spring charging motors for 33 kV circuit breaker
iii. Annunciator and Indication circuit of 33 kV switchgear panel
iv. Auxiliary supply to protection relays
v. Pooling Substation protection and control supply
vi. PLCC equipment

7.2.4. The battery sizing shall account for suitable temperature correction factors, ageing factors of 1.25, design margin of 1.1 & depth of discharge of 80%.

7.2.5. The design of the battery bank and sizing calculation along with the data sheet for the battery and battery charger shall be submitted for approval.

7.3. Battery

The battery shall be VRLA type complying with IEC 60896-21 & IEC 60896-22 / IS 15549. The Contractor shall submit type test reports as per IEC 60896-21 & IEC 60896-22 / IS 15549.

7.4. Battery Charger

7.4.1. The Battery Charger as well as its automatic regulator shall be of static type and shall be compatible with offered batteries. The Battery Charger shall be capable of continuous operation at the respective rated load in float charging mode. The charger shall also be capable of boost charging the associated battery at the desired rate.

7.4.2. The battery charger shall regulate the float/boost voltage in case of prescribed temperature rise of battery as per manufacturer's recommendation to avoid thermal runaway. Necessary temperature sensors shall be provided in mid location of battery banks and shall be wired up to the respective charger for feedback control.

7.4.3. The battery charger shall be provided with facility for both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage/current control, whether automatic or manual. When on automatic control mode during float charging, the charger output voltage shall remain within ±1% of the set value for AC input voltage variation of ±10%, frequency variation of ±5%, combined voltage and frequency variation of ±10%, and DC load variation from zero to full load.

7.4.4. The battery charger shall have a constant voltage characteristics throughout the range (from zero to full load) at the floating value of the voltage so as to keep the battery fully charged but without harmful overcharge.

7.4.5. The battery charger shall have load limiters having drooping characteristic, 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. The load-limiter characteristics shall be such that any sustained overload or short circuit in DC system shall not damage the charger, nor shall it cause blowing of any of the charger fuses. The charger shall not trip on overload or external short circuit.

7.4.6. Uniform and step less adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the charger panel covering the entire float charging output range specified. Step less adjustment of the load limiter setting shall also be possible from 80% to 100% of the rated output current for float charging mode.

7.4.7. During boost charging, the battery charger shall operate on constant current mode (when automatic regulator is in service). It shall be possible to adjust the boost charging current continuously over a range of 50 to 100% of the rated output current for boost charging mode. The charger output voltage shall automatically go on rising, when it is operating on boost mode, as the battery charges up. For limiting the output voltage of the charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage anywhere in the output range specified for boost charging mode.

7.4.8. Suitable filter circuits shall be provided in all the chargers to limit the ripple content (peak to peak) in the output voltage to 1%, irrespective of DC load level, even when

they are not connected to battery.

7.4.9. Digital Outputs shall be configured for connection to the SCADA to monitor the outputs like charger output current, output voltage, float/boost mode, etc.

7.4.10. The battery charger shall have an AC contactor on the input side. It shall be of air break type and suitable for continuous duty. A thermal overload relay incorporating a distinct single phasing protection (using differential movement of bimetal strips) shall also be provided for the AC input. The relay shall trip the above contactor.

7.4.11. The rectifier assembly shall be full wave bridge type and designed to meet the duty as required by the respective charger.

7.4.12. Digital or analog indicating instruments to indicate DC current, DC voltage & AC voltage shall be provided.

7.4.13. The charging equipment shall be housed in a free standing, floor mounted compartmentalized panels. Panel shall have provision for bottom cable entry with removable undrilled cable gland plate of 3.0 mm thickness.

7.4.14. The panel shall be of CRCA sheet steel construction having thickness of at least 2.0 mm. Degree of protection provided by the enclosure to the internals of charger shall be IP 42 (Indoor) / IP 55 (Outdoor).

7.4.15. The instruments, switches and indicating lamps shall be flush mounted on the front panel.

7.4.16. DCDB shall have adequate number of outgoing feeders with double pole, DC MCBs. At least 20% feeders shall be provided as spare.

7.5. Warranty

Batteries and battery charger shall be warranted for minimum of 2 (two) years against all material/ manufacturing defects and workmanship from the date of supply.

7.6. Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

8. Earthing

8.1. Standards and Codes

Earthing system shall comply with latest revisions and amendments of the relevant IEC standards and IS codes. In particular, earthing system shall comply with the following standards and codes.

Standard/Code	Description
IS 3043	Code of Practice for Earthing
IEC 62561-2	Requirements for conductors and earth electrodes
IEC 62561-7	Requirements for earthing enhancing compounds

IEEE 80	IEEE Guide for Safety in AC Substation Grounding
IEEE 142	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
CEA Regulations and other statutory regulations	

8.2. General Requirements

8.2.1. Earthing system shall be designed based on system fault current and soil resistivity value obtained from geo-technical investigation report. Earth grid shall be formed consisting of number of earth electrodes sufficient enough to dissipate the system fault current interconnected by earthing conductors.

8.2.2. The earth electrode shall be made of high tensile low carbon steel rod, molecularly bonded by high conductivity copper on outer surface with coating thickness not less than 250 micron as per relevant standards. Suitable earth enhancing material shall be filled around the electrode to lower the resistance to earth. Inspection chamber and lid shall be provided as per IS 3043. For Plant Pooling Substation earthing, mild steel rod may be used as earth electrode.

8.2.3. Earth conductors shall be made of copper bonded steel, galvanized steel or galvanised iron of sufficient cross section to carry the fault current and withstand corrosion.

8.2.4. Earth conductors buried in ground shall be laid minimum 600 mm below ground level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures.

8.2.5. Earth electrodes shall not be situated within 1.5m from any building whose installation system is being earthed. Minimum distance between earth electrodes shall be two times the driven depth of the electrode.

8.2.6. Transformer yard and switchyard fence shall be connected to the earth grid by one GS flat and gates by flexible lead to the earthed post.

8.2.7. All welded connections shall be made by electric arc welding. For rust protection, the welds should be treated with red lead compound and afterwards thickly coated with bitumen compound.

8.3. Earthing of BESS Yard

8.3.1. Earthing of individual BESS enclosures and PCS units shall be as per the requirements of the respective Manufacturers **and shall be done by the DC Package Contractor. The same is not within the scope of the AC Package Contractor.**

8.3.2. Interface connection drawings shall be developed jointly and submitted during detailed engineering. The system shall be adequate for the detection and clearing of ground faults. Measures to mitigate galvanic corrosion shall be proposed, as required.

8.4. Transformer Earthing

8.4.1. Inverter transformer neutral earthing shall be as per the recommendation of inverter manufacturer.

8.4.2. Transformer tank, cable box, marshalling box and all other body earth points shall be earthed.

8.4.3. Inverter transformer shield shall be earthed separately using minimum two no. of earth electrodes. Earthing conductor between shield bushing and earth electrodes shall be copper flat of suitable size not less than 25 x 6 mm.

8.4.4. Neutral and body of the auxiliary transformer shall be earthed.

8.5. Inverter Room and Main Control Room Earthing

8.5.1. Metallic enclosure of all electrical equipment inside the inverter room and main control room shall be connected to the earth grid by two separate and distinct connections.

8.5.2. Cable racks and trays shall be connected to the earth grid at minimum two places using galvanized steel flat.

8.5.3. SCADA and other related electronic devices shall be earthed separately using minimum two no. of earth electrodes.

8.6. Switchyard Earthing

The metallic frame work of all switchyard equipment and support structures shall be connected to the earth grid by means of two separate and distinct connections.

Switchyard shall be shielded against direct lightning stroke by provision of over-head shield wire or earth wire or spikes (masts) or a combination there of as per CEA regulations 2010 (Technical standards)- 42(2)(C).

8.7. Tests

Type test reports for earthing electrode, earth enhancing compound and its associated accessories shall be submitted during detailed engineering for approval.

On completion of installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded.

The earth plate shall be provided to facilitate its identification and for carrying out periodical inspection.

9. Lightning Protection System

9.1. Lightning Protection System (LPS) for the entire plant except buildings and plant pooling substation against direct lighting strokes shall be provided as per IS/IEC 62305:2010 or NFC 17-102. Lightning Protection System for buildings shall be provided as per IS/IEC 62305:2010.

9.2. Protection level for the entire plant shall be Level-III.

9.3. Air terminals, down conductors and earth termination system shall be designed as per

relevant parts of IS/IEC 62305:2010 or NFC 17-102.

9.4. Necessary foundation/anchoring for holding the air terminal in position to be made after giving due consideration to shadow on PV array, maximum wind speed and maintenance requirement at site in future.

9.5. Type test reports as per IS/IEC 62305:2010 or NFC 17-102 shall be submitted during detailed engineering for approval.

9.6. Lightning Protection System for Plant Pooling Substation

9.6.1. Direct Stroke Lightning Protection (DSLP) for Plant Pooling Substation shall be provided by Lightning Mast and Shield Wires.

9.6.2. The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.

9.6.3. Down conductors shall not be connected to other conductors above ground level. Down conductors shall be cleated on the structures at 2000 mm interval.

9.6.4. Every down conductor shall be provided with a test joint at about 1000 mm above ground level. The test joint shall be directly connected to the earthing system.

10. Communication Cables

10.1. Optical Fibre Cables

10.1.1. Optic Fibre cable shall be 8/12 core, galvanized corrugated steel taped armoured, fully water blocked, for outdoor/ indoor application so as to prevent any physical damage.

10.1.2. The cable shall have multiple single-mode or multimode fibres on as required basis so as to avoid the usage of any repeaters.

10.1.3. The outer sheath shall have Flame Retardant, UV resistant properties and are to be identified with the manufacturer's name, year of manufacturing, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.

10.1.4. The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling.

10.1.5. All testing of the optic fibre cable being supplied shall be as per the relevant IEC, EIA and other international standards.

10.1.6. The Contractor shall ensure that minimum 50% cores (not less than 4) are kept as spare in all types of optical fibre cables.

10.1.7. Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground buried installation.

10.1.8. Spliced/ Repaired cables are not acceptable. Penetration of water resistance and impact resistance shall be as per IEC standard.

10.2. RS-485 Cable

RS-485 Cable to be used shall be shielded type with stranded copper conductor. Cable shall have minimum 2 pair each with conductor size of 0.5 sq.mm. Cable shall be flame retardant according to IEC 60332-1-2.

11. SCADA

Takeover Point: BESS EMS and communication architecture within BESS is not in the scope of the Contractor (AC Package). However, the Contractor under these specifications shall be responsible for the design and supply of the SCADA (specified in this Clause) and PPC (specified in Clause 12). All required connectivity (LAN/fiber) from BESS EMS to the plant-level SCADA and grid interfacing systems shall be provided by the DC Package Contractor. Interface protocols shall be mutually agreed during design stage.

11.1. General Requirements

11.1.1. The Contractor shall provide complete SCADA system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation and monitoring of entire plant and its auxiliary systems.

11.1.2. The Contractor shall provide all the components including, but not limited to, Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cables, firewall etc. needed for the completeness.

11.1.3. SCADA System shall have the provision to perform the following features and/or functions:

i. Web enabled Operator Dashboards: Showing key information on real time status of containers in Single Line Diagram (SLD) format with capability to monitor Container level parameters.
ii. Real time Data Logging with Integrated Analytics & Reporting: Logging of all parameters - import and export power (MW), import and export units (kWh), Container State of Charge (SoC), Container State of Health (SoH), status of auxiliary subsystems, essential KPIs, maximum and minimum temperatures etc. System Run Hours, Equipment Status and Alarms as well as derived/ calculated/ integrated values. The SCADA User interface shall be customizable and enable Report Generation and Graphical Analysis.
iii. Fault and System Diagnostics with time stamped event logging.
iv. Generate, store and retrieve user configurable Sequence of Event (SoE) Reports.
v. Interface with different field equipment in the plant and work seamlessly with field equipment supplied by different companies.

11.1.4. The Control system shall be designed to operate in non-air-conditioned area. However, the Contractor shall provide a Package/ Split AC of suitable capacity decided by heat load requirement in SCADA room at Main Control Room.

11.1.5. The SCADA System shall comply with CEA (Cyber Security in Power Systems)

Guidelines, 2021, amended from time to time, and the technical standards for communication system in Power Sector laid down by the relevant Authority.

11.2. Architecture

11.2.1. The SCADA System shall be built over Industrial IoT architecture with integrated Analytics, secure web access, enterprise software and Database.

11.2.2. Data acquisition shall be distributed across MCR and BESS AC Blocks (constituted by BESS Containers, PCSs and IDTs) while plant level data aggregation shall be done in plant servers. Indicative SCADA Schematic Diagram along with Indicative I/O List has been attached in General Annexure-G.

11.2.3. Analog and Digital IO modules shall have integrated processor for distributed IO processing and control.

11.2.4. Data communication system shall be built over fibre optic cables/ wireless network with high bandwidth TCP/IP communication (Fast Ethernet or 802.11a/b/g/n) across all Inverter and Control Rooms with Internet/Intranet access at Main Control Room. Firewall shall be provided for network security.

11.2.5. Plant SCADA Server shall have Industrial Grade server hardware running SCADA & Monitoring Software with data storage (complete plant data) space for 2 years.

Note: One redundant server shall be provided along with separate SMPS power supply.

11.2.6. Plant data for monitoring and control operations should be accessible without dependence on external network.

11.2.7. Operator Workstation/PC shall be of Industrial Grade for browser-based access to plant data from Plant. Plant control & SLDC/Utility related operations shall only be initiated through browser-based interface requiring no client software or database to be installed on the Workstation. All critical software and Plant Data shall be installed/stored on local and remote servers only with user access control for protecting the software and data assets from accidental deletion or corruption.

11.2.8. Internet/Intranet at Plant: Public or private network access shall be provided at the plant through any broadband/VSAT connectivity of 2Mbps or higher bandwidth. In case no broadband/VSAT connectivity can be provided at the plant, a 3G/4G data card from any Internet Service Provider (ISP) may be provided.

11.2.9. GPS based Time Synchronization System: The SCADA system shall have a Master/Slave Clock system along with antenna, receiver, cabinet and internal interconnection cables. All SCADA controllers, servers, OWS and communicating equipment shall be synchronized to the GPS clock.

11.2.10. A virtual/cloud server running SCADA & Monitoring Software shall be configured in parallel with Plant Server to enable easy access to plant data from outside the plant without having to login to plant server. Effectively, the plant data shall be replicated in both places i.e. between systems at the Plant Server and Remote Server to provide

data redundancy for complete plant data.

11.2.11. Note: Configuration of Cloud server and procurement of associated subscription services shall be in the scope of the EPC Contractor.

11.3. Industrial IoT Controllers & Data Acquisition

The Plant SCADA and Monitoring System may use one or more IIoT Controllers for the purpose of data acquisition and data forwarding to the SCADA Servers. The IIoT Controllers shall meet the following minimum requirements:

11.3.1. The IIoT Controllers shall be distributed in nature and work independently of other IIoT Controllers or any central controller in the system.

11.3.2. Shall be capable of supporting wide range of field protocols to communicate with different field equipment (Modbus over RS485/Ethernet, etc.)

11.3.3. Shall have local storage for a minimum of 2 weeks (in case of network failure).

11.3.4. Provide web-based interface to configure the controller for various equipment in the field.

11.3.5. IO Functionality: Shall support status monitoring of VCBs & Trip relays on RMU/HT & Transformer panels through distributed DI/AI modules.

11.3.6. Controls: Shall be capable of controlling breakers (ON/OFF). Both ON/OFF and Parameter control of inverters shall be supported.

11.3.7. Data Communication with Servers: Shall send the data collected, from all the equipment at BESS AC Block and/or Main Control Room, to the Monitoring & Control Server.

11.3.8. Controllers shall be capable of sending data over Internet connections, USB data cards.

11.4. System Spare Capacity

Over and above the equipment and accessories required to meet the fully implemented system as per specification requirements, Control System shall have spare capacity and necessary hardware/ equipment/ accessories to meet following requirement for future expansion at site:

(i) 10 % spare channels in input/output modules fully wired up to cabinets TB.
(ii) Wired-in "usable" space for 10% modules in each of the system cabinets for mounting electronic modules wired up to corresponding spare terminals in system cabinets.
(iii) Empty slots between individual modules/group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice of Contractor shall not be considered as wired-in "usable" space for I/O modules.
(iv) Terminal assemblies (if any in the offered system), corresponding to the I/O modules shall be provided for above mentioned 10 % blank space.
(v) Each processor / controller shall have 20% spare functional capacity to implement

additional function blocks, over and above implemented logic/ loops. Further, each processor / controller shall have spare capacity to handle minimum 20% additional inputs/ outputs of each type including above specified spare requirements, over and above implemented capacity. Each of the corresponding communication controllers shall also have same spare capacity as that of processor/controller.

(vi) The Data communication system shall have the capacity to handle the additions mentioned above.

(vii) Ten (10) percent spare relays of each type and rating mounted and wired in cabinets TB. All contacts of relays shall be terminated in terminal blocks of cabinets.

(viii) The spare capacity as specified above shall be uniformly distributed throughout all cubicles. The system design shall ensure that above mentioned additions shall not require any additional controller/processor/ peripheral drivers in the system delivered at site. Further, these additions shall not deteriorate the system response time / duty cycle, etc. from those stipulated under this specification.

11.5. Functionalities

11.5.1. The SCADA system shall monitor instantaneous and cumulative electrical parameters from all DC & AC Equipment including BESS Containers, PCSs, weather station, MFM, Transformer and Switchgear (LT & HT Panels) at regular intervals not greater than one minute.

11.5.2. The SCADA system shall monitor instantaneous and cumulative environment parameters from weather sensors or data loggers at same interval as electrical parameters and provide PR, CUF on the fly.

11.5.3. The SCADA system shall provide Alarms and Alerts on equipment faults and failure in less than 5 seconds. Alarms on status change of hardwired DI shall also be provided.

11.5.4. The SCADA system shall provide configurable alerts on any parameter crossing settable thresholds. The list of such parameters shall be finalised in consultation with the Employer.

11.5.5. The SCADA system shall have user-friendly browser-based User Interface for secure access from anywhere, for minimum ten concurrent connections from the Operator PC or other securely connected laptop/mobile, for plant monitoring, O&M, daily reporting, and analysis. A dashboard providing summary details of plant performance, day's import and export, Inverter-wise data etc.

11.5.6. Reporting: The SCADA system shall provide downloadable reports in Excel/PDF, configurable for equipment parameters across the plant.

11.5.7. Data Communication to SLDC/RLDC: SCADA system shall provide required interface to integrate with SLDC/RLDC, in compliance with grid code, to send any parameters specified by SLDC/RLDC.

Note: The methodology and specification of SLDC/RLDC interface will be provided separately by SLDC/RLDC and it shall be the responsibility of the Contractor to

determine the same.

11.5.8. Power Plant Control: SCADA system shall provide required interface to the local SCADA operator to set various power control modes (active/reactive power/frequency/PF) through the inverters over industry standard communication protocols like Modbus over TCP/IP.

11.5.9. All programming functionalities shall be password protected to avoid unauthorized modification.

11.5.10. The Contractor shall provide software locks and passwords to Employer for all operating & application software. Also, the Contractor shall provide sufficient documentation and program listing so that it is possible for the Employer to carry out modification at a later date.

11.6. Earthing

11.6.1. Two isolated electronic earth pits near to SCADA panel at every Inverter and Control Room with < 1 Ohm resistance shall be provided. One earth pit shall be used for protective/body earth and the other to be used for Signal Earth.

11.6.2. Apart from providing separate earth pits, manufacturer specified earthing recommendations shall be followed for all communicating equipment connected to SCADA. This includes but is not limited to SCBs, Inverters, WMS and Switchgear panels.

11.7. Communication Cable Laying

11.7.1. All RS485, IO and CAT6 cables shall be laid in separate conduits with a minimum separation of 1.5ft from AC/DC power cables all along.

11.7.2. Power cables shall be laid deep in the trenches first. Data cables shall be laid in separate conduits after partially filling the trenches to ensure minimum 1.5 ft separation between power and communication cables all along the trench.

11.7.3. IO Cables between switch gear panels and SCADA panel shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables.

11.7.4. RS485 & CAT6 cables between switch gear panels or Inverters and SCADA panel shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables.

11.8. Control Cabinets / Panels / Desks at Main Control Room

11.8.1. The cabinets shall be IP 22 protection class. The Contractor shall ensure that the temperature rise is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets.

11.8.2. The cabinets shall be totally enclosed, free standing type and shall be constructed with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per supplier's standard practice for similar applications.

11.9. Software Licences

The Contractor shall provide software license for all software being used in Contractor's System. The software licenses shall be provided for the project and shall not be hardware/ machine-specific.

11.10. Hardware at Main Control Room

11.10.1. The Hardware as specified shall be based on latest state of the art Workstations and Servers and technology suitable for industrial application & power plant environment.

11.10.2. The Local Monitoring & Control Server and the Operating Work station, to be deployed in the Plant Control Room, shall have the following server hardware and operating system along with accessories:

Plant Server (2 Nos. - Main & Redundant)	
Server Hardware	Hex/Octal Core Xeon, 32GB RAM (expandable to 64 GB RAM), 4 × 2TB SATA hard discs in RAID 5 configuration, 2TB external USB hard disc (for backup), dual power supplies, 2 LAN ports, LCD console, keyboard & mouse. The Server hardware shall be housed in a rugged fan-cooled, and rodent-proof Server Rack.
Operating System	Operating System and Database shall be of enterprise scale (OS - RedHat Linux or Windows Server or equivalent Linux OS; DB - Oracle/MySQL or Windows or equivalent DB), with required AMC for 5 years.
Accessories	1. Monitor: Min 22" LED Flat Monitor with non-interfaced refresh rate min. 75 Hz. 2. Keyboard: ASCII type 3. Pointing Device: Mouse 4. Intelligent UPS (on line): Minimum 2 hour battery backup.
Operator Workstation (OWS) – 2 Nos.	
Hardware	i7 CPU running at 3.0 GHz or faster with 8GB RAM, 2 TB SSD hard disk, 28" LED monitor, keyboard and mouse, 4 USB ports, LAN port
Operating System	Windows operating system with necessary tools, anti-virus software.
Accessories	1. UPS of required capacity with 2 hour battery backup. Common for the Operator Workstations: 1. Screen Display Unit: Min 60" LED Flat Monitor with wall mounted arrangement for the display of SCADA screen 2. A4 size monochrome laser printer.

PPC Workstation – 1 No.	
Hardware	i7 CPU running at 3.0 GHz or faster with 8GB RAM, 2 TB SSD hard disk, 25" LED monitor, keyboard and mouse, 4 USB ports, LAN port
Operating System	Windows operating system with necessary tools, anti-virus software.
Accessories	1. UPS of required capacity with 2 hour battery backup.

11.10.3. All network components of LAN and Workstations shall be compatible to the LAN, without degrading its performance.

11.11. Factory Acceptance Test (FAT)

FAT procedure shall be submitted by bidder for approval. SCADA shall communicate with all third devices which are part of BESS plant and same shall be demonstrated during the FAT.

12. Power Plant Controller

12.1. Power Plant Controller (PPC) shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby. In case of failure of working PPC processor, there shall be an appropriate alarm and simultaneously the hot standby PPC processor shall take over the plant control function automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. It shall be possible to keep any of the PPC processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor.

12.2. BESS is required to have the following basic functions:

(i) Monitoring: Monitor electrical parameters at the POI (V, I, pf), operational parameters, equipment status and communication status, alarm and faults of main equipment and BESS system, etc.

(ii) Information exchange: Receive and process information with RLDC/NLDC including operation parameters, switching information, various alarms and alerts, protective action signals, control information, etc.

(iii) Control: Including control mode and parameter setting with RLDC/NLDC.

12.3. SCADA and PPC networks shall be suitably designed, so that PPC shall communicate with EMS for BESS inverter control. Provisions shall be enabled for the PPC to take voltage and current of POI as a reference to Power Plant Controller for giving command to individual PCUs. Detailed control logic in the PPC shall be finalized during detailed engineering stage. The control logic and setting of the PPC shall be in line with latest CEA (Technical Standards for Connectivity to Grid) and as per RLDC requirement.

12.4. The PPC should be programmable for selecting the optimum-operating mode of the whole plant w.r.t. active and reactive power, grid voltage, grid frequency, etc. Additionally, it can receive external set points and automatically adapt the Plant Facility behaviour to the new settings. At a time, only one operational mode shall be selected.

12.5. The PPC shall allow following operation modes for the Plant facilities.

i. Reactive Control (Q Control, setting point of reactive power Q at PPC)
ii. Power Factor Control (PF Control, setting point of cos(L) at PPC)
iii. Voltage Control (V closed loop control, setting point of V at PPC)
iv. Voltage Droop (Reactive power vs Voltage programmable curve or droop)
v. Apparent Power Control (S Lim, setting point of S Lim at PPC)
vi. Active Power Limitation (P Lim, setting point of P Lim at PPC)
vii. Power Ramp Rate Control (setting point of maximum %Pn/min)
viii. Frequency Regulation (Power vs Frequency programmable curve or droop)

12.6. BESS shall be capacity of operating in the frequency range of 47.5 Hz to 52 Hz and be able to deliver rated output in the frequency range of 49.5 Hz to 50.5 Hz.

12.7. BESS shall be capable of operating when voltage at the interconnection point on any or all phases dips/rises to the high or low levels. The levels applicable for wind/solar inverter-based generation may be referred as available in Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations.

12.8. For grid support operations, PPC shall have provisions to operate BESS for Primary frequency control. However, the activation of Primary Frequency Response shall be as per extant CEA/CERC regulations.

12.9. PPC shall be prepared to work under voltage dips, allowing the PCUs to inject the corresponding reactive power to provide the corresponding voltage support at the PPC. The PPC can receive the target values specified by grid operators using a standard protocol (i.e. Modbus TCP/IP) and over different communication media.

12.10. BESS shall operate to maintain voltages as per specified voltage ranges in Grid standards. BESS shall have feature to detect the voltage of interconnection point, and regulate voltage independently. The response time of the BESS shall not exceed the value specified in relevant standards or grid codes.

12.11. BESS shall also have provision to enable participation in the ancillary services market based on CERC Ancillary Services Regulations, the BESS shall be provided with all required control logic and facility/provision for the following types of Ancillary Services, namely:

(a) Secondary Reserve Ancillary Service (SRAS);
(b) Tertiary Reserve Ancillary Service (TRAS); and
(c) Such other Ancillary Services as specified in the Grid Code.

For this, the bi-directional communication system with RLDC, as per the requirements, shall be provided.

12.12. BESS shall have capability to operate in Automatic Generation Control (AGC). The

details regarding AGC signals required but not limited to, are given (the conventional power plant signal link) at the link:

https://posoco.in/download/detailedsignal-list-for-connecting-generators-under- agc/?wpdml=29546.

BESS shall be able to operate in AGC and be able to comply with the requirements desired by system operators. Some of the BESS signal list for implementation of AGC can be like below (list is indicative only):

a. Maximum MW permissible (dynamic or user entry)
b. Minimum MW permissible (dynamic or user entry)
c. Ramp rate up permissible (dynamic or user entry)
d. Ramp rate down permissible (dynamic or user entry)
e. Actual MW
f. Actual MVAR
g. Auxiliary Consumption MW
h. Scheduled MW (dynamic or user entry)
i. BESS Temperature (for monitoring and correlation)
j. Ambient Temperature (for monitoring and correlation)
k. Cycle limits (0-100%) per day (user entry)
l. Circuit breaker status
m. Local/Remote status
n. AGC Set Point MW from NLDC to BESS
o. Voltage (kV) at grid level
p. Voltage (V) at BESS LV side

The BESS shall be possible to charge and discharge continuously at any power between 0 (zero) to rated power.

The BESS charging and discharging power shall be limited to it is rated power for all operation control modes. The BESS active power capacity shall be the remaining capacity left after providing reactive power.

12.13. The BESS should provide reliable protection and not be limited to as an overvoltage/under-voltage protection, overcurrent protection, low-temperature/over-temperature protection of battery, DC insulation monitoring, etc.

12.14. The PPC shall comply with cyber security guidelines issued by the Central Government, from time to time, and the technical standards for communication system in Power Sector laid down by the Authority.

12.15. The static information like detailed write-up on present operation methodology of BESS, forbidden zones, number of cycle limits, Auxiliary consumption details, capability curve, simulation models (RMS/PSCAD) along with description or any specific information about BESS shall also be furnished as and when required by RLDC/NLDC.

12.16. Measurements

12.16.1. The measurements at the PCC shall include, but not limited to:

- Voltage
- Current
- Output power (Active and Reactive)

12.16.2. Suitable PQ meters (class-A type) at plant final output for measurement of required electrical parameters (active power, reactive power, power factor, voltage, current, frequency, etc.) shall also be provided for this purpose.

12.17. Control & Power Supply Scheme

The Contractor shall provide UPS/ DC Power supply of suitable rating to cater all the load requirements of PPC system and its auxiliaries.

12.18. Software Documentation & Listings

All technical manuals, reference manuals, user's guide etc. in English required for modification/editing/addition/deletion of features in the software of the PPC System shall be furnished. The Contractor shall furnish a comprehensive list of all system/application software documentation after system organization for Employer's review and approval. All The software listings for application software, Project data files etc. shall be submitted by the Contractor. All the PPC Software with license Key shall be handed over to the Employer. All the hardware and software shall be licensed to SECI.

13. Power Transformer

As specified in Section I (Scope of Works), Power Transformer of 33/220 kV ONAN/ONAF with OCTC Power Transformer shall be provided in line with "Standard Technical Specifications of Transformer(s) for Solar Park pooling station" issued by Central Electricity Authority (CEA). The transformer shall be capable of being overloaded to 110% for four hours in a 24-hour cycle.

14. Nitrogen Injection Fire Protection System

Nitrogen Injection Fire Protection System (NIFPS) shall use nitrogen as fire quenching medium. The protection system shall prevent transformer oil tank explosion and possible fire in case of internal faults. In the event of fire by external causes such as bushing fire, OLTC fire, fire from surrounding equipment etc., it shall act as a fast and effective fire extinguisher without any manual intervention.

14.1. Standards and Codes

All the equipment of NIFPS shall comply with the latest edition of the following standards and codes including amendments.

Standard	Description
IS 10028-2	Code of practice for selection, installation and maintenance of transformers; Part 2: Installation

IS 7285-2	Refillable Seamless Steel Gas Cylinders - Specification Part 2: Quenched and Tempered Steel Cylinders With Tensile Strength Less Than 1100 MPa (112 kgf/mm^2)
CEA Technical Standards for Construction of Electrical Plants and Electric Lines Regulations, 2010 with 2015 amendment	
CEA Measures relating to Safety and Electric Supply Regulations, 2010 with 2015 amendment	
CBIP Manual on Transformers, Publication No. 317	

14.2. Technical Requirements

Parameter	Specification
Fire extinction period from commencement of nitrogen injection	30 second (maximum)
Total time duration to bring oil temperature below flash point	30 minute (maximum)
Fire detector heat sensing temperature	141°C
TCIV setting for normal operation to ensure no obstacle for transformer breathing	40 litre per minute
TCIV setting for operation during abnormal flow of oil	60 litre per minute
Capacity of nitrogen gas cylinder	10 m^3 gas at pressure of 150 kg/cm^2 for up to 60,000 litre of oil 20 m^3 gas at pressure of 150 kg/cm^2 for above 60,000 litre of oil

14.3. System Components

NIFPS shall broadly consists of the following components. However, all other components which are necessary for fast, reliable and effective working of the fire protection system shall be deemed to be included in the scope of supply. The NIFPS shall have provision for SCADA connectivity.

14.3.1. Fire Extinguishing Cubicle

The Fire Extinguishing Cubicle (FEC) shall be made of CRCA sheet of minimum 3 mm thick with Polyurethane painting. The degree of protection shall be IP 55 or better. It shall have hinged split doors fitted with high-quality tamper-proof lock. The following components shall be provided in the FEC.

i. Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer. The nitrogen gas cylinder should have been certified by Bureau of Indian Standards and approved by Chief Controller of Explosives, Government of

India.

ii. Oil drain pipe with mechanical quick drain valve
iii. Control equipment for draining of oil and injecting nitrogen gas
iv. Pressure monitoring switch for backup protection for nitrogen release
v. Limit switches for monitoring of the system
vi. Valve with flanges on top of the cubicle for connecting oil drain pipe and nitrogen injection pipe
vii. Panel lighting
viii. Oil drain pipe extension of suitable sizes for connecting pipes to oil pit

14.3.2. Control Box

Control box shall be placed in the Master Control Room (MCR) for monitoring, automatic control and remote control. The rated control voltage of the control box shall be 110 VDC. The control box shall have suitable indications, alarms, switches and push buttons for complete monitoring and control of the system.

14.3.3. Transformer Conservator Isolation Valve

Transformer conservator isolation valve (TCIV) shall be fitted in the conservator pipe line between conservator and buchholz relay which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling. Locking plates shall be provided with handle for pad locking. It shall have proximity switch for remote alarm and indication glass window for visual inspection for physical checking of the status of valve. The TCIV shall be of the best quality and proven design as malfunctioning of TCIV could lead to serious consequences.

14.3.4. Fire Detector

Adequate number of fire detectors shall be fitted on top cover of the transformer and OLTC with brackets. Heat sensing temperature of the fire detectors shall be 141°C.

14.3.5. Signal Box

Signal box shall be mounted way from the transformer preferably near the marshalling box for terminating the cables from TCIV & fire detectors and to further connection to control box at the MCR. The degree of protection of the signal box shall be IP 55 or better.

14.3.6. Cables

The interconnecting cables shall be Fire Retardant Low Smoke (FRLS) type. Cables passing along the top of the transformer shall be Fire Survival type.

14.3.7. Pipes

Heavy duty pipe connecting the transformer tank for oil drain and for nitrogen injection

shall be provided. Pipes, complete with supports, connections, flanges, bends and tees etc. shall be supplied along with the system.

14.3.8. Other Items

i. Doors and covers of all the panels (FEC, Control box, Signal box, etc.) shall be provided with neoprene gaskets.
ii. All the panels and piping system shall be painted with enamelled paint.

14.4. Operation

14.4.1. On receipt of signals, e.g. Differential protection parallel with fire detector, Buchholz (surge) parallel with PRV and transformer isolation signals, a pre-determined quantity of oil drain shall commence and simultaneously nitrogen shall be injected at a pre-determined flow rate to create stirring action and to bring down temperature of top oil surface below ignition point and shall extinguish fire within short possible time. TCIV shall block oil passage and isolate conservator tank oil and shall prevent escalation of fire.

14.4.2. The system shall operate in automatic, remote and manual mode in the event of power failure.

14.4.3. The system shall have provision of testing on live transformers to ensure healthiness at all times.

14.4.4. The system shall have interlock to ensure operation of system only after transformer electrical isolation to avoid nitrogen in energised transformer.

14.4.5. The system shall have mechanical locking arrangement for nitrogen release system as well as oil drain to avoid unnecessary operation during maintenance and/or testing of the transformer and/or system.

14.4.6. The system shall have provision to monitor nitrogen injection pressure as well as cylinder pressure.

14.4.7. Pressure monitoring switch for back-up protection for nitrogen release as redundancy to first signal of oil draining commencement for nitrogen release shall preferably be provided.

14.4.8. The system shall have individual mechanical release devices and provision for oil drain and nitrogen release to operate manually in case of operation of DC supply failure.

14.4.9. Nitrogen release scheme shall be designed in such a way that the nitrogen gas shall not enter the energised transformer even in case of passing/leakage of valve.

15. Control and Relay Panel

15.1. Standards and Codes

All equipment provided under Control and Relay Panel shall comply with latest editions

and amendments of the relevant IEC standards and IS codes. In particular, the C&R Panel shall comply with the following standards and codes.

Standard/Code	Description
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment
IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV
IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 15086-4	Surge Arresters, Part 4: Metal-Oxide Surge Arresters Without Gaps for A.C. systems
IEC 62052-11	Electricity metering equipment (A.C.) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) - Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

15.2. Construction

15.2.1. The control and relay panel shall be free standing, floor mounted, simplex type, metal enclosed construction. The panel enclosure shall be made of CRCA steel sheet. The thickness of load bearing members shall be minimum 3 mm and that of non-load bearing members shall be minimum 2 mm.

15.2.2. All external surface shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. Internal surface shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 micron.

15.2.3. Controls, indications, relays, meters and other instruments shall be flush mounted on the front of the panel. Door shall be provided at the rear of the panel. All doors and removable covers shall be provided with neoprene or synthetic rubber gasket.

15.2.4. The panel shall be dust, moisture and vermin proof with degree of protection not less than IP 4X as per IEC 60529.

15.2.5. Cable entry shall be through the bottom of the panel. Gland plate of thickness not less than 3 mm shall be provided.

15.3. Relays

15.3.1. All relays shall be microprocessor based numerical type. However, auxiliary relays can be static or electromechanical type. The relays shall be flush mounted on panel front with connections from the inside.

15.3.2. Auxiliary voltage of the relays shall be 110 VDC / 220 VDC and the relays shall be capable of operating continuously between 80 – 120% of auxiliary voltage.

15.3.3. All numerical relays shall have adequate number of freely configurable, optically isolated, Binary Inputs (BI) and potential free Binary Outputs (BO). All I/O's shall have galvanic isolation. Analog inputs shall be protected against switching surges and harmonics.

15.3.4. All numerical relays shall have sufficient number of current and voltage inputs required for all the required protection functions.

15.3.5. The numerical relay shall provide choice of ANSI/IEC/IEEE relay characteristic curves with wide protection setting ranges through a minimum of two protection setting groups.

15.3.6. Making, breaking and continuous capacity of the relay contacts shall be adequate enough for the circuits in which they are used.

15.3.7. All numerical relays shall have provision for measurement and storage of electrical parameters such as voltage, current, frequency, active power, reactive power etc.

15.3.8. The numerical relay shall be able to record faults and events in non-volatile memory.

i. Fault record – At least 5 recent faults including the protection function operated, operating phase(s), voltages and currents along with date and time stamp.
ii. Event record – At least 200 events with date and time stamp.

15.3.9. The numerical relay shall have trip circuit supervision facility to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions. The relay shall also be able to provide circuit breaker monitoring, CT and VT supervision.

15.3.10. The numerical relay shall have self-diagnostic feature with separate output contact for indication of any internal relay failure.

15.3.11. The numerical relay shall have two serial communication ports, one on front side for local communication with PC and another on rear side for remote communication with SCADA system as per IEC 61850.

15.3.12. The numerical relay shall have feature for time synchronization through the SCADA System / networking.

15.3.13. The numerical relay shall be provided with backlit alphanumeric LCD or LED to access protection settings, measurement parameters, fault and event records. Read and write access to protection settings shall be password protected.

15.3.14. Necessary software and hardware to up/down load the data to/from the relay from/to the PC shall also be provided.

15.3.15. Each feeder shall have two lock out relays powered through independent DC supplies. Each lock out relay shall send signals to the respective independent trip

coils through separate potential free output contacts.

15.4. Protection Scheme

15.4.1. The following protection schemes shall be implemented for the protection of power transformer and its feeder.

(i) Biased Differential Protection with Second Harmonic Restraint
(ii) Non-directional Over Current and Earth Fault Protection
(iii) Restricted Earth Fault Protection
(iv) Under Voltage and Over Voltage Protection
(v) Buchholz Alarm and Trip
(vi) OTI Alarm and Trip
(vii) WTI Alarm and Trip
(viii) PRV Trip
(ix) MOG Alarm
(x) OSR Trip

The above-mentioned protection schemes are indicative only. All the protection schemes required for safe and reliable operation of power transformer and the feeder shall be provided.

15.4.2. Protection philosophy for the protection of line feeders shall be as per remote end substation requirements.

15.5. Measuring Instruments

15.5.1. All measuring instruments shall be enclosed in dust proof, moisture resistant cases and flush mounted on the panel.

15.5.2. Analog Ammeter and Voltmeter with selector switch shall be provided. Accuracy class shall be 0.5 or better. Instrument dial shall be with white scale, black pointer and black numerals.

15.5.3. Digital Multi-Function Meter (MFM) of accuracy class 0.2 or better shall be provided. It shall have communication capability for integration with SCADA. MFM shall be able to measure line & phase voltages, line & phase currents, active power, reactive power, apparent power, power factor and frequency.

15.6. Control Switches

All control switches shall be rotary operated type with adequate making, carrying and breaking current ratings. The control switches shall be pistol grip type, lockable with spring return to normal position. They shall be flush mounted on the panel with shrouded terminals.

15.7. Indications

All indicating lamps shall be flush mounted LED type with supply voltage of 110 VDC / 220 VDC. Lamp covers shall preferably be screwed type and moulded from heat resisting material. Indicating lamps shall be provided for R, Y, B PT supply, Breaker

ON & OFF, Auto trip, Spring charged, Trip circuit healthy, etc.

15.8. Annunciation

Flush mounted static type annunciator with sufficient number of windows to accommodate all trip and alarm signals shall be provided. Separate audible annunciation for alarm and trip shall be provided by means of buzzer and hooter. Visual annunciation shall be by flickering of facia. Push buttons for test, accept and reset shall also be provided.

15.9. Earthing

15.9.1. An earth bus made of copper or aluminium shall be provided throughout the length of the panel and bolted to the framework of the panel. The earth bus shall have sufficient cross section to carry maximum fault current without exceeding the allowable temperature rise.

15.9.2. All non-current carrying conductors of the panel shall be connected to the earth bus. All joints to the earth bus shall be made through at least two bolts. Hinged doors shall be earthed through flexible earthing braid of adequate cross section. Suitable provision shall be provided at each end of the earth bus for connection with earth grid.

15.9.3. All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth bus by independent copper wires of size not less than 2.5 sq. mm with green colour insulation.

15.9.4. Instrument transformer secondary neutral point shall be earthed at one place only on the terminal block. Such earthing shall be made through links so that earthing of one circuit may be removed without disturbing the earthing of other circuits.

15.10. Mimic Diagram

Coloured mimic diagram made of metal or plastic with symbols to facilitate exact representation of the system shall be fixed on the front of control panel. Semaphore indicators shall be incorporated in the mimic diagram for indicating position of circuit breakers, isolators and earthing switches. The rated control voltage of semaphore indicator shall be 110 / 220 VDC.

15.11. Wiring and Terminal Blocks

15.11.1. All internal wiring shall be done with 1100 V grade, 2.5 sq.mm. PVC insulated stranded flexible copper wire. For CT secondary circuits, 4 sq.mm copper wire shall be used.

15.11.2. Wire terminations shall be made with solderless crimping type tinned copper lugs, which shall firmly grip the conductor. Insulation sleeves shall be provided at all the wire terminations.

15.11.3. Printed identification ferrules, marked to correspond with panel wiring diagram shall be provided at both ends of each wire. The ferrules shall be firmly located on each wire so that they cannot move or turn freely on the wire. Wire identification shall be

done in accordance with IS 11353.

15.11.4. The Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

15.11.5. All internal wiring to be connected to the external equipment shall terminate on terminal blocks. Terminal blocks shall be rated for 1100 V, 10 A and made of non-inflammable material.

15.11.6. CT and VT secondary circuits shall be terminated on stud type, non-disconnecting terminal blocks.

15.11.7. At least 10% spare terminals shall be provided on each panel and these spare terminals shall be distributed on all terminal blocks.

15.11.8. Screw driver operated stud type test terminal block shall be provided.

15.12. Accessories

(i) Thermostatically controlled space heater with switch for isolation
(ii) 240 V, 15 A industrial socket with ON/OFF switch
(iii) LED lamp controlled by door switch

15.13. Warranty

The control and relay panel unit shall be warranted for minimum of 5 (five) years against all material/ manufacturing defects and workmanship from the date of supply.

15.14. Testing and Inspection

15.14.1. Type Tests

The Contractor shall submit type test report of the panel for degree of protection as required by the Technical Specifications as per IEC 60529. The test should have been conducted by NABL accredited laboratory.

15.14.2. Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

16. Plant Pooling Substation Equipment

16.1. Standards and Codes

All equipment provided shall comply with latest editions and amendments of the relevant IEC standards and IS codes. In particular, the switchyard equipment shall comply with the following standards and codes.

Standard/Code	Description
IS/IEC 62271-100	High Voltage Switchgear and Control gear - Part 100: AC Circuit Breakers

IEC 60376, IS 13072	Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
IS/IEC 62271-102	High Voltage Switchgear and Control gear - Part 102: AC Disconnectors and Earthing Switches
IEC 61869	Instrument Transformers
IS 2099	Bushings for alternating voltages above 1000 Volts
IS/IEC 60168	Tests on Indoor and Outdoor Post Insulators of Ceramic Material or Glass for Systems with Nominal Voltages Greater than 1000 V
IS 16683, IEC TS 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
IEC 60273	Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IS 335, IEC 60296	Insulating oil
IS/IEC 60034	Rotating electrical machines
IS 996	Single-phase AC industrial motors for general purpose
IS 15086-4, IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
CEA (Technical Standards for Construction of Electrical Plants & Electric Lines) Regulations, 2022	
Indian Electricity Act, CBIP manual	

16.2. General Technical Parameters

System Parameters	Specification
Highest system voltage	245 kV
Rated system voltage	220 kV
Rated frequency	50 Hz
Number of phases	3
One minute power frequency withstand voltage	460 kV (rms)
Full wave impulse withstand voltage (1.2 / 50 µs)	1050 kV (peak)
Rated short-time withstand current	50 kA for 1 s
Rated peak withstand current	100 kAp
System neutral earthing	Effectively earthed
Minimum creepage distance	As per site pollution level
Minimum clearance	

(i) Phase to phase clearance	2100 mm
(ii) Phase to earth clearance	2100 mm
(iii)Sectional clearance	5000 mm
(iv)Ground clearance	5500 mm

16.3. Supplier Qualification Criteria

Only PGCIL approved components shall be used for construction of 220 kV substation.

16.4. Circuit breaker

16.4.1. Technical Parameters

Parameters	Specification
Type	Outdoor SF6, single pressure
Maximum Radio Interference Voltage between 0.5 MHz and 2.0 MHz	1000 µV at 156 kV rms
Minimum corona extinction voltage	156 kV rms
Operating duty cycle	O – 0.3sec – CO – 3min – CO
Rated break time	60 ms
Total break time	65 ms
Total closing time	Not more than 150 ms
Re-strike performance class	C2
Mechanical endurance class	M2
First pole to clear factor	1.3
Reclosing	Single phase & three phase high speed auto reclosing
Rated terminal load	Adequate to withstand 100 kg static load as well as wind, seismic and short circuit forces without impairing reliability or current carrying capacity
Noise level	Maximum 140 dB at 50 m distance from base of circuit breaker
Seismic level	0.5 g horizontal for the site location under Zone-V as per IS 1893 0.3 g horizontal for the site location under other than Zone-V as per IS 1893
Auxiliary contacts	
No. of contacts	As required plus 10 NO and 10 NC contacts per pole as spare

Thermal rating	10 A at 220 V DC
Breaking capacity	2 A DC with circuit time constant not less than 20 ms

16.4.2. Duty Requirements

16.4.2.1. The circuit breaker shall be shall be capable of performing their duties without opening resistors. The circuit breaker shall meet the duty requirements for any type of fault or fault location and shall be suitable for line charging and dropping when used on effectively grounded or ungrounded systems and perform make and break operations as per the stipulated duty cycles satisfactorily.

16.4.2.2. The circuit breaker shall be capable of breaking the steady and transient magnetizing current corresponding to power transformers of applicable rating. It shall be capable of breaking line charging currents as per IEC 62271-100 with a voltage factor of 1.4. The rated transient recovery voltage for terminal fault and short line faults shall be as per IEC 62271-100.

16.4.2.3. The total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage, pneumatic/hydraulic pressure and arc extinguishing medium pressure, etc. While furnishing the proof of the total break time of complete circuit breaker, the effect of non-simultaneity between contacts within a pole or between poles shall be brought out to establish the guaranteed total break time. While furnishing particulars regarding the D.C. component of the circuit breaker, the Contractor shall note that IEC 62271-100 requires that this value should correspond to the guaranteed minimum opening time under any condition of operation.

16.4.3. Construction

16.4.3.1. Circuit breakers shall be SF6 insulated, single pressure type. The design and construction of the circuit breaker shall be such that there is a minimum possibility of gas leakage and entry of moisture. There should not be any condensation of SF6 gas on the internal insulating surfaces of the circuit breaker.

16.4.3.2. Each pole shall form an enclosure filled with SF6 gas independent of two other poles and the SF6 density of each pole shall be monitored individually.

16.4.3.3. The SF6 gas density monitor shall be adequately temperature compensated to model the density changes due to variations in ambient temperature within the body of circuit breaker as a whole. It shall be possible to dismantle the monitor without removal of gas. Temperature compensated SF6 pressure gauge shall be provided which will be visible from ground level.

16.4.3.4. Sufficient SF6 gas shall be supplied to fill all the circuit breakers installed plus an additional 20% of the quantity as spare.

16.4.3.5. All making and breaking contacts shall be sealed and free from atmospheric effect.

In the event of leakage of extinguishing medium to a value, which cannot withstand the dielectric stresses specified in the open position, the contacts shall preferably self-close. Main contacts shall be easily accessible for inspection and replacement. If there are no separately mounted arcing contacts, then the main contacts shall be easily accessible for inspection and replacement. Main contacts shall have ample area and contact pressure for carrying the rated current under all conditions.

16.4.3.6. All the three poles of the breaker shall be linked together either electrically/pneumatically or electro hydraulically.

16.4.3.7. Circuit breakers shall be provided with two (2) independent trip coils, suitable for trip circuit supervision. The trip circuit supervision relay would also be provided. Necessary terminals shall be provided in the central control cabinet of the circuit breaker.

16.4.4. Operating Mechanism and Control

16.4.4.1. Circuit breaker shall be operated by pneumatic mechanism or electrically spring charged mechanism or electro-hydraulic mechanism or a combination of these. It shall be gang operated for 3-phase reclosing operation.

16.4.4.2. The pneumatically operated mechanism shall offer unit compressor with each circuit breaker with the breaker local air receivers having a capacity for two 'CO' operations of the breaker at the lowest pressure for reclose duty without refilling.

16.4.4.3. The spring-operated mechanism shall be complete with motor, opening spring & closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit. As long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty. After failure of power supply to the motor, one close-open operation shall be possible with the energy contained in the operating mechanism. Motor ratings shall be such that it requires not more than 30 seconds for fully charging the closing spring.

16.4.4.4. The hydraulic mechanism shall be suitable for at least two close open operations after failure of ac supply to the motor starting at pressure equal to lowest pressure of auto-reclose duty. All hydraulic joints shall have no oil leakage under the site conditions and joints shall be tested at factory against oil leakage at a minimum of 1.5 times maximum working pressure.

16.5. Disconnector

16.5.1. Technical Parameters

System Parameters	Specification
Service	Outdoor
Type	Gang operated, Double break type
Rated short-time withstand current for isolator & earth switch	50 kA for 1 s

Rated peak withstand current for isolator & earth switch	100 kAp
Maximum Radio Interference Voltage between 0.5 MHz and 2.0 MHz	1000 µV at 156 kV rms
Minimum corona extinction voltage	156 kV rms
Operating Mechanism	AC / DC / Universal motor operated
Maximum operating time	12 s
Control Voltage	110 / 220 V DC
Auxiliary contacts	
No. of contacts for isolator	As required plus 8 NO and 8 NC contacts per pole as spare
No. of contacts for earth switch	Total 6 NO and 6 NC
Thermal rating	10 A at 220 V DC
Breaking capacity	2 A DC with circuit time constant not less than 20 ms
Mechanical endurance class a) Isolator b) Earth switch	 M2 M0

16.5.2. Duty Requirements

16.5.2.1. Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the system in their closed position. They shall be constructed such that they do not open under influence of short circuit current and wind pressure together.

16.5.2.2. The earth switches, wherever provided, shall be interlocked so that the earth switches can be operated only when the isolator is open and vice versa. In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of fail-safe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within stipulated variation range. The interlock coil shall be provided with adequate contacts for facilitating permissive logic for DC control scheme of the isolator as well as for AC circuit of the motor to prevent opening or closing of isolators when the interlocking coil is not energised.

16.5.2.3. The earthing switches shall be capable of discharging trapped charges of the associated lines. Isolators and earth switches shall be able to bear on the terminals the total forces including wind loading and electrodynamic forces on the attached

conductor without impairing reliability or current carrying capacity.

16.5.2.4. The isolator shall be capable for making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of the isolator on account of making/breaking operation.

16.5.3. Construction

16.5.3.1. Contacts

(i) The contacts shall be self-aligning and self-cleaning type and shall be so designed that binding cannot occur after remaining in closed position for prolonged period in a heavily polluted atmosphere.

(ii) No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.

(iii) Contact springs shall not carry any current and shall not lose their characteristics due to heating effects.

(iv) The moving contact of double break isolator shall preferably be turn-and-twist type or other suitable type of locking arrangement to ensure adequate contact pressure.

(v) Flexible braided copper, where used, shall have corrosion resistant coating such as tinning or silvering.

16.5.3.2. Base

Each single pole of the isolator shall be provided with a complete galvanised steel base provided with holes and designed for mounting on a standard supporting structure.

16.5.3.3. Blades

(i) All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. Ferrous parts, other than stainless steel shall not be used in close proximity of main current path. All ferrous castings, if used elsewhere shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

(ii) The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces. Where this is impracticable, adequate corona rings shall be provided. Corona shields are not acceptable. Corona rings shall be made up of aluminium/aluminium alloy.

(iii) Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.

(iv) The isolator and earth switch shall be designed such that no lubrication of any part is required except at very infrequent intervals. i.e., after every 1000 operations or after 5 years whichever is earlier.

16.5.3.4. Insulator

(i) The insulator shall conform to IS / IEC 60168 and IS 16683 / IEC TS 60815.

(ii) In addition to all type, routine and acceptance tests, as per IS / IEC 60168, the following additional routine/ acceptance tests shall also be carried out.

(a) Bending load test in four directions at 50% of minimum bending load guaranteed on all insulators, as routine test

(b) Bending load test in four directions at 100% of minimum bending load guaranteed as a sample test on each lot

(c) Torsional test on sample insulator of a lot

(d) Ultrasonic test as a routine test

(iii) The porcelain of the insulator shall have minimum cantilever strength of 1000 kg.

(iv) Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.

16.5.3.5. Earthing Switches

(i) Where earthing switches are specified, these shall include the complete operating mechanism and auxiliary contacts. The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator.

(ii) Earthing switches shall only be locally operated.

(iii) Each earth switch shall be provided with flexible copper/aluminum braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through swivel connection will not be accepted.

16.5.4. Operating Mechanism and Control

16.5.4.1. The Contractor shall offer motor operated switches having padlock arrangement for both ON and OFF positions.

16.5.4.2. Limit switches for control shall be fitted on the isolator / earth switch shaft within the cabinet to sense the open and close positions of the isolators and earth switches.

16.5.4.3. It shall not be possible, after final adjustment has been made, for any part of the mechanism to be displaced at any point in the travel sufficient enough to allow improper functioning of the isolator when the isolator is opened or closed at any

speed.

16.5.4.4. Control cabinet / operating mechanism box shall conform to requirements stipulated elsewhere in the document and IS/IEC 61439 as applicable.

16.5.5. Operation

16.5.5.1. Isolator shall be electrically/mechanically gang operated for main blades and earth switches. The operation of all the three poles shall be well synchronized and interlocked.

16.5.5.2. The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection. The length of inter insulator and interpole operating rods shall be capable of adjustments.

16.5.5.3. The isolator and earth switches shall be provided with 'dead centre mechanism' to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.

16.5.5.4. The design of linkages and gears be such so as to allow one man to operate the handle with ease for isolator and earth.

16.6. Surge Arrester

16.6.1. Technical Parameters

Parameter	Specification
Arrester Classification	Station Medium (SM)
Nominal discharge current (8/20 µs)	10 kA
Repetitive charge transfer rating	1.6 coulomb
Rated thermal energy rating	7 kJ/kV
Rated arrester voltage	216 kV
Continuous operating voltage at 50°C	168 kV
Maximum Radio Interference Voltage between 0.5 MHz and 2.0 MHz	500 µV at 156 kV rms
Maximum Residual Voltage (iv) At 30/60 µs, 1 kA current (v) At 8/20 µs, 5 kA current (vi) At 8/20 µs, 10 kA current	 500 kVp 560 kVp 600 kVp
High-current short duration test value (4/10 µs)	100 kAp
Current for pressure relief test	40 kA
Partial discharge at 1.05 times the continuous operating voltage	≤ 10 pC

16.6.2. Duty Requirements

16.6.2.1. The Surge Arresters shall be capable of discharging over-voltages occurring due to switching of unloaded transformers, reactors and long lines.

16.6.2.2. The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

16.6.2.3. The Surge Arresters shall be capable of withstanding meteorological and short circuit forces under site conditions.

16.6.2.4. The SAs shall protect power transformers, circuit breakers, disconnecting switches, instrument transformers, etc. with insulation levels specified in this specification.

16.6.3. Construction

16.6.3.1. Each surge arrester shall be hermetically sealed single-phase unit. The non-linear blocks shall be made of sintered metal oxide material. The surge arrester construction shall be robust with excellent mechanical and electrical properties.

16.6.3.2. Surge Arresters shall be fitted with pressure relief devices and arc diverting ports suitable for preventing shattering of polymer housing and to provide path for flow of rated fault current in the event of SA failure.

16.6.3.3. Outer insulator of surge arrester shall be made of porcelain/polymer. The outer insulator housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage up to the maximum design value for arrester. Arresters shall not fail due to insulator contamination.

16.6.3.4. Seals shall be provided in such a way that they are always effectively maintained even when discharging rated lightning current.

16.6.3.5. The cantilever strength of the insulator shall be minimum 150 kg.

16.6.3.6. The following details shall be furnished for quality checks.

(i) The heat treatment cycle details along with necessary quality checks used for individual blocks and insulation layer formed across each block.
(ii) Metalizing coating thickness for reduced resistance between adjacent discs.

16.6.4. Fittings and Accessories

16.6.4.1. Surge arrester shall be complete with insulating base having provision for mounting to structure.

16.6.4.2. Grading/corona rings shall be provided on each surge arrester unit, as required.

16.6.4.3. The end fittings shall be made of corrosion proof material and preferably be nonmagnetic.

16.6.4.4. Self-contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit along with necessary connection arrangement. Suitable leakage current meters shall also be provided in the same enclosure. The reading of ammeter and counter

shall be visible through an inspection glass panel to maintenance personnel standing on ground. The terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The surge counter shall be provided with a potential free contact rated for 220 V DC which shall close whenever a surge is recorded by the surge monitor. Necessary arrangement shall be provided for extending the contact information to Substation Automation System/RTU.

16.7. Instrument Transformer

16.7.1. Technical Parameters

Parameter	Specification
Current Transformer	
Accuracy class	Metering – 0.2S Protection – PS / 5P20
Rated VA burden	As per requirement
Insulation class	Class A
One minute power frequency withstand voltage between secondary terminals & earth	5 kV
Maximum Radio Interference Voltage between 0.5 MHz and 2.0 MHz	1000 µV at 156 kV rms
Rated short time thermal withstand current	50 kA for 1 s
Rated dynamic current	100 kAp
Partial discharge level	10 pico Coulomb (max)
No. of terminals	All terminals of control circuits wired up to marshalling box plus 20% spare
Capacitive Voltage Transformer	
Accuracy class	Metering – 0.2 Protection – PS / 3P
Rated VA burden	As per requirement
Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
High frequency capacitance for entire carrier frequency range	Within 80% to 150% of rated capacitance
Equivalent series resistance over entire carrier frequency range	< 40 ohm
One minute power frequency withstand voltage between secondary terminals & earth	

(i) Between LV (HF) terminal and earth terminal	10 kV for exposed terminals 4 kV for terminals enclosed in a weather proof box
(ii) For secondary winding	3 kV
Partial discharge level	10 pico Coulomb (max)
Rated voltage factor	1.2 continuous and 1.5 for 30 sec.
No. of terminals	All terminals of control circuits wired up to marshalling box plus 20% spare

16.7.2. General Requirements

16.7.2.1. Instrument transformers shall be hermetically sealed single-phase units, oil immersed, self-cooled suitable for outdoor installations and shall be supplied with common marshalling box for a set of three single phase units.

16.7.2.2. The external surface of instrument transformer, if made of steel, shall be hot dip galvanized or painted with colour shade as decided by the Employer during detailed engineering.

16.7.2.3. Insulating oil to be used for instrument transformers shall be of EHV grade and shall conform to IS 335 / IEC-60296. Non–PCB based synthetic insulating oil conforming to IEC 60867 shall be used in the capacitor units of CVT.

16.7.2.4. Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

16.7.2.5. The insulators shall have cantilever strength of more than 350 kg.

16.7.2.6. Marshaling box shall conform to all requirements given elsewhere in the document. The wiring diagram for the interconnection of three phase instrument transformer shall be pasted inside the box. Terminal blocks in the marshaling box shall have facility for star/delta formation, short circuiting and grounding of secondary terminals. The box shall have enough terminals to wire all control circuits plus 20 spare terminals.

16.7.3. Current Transformer

16.7.3.1. Current transformer shall have single primary of either ring type or hair pin type or bar type. Wound type primary is acceptable only for metering CTs of ratio less than 400/1. In case of inverted type/live tank CT, the following requirements shall be met.

(i) The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

(ii) The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

(iii) The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement

between insulation assembly & top dome.

(iv) The insulator shall be one piece without any metallic flange joint.

16.7.3.2. Core lamination shall be of cold rolled grain-oriented silicon steel or other equivalent alloys. The cores shall produce undistorted secondary current under transient conditions at all ratios with specified parameters.

16.7.3.3. The CT shall be provided with oil filling plug, drain plug, and oil sight glass which should be clearly visible to maintenance personnel standing on ground.

16.7.3.4. The secondary terminals of CT shall be terminated to suitable number of stud type non-disconnecting and disconnecting terminal blocks as required inside the terminal box of degree of protection IP 55 at the bottom of CT.

16.7.3.5. Different ratios shall be achieved by secondary taps only; primary reconnection shall not be accepted.

16.7.3.6. The Instrument Security Factor (ISF) at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactors are used, then all parameters specified shall be met treating auxiliary CTs as an integral part of the CT. The auxiliary CTs/reactors shall preferably be in-built construction of the CT. In case these are to be mounted separately, these shall be mounted in the central marshalling box suitably wired up to the terminal blocks.

16.7.3.7. Current transformers shall be suitable for high-speed auto reclosing.

16.7.4. Capacitor Voltage Transformer

16.7.4.1. Capacitor Voltage Transformer shall consist of a capacitor divider and an electromagnetic unit housed in independent, non-oil communicating hermitically sealed compartments.

16.7.4.2. The capacitor divider shall consist of primary and secondary capacitance housed in high quality porcelain insulators filled with oil. The electromagnetic unit shall comprise of compensating reactor, intermediate transformer, protective and damping devices.

16.7.4.3. Suitable damping device shall be permanently connected to one of the secondary windings and shall be capable of suppressing ferro-resonance oscillations.

16.7.4.4. All the secondary windings of the CVT shall be protected by HRC cartridge type fuses or MCBs. In addition, fuses/MCBs shall also be provided for protection and metering windings for connection to fuse monitoring scheme.

16.7.4.5. The secondary terminals of the CVT shall be terminated to stud type non-disconnecting terminal blocks via fuses/MCBs inside the terminal box of degree of protection IP 55. It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

16.7.4.6. CVTs shall be suitable for High Frequency (HF) coupling required for Power Line Carrier Communication (PLCC). Carrier signals must be prevented from flowing into EMU circuit by means of RF choke/reactor over the entire frequency range of

40 to 500 kHz. HF terminal shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment. Further, earthing link with fastener to be provided for HF terminal.

16.7.4.7. A protective surge arrester/spark gap shall preferably be provided to prevent break down of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor, tuning reactor, RF choke, etc. due to short circuit in transformer secondary. The details of this arrangement (or alternative arrangement) shall be furnished by Contractor for Employer's review.

16.7.4.8. The accuracy of metering core shall be maintained through the entire burden range up to rated value without any adjustments during operations.

16.7.4.9. The protection cores shall not saturate at about 1.5 times the rated voltage for a minimum duration of 30s.

16.8. Bus Post Insulator

16.8.1. Technical Parameters

Parameters	Specification
Type	Solid Core
Maximum Radio Interference Voltage between 0.5 MHz and 2.0 MHz	500 µV at 156 kV rms
Minimum corona extinction voltage	156 kV rms
Minimum cantilever strength	800 kgf

16.8.2. Post insulators shall conform to IS/IEC 60168, IEC 60273 and IS 16683 / IEC 60815.

16.8.3. Post insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators will be acceptable.

16.9. Warranty

All substation equipment shall be warranted for minimum of 2 (Two) years against all material/ manufacturing defects and workmanship from the date of supply.

16.10. Testing and Inspection

16.10.1. Type Tests

All substation equipment shall be of type tested design. Type test reports as per the relevant IEC/IS standards shall be submitted during detailed engineering. The tests should have been conducted on the similar equipment by NABL accredited laboratory. Validity period of type tests conducted on the equipment shall be as per 'CEA Guidelines for the Validity Period of Type Test(s) conducted on Major Electrical Equipment in Power Transmission'. In case the contractor is not able to submit the test

reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by Employer.

16.10.2. Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

17. Illumination

17.1. Standards and Codes

LED luminaires shall be tested as per the following test standards.

Standard/Code	Description
LM79-08	Electrical and Photometric Measurements of Solid-State Lighting Products
LM 80-15	Measuring Luminous Flux and Colour Maintenance of LED Packages, Arrays and Modules

17.2. General Specification

17.2.1. This specification covers design, supply and installation of uniformly Illumination system along the peripheral corridor, access & internal roads, main control room & inverter rooms, switchyard and other facilities including entry points/gate(s) inside the plant area.

17.2.2. The Contractor shall furnish Guaranteed Technical Particulars of the LED luminaires, from renowned brands available in the market for approval of Employer.

17.2.3. Lighting system shall work on the auxiliary supply and same shall be incorporated in auxiliary loads. The Contractor shall provide minimum 20% of total lighting points as emergency lighting points, fed from UPS DB or DCDB as per scheme adopted by the Contractor.

17.3. Lighting Levels

17.3.1. The lighting system of BESS power plant shall be designed in such a way that uniform illumination is achieved. Average LUX level to be maintained in different areas shall be as under:

Area	LUX
Control Room and equipment rooms	300
Office	300
Battery & other rooms	150
Internal / Access Roads	4
Transformer yard/Switchyard	20

H – pole and metering point	10

17.3.2. The lighting level shall take into account appropriate light output ratio of luminaires, coefficient of utilization maintenance factor (of 0.7 or less) to take into account deterioration with time and dust deposition and illuminance uniformity [Uo] shall be min 0.3.

17.4. LED Luminaire for Outdoor Applications

17.4.1. LED luminaires shall meet the following parameters.

Parameter	Specified Value
Input voltage	170 - 260 V
Input Frequency	50 Hz +/-1 Hz
Power Factor	0.90 (Minimum)
Luminaire efficacy	> 90 lumens per watt
Beam Angle	Minimum 120°
Total Harmonic Distortion	< 10 %
Working Humidity	10% - 90% RH (Preferably Hermetically sealed unit)
Degree of Protection	Minimum IP 65 (for Outdoor fixtures)
Luminaire Casing	Powder coated metal / Aluminum.
Colour Temperature	5700 K (cool day light)
Colour Rendering Index	> 65

17.4.2. LED luminaire of minimum 50 W mounted at a pole height of 4 m shall be provided at every 100 m interval for plant boundary.

17.4.3. The LED luminaire (outdoor) housing, heat sink, pole mounting bracket, individual LED reflectors and front heat resistant tempered glass should be provided.

17.4.4. The LED luminaire (outdoor) housing should be made of non-corrosive, high-pressure, die-cast aluminium and the housing should be power coated grey, so as to ensure good weatherability. Each individual LED source should be provided with an asymmetrical distribution high reflectance aluminized reflector, which should ensure that the light distribution of the luminaire is suitable for road lighting applications (wide beam distribution) and should ensure high pole to pole spacing.

17.4.5. The luminaire should be provided with in-built power unit and electronic driver.

17.4.6. The luminaire should be suitable for standard street light poles and should be suitable for side entry and bottom entry (post top).

17.4.7. GI Lighting pole of suitable diameter capable of withstanding system and wind load, shall be provided with average Zn coating thickness of 80 micron. The street light

poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB.

17.4.8. All outdoor lighting system shall be automatically controlled by synchronous timer or photocell. Provision to bypass the timer or photocell shall be provided in the panel.

17.4.9. Lighting panels shall be earthed by two separate and distinct connections with earthing system. Switch boxes, junction boxes, lighting fixtures, etc. shall be earthed by means of separate earth continuity conductor. Cable armour shall be connected to earthing system at both the ends. Proper earthing of street light poles shall be ensured.

17.4.10. Junction box for lighting shall be made of fire-retardant material. The degree of protection shall be IP 55 for outdoor JB.

17.4.11. Lighting cables, wherever exposed to direct sunlight, shall be laid through Double Wall Corrugated (DWC) HDPE conduits.

17.5. LED Luminaire/Lamps for Indoor Applications

All indoor LED luminaire/lamps shall be supplied with proper diffuser to avoid direct visibility of LED and suitable heat sink for longer life.

17.6. Warranty

All luminaires shall be warranted against all material/manufacturing defects and workmanship for minimum of 2 (two) years from the date of supply.

18. Weather Monitoring System

As a part of weather monitoring system, the Contractor shall provide the following measuring instruments with all necessary software and hardware required to integrate with SCADA.

18.1. Temperature Sensor

18.1.1. The temperature sensor shall be Resistance Temperature Detector (RTD)/ Semiconductor type with measurement range of 0°C to 80°C. The instrument shall have valid calibration certificate.

18.1.2. The Contractor shall provide minimum 6 (six) temperature sensors for ambient temperature measurement with shielding case. Sensors should be spatially distributed throughout the plant area, as is possible.

18.2. Anemometer

Contractor shall provide minimum five nos. ultrasonic wind sensors (no moving parts), spatially distributed throughout the Plant Area for wind speed and direction monitoring.

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^{o} (No dead band) with +/-2^{o} accuracy @12 m/s; Resolution: 1^{o}

Mounting Bracket	Anodized Aluminium bracket to reduce corrosion, all mounting bolts of SS
Protection Class	IP 66
Output	RS 485

18.3. Sensors required for measurement of following parameters shall also be provided.

(i) Rainfall (mm) – 6 nos.
(ii) Relative humidity (%) – 6 nos.

18.4. Data logger and Data Acquisition System

Data logger for the weather monitoring station should have the following features:

18.4.1. 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:

- RS485 MODBUS interface for data collection and storage on SCADA
- 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: IP 65

19. CCTV Camera

19.1. CCTV Cameras along with monitoring stations (sufficient numbers) and all other accessories required for its proper operation must be installed to have complete coverage of following areas for 24 hours.

(i) Main entry: Covering all the entry/exit
(ii) Along the Plant Perimeter: Any strategic location in the Plant Area required to be monitored.
(iii) Main Control Room: Covering Entry/Exit and Equipment Rooms
(iv) Inverter Station & Inverter Transformer Yard
(v) Plant Pooling Substation

19.2. Monitoring stations of the CCTV Network shall be installed in Main Control Room.

19.3. The CCTV system shall be designed as a standalone IP based network architecture. System shall use video signals from different cameras at defined locations, process the video signals for viewing on monitors at control room and simultaneously record all video streams using latest compression techniques.

19.4. Camera shall be colour, suitable for day and night surveillance (even under complete darkness) and network compatible.

19.5. It shall be possible to control all cameras i.e., PTZ auto/ manual focus, selection of pre-sets, video tour selection etc. The software shall support flexible 1/2/4 windows split screen display mode or scroll mode on the display monitor for live video.

19.6. The system shall support video analytics in respect of the following:

(i) Video motion detection
(ii) Object tracking
(iii) Object classification
(iv) Camera server shall be provided with sufficient storage space to storage recordings of all cameras at HD mode for a period of 15 days. All recordings shall have camera ID, location, date and time of recording.

20. Fire Alarm System

20.1. Standards and Codes

Standard/Code	Description
IS 2189	Selection, Installation and Maintenance of Automatic Fire Detection and Alarm System - Code of Practice
IS 15683	Portable Fire Extinguishers - Performance and Construction - Specification
IS 2546	Specification for galvanized mild steel fire bucket
National Building code 2016	

20.2. The Contractor shall ensure the compliance of fire detection and alarm system as per relevant standards and regulations. The installation shall meet all applicable statutory requirements and safety regulations of state/central fire department/body or any other competent authority in terms of fire protection.

20.3. Firefighting system for the proposed power plant for fire protection shall be consisting of but not limited to:

(i) Sand buckets

(ii) Portable fire extinguishers (CO2 and dry powder type)
(iii) Microprocessor based fire alarm panel
(iv) Multi sensor smoke detectors
(v) Hooter cum strobe
(vi) Manual call points
(vii) Cables from sensor to fire Panel.

20.4. Minimum two numbers of fire extinguishers (CO2 and Foam type each, of capacity 9 kg having BIS certification marking as per IS 15683) shall be provided at every building/ enclosure, transformer yard and switchyard. However, contractor must comply with existing building code for fire protection and relevant IS codes.

20.5. Four numbers of stand with four sand buckets on each stand shall be provided in the Transformer Yard. Sand buckets inside the building shall be provided at strategic locations as decided during detailed engineering.

20.6. Digital output from the fire detection system shall be integrated with SCADA.

20.7. The Contractor shall submit the plan for fire and smoke detection system for the Employer's approval.

21. Testing Instruments

The Contractor shall provide the following set of instruments for on-site testing.

21.1. Earth resistance tester

Parameter	Specification
Display	Backlit LCD or LED display
Range	Earth Resistance: up to 2000 Ω Earth Voltage: 200 V
Accuracy (Earth Resitstance)	± (2% + 3)
Accessories	
Earth Ground Stakes – 4 Nos.	
Cable Reels – 3 Nos.	
Battery – 2 set	
Carry Case with sufficient space for accommodating accessories	

21.2. Insulation tester

Parameter	Specification
Display	Backlit LCD or LED display
Insulation Test Range	0.1 MΩ to 10 GΩ
Test Voltage	250V, 500V, 1000V, 5000V

Test Voltage accuracy	± 10%
Accessories	
Heavy duty Test Leads with Alligator Clips – 1 set	
Battery – 2 set	
Carry Case with sufficient space for accommodating accessories	

21.3. Digital Multimeter

Parameter	Specification
Voltage Range	1500 V DC / 1000 V AC (True RMS)
Display	43 ½ digits, Backlit LCD or LED
Measuring Category	1000 V CAT III as per IEC Standard 61010-1
Additional Functions	Resistance, Temperature (°C), Continuity, Diode, Capacitance, Frequency, Duty cycle measurement
Accessories	
Temperature Probe – 1	
Test Leads with Alligator Clips – 1 set	
Battery – 2 set	
Carry Case with sufficient space for accommodating accessories	

21.4. Clamp meter

Parameter	Specification
Current Range	400 A DC / 1000 A AC (True RMS)
Display	Backlit LCD or LED display
Measuring Category	1000V CAT III as per IEC 61010-1
Additional Functions	Active, Reactive and Apparent Power, THD, PF
Accessories	
Test Leads – 1 set	
Battery – 2 set	
Carry Case with sufficient space for accommodating accessories.	

21.5. Infra-red thermal imaging camera

Parameter	Specification
Spectral response	8 μm to 14 μm (LW)
Temperature-sensitivity and calibration range	–20 °C to +120 °C
Atmospheric air temperature	-10 °C to +40 °C
Thermal sensitivity	NETD ≤ 0.1 K
Geometric resolution	640 x 480 pixels
Absolute error of measurement	< ± 2 K
Adjustable parameters	Emissivity, Reflected 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 thermographic camera has to be traceably calibrated at least every two years. The calibration has to be documented. If the camera is not compliant (absolute temperature and/or temperature differences), it has to be readjusted by the manufacturer.
Documentation	Storing of the infrared picture with the radiometric data to be able to determine absolute temperatures

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

21.7. Instruments of superior rating is allowed after seeking consent of the Employer.

21.8. Maintenance, calibration, up keeping, repair & replacement of these tools will be in the scope of the Contractor during O&M.

21.9. It is Contractor's responsibility to arrange for tools, tackles, logistics, test kits, manpower, experts etc. required for trouble free operation of Plant.

22. Power Evacuation System

22.1. The Contractor shall design and construct the power evacuation system to and with the designated interconnection point (as mentioned in Section I: Scope of Works) via either overhead transmission line or underground cables at specified grid voltage with all necessary infrastructure such as protection switchgears and metering systems as per the requirement of the CTU.

22.2. The Contractor shall get the route approval from the Employer prior to start of the

construction. Any changes in the route or scheme due to ROW issues at any point of the time prior to commissioning shall be complied without any additional cost to the Employer.

22.3. The ROW for the TL/UG cable shall be obtained prior to the construction of the line from the concerned authorities.

22.4. Overhead Transmission Line

In case the power evacuation is planned with overhead transmission line for plant external evacuation, the design of tower/pole and its accessories shall be as per the CTU's requirement and the design shall be submitted to Employer for approval/ accord.

22.5. Underground cable

In case the power evacuation is planned with underground cable for plant internal evacuation, the cable shall be approved by the Employer. However, in case of external power evacuation, the evacuation plan shall be as per CTU's requirement and the same shall be submitted to Employer for approval/ accord.

III. TECHNICAL SPECIFICATIONS (TS)- CIVIL, MECHANICAL & PLUMBING WORKS

1. General Requirement

1.1. This section of Technical Specifications describes detailed technical and functional requirements of all civil, structural, mechanical & plumbing works included in the scope as detailed under Section I, Scope of Works.

1.2. This specification does not cover design of transmission line poles, towers, tower extensions and accessories. They shall be designed as per latest CTU/STU/DISCOM guidelines and relevant IS standards. Poles at corner with angle > 10° shall be provided with 4-pole structure or lattice tower. Use of Pre-stressed cement concrete spun poles is not acceptable. Copies of released for construction (RFC) designs & drawings for transmission line poles, towers, tower extensions and accessories approved by CTU/STU/DISCOM shall be submitted to the employer for reference and record.

1.3. Earthing mat shall be provided around buildings and structures as per design requirements / approved drawings.

1.4. Standards & Codes

1.4.1. All design and construction of civil works shall conform to relevant Indian standards such as BIS, IRC, MORTH, NBC, CBIP manuals etc.

1.4.2. Design of steel structures shall conform to IS: 800, 801 or 802 as applicable. Ductile design and detailing as per IS 13920 shall be followed in concrete structures except in case of concrete support structure up to plinth level supporting open installations of inverter transformers, control panels at ICR/LCR etc. wherein the detailing shall conform to IS 456 and SP 34. For design of liquid retaining structure IS: 3370 shall be followed. Only in case of non-availability of Indian standard, equivalent American or British standard may be used for design with prior approval of the Engineer and the contractor shall submit proper justification for the same along with his request to the Engineer for review and approval, and the decision of the Engineer shall be final and binding.

1.4.3. All the design/ drawings shall be prepared/ approved either by in-house Engineering Team of the contractor (or by his Engineering Consultant) with qualified engineering staff with relevant experience in successful design of power plants.

1.4.4. The design calculations for RCC structure, Steel structure, Foundation system including piling, Road work, Drainage work, etc. shall be submitted for prior approval of Engineer before commencement of construction.

1.4.5. As per project requirements, the Employer may ask for approval of all civil designs and drawings by a Chartered Civil/ Structural Engineer the cost of which is included in the bid price.

1.5. The design calculations shall be supplemented with a neat sketch showing the structure geometry, node and member nos., lengths of various typical members, support points

and type of supports, types of materials & type of sections with properties considered in analysis & design. The report shall also include back-up calculations for various loads adopted in design, brief write-up on primary load cases and design load combinations considered and conclusions on design results (with supporting sketches) for easy reference and clarity. Where a computer program (other than STAAD) is used for analysis and design, the contractor shall include a write-up on the computer program used along with examples for validation check. Design Input (format suitable to the programme used and also in STAAD format) and output file shall also be given in the design report and in soft copy to facilitate its review and approval by the Engineer. The submission of design documents and drawings shall be as per the details listed under Section I: Scope of Works.

1.6. The methodology for construction of Road & drainage works shall also be submitted for prior approval of Engineer before start of these works.

2. Topographical Survey

2.1. The contractor shall be responsible for detailed Topographical Survey of the proposed project site. The work shall be carried out through an agency with relevant experience and qualified survey team.

2.2. The Topographical survey shall be conducted at 20m x 20m grid, or as directed by the Engineer, only with the help of digital surveying instruments like Total Station/ Auto level.

2.3. The Contractor shall carry the Bench Mark from nearest GTS Bench mark or any other established source like Railway station, Permanent PWD/ WRD structure etc. as approved by the Engineer, by fly-levelling and establish two permanent bench marks (PBM) at site. All subsequent transfer of levels shall be carried out with respect to these PBMs. The work shall also include constructing permanent reference pillars (RP) at suitable locations as directed by the Engineer. These reference pillars shall be labelled permanently with their respective coordinates and reduced levels for future use. The Permanent Bench Marks (PBM) and reference pillars (RP) shall be shown on the survey drawings.

2.4. While carrying bench mark to the project site, levels shall also be established on the permanent objects like culverts etc. at least on one object in every 1 (one) km if available along with route with adequate description about the objects. These levels shall be maintained at site & also mentioned in the survey report to facilitate locating these objects later on.

2.5. The survey work shall be carried out in UTM grid system. The contractor shall also establish the latitudes and longitudes and UTM coordinates of all the corners of the project site. At least 50m width of the adjoining plots and surrounding areas shall also be covered in the survey for correlation with adjoining plots and facilities. The grids for the survey work shall be established in N-S & E-W direction (corresponding to Geographical North or Plant North) as directed by the Engineer.

2.6. Positions, both in plan and elevation, of all natural and artificial features in the area like

waterways, railway tracks, trees, cultivation, houses, fences, pucca and kutcha roads including culverts and crossings, foot tracks, other permanent objects like telephone posts and transmission towers etc. are to be established and subsequently shown on survey maps by means of conventional symbols (preferably symbols of survey of India Maps). All hills and valleys within the area/areas are to be surveyed and plotted on maps by contours. Any unusual condition or formation on the ground, locations of rock outcrops (if visible on the surface) and springs/falls, sand heap/dune, possible aggregate deposits etc. shall also be noted and plotted on contour maps. The C/L coordinates of existing road & cross drainage (CD) works (culverts etc.) at intermediate points & at corners/ intersections and width of carriage way of the road shall be recorded with their position on the contour maps.

2.7. The record of measurement of all Reduced Levels (RL) shall be submitted in digital format, (in x, y z coordinate system) along with preliminary contour plan of the site, for Engineer's review before submission of final contour map. The contour interval shall be as required for proper representation of the topography however it shall not be more than 0.5m. The Contractor shall submit survey maps of the site in 1:10,000 scale indicating grid lines and contour lines, demarcating all permanent features like roads, railways, waterways, buildings, power lines, natural streams, trees, sand dunes etc. Present use of the site i.e. mining, quarrying, agriculture etc., existing drainage pattern of the site, possibility of water logging and high flood level of the area shall also be captured in the document. The project plot boundary with coordinates of all corner points along with coordinate grid of 50m x 50m interval shall be marked on the contour map.

3. Geotechnical Investigations

3.1. The contractor shall be responsible for detailed Geotechnical investigations at the proposed project site for the purpose of foundation design for various buildings, structures, HT lines etc. and other design/ planning requirements. The investigation work shall be carried out through any Govt. approved/ NABL accredited agency. The contractor shall submit the credentials of the proposed agency along with relevant certificates in support thereof for verification/ approval of the Investigation Agency by the Engineer.

3.2. The scope of work includes execution of complete soil exploration including boring and drilling with rotary drilling rig (DTH in case of rocky strata), standard penetration test (SPT), collecting disturbed (DS) and undisturbed samples (UDS), collecting ground water samples, trial pits, electrical resistivity tests (ERT), field & laboratory CBR tests, conducting laboratory tests on collected samples of soil & ground water and preparation and submission of report. SPT shall be carried out in all types of soil deposits and in all rock formations with core recovery up to 20% met within a borehole (BH). SPT test shall be conducted at every 1.5m interval or at change of strata. The starting depth of SPT shall be 0.5m from ground level. UDS shall be collected at every 1.5m interval or at change of strata. The min. size of trial pit shall be 2.0mx2.0mx2.5m deep.

3.3. The field investigations shall mainly include drilling of min. 5 m deep BHs, conducting

SPT and collecting Disturbed (DS) and Undisturbed samples (UDS), conducting in-situ CBR test for approach road to the plant, internal roads & peripheral road; Trial pits (TP) and Electrical resistivity tests (ERT). Number and location of BHs, California bearing ratio (CBR) tests, ERTs and TPs shall be decided as per the project layout, site topography and soil conditions in consultation with the Employer. The proposed locations shall fairly represent the total project site to get the complete required geotechnical information. The BH near MCR, ICR and Switchyard shall be 10m deep. There shall be minimum 1 no. of BH per 12.5 acres of the area, 1 no (each). of Trial pit, CBR test, ERT & Ground water samples for laboratory investigations for every 25 acres of area. The soil/ rock samples for laboratory investigations shall be collected from each borehole and trial pit in sufficient nos. (Note- In case the project plot is divided into number of discrete blocks (< 25 acres) separated from each other, there shall be min. 3 nos. of bore holes, 2 nos. of trial pits, 2 nos. of CBR test & ERT, 2 nos. of Ground water samples for laboratory investigations per such block.

3.4. The proposed Geotechnical investigation plan indicating proposed locations of TPs, BHs, water sample collection points, CBR test & ERT shall be submitted to the Employer for review and approval before start of work.

3.5. Laboratory tests shall be conducted on DS & UDS samples and ground water samples in sufficient no. & shall include, Soil classification, Grain size analysis including Hydrometer analysis, determination of Bulk and dry density, Specific gravity, Natural moisture content, Atterberg limits, Tri-axial shear tests (Unconsolidated Undrained – UU) on UDS, Undrained shear test, Consolidation tests, Unconfined compression tests (UCS), Free swell index, chemical analysis of soil and water samples to determine the carbonates, sulphates, chlorides, nitrates, pH, Organic matter and any other chemicals harmful to concrete and reinforcement/ steel. Laboratory tests on rock samples shall be carried out for Hardness, Specific Gravity, Unit Weight, Uniaxial Compressive Strength (in-situ & saturated), permeability test (in-situ, to be conducted at a depth of 750 mm), Slake Durability etc. Laboratory CBR test on soaked samples shall also be conducted to ascertain the suitability of soil for sub-grade and requirement of any treatment of subgrade soil in case of CBR <2% as per IRC requirements.

3.6. After completion of field and laboratory work, the contractor shall submit a Geotechnical Investigation Report for Engineer's approval. All bore log details and lab test results shall be presented in the report as per provisions of relevant BIS standards indicating BH coordinates, Existing GL, Depth of water table, Method of drilling etc. The report shall include a Map showing the locations of various field tests including coordinates, calculations and recommendations for foundation type and safe bearing capacity (SBC) for various Plant buildings & Open installations (as applicable), Switch Yard structures & Sub-Station (as applicable), Transformer foundation, HT lines (as applicable) etc. corresponding to settlement of 25mm.

3.7. The report shall include the study for "Liquefaction potential assessment of the ground and suggestions for any ground improvement measures" as required.

3.8. The report shall also include ground water analysis (water sample collected from bore

well) to ascertain its suitability for construction purposes, recommendations for type of cement, grade of concrete & minimum cement content as per prevalent soil characteristics with respect to presence of aggressive chemicals and environment exposure conditions as per relevant BIS specifications. However, minimum grade of concrete shall be as specified under Cl.12: Concrete Works of this Section.

3.9. In case the contractor wishes to adopt concrete pile foundation the Geo-tech. report shall also include the calculations, based on soil properties, for safe pile capacity under direct compression, lateral load and pull out as per IS:2911. For piles in rock, the safe pile capacity shall be calculated as per IS:14593. For single pile, Lateral load capacity shall be min. of the values obtained as per IS:2911 & Brom's method corresponding to free pile head. The report shall also include recommendations about type of pile, its depth and dia. to be used.

3.9.1. In coastal areas and in marshy or swelling type soil, under reamed or driven precast concrete pile shall be used. In case contractor wishes to use helical piles the design, fabrication and installation shall conform to IBC (International building code).

3.9.2. The contractor shall carry out field trials for initial load test on pile to verify the pile design to confirm the safe load carrying capacity under direct compression, Lateral load and Pull out. The min. of the two values (design value as per soil characteristics & field test results) shall be adopted.

3.9.3. The nos. of piles to be tested under each category shall be finalized corresponding to geotechnical characteristics at site, plot area and as per the provisions of IS 2911 Part 4. However, minimum 5 nos. of piles shall be tested {min. 3 nos. in each block (block size < 25 acre) and min. 5 nos. in each block (block size >25 acres) if the plant site is divided in discrete blocks separated from each other} under each category of load.

3.9.4. The contractor shall submit detailed methodology for conducting the tests in line with IS: 2911 (Part 4) for Engineer's approval before commencement of any test. For reference, the standard pile test procedures for compression & pull out and lateral load test given Annexure-H. After completion of these tests the contractor shall compile the test results and submit the report in a proper format as specified in the BIS standard with recommendations/ conclusions for Engineer's approval. The pile work shall start only after approval of the final pile design duly verified/ confirmed with initial load test results.

3.10. All buildings and Plinth for Open installations (MCR, ICR etc.), Transformer yard, Switchyard and Sub-station area shall have levelled ground as detailed under Clause No. 5: Area Grading and Land Development of this Section.

4. Other Investigations

4.1. The contractor shall also obtain and study other input data at proposed project site for design of the project from metrological department/ local govt. authorities. This shall include data related to Rainfall, Maximum & Minimum ambient Temperature, Humidity, HFL, etc.

4.2. The contractor shall also identify potential quarry areas for coarse and fine aggregates to be used for concrete and shall carry out the concrete mix design for concrete grades to be used in construction of all concrete works (M25 and above) before start of construction. However, for piling M25 concrete with nominal mix of (1:1:2) may be used. For grades of concrete less than M25 to be used in PCC works, nominal mix as specified in IS:456 may be used. The concrete mix shall be designed for each source of cement and aggregates as per provisions of IS:10262 Standard and confirmed through 28 days compressive strength of concrete trial mix samples. Target mean strength of concrete for mix design shall be based on σ (standard deviation) = 5. The concrete mix design shall be carried out through NABL accredited laboratory or any Govt. agency approved by the Engineer. In case the contractor proposes to use RMC, the same shall conform to IS: 4926. The Contractor shall submit the Concrete mix design proposed to be used by the RMC for review and approval by the Employer. (Reports of periodic quality tests for the supply concrete batch shall be maintained by the RMC supplier as per approved Quality Plan and the same shall be submitted to the Employer for review and record).

5. Area Grading and Land Development

5.1. The Finished Grade Level (FGL) of the proposed plant shall be fixed with reference to the highest flood level (HFL) and surrounding ground profile at proposed site to avoid flooding of plant site. The data regarding HFL at proposed site shall be obtained from the metrological department by the contractor. In case of absence of this data, the contractor shall assess the required information through local site reconnaissance. The area at and around (up to 10m beyond external wall/ area including access road & parking whichever is minimum) all buildings/ plinth for open installations (MCR, ICR, etc.), transformer yard and switchyard shall be uniformly levelled at suitable RL (i.e. FGL) to be finalized considering topography and HFL at site. The minimum plinth level of all buildings/ open installations shall be 450mm above FGL. Pile cap or any other pedestal shall be min. 200mm above FGL. Top of transformer foundation pedestal shall be min. 500mm above the FGL.

5.2. A detailed drawing for site levelling and grading (if envisaged) shall be submitted by the contractor before commencement of construction of all buildings, plinth for open installation and transformer/switchyard works. The levelling and grading drawing shall provide finished grade levels of different grading zones over original ground contours as background. All the coordinates of the grading zones shall be clearly mentioned on the drawing. The estimated volume of cutting and filling shall also be marked on the Grading drawings for reference. The final grade levels to be adopted for different blocks shall be clearly marked on the Plant Layout drawing.

5.3. The contractor is responsible for making the site ready and easily approachable by clearing bushes, felling of trees (mandatory permissions/ licenses/ statutory clearances from competent authorities if required for cutting of trees, blasting or mining operations, disposal of waste material etc. shall be obtained by the contractor), cutting, filling with selected excavated earth or borrowed earth including identifying borrow areas. Except

in exceptional cases (with approval of the Engineer), filling shall be made up of cohesive non-swelling material. The filling for levelling/ reclaiming the ground/ area shall be done in layers not more than 150mm of compacted thickness in case of cohesive (clayey) soils and 250mm compacted thickness in case of granular (sandy) soils with compaction up to 95% (of modified proctor density) and 80% (of relative density) respectively. The slope at edge of graded areas shall not be steeper than 1:1.5 (1 Vertical: 1.5 Horizontal) in cutting and 1:2 (1 Vertical: 2 Horizontal) in filling. In case of filling with rock material, the edges shall be provided in line with provisions of relevant BIS standard.

5.4. It shall be ensured that the land grading and levelling is done properly to ensure for free flow of surface run-off and the grade levels shall be fixed with respect to high flood level at site, drainage pattern and system requirements. It is advisable to follow the natural flow of water at the ground as far as possible for drainage design.

5.5. In case the filled up earth is brought from outside the plant or borrow areas (when the material inside plant area is not found suitable for grading work or if directed by the Engineer), the contractor shall carry out all required soil investigations to ascertain the suitability of the borrowed soil for land development and filling purposes. Contractor's scope shall also include arranging land lease, getting all necessary statutory approvals for mining, payment of necessary challan etc. Excess earth, if any, shall be disposed of properly at location as directed by the Engineer.

6. Roads

6.1. Suitable approach road (as applicable) from nearest public road up to plant Main gate, Access road from Main gate to Main control cum office room (MCR), Internal roads connecting MCR and other facilities/ buildings/ open installations like Local control room(s) (LCR)/ Inverter control room(s) (ICR), Sub-station & Switch yard (as applicable) etc. shall be provided for safe and easy transportation of men, material and equipment during construction and maintenance.

6.2. The Approach road connecting nearest public road and the Main gate shall be of 4.0m wide carriage way with 0.5m wide shoulders on either side. The access road connecting Main gate and MCR and internal service road(s) connecting MCR to various facilities/ buildings/ open Installations shall be of 3.0m wide carriage way with 0.5m wide shoulders on either side. The top of road (TOR) elevation shall be minimum 200 mm above FGL to avoid flooding of roads during rains. The roads shall be provided with alongside drains as per design requirements of drainage system for effective disposal of storm water and to avoid cross flow of storm water over the road. The roads shall be designed as per IRC SP-72 corresponding to traffic category T4 (10 HCV per day) and critical field CBR value of the subgrade.

6.3. However, following minimum road section details shall be followed:

(i) Topping: Surface dressing with gravel or gravel-soil mixture conforming to Cl. 402 of MORD specifications for rural roads published by IRC (MORD specs). However, for sites with average annual rainfall > 1500mm, either 2 course surface bituminous dressing conforming to Cl. 505 of MORD specs or 20 mm thick open graded pre-

mix carpet + Type – B or Type –C seal coat conforming to Cl. 506 of MORD specs. shall be provided.

(ii) Base course WBM (CBR>100%) conforming to Cl. 405 of MORD specs: 75mm compacted thick, Grade III

(iii) Base course WBM (CBR>100%) conforming to Cl. 405 of MORD specs: 75 mm compacted thick, Grade II

(iv) Granular/ gravel sub-base course (CBR>20%), conforming to Cl. 401 of MORD specs: 175 mm compacted thick, compacted to 100% of max dry density

(v) Compacted subgrade: 300mm thick below sub-base (non-expansive soil with max. dry density > 1.65 kN/m3) conforming to Cl 303 of MORD specs, compacted up to 98% of standard proctor density in layers of 150mm thickness. In case of expansive soils like black cotton soil suitable treatment as per Cl. 403 of MORD specs shall be provided before laying sub-base course.

(vi) Gravel Shoulders conforming to Cl 407 of MORD specs: 150mm compacted thick, compacted to 100 % of max. dry density

6.4. Soaked CBR value of sub-grade shall not be less than 2%. Where the CBR of the subgrade is less than 2 % a capping layer of 100 mm thickness of material with a minimum CBR of 10 % is to be provided in addition to the sub-base required for CBR of 2 %. When the subgrade is silty or clayey soil and the annual rainfall of the area is more than 1000 mm, a drainage layer of 100 mm over the entire formation width should be provided conforming to the gradation given in Chapter 6 of IRC SP-20. This layer will form a part of the designed thickness of sub-base.

6.5. In case of no-availability of murrum in the nearby areas of the project site, suitable other screening/ blending material for WBM construction may be used conforming to provisions of IRC SP 20.

6.6. The construction of road shall conform to MORD specifications for Rural roads published by IRC.

6.7. Drain, cable or any other crossing shall be provided with RCC box or precast concrete pipe culvert. The culvert design shall conform to relevant IRC standard. The pipes for road culverts shall be of minimum class NP3 conforming to IS 458 with min. soil cover of 750mm above the pipe. In case of soil cushion less than 750mm the pipe shall be provided with 100 mm thick M20 reinforced concrete encasement with 10 dia. reinforcement rods @ 150mm c/c both ways. However, the water supply pipe for service/ drinking water shall be routed through Medium class GI steel pipe of required dia. conforming to IS: 1161.

6.8. Minimum dia. of casing pipe to be used at any facility like electric cable, water pipe line etc. shall be 150mm.

6.9. 2.5m wide corridor compacted to a depth of 300mm shall be left along inside of the plant boundary suitably maintained clean of any vegetation and shall be provided with adequate illumination for movement of security personnel. Any undulations shall be made good with locally available coarse grained material to have fairly level passage

way.

6.10. The design and drawings for approach road, all internal roads and culverts shall be submitted to the Engineer for approval before execution.

7. Surface/ Area drainage

7.1. The contractor shall design and construct storm water drainage network for smooth disposal of storm water from the plant to the nearest available drainage outlet.

7.2. The storm water drainage system shall be designed and planned to ensure no water stagnation in the plant.

7.3. The plant drainage system shall be designed for maximum hourly rainfall intensity and relevant time of concentration.

7.4. The design shall conform to the provisions of IRC SP 42 and best Industry practices. (The design rainfall shall be taken as max. hourly rainfall at 25 years return period at project site as provided in the Isopluvial map of the relevant subzone annexed with Flood Estimation Reports of Central Water Commission (CWC).

7.5. The coefficient of run-off for estimation of design discharge shall be considered as per catchment characteristics, however it shall not be less than 0.6.

7.6. The drainage scheme shall be designed considering the plant plot area and the surrounding catchment area contributing to the plant area drainage as per the topography.

7.7. The storm water drainage system shall be a network of open surface drains (with rectangular or trapezoidal cross section) and shall generally be designed to follow the natural flow of water and ground contours.

7.8. Suitable size plant peripheral drain as per design and requirement (min. 450mm wide x 450mm deep) along inside of plant boundary wall/ fence shall be provided for smooth channelization of outside storm water and to avoid flooding in the plant. The size of all internal and road side drains shall not be less than 300mm (bottom width) x 300mm (depth).

7.9. All trapezoidal drains shall have side slopes not steeper than 1:1. Unlined drains may be provided depending upon the geotechnical characteristics and drainage design in the view of the stability and erosion of drain walls. However, the drain segments near outfalls and drain crossings shall be lined. Thickness of the lining shall be minimum 115mm for brick masonry, 75mm for concrete slabs, 100mm for RR masonry and 50mm for stone slabs. The lining shall be in CM (1:4) and the joints shall be raked and pointed with CM (1:3), however the joints in lining of plant peripheral drain may be left without pointing.

7.10. In case of rectangular drain, the thickness of the wall shall be checked against structural stability under action of the design loads as specified in Cl. No. 10 ‘Design Loads’ of this Section. However, the min. wall thickness shall be 230mm, 300mm and 125mm respectively for brick masonry, RR masonry and RCC work, except for garland drain

around buildings where the min. wall thickness can be 115mm, 200mm and 100mm respectively for brick masonry, RR masonry and RCC work.

7.11. The structural design of drains shall be as per provisions of relevant BIS standards and good industry practice.

7.12. The drain outfall shall be connected to the nearest existing natural drain(s)/ water body outside plant premises and it shall be ensured that the drainage water shall not re-enter the plant nor encroach/ flood in the adjacent property/ plot.

7.13. The proposed drainage scheme along with design calculations and drawings shall be submitted to the Engineer for review/ approval before start of construction.

7.14. The contractor shall provide percolation/recharge pit for harvesting of water in the MCR area. For the remaining plant facilities, the Contractor shall explore provisions for rain water harvesting system for water conservation by constructing suitable collection wells along the drains or through provision of detention ponds or percolation/recharge pit etc. at major drainage outfalls. The scheme for rain water harvesting along with design calculations shall be submitted for approval.

8. Peripheral Fence & Main Gate

8.1. The plant peripheral boundary shall be provided with chain link fence as per the tender drawing titled 'Chain link fence Drawing' attached in Annexure-E (Tender Drawings).

8.2. The fence shall be provided with Main Gate as per the tender drawing titled 'Main Gate Drawing' attached in Annexure-E (Tender Drawings).

9. Plant Layout

9.1. The contractor shall submit drawing showing proposed Project Plant Layout.

9.2. The Plant layout shall be a comprehensive drawing showing various requirements of the project like, Reference coordinate grid, Geographical and Plant North, Layout of boundary fence including coordinates of all corner points, Location of main entrance gate and any other access gates as per project needs, Block wise FGL, Layout of main approach road to the plant, Internal and peripheral roads, Security Room/ cabin (s), all Buildings and Open installations with coordinates, Temporary Storage yard/ facility to be used by the contractor during construction, Lightening arrester, UG/Over ground water Tank(s), Storm water drains, Corridor for buried cables etc.

9.3. All the facilities and buildings shall be presented with suitable Legend.

9.4. The drawing shall be in suitable scale to have proper representation of the information.

9.5. The Plant layout drawing shall be submitted by the contractor for review/ approval by the Engineer.

10. Design Loads

10.1. Unless otherwise specified elsewhere, Dead load, Live load, Wind load and Seismic load for buildings and structures shall be considered as per provisions of relevant BIS standards.

10.2. The following minimum imposed load as indicated for some of the important areas shall, however be considered for the design. If actual expected load is more than the specified minimum load, then actual load is to be considered.

S. No.	Area	Imposed (Live) Load
1	Roof (accessible and inaccessible)	1.50 kN/ Sqm
2	Building floors (GF) & Grade Slab	10.00 kN/ Sqm
3	RCC Floors (General)	5.00 kN/ Sqm
4	Outdoor platforms, Stairs, Landing and Balconies, Walkway, Chequred plate & Grating (except cable trench cover)	5.00 kN/ Sqm
5	Road culverts & allied structures over drain & pipe crossings subjected to vehicular traffic	Design for Class – 'AA' loading (Wheeled & Tracked both) and check for Class – 'A' loading as per IRC Standard
6	Underground structures such as Sump, Pit, Trench, Drain, UG tank etc.	In addition to Earth pressure and Ground water table at FGL, a surcharge of 20kN /Sqm (10kN/Sqm for drains) shall also be considered. The structure shall be designed for following criteria – (a) Inside empty with outside fill+ surcharge and water table at GL & (b) Inside water with no fill & water table outside
7	Pre-cast and chequred plate cover over cable trench	4.00 kN/ Sqm
8	Roads	As per IRC SP 72 corresponding to vehicular traffic of T4 (10 HCV per day) and critical in-field CBR

10.3. Primary Loads

(i) Dead Load (DL)
(ii) Live Load (LL)
(iii) Wind Load (WL) – Both along ±X & ±Z horizontal direction

(iv) Seismic Load (EL) – Both along ±X & ±Z horizontal direction

10.4. Basic wind speed (Vb) at project site shall be taken as per IS 875 (part-3) unless otherwise specified elsewhere.

10.5. To calculate the design wind speed (Vz), the factors k1 (probability factor or risk coefficient), k2 (terrain roughness and height factor) and k3 (topography factor) shall be considered as per IS 875 (Part-3). Terrain category shall be taken as category 2.

10.6. Topography factor 'k3' shall be taken as 1.0 upto upwards slope of 3°. For topography with upward slope greater than 3°, the value of 'k3' shall be calculated as per Annexure-C of IS 875 (Part-3).

10.7. Importance factor k4 shall be taken as 1.0. However, in case of plant site within 60 km of sea coast, the importance factor for cyclonic region, 'k4' shall be taken as 1.15.

10.8. To calculate the design wind pressure 'pd', factors 'ka' (area averaging factor) and 'kc' (combination factor) shall be taken as 1.0. However, the factor 'kd' shall be taken as 1.0 in case of plant site within 60km of sea coast.

10.9. The Seismic Load shall be considered corresponding to Earth quake zone at site as per IS: 1893 (Part- 4) with Importance factor 1.5. Ductile design and detailing as per IS 13920 shall be followed in all RCC framed structures except for plinth for open installations.

10.10. Design Load combinations

10.10.1. Concrete structures shall be designed as per limit state method of design with appropriate load factors as per IS:456. Cold formed light gauge steel structures shall be designed by working stress method as per IS:801 with appropriate factor of safety. All other steel structures shall be designed by working stress method as per IS:800 with appropriate factor of safety.

10.10.2. Following load combinations shall be considered in design:

- For RCC and Steel structures:
  i. DL
  ii. DL + LL
  iii. DL ± WLx
  iv. DL ± WLz
  v. DL ± ELx
  vi. DL ± ELz
  vii. DL + LL ± WLx
  viii. DL + LL ± WLz
  ix. DL + LL ± ELx
  x. DL + LL ± ELz

10.10.3. All buildings, structures and foundations shall be designed to withstand loads corresponding to worst design load combination.

11. Foundations (General)

11.1. The Contractor shall design all foundations for buildings, equipment, Transmission line towers, In-plant sub-station (switch-yard) structures, Transformer and other structures as per recommendations of Geotechnical investigation report and relevant BIS standards.

11.2. No foundation for buildings, switchyard equipment and structures, sub-stations, Transmission line towers, transformers, etc. shall rest on filled-up ground. However, minor structures like cable trench, cable rack, pipe pedestal, etc. may rest on filled-up soil with max. safe bearing capacity for design considerations not more than 3 T/Sqm.

11.3. Min. depth of foundation for all buildings and plinth for open installations shall be 1.5 m below NGL. Min. depth of foundation for steps in brick and concrete masonry shall be min. 450mm below FGL. For all other structures, min. depth of foundation shall be 1.0 m unless specified otherwise.

11.4. All foundations of a building shall be founded at same RL (Reduced level) with respect to foundation depth below lowest NGL (Natural ground level) in the building area. The Levels shall be obtained with reference to the already established TBM using digital survey instrument such as Total Station/ Auto Level. The foundations of all buildings and plinths for open installation platforms shall be constructed after grading the area to the design FGL.

11.5. All design & drawings for foundations shall be submitted to the Engineer for approval before execution.

12. Concrete Works

12.1. Construction of all RCC works shall be done with approved design mix as per IS 456 and the materials used viz. Cement, coarse & fine aggregate, Reinforcement steel etc. shall conform to relevant BIS standards.

12.2. The min. grade of concrete shall be M25 (M30 in coastal areas/marshy soil) for all RCC works except liquid retaining structures like underground water tank, septic tank, etc. where minimum grade of concrete shall be M30 (M35 in coastal areas/marshy soil).

12.3. Cement higher than 43 Grade shall not be used in construction.

12.4. Unless otherwise specified elsewhere, PCC shall be of min. grade M10 (nominal mix 1:3:6) except for mud mat, back filling of ground pockets or levelling course which shall be of grade M7.5 (nominal mix 1:4:8).

12.5. Reinforcement steel shall be of high strength thermo mechanically treated (TMT) bars of grade Fe500D conforming to IS: 1786.

12.6. All pockets, block-outs, sleeves and the openings around the embedment, inserts, bolts etc. and under pinning below the base/sole plate shall be grouted. Grouting shall be with anti-shrink ready mix grout of approved make or cement mortar (CM) grout with non-shrink compound. The grout shall be high strength grout having min. characteristic strength of 35 N/mm2 at 28 days.

12.7. MS Angles of minimum size 50 x 50 x 6 mm with 8 mm dia - 150mm long MS lugs @ 150mm c / c shall be provided for edge protection around all cutouts / openings in RCC floor slabs / walls, edges of drains supporting grating / pre-cast covers, edges of manhole supporting covers, around periphery of all removable pre-cast covers and any other place where breakage of corners of concrete is expected.

13. Miscellaneous Steel Works

13.1. Structural steel hot rolled sections, flats and plates shall conform IS: 2062. Structural steel (including embedded steel) shall be straight, sound, free from twists, cracks, flaw, laminations and all other defects. Structural steel shall be of tested quality and shall be of Mild steel of Grade 'A' up to 20mm thickness and of Grade 'B' normalised for thickness above 20 mm conforming to IS 2062: 2011.

13.2. Structural Pipes shall be medium (M)/ high (H) grade conforming to IS: 1161, chequered plate shall conform to IS: 3502 and Hollow steel sections for structural purposes shall conform to IS: 4923. Pipes for hand rail shall conform to medium grade IS: 1161.

13.3. All gratings shall be pressure locked/ electro forged. Minimum thickness of the grating shall be 40mm. The opening size shall not be more than 30mm x 100mm.The minimum thickness of the main bearing bar shall be 3mm. All gratings shall be hot double dip galvanized at the rate of 610 g / Sqm.

13.4. Minimum 900 mm high hand railing shall be provided around all floor/ roof openings, projections/ balconies, platforms, walkways etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) conforming to IS: 1161 and shall be galvanized as per IS: 4736 and IS: 1239. All rungs and ladders shall also be galvanized unless otherwise specified. Minimum weight of galvanizing shall be 610g/ sqm.

14. Buildings and Plinth (Support Structure) for Open Installations

14.1. General Requirement

14.1.1. Plant buildings and plinth for open installations as required as per the plant design and approved layout shall be constructed for housing the electrical equipment/ panel (Local Control Room - LCR) and Control room cum office cum store (Main Control Room Building - MCR) etc. for operation and maintenance of Plant Facilities. Security room at main gate & Security cabin(s) (at strategic locations) shall also be provided to secure the plant from any theft/ burglary/unauthorized entry.

14.1.2. Unless otherwise specified elsewhere, all buildings and plinth (support structure) for open installations except Security room/ cabin shall have RCC framed structure. Masonry partition walls shall be provided for Kitchen, Pantry, Battery room and Toilet units. For other rooms, AL Glass partitions shall be provided. The size of the plinth (framed structure) for open installations and equipment area shall as per OEM requirements. The security room/ cabin(s) shall be of prefabricated structure.

14.1.3. All buildings shall have provision of adequate windows for natural light & ventilation, fire safety provisions and shall be designed as per provisions of National building code (NBC).

14.1.4. The contractor shall submit the proposed equipment layout drawings to the Engineer for approval before development of Architectural drawings. The building layout, exterior elevations shall be aesthetically designed following good architectural practices to get a pleasant look. Horizontal/ vertical bands through projections/ groves in external plaster may be provided to break the monotony. Roof slab shall have projection of 450mm beyond the external walls with RCC parapet wall of 450 mm clear height all-around which shall form a projected band at roof level. For weather protection all doors and windows shall be provided with 450mm wide RCC chajja. However, chajja for rolling shutter shall be 750mm wide.

14.2. Functional requirements

14.2.1. MCR Buildings

For operation & maintenance of BESS Plant, unless otherwise specified elsewhere, Control room cum office area of MCR building shall provide following facilities:

- Air-conditioned area (with provision of split A/C unit of adequate capacity) for SCADA room (min. carpet area 32m2), Conference room (min. carpet area 32 m2) & Supervisor cabin (15 m2) and office area (min. carpet area 25 m2)
- Switchgear, equipment room(s) as per OEM requirements (can be in a separate building adjacent to the MCR)
- Tool room (12.5 m2)
- Store cum record room (min. carpet area 15 m2)
- Battery room as per requirement (can be in a separate building adjacent to the MCR)
- Toilet block with separate gents and ladies wash room facilities (min. total carpet area 12 m2)
- Pantry with service platform and utensil washing facilities (min. carpet area 5 m2)
- Suitable provision for passage (for smooth movement of O & M personnel), cable trenches, operating area etc. (min. clear width 1500mm)
- GI Ladder with hand rail for roof access
- MCR Building shall be RCC Framed Structure.

14.2.2. LCR/ ICR

- Inverter and associated equipment shall be installed on plinth (support structure) as open installations. They shall generally comprise of data loggers, battery, inverter, electrical panels, etc. as per requirements and as per approved system drawings.
- There shall be suitable provision for easy/smooth passage of O&M personnel, cable trench, operating area, etc.
- The plinth supporting the ICR/LCR equipment shall have RCC framed structure up to plinth level (equipment support level) with foundations, columns, beams and RCC floor slab. The RCC floor slab shall be provided with PVC pipe sleeves of required size for cable entry which shall be sealed with fire sealant after cable

installation.

- The size and clear head room (below soffit of floor beam) above FGL for LCR/ICR shall be provided as per system/O&M requirements with min of 750mm.
- When LCR/ICR and MCR building facilities are clubbed in one single building, the Equipment area (inverter room) and Office cum Control room area shall be separated by a 345mm thick brick wall with provision of internal fire proof entry door.
- MCR building shall have separate main entry to office area.
- The size of inverter/HT panel area shall be provided as per system requirements.
- ICR/ LCR with open installation shall be provided with metal canopy for protection of O & M staff from weather. This weather protection canopy shall be an open steel shed structure designed and constructed with columns/ stanchions, rafters and purlins using hot rolled steel sections. The canopy shall be provided with suitable bracing system including roof (plan) and vertical bracings. The columns/ stanchions shall be fixed with base plate and foundation bolt assembly to the columns of support frame structure. The roof shall be of Al-Zn alloy coated high tensile steel troughed metal panels (BMT- 0.45mm, Al-Zn alloy coating - 150 GSM total on both sides). The roof shall be provided with suitable slope, not less than 10° to the horizontal for proper drainage of rain water and shall project 300mm beyond the plinth or support platform. The make and (colour) shade of pre- coated metal panels shall be subject to approval by the Engineer. Min. thickness of colour coating shall be 20 micron (DFT) excluding prime coat 5 micron (DFT). The coating system shall confirm to IS: 15965.
- 150 mm thick gravel layer shall be provided on the finished ground level over the whole foot print of the support framed structure after application of anti-weed treatment on the ground.

14.2.3. Storage cabin for plant Spare

14.2.3.1. Contractor shall provide storage cabin having area adequate for storage of plant spares including cables.

14.2.3.2. Storage cabin shall be of PEB (Pre-engineered building) type with RCC framed structure up to plinth level with foundations, columns, beams and RCC grade slab (if applicable).

14.2.3.3. Structural members for the superstructure shall be as detailed under PEB specifications under Cl. 36: Pre-Engineered Building (PEB) of this Section.

14.2.3.4. The walls and roof shall be fabricated with double skin insulated sandwiched Al-Zn alloy coated high tensile steel metal panels (BMT- 0.45mm, Al-Zn alloy coating - 150 GSM total on both sides). The insulation shall be of PUF with min. density 40 kg/ cum and adequate thickness. Roof shall be provided with suitable slope, not less than 10° to the horizontal (approx. 1V:6H) and shall project 300 mm beyond the

walls. The make and (color) shade of pre- coated metal panels shall be subject to approval by the Engineer. Min. thickness of color coating shall be 20 micron (DFT) excluding prime coat 5 micron (DFT). The coating system shall confirm to IS: 15965.

14.2.3.5. The doors and windows shall have AL frame with glazing and shall be provided with all necessary fitting and fixtures like handles, tower bolts, mortise lock for door, stays, door stopper etc. All glazing shall be of clear float glass with thickness of 4mm for window and 6 mm for door panel. All AL sections for doors and windows shall be anodized (min. average thickness 25 microns) or polyester powder coated (min. DFT 50 microns) with approved color shade for protection against weather. Specially coated/ SS self-drilling screws/ fasteners conforming to class 3 as per ASTM: 3566.1 and 3566.2 shall only be used for all connections.

14.2.3.6. Doors shall be of adequate size to facilitate movement of O & M personnel and spares. There shall also be provision of Ramp and rolling shutter for the storage cabin.

14.2.3.7. Anchor/ foundation bolts shall conform to IS: 5624 and IS 800.

14.2.3.8. Alternatively, prefabricated storage containers conforming to ISO 668 may be used for housing the plant spares. The containers shall have sufficient area for storage and handling of spares during O&M phase. The containers shall be provided with the necessary lighting, HVAC and safety arrangements, etc. Further, the containers shall also be structurally adequate to cater for the applicable design loads and shall be supported on suitable RCC Foundation.

14.2.4. <u>Security Room/ Cabin</u>

14.2.4.1. Contractor shall provide required number of pre-fabricated security cabins at strategic locations & at corners of the plot and 1 nos. security room at Main entry gate.

14.2.4.2. The Security room shall be of min. size 3m x 3m x 2.75m height. The Security cabin shall be of min. size 1.2 x 1.8m x 2.5m height.

14.2.4.3. Security room/ cabin shall be a pre-engineered & pre-fabricated structure. The walls and roof of the building shall be fabricated with double skin insulated sandwiched Al-Zn alloy coated high tensile steel metal panels (BMT- 0.45mm, Al-Zn alloy coating -150 GSM total on both sides). The insulation shall be of PUF with min. density 40 kg/ cum and adequate thickness. Roof shall be provided with suitable slope, not less than 10° to the horizontal (approx. 1V:6H) for proper drainage of rain water and shall project 300mm beyond the walls. The make and (color) shade of pre-coated metal panels shall be subject to approval by the Engineer. Min. thickness of color coating shall be 20 micron (DFT) excluding prime coat 5 micron (DFT). The coating system shall confirm to IS: 15965.

14.2.4.4. The Main security room shall be provided with one Aluminum (AL) glazed door (0.75m wide x 2.1m height) on one face and AL glazed sliding windows (1.2m width x 1.0 m height) with AL grill on remaining three sides. Security cabin shall have one

AL glazed door (0.75m widex2.1m height) and 1 no. AL sliding window (0.8m width x 1.0 m height) with AL (anodized) grill on one side. All glazing shall be of clear float glass with thickness of 4mm for window and 6 mm for door panel.

14.2.4.5. The door and windows shall be provided with all necessary fitting and fixtures like handles, tower bolts, mortise lock for door, stays, door stopper etc. All AL sections for doors and windows shall be anodized (min. average thickness 25 microns) or polyester powder coated (min. DFT 50 microns) with approved color shade for protection against weather.

14.2.4.6. Specially coated/ SS self-drilling screws/ fasteners conforming to class 3 as per ASTM: 3566.1 and 3566.2 shall only be used for all connections.

14.2.4.7. Anchor/ foundation bolts shall conform to IS: 5624 and IS 800.

14.2.4.8. The Security Cabin may be installed on concrete M20 skid platform (min. 250 mm thick, over 250 mm thick compacted rubble soling with interstices filled with sand). The top of skid shall be 200 mm above FGL. The concrete skid shall be provided with shrinkage reinforcement (8 dia @ 200 c/c both ways) near top surface. The concrete skid shall project 200mm beyond the walls.

14.2.4.9. The Security Room shall be supported on RCC framed structure with columns supported on foundations. The Finished Floor Level shall be 450mm high above FGL.

14.2.5. Watch Tower

Watch tower shall comprise of galvanized steel support structure with galvanized steel ladder for access. Minimum height of the watch tower shall be 10m above ground level. Cabin provided at the top of watch tower shall be as per the provisions of Clause 14.2.3.Storage cabin for plant Spare.

14.3. The Design and drawings shall be submitted for approval prior to fabrication and installation.

15. Flooring, Skirting and Dado

15.1. Min. 40 mm thick floor finish shall be provided for all buildings.

15.2. Store area, Equipment Area

40 mm thick Cement concrete (IPS) flooring (1:2:4), aggregate size 10 mm down, conforming to IS 2571 with 2mm thick Heavy-duty epoxy coating (Industrial grade) of approved make on top as per manufacturer specifications and 10mm thick matching skirting of 100mm height.

15.3. SCADA Room, Control cum Office Room, Supervisor Room and Lobby

1200 mm X 1200 mm Heavy duty vitrified tile (8mm thick or more) flooring with matching skirting of 100mm height.

15.4. Battery Area/Room

Acid/ Alkali resistant tile flooring and 2100 mm height dado, Floor and dado tiles – min 20mm and 12 mm thick respectively. However, in case of maintenance free batteries/dry batteries, Acid/ Alkali resistant tile (min 10mm thick) flooring and dado shall be provided.

15.5. Toilet

- Vitrified anti-skid floor tiles of size 600x600 mm laid on 20mm thick bed of cement mortar 1:4 with 2100 mm height dado.
- 20mm thick Granite stone finish over platform for wash basin.

15.6. Pantry

Heavy duty vitrified tile (8 mm thick) flooring and glazed tile (6mm thick) 2100 mm height dado, 20mm thick Granite stone finish over service platform.

15.7. Passage/ Corridor

Heavy duty vitrified tile (8mm thick) flooring with matching skirting of 100mm height.

15.8. Steps

Kota stone (20 thick) or 50 thick mosaic tiled flooring in white cement.

15.9. All items shall be of reputed make. Only Items with approved samples by the Engineer shall be used.

16. Doors and Windows

16.1. Doors, windows, louvers and ventilators shall be made of AL sections (minimum average thickness 2.5mm), industrial grade, anodized (grade AC25, min. thickness 25 micron conforming to IS: 1868) or with polyester powder coating (Total DFT 50 microns conforming to IS: 13871) and shall be of approved make & colour shade. All sections, fittings and fixtures shall be anodized (min. thickness of coating 20 micron). The window and door shutters shall be of clear float/ wired/ ground glass as per design/ functional requirements. The doors in toile area shall be of steel frame with solid core (MDF) flush shutter, 35mm thick, with laminated finish on both sides conforming to IS: 2202.

16.2. AL Louvers, duct/ ventilation openings shall be provided as per functional requirement.

16.3. All doors, windows and ventilators shall be provided with all necessary fittings and fixtures like handles, tower bolts, wind stays, hinges etc. of heavy-duty anodized AL. All doors shall be provided with hydraulic door closure of required capacity.

16.4. All windows shall be provided with suitable AL grill of anodized sections with adequate thickness for security purposes.

16.5. Clear float glass for window and door shutter shall be of min 4mm and 6mm thickness respectively. Wired/ ground glass where provided shall be of min thickness 6mm.

16.6. Entrance door and door in passage shall be min. 1.5m wide (double leaf) x 2.1 m height while door for Conference room and Store room shall be min. 1.2m wide x 2.1m height.

All other doors shall be min. 1.0m widex2.1m height except for WC which may be of 0.8m width.

16.7. Rolling shutters shall be of required size and shall be made of cold rolled steel strips with adequate gauge thickness (min. 18 gauge) and shall conform to IS 6248. Rolling shutter shall be provided with all fixture, accessories, paintings etc. all complete and shall be mechanically operated type.

17. Roofing

17.1. The roof of all buildings shall be provided with min. slope of 1:100 for effective drainage of rain water. The slope shall be achieved either by application of screed concrete of grade 1:2:4 (with 12.5mm down coarse aggregate) with min. 25mm thick CM 1:4 layer on top to achieve smooth surface to facilitate application of water proofing treatment.

17.2. The water proofing treatment shall be in situ five course water proofing treatment with APP (Atactic Polypropylene) modified Polymeric membrane over roof consisting of first coat of bitumen primer @ 0.40Kg per sqm, 2nd & 4th courses of bonding material @ 1.20 kg/sqm, which shall consist of blown type bitumen of grade 85/25 conforming to IS : 702, 3rd layer of roofing membrane APP modified Polymeric membrane 2.0 mm thick of 3.00 Kg/sqm weight consisting of five layers prefabricated with centre core as 100 micron HMHDPE film sandwiched on both sides with polymeric mix and the polymeric mix is protected on both sides with 20 micron HMHDPE film. The top most layer (5th layer) shall be finished with brick tiles of class designation 10 grouted with cement mortar 1:3 (1 cement: 3 fine sand) mixed with 2% integral water proofing compound by weight of cement over a 12 mm layer of cement mortar 1:3 (1 cement: 3 fine sand) and finished neat. The water proofing treatment shall be extended over golla/ fillet and inner face of the parapet up to 450mm height. The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test.

17.3. The corners at parapet wall and slab shall be provided with 50 thick fillet/ golla in CM 1:3 with neat finish.

17.4. Required no. of rain water down take pipes min. 100mm dia. PVC pipes (UV resistant), with 450x450mmx15mm deep khurra and MS grill at inlet shall be provided for rain water disposal.

18. Plinth protection and drain

18.1. 750mm wide plinth protection with min. 75mm thickness of PCC (1:3:6) over 75 mm thick bed of dry brick ballast, 40mm nominal size well rammed and consolidated and grouted with fine sand, shall be provided around all the buildings.

18.2. A peripheral drain (except for Security room/ cabin) of min. internal size 250mm x 250mm with brick walls in CM 1:6 over 75mm thick PCC (1:3:6) bedding with 12mm thick plaster in CM 1:5 and 25thk PCC (1:3:6) coping at top shall be provided along the periphery of the plinth protection for collection and disposal of rain water from building

roof.

19. Plinth filling for buildings

Plinth beam, when provided, shall be taken minimum 200mm below FGL. The plinth filling below Ground floor (GF) for all buildings shall be provided with following specifications.

(i) Well compacted sub-grade
(ii) Well compacted boulder soling with interstices filled with sand over compacted sub-grade.
(iii) 75mm thick PCC 1:3:6 over (ii)
(iv) 100mm thick PCC 1:2:4 over (iii)
(v) 40mm thick floor finish over (iv)

20. Anti- termite Treatment

In case of presence of termites at the project site, an anti-termite treatment shall be provided for all foundation pits and building plinth in MCR building conforming to IS: 6313 to control entry of termites.

21. Plumbing & Sanitary Works

21.1. Toilet block shall have following min. fittings:

- Wall mounted WC (Western type) 390 mm high with toilet paper roll holder, low height flushing tank and all fittings
- A set of 2 wall mounted Urinals (430 x 260 x 350 mm size) with flushing tank and all fittings (Gent's wash room only)
- Wash basin (550 x 400 mm) over concrete platform with all fittings including 2-pillar cocks
- Wall mirror (600 x 450 x 6 mm thick clear float glass) with hard board backing
- CP brass towel rail (600 x 20 mm) with C.P. brass brackets – one each in common area and bathroom (bathroom if applicable)
- Soap holder and liquid soap dispenser one each in common area and bathroom (bathroom if applicable)
- Shower and mixer for hot and cold water in bathroom (if applicable)
- Ventilators – Mechanical exhaust facility of adequate capacity
- Overhead PVC water storage tank – Capacity 1000 litres (common for both wash rooms) (2000 litres in case bathroom is to be provided)

21.2. Pantry room shall be provided with kitchen sink cum drain board and provision for installation of Water Cooler.

21.3. One toilet room with provision of WC and Wash basin shall be provided at Security Room near main gate.

21.4. Necessary plumbing lines for MCR building and Security Room near main gate.

21.5. All sanitary ware, fittings and fixtures shall be of reputed Make and Type and approved by the Engineer. All fittings, fastener, grating shall be of CP brass conforming to

relevant BIS standards.

22. Painting & Other Finishes

Painting and white wash/ colour wash for the buildings shall conform to relevant BIS standards. The make and colour shade of the finish shall be as advised and approved by the Engineer.

Internal Walls except toilets & battery room	Acrylic emulsion (for MCR) & Oil bound distemper (for LCR/ Security Room)
Battery room	Acid/ Alkali resistant tiled dado of 2100 mm height & Acid resistant resin-based epoxy paint above dado (Vitrified tile flooring and dado with oil bound distemper in case of maintenance free batteries)
Toilet	Oil bound distemper
External Walls	All weather proof cement based acrylic emulsion paint, exterior grade
Earth pit Enclosure	Cement paint
Underside of roof slab, Plinth (support structure) for open installation	White wash
Air-conditioned areas	Underside of roof slab- Under deck insulation with 50mm thick mineral wool, min. density 45 kg/ m3 and Gypsum board false ceiling with GI grid/ Gypsum tile (600x600 mm x 12 thick) false ceiling with AL grid as per manufacturer's details
Structural steel work	2 coats of synthetic enamel paint over 2 coats of suitable primer

23. Air conditioning & Ventilation for MCR and Other Buildings

23.1. All buildings shall be equipped with appropriate numbers of fans for effective heat dissipation.

23.2. In MCR building, the supervisor room, Conference room and SCADA room shall have split type air conditioning units.

24. Fire Extinguishers

24.1. All buildings shall be installed with required no. of fire extinguishers as per relevant BIS standard and NBC. Liquefied CO2 / foam / DCP type fire extinguisher shall be upright type of capacity 9 kg conforming to IS 15683 / IS 2878.

24.2. The fire extinguisher shall be suitable for fighting fire of Oils, Solvents, Gases, Paints, Varnishes, Electrical Wiring, Live Machinery Fires, and all Flammable Liquid & Gas.

25. Sand buckets

25.1. Sand buckets shall be wall mounted made from at least 24SWG sheet with bracket fixing on wall conforming to IS 2546.

25.2. All buildings shall be provided with required no. of sand buckets as per relevant BIS standard and NBC. 4 No. of Bucket stands with four buckets on each stand shall be provided in the Transformer Yard.

26. Sign Boards and Danger Boards

26.1. The sign board containing brief description of major components of the power plant as well as the complete power plant in general shall be installed at appropriate locations of the power plant as approved by Engineer.

26.2. The Signboard shall be made of steel plate of not less than 3 mm. Letters on the board shall be with appropriate illumination arrangements.

26.3. Safety signs, building evacuation plan and direction signs, assembly points shall also be placed at strategic locations.

26.4. The Contractor shall provide to the Engineer, detailed specifications of the sign boards.

27. Masonry Work

27.1. The masonry work shall be of bricks, laterite blocks (as per site conditions) or concrete blocks.

27.2. All external walls of buildings shall be 230mm and internal walls shall be 230mm or 115mm as per requirements.

27.3. All concrete block masonry walls shall be min. 200mm thick.

27.4. Brick work shall be in cement mortar (CM) 1:6 & 1:4 for 230 mm and 115 mm thick brick wall respectively unless specified.

27.5. Unless otherwise specified elsewhere, Bricks shall be of class designation 7.5 conforming to IS: 1077, IS: 2212 & IS: 3495.

27.6. All concrete blocks shall be of min. compressive strength of 7.5 N/mm2 and shall be of Grade-A conforming to IS: 2185.

27.7. The laterite blocks shall conform to IS: 3620.

27.8. All buildings shall be provided with suitable damp-proof course (DPC). The DPC shall be with PCC (1:2:4) using 6 down coarse aggregate and water proofing admixture. The min. thickness of DPC shall be 40mm.

27.9. The construction of brick masonry shall conform to IS: 2212. Construction of Concrete block masonry shall conform to IS: 2572.

28. Plastering, Pointing & Coping Works

28.1. All brick masonry work shall be provided with plaster.

28.2. Wall and ceiling plaster shall be in cement mortar (CM) 1:6 and 1:3 respectively.

28.3. Thickness of plaster shall be 18mm and 12mm respectively for rough and smooth surface of the masonry wall. The ceiling plaster shall be 6mm thick.

28.4. All joints in stone masonry shall be raked and pointed in cement mortar (CM) 1:3 except specified otherwise.

28.5. Exposed top surface of brick or stone masonry shall be provided with 25 mm thick plain cement concrete (PCC) coping (1:2:4) with trawl finish. All exposed coping shall be provided with suitable slope and projection for easy drainage of water.

28.6. All door and window chajja shall be provided with 10mm wide drip course.

29. Building Water Supply & Plumbing Works

29.1. C-PVC pipes shall be used for all internal building water supply works while all external water supply pipes shall be UPVC conforming to relevant BIS standard.

29.2. Rain water pipe shall be of PVC conforming to relevant BIS standard.

29.3. All sewerage, waste water and ventilation pipes shall be of HDPE conforming to relevant BIS standard.

29.4. MCR building and Security room shall be connected to Sewage treatment facility including all associated works like Manholes etc.

30. Sewage Treatment facility

The Contractor shall design & provide soak pit and septic tank for treatment of sewage and waste water from MCR building and Security room. The design of the septic tank shall conform to IS 2470 (Part 1). However, in case of ground water within 1.5m of finished grade level or the soil strata being of low permeability (permeability $\leq$ 10-6 m/s) where septic tank and soak pit arrangement is not effective, suitable packaged sewage treatment plant of reputed make/manufacture shall be provided. The sewage treatment facility shall be of required capacity and of proven design suitable for total of 15 people.

31. Pipe & Cable Trenches

31.1. All trenches inside the building and transformer area shall be of RCC. The min. wall and base slab thickness shall be 100mm for depth $\leq$ 850mm and 150mm for depths > 850mm.

31.2. The trench shall be designed for loads as specified under 'Design Loads'. External trenches shall be kept min. 150 mm above FGL to avoid entry of rain water. In case of straight length of the trench being more than 40m, suitable expansion joints with PVC water stop shall be provided.

31.3. Internal trenches (inside buildings) shall be provided with chequered plate (min. 8mm thick with stiffening angle ISA 50x50x6 @ 750 mm c/c for trench width greater than 800 mm) covers while external trench shall have precast concrete covers.

31.4. Min. thickness of precast cover shall be 50mm. Both bearing edges of the cable trench and all edges of pre-cast concrete covers shall be provided with min. 50x50x6 mm edge protection angle with MS lugs.

31.5. The trench cover (chequered or pre – cast both) shall be provided with suitable lifting hooks.

31.6. As required, suitable MS insert plates shall be provided on trench wall to support the cable rack/ pipe.

31.7. The trench bed shall have a slope of approx. 1(V):250(H) along and 1(V):50(H) across the length of the trench. The cable trench shall have a dewatering sump(s) of size 450x450x450 mm depth at suitable location to facilitate collection & pumping out of rain water from the trench.

31.8. The external buried cables shall be laid in excavated trench as specified under specifications for Electrical works.

32. Transformer Yard Civil Works

32.1. Transformer and equipment foundations shall be founded on piles/isolated spread footings or block foundation depending on the final geotechnical investigation report and functional requirements.

32.2. Requirement of Soak Pit and Oil collecting pit shall be as per CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations.

32.3. Requirement of Soak Pit and Oil collecting pit shall be as per CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations.

32.4. Both, the transformer soak pit including side walls and the burnt oil pit shall be of RCC and shall be provided with sump (min. 500 mm x 500 mm x 400mm deep) and slope of 1:50 in concrete screed of 1:1 – ½:3 to the floor slab towards the sump pit. The burnt oil pit shall be provided with 20mm dia. MS rung ladder with 2 coats of epoxy paint over 2 coats of primer, a manhole & removable RCC cover. The inside of burnt oil pit shall be plastered with 6 mm thick CM 1:6 and painted with 2 coats of epoxy paint over 2 coats of primer.

32.5. The area around the transformer and equipment shall be covered with uniformly graded granite stone gravel of size 40mm.

32.6. The requirement of fire barrier wall between transformers shall be as per Electricity Rules and IS: 1646 recommendations. Minimum wall thickness shall be 230mm for RCC wall and 300mm for masonry wall.

33. Underground Liquid Retaining RCC Structures

33.1. The top of the UG tank shall be 250 mm above FGL.

33.2. The tank shall have clear free board of 300mm above MWL.

33.3. The tank bottom shall have a slope of 1:100 towards drainage sump (500x500x500 mm deep). The slope shall be provided either in structural slab or in screed concrete (1:2:4) trawl finished. 1000x1000 mm size Manhole in roof slab and 20 mm MS rung ladder shall be provided for easy access to the storage tank and silting chamber for periodic

cleaning. The manhole shall be covered with RCC precast cover. 50x50x6 mm MS angle with lugs shall be provided around precast cover and tank slab opening for edge protection. Rungs shall be painted with 2 coats of epoxy paint over 2 coats of primer.

33.4. The underground RCC tank shall be designed for following load conditions:

- External earth pressure + hydrostatic pressure due to ground water table (to be considered at FGL for design purposes) + Surcharge of 20 kN/ Sqm and Tank Empty.
- Tank full up to MWL and no external loads

33.5. The design shall conform to IS: 3370 with maximum crack width of 0.1mm for wall, bottom slab and roof slab. Min. grade of concrete shall be M30 (M35 in coastal areas, marshy and saturated soils) conforming to IS: 456. Suitable construction joints shall be provided as per provisions of IS: 3370 (Part 1). Water proofing admixture conforming to relevant BIS standard and of approved make shall be added to concrete as per manufacturer's recommendations.

33.6. The underground water tank shall be tested for water tightness as per the provisions of IS 3370 (Part-4). In case any leakage is noticed the same shall be repaired by injection of cement grout installing suitable nozzles around affected areas. Outside face of water tank in contact with water and soil and underside of roof slab shall be painted with 2 coats of epoxy paint.

34. In-plant Sub-Station/ Switch-Yard Civil Works

34.1. The specifications cover levelling and grading, construction of all sub-station/ switchyard structures and facilities including gantry towers & beams, lightning mast, equipment supporting structures, transformer foundations including oil pit, rail track, fire wall, cable trenches, roads, culvert, drains, sewers, water supply, fencing with gates, gravel filling & anti-weed treatment etc. and other related works in switch yard area as per the scope.

34.2. Gantry towers & beams, lightning mast, equipment supporting structures

34.2.1. Gantry towers and beams, equipment support structures shall be latticed steel structures. Height & type of towers and beams shall be established based on electrical requirements.

34.2.2. Loads and Loading Conditions:

Switchyard structures shall be designed for the worst combinations of following loads. Structures shall be checked for safe design under Reliability (normal) and Security (short circuit) conditions:

- Dead loads (load of wires/conductors, insulator, electrical equipment and structural members)
- Imposed loads – These are vertical loads. Load of 1500 N considered acting at each cross arm, as a provision of weight of lineman with tools. Load of 3500 N considered acting at the tip of cross arms up to 220 kV and 5000 N for 400 kV

and higher voltage for design of cross arms. All bracing and redundant members of the towers which are horizontal or inclined up to 15° from horizontal shall be designed to withstand ultimate vertical loads of 1500 N considered acting at centre independent of all other loads.

- Wind load on bus bars, shield wires, insulator strings, electrical equipment, structural members, etc.
- Seismic loads
- Conductor sag tension
- Loads due to line deviation (gantries shall be checked for ± 30^0 deviation in horizontal plane and ± 30^0 deviation in vertical plane.
- Temperature effects
- Erection loads – Erection loads at lifting points for 400 kV and higher voltage shall be taken as per Cl. No. 12.2.3 (d) of IS:802-part 1 (section-1)
- Short circuit forces including snap in case of bundled conductors, etc.

34.2.3. Wind load on Gantry structure (tower and beam), equipment, conductor, ground wire and insulator strings shall be calculated as per IS:802-part 4, IS:802-part 1 (section-1). Terrain roughness coefficient k2 in calculation of design wind speed Vd shall be min. 1.0 (terrain category 2). However, for site with hills/ ridges the value of k2 shall be taken as 1.08 corresponding to the next higher value (k2 corresponding to terrain category 1).

34.2.4. Temperature effects shall be considered as per IS:802-part 4.

- The average everyday temperature shall be 32°C anywhere in the country, except in regions experiencing minimum temperature of –5°C or lower, where everyday temperature may be taken as 15°C or as specified elsewhere.
- The beam/column may generally be designed to suit the conductor temperature of 85°C (Max) for Aluminium Conductor Steel Reinforced (ACSR) and 95°C for All Aluminium Alloy Conductor (AAAC). The maximum temperature of ground wire exposed to sun may be taken as 53°C. If the new generation conductors such as AL-59, Aluminium Conductor Steel Supported (ACSS) Trapezoid Wire (TW), gap conductor, Aluminium Composite Core Conductor (ACCC) etc, are deployed, maximum allowable temperature of the conductor based on the permissible/designed ampacity, shall be considered.
- The minimum every day and maximum temperature of the conductors shall be as per electrical considerations.

34.2.5. Sag tension calculation for conductor and ground wire shall be made in accordance with the relevant provisions of IS 5613 (Part 2/Sec 1) for the following conditions:

(a) 100 percent design wind pressure at everyday temperature or 36 percent design wind pressure at minimum temperature after accounting for drag co-efficient and gust response factor (design wind pressure = $P_d * C_{dc} * G_c$).

(b) The values of sag and tension on conductor shall be corrected to account for the weight tension and wind effect on the droppers.

(c) Effect of insulator weight, spacer weight, dropper weight and weight of other hardware to be considered suitably in the sag tension calculations.

34.2.6. Transverse loads due to line deviation shall be the component of 100 percent mechanical tension of conductor and ground wire/OPGW.

34.2.7. The mechanical tension of conductor/ground wire is the tension corresponding to (a) 100 percent of design wind pressure at everyday temperature or (b) 36 percent of design pressure at minimum temperature after accounting for drag co-efficient and gust response factor. Mechanical tension shall be considered as a longitudinal load for reliability condition and security condition.

34.2.8. Design load cases, load combinations and design criteria for gantry structure (beam and column/tower) and equipment support structures shall be as per IS:802-part 4.

34.2.9. Following factor of safety/overload factor shall be provided in the design of members:

- *Normal Condition (Reliability Condition)* — In normal condition, factor of safety/overload factor shall be taken as 2.0 in the design of members and the bolts.
- *Short Circuit Condition (Security Condition)* — In short circuit condition, factor of safety/overload factor shall be taken as 1.5 in the design of members and bolts.

34.2.10. The equipment support structures shall be designed for the weight of the equipment, self-weight of the structure, tensions of strung conductor, wind on strung conductor or pipe, wind on equipment and the support structure. Short circuit forces shall also be considered as acting on the equipment and getting it transferred to the structure along the strung conductor or pipe.

34.2.11. Other structures like, lightning mast, lighting mast watch and ward towers etc. shall be designed for wind loads and self–weight.

34.2.12. Special design considerations for equipment support structures:

- The supporting structure for B.P.I., LA, CVT and Isolator equipment shall be comprised of GI (ERW) pipe of grade YST:210 or of higher grade conforming to IS: 1161 & shall be designed as per IS:806. Minimum diameter of the pipe type support for structures shall be 200NB.For higher voltage levels, relevant standard shall be followed.
- The supporting structure for CT equipment shall be comprised of lattice structural steel conforming to IS 2026 and shall be designed as per IS: 802.
- Common raft foundation shall be provided for each pole of isolator.

34.2.13. Special design considerations for Lightning mast (as applicable):

Diagonal wind condition shall be considered for Lightning Mast. Diagonal wind shall be taken as 1.2 times the wind calculated on longitudinal/transverse side. Lightning mast shall be provided with minimum two nos. of platforms as per requirement and an internal ladder for climbing purpose shall be provided up to the platforms. Top of platform shall have grating, railing and two guard plates. The minimum width of

platform shall be 900mm. Live load of 300kg/m2 above platforms shall be considered for design of Lightning Mast. The fabrication and erection of the switchyard works shall be carried out generally in accordance with IS: 802 and IS: 800. All materials shall be completely shop fabricated and galvanized.

34.2.14. Materials:

- Gantry structure, which consists of open web towers connected by girders, shall be made of structural steel conforming to Grade IS:2062 or IS:8500 and duly galvanized conforming to IS: 2629 and IS: 4759.
- Minimum thickness of Leg members, ground wire peak members and lower members of cross arms in compression shall be 5 mm and min thickness of gusset plates shall be 6 mm. Minimum section thickness for other members shall be 4 mm.
- All joints shall be bolted connections.
- All bolts for connections shall be of 16mm dia. conforming to IS: 12427, property class 5.6 as specified in IS: 1367 (Part 3). Nuts shall conform to I.S 14394 (Part 3) of property class 5. Foundation bolts shall conform to IS: 5624, property class 4.6 as specified in IS: 1367 (Part 3).
- Butt splice shall be used for splicing the main members and splice shall be located away from the node point.
- Washers shall conform to IS 2016 with thickness as required based on connection details. Spring washers shall conform to type B of IS 3063. Heavy washers shall conform to IS 6610.
- Washers to be used with high strength bolts and nuts shall conform to IS 6649.
- All gratings shall be blast cleaned to Sa 2½ finish of Swedish standard SIS–05-5900 and shall be hot dip galvanised at the rate of 610 GSM.
- All handrails and ladders shall be galvanised at the rate of 610 GSM as per IS: 4736.
- Other material used in the construction of switch yard structures shall conform to appropriate Indian Standards, wherever available.

34.2.15. Galvanization:

- All steel sed in construction of switchyard structures such as Towers & Beams, Lightning mast and equipment supporting structures shall be galvanized in accordance with the provisions of IS 4759. Weight of zinc coating shall be at least 0.610 kg/m2 and foundation bolts shall have heavier zinc coating of at least 0.80 kg/m2.
- Threaded fasteners shall be galvanized to conform to the requirements of IS 1367 (Part 13).
- Spring washers shall be electro galvanized as per grade B of IS 1573 as and plain washers shall be hot dip galvanized as per service Grade 4 of IS 4759 or electro galvanized as per service Grade 3 of IS 1573.

34.3. Tie-Transformer/ power transformer foundations:

Foundations of transformer shall be designed for Equipment, seismic and wind loads.

Block foundations shall be provided for the main transformer block. Oil soak pit shall be provided around the transformer to prevent spillage of oil from transformer onto the ground. The oil soak pit shall be filled with gravel of size 40mm. The volume of the soak pit shall be sufficient to store complete oil of the transformer along with 10 minutes of fire water considering only 40% of the volume as available voids between gravel filling. However, in case a separate oil collection pit (burnt oil pit) is provided for the transformer, the minimum volume of oil soak pit around transformer shall be provided as one-third of the oil volume of transformer. The oil collection pit (burnt oil pit) in such cases, shall be designed for an effective capacity of complete oil of the transformer along with 10 minutes of fire water. Free space of 250mm height above gravel fill shall be provided in the soak pit. This free volume above the gravel free shall not be considered in effective capacity calculations. In capacity calculations for oil collection pit (burnt oil pit) the volume below the invert level (IL) of inlet pipe shall be considered, the inlet pipe shall be laid with adequate slope to avoid back flow of oil to the transformer soak pit. In oil collection pit, a min. free board of 300 mm shall be provided over IL of the inlet pipe. The transformer oil soak pit and oil collection pit (burnt oil pit) shall also be provided with a sump (min. 500x500x500mm) at the corner to allow disposal of water/oil from the soak pit. A rung ladder with 20 dia. MS rungs (painted with 2 coats of epoxy paint over 2 coats suitable primer) shall be provided in the oil collection pit.

Arrangement for moving the transformer in place using rail cum road, jacking pads and pulling blocks including inserts, as required, shall be provided along with the transformer foundations.

Fire protection wall shall also be provided between the transformers wherever required as per relevant standards and statutory requirements. The height and thickness of fire protection wall between transformers shall be as per system and statutory requirements Fire wall shall be provided with an independent foundation.

300 mm thick PCC M20 (1:1-1/2:3) encasement all around the pylon supports for firefighting system shall be carried out up to top of gravel filling. Supply and erection of complete fire-fighting system including pylon supports with anchor fasteners for HVW / N2 spray system shall be as defined under scope of work.

Coarse aggregate filling inside the transformer oil soak pit shall be carried out only after construction/erection of Pylon supports and PCC encasement.

34.4. Gravel filling:

Gravel filling shall be provided in the switchyard extension area inside the fence as indicated in the tender drawing with broken stone filling which shall consist of two layers. The first layer shall be 75mm thick base course of 20mm of normal size and second layer shall be 75mm thick surface course of 40mm nominal size. Each layer shall be compacted by using half ton roller with 4-5 passes and suitable water sprinkling. Before laying the gravel/stone fill, the top layer of the soil shall be treated for anti-weed considering the type of weeds found in the vicinity. The anti-weed - soil sterilization

details such as manufacturer's name, their specification, test certificate, etc. shall be furnished for Employer's approval. Any modification if required in the proposed anti-weed treatment chemical shall have to be done by the contractor at no extra cost to the Employer. The contractor shall be required to furnish a performance guarantee of three years for the anti-weed treatment. This guarantee shall be commenced from the date of completion of work or date of handing over, whichever is later.

34.5. Cable trenches:

RCC cable trenches shall be provided for routing of cables as required and shall be of adequate size. The trenches located within switchyard shall project at least 250 mm above the finished grade level (FGL) so that no storm water shall enter into the trench. The bottom of trench shall be provided with a longitudinal slope of 1:500. The downstream end of cable trenches shall be connected to sump pits. Heavy duty precast RCC covers with 20 dia. MS lifting hooks shall be provided over the cable trench. Trenches shall be given a slope of 1:250 in the direction perpendicular to the run of the trenches. Angle of size 50x50x6 mm (minimum) with lugs shall be provided in the edges of RCC cable trenches and any other place where breakage of corners of concrete is expected. The design and other requirements of the cable trench shall be as specified under Cl. No. 31: Pipe & Cable Trenches of this Section.

34.6. Switch yard storm water drains:

Open RCC storm water drains shall be provided on both sides of the road and inside switchyard area for proper drainage. All drains shall be designed for maximum runoff velocity of 1.8 m/sec.

RCC box/pipe culvert shall be provided for road, rail and trench crossings.

The design and other requirements of switch yard drainage system shall be as specified under Cl. No. 7: Surface/ Area drainage of this Section.

34.7. Switch yard roads:

Internal service roads shall be provided in the switch yard as required and per the approved layout. The road shall be of 3.0m wide carriage way with 0.5m wide shoulders on either side. The top of road (TOR) elevation shall be minimum 200 mm above FGL to avoid flooding of roads during rains and shall be provided with alongside drains as per design requirements of drainage system for effective disposal of storm water and to avoid cross flow of storm water over the road. The design and other requirements of roads shall be a specified under Cl. No. 6:Roads of this Section.

34.8. Chain link fencing:

The entire switch yard area shall be provided with chain link fencing with main gate(s) and wicket gate(s) as per approved layout. The design and details shall be as specified under Cl. No. 32.8:Chain link fence of this Section.

34.9. Switch yard control building and other buildings shall be provided as required as per approved building layout. The buildings shall be of RCC framed structure. The design

and details including finishing items and construction of all the buildings shall be as specified under relevant clauses of this specification.

34.10. Duct banks consisting of PVC conduits for cables shall be provided with proper sealing arrangement consisting of fire-retardant sealing compound.

34.11. Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns.

34.12. Design, construction and joints of all the structures shall be as per relevant Indian Standard Codes unless specified otherwise.

34.13. All foundation embedment, inserts, block-outs required for mounting of equipment and supporting any other facility like pipes etc. shall be provided.

34.14. All cable trenches shall be provided with suitable MS insert plates for fixing support angles of cable trays.

34.15. Broad gauge rail (52kg/m minimum) shall be used for rail tracks required for movement of Transformer.

35. Miscellaneous structures

35.1. Support structure for weather monitoring device

35.1.1. Weather monitoring device shall be mounted on tubular steel pole of required height. The pole shall conform to IS: 2713.

35.1.2. The pole shall be secured to an independent RCC foundation structure through Base plate and Anchor bolt assembly.

35.1.3. The support structure shall be hot dip galvanized.

35.2. LA Mast and Foundation (Other than Sub-station)

35.2.1. LA Mast shall be self-supporting structure with GI tubular pole of required height. The pole shall conform to IS 2713.

35.2.2. The pole shall be supported on RCC pedestal and foundation structure through base plate and anchor bolt assembly.

35.2.3. 200 mm long, 20 dia. rods shall be welded to the pole at 300 mm c/c for access to the device for maintenance purposes.

35.2.4. The support structure shall be hot-dip galvanized. Minimum depth of foundations shall be 1200 mm below GL.

36. Pre-Engineered Building (PEB)

36.1. General:

The PEB shall be made of structural steel construction with double skinned metal roofing and wall cladding of appropriate profile. PEB shall be complete with painting, metal fascia, metal gutter, rain water down comers, sun-shades, openings, etc., along with associated structural steel, cladding and roofing work insulation, trims & flashings,

etc. Each item of PEB like panels, masonry, plastering, flooring, foundation, fittings etc. shall be suitable for complete life of Plant.

36.2. Design parameters and design loads shall be as per Cl. 10: Design Loads of this Section. Limiting deflections shall be as per IS 800.

36.3. Structure and material specification:

Component	Description	Reference Standard
Primary Structural Members: including the transverse rigid frames, columns, corner columns, end wall wind columns, beams, truss member, base pate.	Steel frame members with minimum thickness 4 mm with minimum yield strength of 350 MPa	IS 2062 min Grade E350 Quality C
Secondary Members: including the purlins, Girts, eave struts, bracing, flange bracing, base angles, clips, flashings and other miscellaneous structural parts. Suitable wind bracings, sag rods to be reckoned while designing the structure.	Minimum thickness 3.15 mm. Secondary members for purlins and Girts shall have minimum yield strength of 350 MPa. Miscellaneous secondary members shall have minimum yield strength of 250 MPa.	IS 2062: Quality C
Other Details:		
Paint and Coating	The structural steel shall be hot-dipped galvanized (Min 610 GSM), conforming to IS: 4759 or relevant Indian standard. Cladding sheet steel shall be colour coated with total coating thickness of 25 microns (nominal) dry film thickness (DFT) comprising of silicon modified polyester (SMP with silicon content of 30% to 50 %) paint or Super Durable Polyester (XRW) paint of 20 microns (nominal) on one side (exposed face) over 5 micron (nominal) primer coat and 10 microns (nominal) SMP or Super Durable Polyester paint over 5 micron (nominal) primer coat on other side. SMP and polyester paints system shall conform to Product type 4 as per AS/ANZ 2728.	
Rolling shutter	Shall conform to IS: 6248.	
Wall & Roof Cladding	Unless specified otherwise, Insulated wall cladding or roofing shall consist of double skin metal cladding with Poly Urethane Foam (PUF). PUF must be made of continuous method PU foam and must be CFC free, self-extinguishing, fire retardant type with density 40+/-2 kg/m3 and thermal conductivity 0.019-2.2 W/ (m.K) at 10°C. The PUF panels shall be a factory made item ready	

	for installation at site.
Roof Insulation and detail	Both metal sheets shall have an under insulation of minimum 150 mm thick PUF with gutters and down take pipes along with Flashing & Top cap of required size and colour complete with all necessary hardware. Roof shall be projected at-least 300 mm from the wall. Both upper and lower sheets shall be separated through spacers and fastened through zinc /zinc-tin coated self-drilling screws. The fastener size shall be calculated as per the design or manufacturers recommendations. Contractor may also alternatively make the PEB roofing with composite slab (RCC slab with permanent formwork). The composite slab scheme, design and drawings shall be subject to approval from Employer before start of work.
Wall Insulation and detail	Unless specified otherwise, all voids of external and internal metalled walls shall have an under insulation of minimum 120 mm thick PUF with proper supports etc. as approved. Both the walls should be separated by spacers system made up of steel and fastened through zinc /zinc-tin coated self-drilling screws. The fastener size shall be calculated as per the design or manufacturers recommendations.

36.4. PEB shall be provided with suitable bracing system including roof (plan) and vertical bracings.

37. BESS Yard Civil Works

37.1. The specifications cover levelling and grading, construction of all structures and facilities including BESS container support structure, equipment supporting structures, transformer foundations including oil pit, rail track, fire wall, cable trenches, roads, culvert, drains, sewers, water supply, gravel filling & anti-weed treatment etc. and other related works in BESS yard area as per the scope.

37.2. Grading and levelling shall be carried out in line with Cl. No. 5: Area Grading and Land Development of this Section.

37.3. Layout of BESS yard shall be such that crane movements for placing, lifting of battery units, PCS units, transformer, etc. shall not disturb the adjacent facility. All side fencing, cladding/ roof sheets shall be fitted in such a way that they can be removed at any point of time.

37.4. BESS PCS and associated equipment shall be installed in buildings/open installations

with specifications as applicable for LCR/ ICR (Cl. No. 14.2.2) of this Section.

37.5. BESS Transformer Area:

Design and other requirement for BESS transformer foundation, Soak Pit, Burnt Oil Tank, etc. shall be as per Cl. No. 32: Transformer Yard Civil Works of this Section.

37.6. BESS yard storm water drains:

Design and other requirements of BESS yard drainage system shall be as specified under Cl. No. 7: Surface/ Area drainage of this Section.

RCC box/pipe culvert shall be provided for road, rail and trench crossings.

37.7. BESS yard roads:

Roads shall be provided in the BESS yard as required and as per the approved layout. The road shall be of 4.0 m wide carriage way with 0.5m wide shoulders on either side. The top of road (TOR) elevation shall be minimum 200 mm above FGL. The design and other requirements of roads shall be a specified under Cl. No. 6: Roads of this Section.

Area between the BESS containers envisaged for forklift/equipment movement shall be provided with 150 THK PCC (1:1.5:3) course to be laid over well compacted subgrade (up to 95% of MDD).

37.8. BESS Support Structure:

37.8.1. BESS container shall be placed on Min 150 mm thick grade slab (with minimum shrinkage reinforcement) laid over 75 thick PCC (1:2:4), over 230 THK boulder soling with interstices filled with sand properly compacted in layers of 150mm by adding water, over well compacted sub grade (up to 95% of MDD). Grade slab thickening shall be provided at the edges and reinforcements shall be provided at top and bottom at the thickened edges.

37.8.2. The grade of concrete for grade slab shall be min M25.

37.8.3. The grade slab shall be confined from all the sides with brick masonry (Min 345 mm thick). The bricks shall be of class designation 7.5 conforming to IS 1077, IS 2212 & IS 3495. The foundation for brickwork shall extend min 500mm below FGL and shall be laid over 100 thick PCC (1:2:4). Brick work shall have 18 thick cement plaster in CM 1:4. All exposed portion of the brick work shall be provided with exterior grade paint finish.

37.8.4. Finished level of the grade slab shall be min 450mm from the finished ground level.

37.8.5. For preventing water stagnation on the grade slab, PCC (1:1:2) fillet with water proofing compound and suitable adhesive shall be provided between the container base frame and grade slab. General slope of the grade slab & brick wall top beyond the container shall be directed outward with screed concrete. At locations of isolation joint between brick wall and grade slab, water sealant shall be provided.

37.8.6. Cut outs shall be provided with edge protection angle along with lugs.

37.8.7. Access platform with steps shall be provided if required.

37.8.8. Support structure shall be in line with the OEM requirements.

37.9. Cable trenches:

37.9.1. RCC cable trenches shall be provided for routing of cables as required and shall be of adequate size. The trenches located within BESS-Yard shall project at least 250 mm above the finished grade level (FGL) so that no storm water shall enter into the trench. The bottom of trench shall be provided with a longitudinal slope of 1:500. The downstream end of cable trenches shall be connected to sump pits. Heavy duty precast RCC covers with 20 dia. MS lifting hooks shall be provided over the cable trench. Trenches shall be given a slope of 1:250 in the direction perpendicular to the run of the trenches. Angle of size 50x50x6 mm (minimum) with lugs shall be provided in the edges of RCC cable trenches and any other place where breakage of corners of concrete is expected. The design and other requirements of the cable trench shall be as specified under Cl. No. 31:Pipe & Cable Trenches of this Section.

37.9.2. In case of over ground cable routing, suitable arrangement with cable tray and support structure may be adopted subject to approval of the Engineer.

IV. GENERAL ANNEXURE A: SINGLE IBR UNIT SIMULATION MODEL AND BENCHMARKING REPORT

1. Requirement of Single IBR unit Simulation model & Benchmarking report.

(a) Single SoC (Statement of Conformity) and Evaluation Report for Type test report as per CEA Connectivity standard mentioning all Hardware/software/Firmware version.

(b) Fault current characteristics (voltage -current) of Inverter (PCS) during fault condition. The Reactive power response of the Inverter (PCS) in case of fault condition, should be faster to support Grid or as per Grid operator.

(c) Current and voltage Waveform capture facility during LVRT/HVRT at Inverter (PCS) output terminal during event and accessible to SECI in EMS/ SCADA /PPC. Availability of high resolution data with pre fault/post fault time and automatic extraction of the above data into EMS/ SCADA /PPC subsequent to fault avoiding manual/OEM intervention.

(d) During LVRT and HVRT, the Inverter (PCS) shall distribute its active and reactive capacity in such a way that first priority will be reactive power support as per voltage dip. The active current and overall current shall be limited as per the transient rated current limit of inverter (PCS). Inverters should be capable to support reactive current in case of asymmetrical (1 ph/2 ph) fault condition. Active and reactive power response shall be oscillation free.

(e) Inverter (PCS) controller Setting facility from local as per CEA Regulation. The Inverter (PCS) and its PSS/e and PSCAD model should have the tuneable parameters: FRT Voltage threshold, K factor, Proportional Gain, Integral Gain and Active and reactive power recovery gain during fault recovery duration etc as recommended by grid Operator.

(f) Time synchronization facility of Inverter with PPC/SCADA.

(g) Single IBR Controller Setting in compliance with CEA grid connectivity regulation.

(h) Single IBR model shall be prepared or get from OEM (for PSS/E and PSCAD) and benchmark it with the lab/factory/field test measurements taken during certification process. Benchmarking report shall include model validation against all the clauses mentioned in B1 & B2 of CEA Technical Standards for Connectivity to the Grid (Amendment) Regulation, 2019. (Bidder to refer Report of the Working Group in respect of Data Submission Procedure and Verification of Compliance to CEA Regulations on Technical Standards for Connectivity to the Grid by RE Generators July 2022 and it's amendments/clarifications for detailed requirement of Benchmarking Report of single IBR.

(i) Provision to change setting in inverter according to various operating condition at site is to be provided.

(j) A separate benchmarking report /simulation comparison is required for SCR=5 and 3 for PSS/E and PSCAD software and furnishing the Parameters for the same. Provision to change setting in inverter according to various operating condition at site is to be provided.

Following shall be part of submission-

1. Comparison of field test measurement with simulation results numerical values & as well as graphical values for following points.
   (a) Power Quality (only in EMT).
   (b) Active power set change (RMS & EMT)
   (c) Reactive power control- V control, pf & Q control (RMS & EMT)
   (d) IBR capability demonstration (RMS & EMT)
   (e) LVRT (RMS & EMT)
   (f) HVRT (RMS & EMT)
   (g) Frequency response (RMS & EMT)
2. Final simulation model parameters like Generator model, Electrical control model, drive train model etc. shall be included in benchmarking report. (RMS & EMT).
3. Firmware version of IBR unit controller for which IBR unit got certified shall also be included in this report.
4. Field test report documents shall be referenced in the benchmarking report.
5. Ensure the setting kept in IBR while field testing & actual IBR installed at site are same, if any alteration kindly include justification for the same.
6. IBR simulation model flat run results for 100 seconds with simulation time step of 1ms shall be included for electrical parameters (P, Q, V, f) and speed to be included (RMS)
7. EMT model of IBR unit- flat run results for 100 seconds with simulation time step of 10us or greater shall be included for electrical parameters (P, Q, V, f) and speed. Further, model shall get initialised within 3 seconds & shall have snapshot capability.
8. Model compatibility: EMT models provided to shall be compatible with PSCAD version 4.6 and above and Intel Visual FORTRAN version 15 or higher and RMS model for PSS/E version 34.4 and above. Same shall be included in the report. The models which is compatible with PSCAD V5 (latest version) with GNU Fortran compiler and with intel Fortran compiler need to be provided. If the model compiled in one compiler is not compatible with other compiler, it is requested to provide both models
9. Include a table having IBR controller setting, RMS & EMT model parameter for different control parameters as specified. (RMS & EMT).
10. IBR unit model for PSS/E shall include .sav, .dyr, .py, .idv, .sld, .out files and PSCAD .pscx and other supporting files.
11. Conclusion part include table for which models are benchmarked & whether the model replicates the actual. Error in simulation vs. actual shall be minimum to the extent possible, however it shall not be more than 5%.

V. GENERAL ANNEXURE B: EQUIPMENT INSPECTION CATEGORY

1. Equipment Inspection Category

All equipment is classified into three categories namely, Category – A, Category – B and Category – C on the basis of pre-dispatch inspection requirement by SECI and AC Contractor.

Category	Stake holder	Pre-dispatch inspection
Category – A	SECI	Yes
	AC Contractor	Yes
Category – B	SECI	No
	AC Contractor	Yes
Category – C	SECI	No
	AC Contractor	No

However, SECI reserves the right to conduct pre-dispatch inspection for Category-B and Category-C equipment also.

S. No.	Equipment Code	Equipment
Category – A		
1	ITR	Inverter Transformer
2	HTP	HT Switchgear Panel
3	PTR	Power Transformer
4	CRP	Control & Relay Panel
5	SCADA	SCADA
6	PPC	Power Plant Controller
Category – B		
1	ATR	Auxiliary Transformer
2	LTC	LT Cable (PCS to Inverter Transformer)
3	HTC	HT Cable (Inverter Transformer to HT Switchgear/ Power Transformer)
4	LTP	LT Panels (ACDB & DCDB)
5	SWO	Substation Equipment – CT, PT, CB, Isolator etc.
6	ABT	Metering Set (Main, Check, Standby)
7	NIFPS	Nitrogen Injection Fire Protection System
Category – C		
1	TLC	Transmission Line Conductor/Cable

2	LDC	LT Distribution Cable
3	UPS	Uninterrupted Power Supply
4	BBC	Battery Bank and Battery Charger
5	EES	Earth Electrode and Accessories
6	LPS	Lightning Protection System
7	CMC	Communication Cable
8	TEA	Telemetry Equipment and accessories
9	LED	Plant Illumination equipment and accessories
10	WMS	Weather Monitoring Station
11	CCTV	CCTV Camera
12	FAS	Fire Alarm System
13	TI	Testing instruments
14	CPC	Control and Power Cables
15	CTK	Cable Termination Kits
16	TLT	Transmission Line Tower/Pole and Accessories
17	FST	Fasteners
18	OTR	Equipment Pre-Approved by DISCOM/TRANSCO

1.1. **Category – A**

The Contractor shall give inspection call to SECI for pre-dispatch inspection of Category – A equipment at Manufacturer's/Supplier's factory. The inspection call shall be given only after the approval of equipment documents under Category – I as per Drawing and Document Control Index and be attached with internal routine test reports performed by the Manufacturer/Supplier as per the approved Quality Assurance Plan. Inspection call should be given at least 7 working days before the scheduled start date of pre-dispatch inspection for a location within India and 15 working days in case of a foreign country. Based on the inspection report and compliance report (if any), Material Dispatch Clearance Certificate (MDCC) will issued by SECI.

1.2. **Category – B**

For Category – B equipment, the Contractor shall intimate SECI about the proposed inspection at least 3 working days before the scheduled start date of pre-dispatch inspection. Such intimation shall be given only after the approval of equipment documents under Category – I as per Drawing and Document Control Index and be attached with internal routine test reports performed by the Manufacturer/Supplier as per the approved Quality Assurance Plan. SECI will participate in the predispatch inspection, if required.

If SECI participates in the pre-dispatch inspection, based on the inspection report and

compliance report (if any), Material Dispatch Clearance Certificate (MDCC) will issued by SECI. In case SECI does not participate in the pre-dispatch inspection, the Contractor shall submit the Inspection Report signed by Contactor and Manufacturer/Supplier Representatives to SECI for issuance of Material Dispatch Clearance Certificate (MDCC).

1.3. **Category – C**

For Category – C equipment, the Contractor shall submit internal routine test reports performed by the Manufacturer/Supplier as per the approved Quality Assurance Plan. For all equipment inspected by the DISCOM, Inspection Report/Test Report signed by DISCOM shall be submitted to SECI for information and payment recommendation.

The methodology proposed for conduct inspection and issuance of MDCC is as under:

Category	Inspection done by	MDCC issued by	
A	SECI	SECI	Inspector will submit the inspection report to SECI along with its observations, if any. In case of any observation reported by Inspector, then Contractor shall submit compliance report for the same to SECI. SECI shall review the inspection report, along with the compliance report submitted by Contractor, in line with the approved QAP and Drawings/ Documents and if found satisfactory, shall recommend issue of MDCC. MDCC shall be issued by SECI.
B	AC Contractor (SECI optional)	SECI	Contractor shall submit all the test report / material certificates to SECI. SECI shall review these documents and if found satisfactory, shall issue MDCC.
C	Certificate of Compliance (CoC) by Manufacture / Supplier	SECI	Contractor will verify the CoC and issue the MDCC which will be verified by SECI.

VI. GENERAL ANNEXURE C: MANDATORY SPARES

S. No.	Equipment/Material	Quantity (For each type and rating)
1	**Inverter Transformer**	
	(i) HV bushing with metal parts and gaskets	2 set
	(ii) LV bushing with metal parts and gaskets	2 set
	(iii) WTI with contacts	2 set
	(iv) OTI with contacts	2 set
	(v) Buchholz relay	2 set
	(vi) Magnetic Oil Gauge	2 set
	(vii) Breather assembly	2 set
	(viii) Complete set of gaskets & valves	2 set
	(ix) Tap Changer Contact Assembly	2 set
2	**Power Transformer**	
	(i) HV bushing with metal parts and gaskets	1 set
	(ii) LV bushing with metal parts and gaskets	1 set
	(iii) WTI with contacts	1 set
	(iv) OTI with contacts	1 set
	(v) Buchholz relay	1 set
	(vi) Magnetic Oil Gauge	1 set
	(vii) Breather assembly of Main tank	1 set
	(viii) Cooler Fan with motor, Contactor, Relay and MCB	1 set
	(ix) Insulating Oil	10%
	(x) Complete set of gaskets & valves	1 set
	(xi) Tap Changer Contact Assembly Spares	1 set
	(xii) Pressure release device	1 set
3	**33 kV Circuit breaker / switchgear assembly**	
	(i) Circuit breaker pole	2 nos.
	(ii) Contact assembly (for indoor panels)/ Contact flange (for outdoor CB)	Suitable for one 3-phase CB
	(iii) Closing coil	2 nos.
	(iv) Tripping coil	2 nos.
	(v) Spring charging motor	2 nos.
	(vi) Relay (each type)	2 nos.

S. No.	Equipment/Material	Quantity (For each type and rating)
	(vii) Meter (each type)	2 nos.
	(viii) Current Transformer	2 nos.
	(ix) MCCB	2 nos.
	(x) MCB	2 nos.
	(xi) Fuse	10% of total supply
	(xii) Indicating lamp	10% of total supply
	(xiii) Rotary switch	10% of total supply
4	**33 kV outdoor disconnector**	
	One pole (metallics & insulators)	2 sets
	Fixed and moving contact assembly	4 sets
	Drive mechanism box	1 set
	Relays, contactors, switches and push buttons	Two of each type
5	**33KV LA, CT & VT (indoor and outdoor)**	**One of each type together with terminal connectors**
6	**Control and Relay Panel**	
	(i) Relay (each type)	1 no.
	(ii) Meter	1 no.
	(iii) MCB	2 nos.
	(iv) Fuse	10% of total supply
	(v) Indicating lamp	10% of total supply
	(vi) Rotary switch	10% of total supply
	(vii)BCU	1 no.
7	**LT Switchgear**	
	(i) ACB	1 no.
	(ii) MCCB	2 nos.
	(iii) MCB	2 nos.
	(iv) Fuse	10% of total supply
	(v) Relay	2 nos.
	(vi) Meter	2 nos.
	(vii) Current Transformer	2 nos.
	(viii) Voltage Transformer	2 nos.
	(ix) Contact Assembly	2 sets

S. No.	Equipment/Material	Quantity (For each type and rating)
	(x) Indicating lamp	10% of total supply
	(xi) Rotary switch	10% of total supply
8	**DC Cable**	**1 Drum**
9	**AC Cable**	**1 Drum**
10	**Communication Cable**	**1 Drum**
11	**Control Cable**	**1 Drum**
12	**Fuse**	**10% of total supply**
13	**33 kV Internal Transmission Line (if applicable)**	
	(i) Line supports, MS Angle, Back Clamp, Top Clamp, Earthing Coil, Insulators	2 set
	(ii) Conductor	1 km
	(iii) Jointing Sleeves, Stay set complete with turn buckles, stay wire, stay insulators, Anti-climbing Devices, Danger Boards	2 set
14	**220 kV Pooling Substation Equipment**	
	(i) SF6 Circuit Breaker	
	(a) One complete pole of Circuit Breaker, pole column, Interrupter, with driving mechanism Box and MB but without support structure	1 no.
	(b) Grading capacitors (if applicable)	1 no.
	(c) Rubber gaskets, O rings and seals for SF6 gas (complete replacement for one breaker)	1 set
	(d) Trip coils with resistor	2 nos.
	(e) Closing coils with resistor	1 no.
	(f) Molecular filter for SF6 Circuit for 1 Pole of CB	2 nos.
	(g) Terminal pads and connectors	2 nos.
	(h) Corona rings	1 no.
	(i) Relays, power contactors, switch-fuse units, limit switches, push buttons, timers and MCBs etc.	1 set
	(j) Pressure switches	1 set
	(k) Auxiliary Switch Assembly	1 set

S. No.	Equipment/Material	Quantity (For each type and rating)
	(l) SF6 gas	1 complete fill for at least two CBs
	(ii) Disconnector	
	(a) One complete pole of disconnector including support insulator with 1 E/S with motor operating mechanism for main isolator and earth switch (excluding structure)	1 no.
	(b) Copper contact fingers for female & male contacts	2 set
	(c) Open/Close Contactor Assembly, Timer, Key Interlock push button switch & auxiliary switches	1 set
	(d) Limit switch	2 nos.
	(e) Terminal pads & Connectors	3 nos.
	(f) Corona shielding ring	3 nos.
	(iii)Surge Arrester	1 no.
	(a) Complete surge arrester excluding support structure	1 no.
	(b) Surge counter / monitor	5 nos.
	(iv)Current Transformer (excluding support structure / common JB)	1 no.
	(v) Voltage Transformer (excluding support structure / common JB)	1 no.
	(vi)Bus Post Insulator	3 nos.
	(vii) Conductor	200 m of each type
	(viii) Erection Hardware Items (Insulator strings & Hardware, Clamps & Connectors)	3 nos. of each type
	(ix)Terminal Clamps	1 set
	(x) Lugs	20 of each type
	(xi)Heat shrinkable Termination and Jointing kits	5% of Total quantity used
15	**220 kV Transmission Line**	

S. No.	Equipment/Material	Quantity (For each type and rating)
	(i) Steel Tower - Transmission towers including body and leg extensions (complete) including stubs and hangers, cleats, Galvanized Steel Sections (for replacement), nuts and bolts	15% of each member / component used in each type of tower
	(ii) Conductor Joint Sleeve, Earth Wire Joints, Armor Rods, Suspension insulator string with fittings and clamp, Tension insulator string with fittings and clamp	2 set
	(iii)Conductor, Earth Wire and OPGW	1 km each

Spares, if used, during the O&M period shall be replenished by the Contractor. All the mandatory spares shall be handed over to SECI in working condition at the end of O&M period along with list of utilized items and replaced items.

VII. GENERAL ANNEXURE D: FQP AND MQP FOR CIVIL WORKS

The FQP and MQP for Civil Works is attached as a separate document named as "GA-D_FQPMQP_CivilMMS_Works_1200 MWh BESS_AC Package from IDT"

VIII. GENERAL ANNEXURE E: TENDER DRAWINGS

The Tender Drawings are attached as a separate document named as "GA-E_Tender Drawings_1200 MWh BESS_AC Package from IDT"

IX. GENERAL ANNEXURE F: PLANT DOCUMENTATION, COMMISSIONING & PG TEST PROCEDURE

1. INTRODUCTION

This document lays down the procedures, requirements and templates for conducting commissioning tests and inspection of the Plant Facilities after installation and for subsequent re-inspection, maintenance or modifications in accordance with the Tender Specifications. This document shall serve as the template for the Commissioning and PG Tests to be jointly conducted by AC and DC Package Contractors.

2. CODES AND STANDARDS

The Testing and Commissioning Procedures shall, in general, comply with the following standards:

i. IEC 62446 standard (Part 1: Grid connected systems – Documentation, commissioning tests and inspection).
ii. IEC 60364-6:2016 - Low voltage electrical installations - Part 6: Verification.
iii. IEC 62305-3– Protection against lightning - Part 3: Physical damage to structures and life hazard
iv. IS/IEC 61557 : Part 2 : 2007 - Electrical safety in low voltage distribution systems up to 1000 V ac and 1500 V dc - Equipment for testing, measuring or monitoring of protective measures: Part 2 insulation resistance
v. IEC 62933-2-1: Electrical energy storage (EES) systems - Part 2-1: Unit parameters and testing methods - General specification

3. COMMISSIONING

3.1. General

Objective:

The Commissioning Procedure defined in this document aims to:

- Verify that the power plant is structurally and electrically safe
- Verify that the power plant is structurally and electrically robust to operate for the specified lifetime of a project
- Verify that the power plant operates as designed and its performance is as expected

3.1.1. The Commissioning Process shall be witnessed by the Employer or their duly appointed representative.

3.1.2. The following equipment shall be used during the commissioning process (Refer clause 21 of Section II: Technical Specifications for testing instruments):

- Earth resistance tester
- Insulation tester
- Digital multi-meter
- Clamp meter
- Infrared camera
- Digital lux meter

- Electroluminescence camera, power supply and accessories

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

3.2. Cold Commissioning

3.2.1. DC Commissioning

Battery Energy Storage System (BESS)

The visual inspection shall be conducted on 5% of the system split in subareas equally distributed in the field. Unless otherwise specified, Approved Cat I Drawings shall be referred for correctness/verification. At least following aspects shall be verified visually on the DC side:

Before energizing the BESS, following visual checks shall be made to check the required design compliance:

- Installation of protective cover for live, hot and cold parts, and the adequate distance from the person;
- Installation of fence, wall, locking system of doors and access panels, and notice boards
- Installation of ventilation system;
- Installation of fire-fighting system;
- Installation of lightning protections devices.
- Wiring
  - All wiring shall be continuous and without splices.
  - Wiring that may be exposed to mechanical damage are placed in conduit or armoured.
  - Wires have permanent and durable identifying labels or markings on both ends.
  - Control and instrumentation wiring shall be separated from power and high-voltage wiring by use of separate compartments or enclosures or by use of separate wireways and appropriate barrier strips.
  - BESS and PCS control and instrumentation system wiring shall be bundled, laced, and otherwise laid in an orderly manner.
  - Cable systems do not block access to equipment by personnel. There are no exposed current-carrying or voltage-bearing parts.

Acceptance criteria

Each deviation from industrial best practices, norms, standards and good workmanship shall be documented in a punch list. All items shall be categorized as “critical”, “important” or “minor”.

3.2.1.1. Continuity test

Continuity of power, control and auxiliary circuit in the system shall be verified through visual inspection, continuity tester and insulation resistance test.

Phase sequence and terminal marking shall also be verified with drawing and design

documents.

3.2.1.2. Earthing test

Following element to be check according to the design and applicable standards:

- Proper connection of the earthing busbar to the local earthing busbar;
- Individual earthing connection of main equipment to the earthing busbar;
- Connection of earthing cables to structures via proper connectors to prevent corrosion from dissimilar metals.

3.2.1.3. Insulation test

For low-voltage Electrical systems, the insulation resistance test and withstand voltage test shall be performed according to IEC 60364-6.

For Electrical systems exceeding 1 kV AC or 1,5 kV DC, the withstand voltage test shall be performed according to IEC 61936-1.

Acceptance criteria

The DC commissioning will be passed when the aforementioned verifications are successfully passed in 100% of the sample according to Sampling Plan agreed with the Employer.

3.2.2. AC Commissioning

3.2.2.1. Visual Inspection

The visual inspection shall be conducted on 5% of the system. In general, the requirements specified in the IEC 60364-6 -6.4.2 apply. At least following aspects shall be verified visually on the AC side:

General requirements

- Protective requirements against electric shock
- Protection against fire and heat
- Choice, setting, selectivity and coordination of protective and monitoring devices
- Sizing of cables regarding voltage drop and ampacity as per approved Drawings.
- Sizing of protective and monitoring devices as per approved Drawings
- The circuit breakers are correctly located
- Selection, location and installation of suitable isolating, overvoltage protective devices and switching
- The equipment and protective measures are appropriate for the external influences and mechanical stresses
- The diagrams, warning notices or similar information attached to the wall inside the inverter housing or the control room
- Proper labelling of all electrical circuits and devices including the neutral conductor and protective conductor as well as correct connection of single pole devices to the phase conductors

- Adequacy of termination and connection of cables and conductors
- The warning labels and technical documentation physically displayed
- Selection and installation of earthing arrangements, protective conductors and their connections
- The existence and correct use of protective conductors and protective equipotential bonding conductors (PEB)
- Measures against electromagnetic disturbances implemented
- Easy access to the operational devices for maintenance
- Any exposed conductive parts connected to the earthing system
- The RCD type has been selected according to the requirements of the IEC 62548
- The isolation means of the inverter on the AC side are functional and correctly sized
- The fire protection requirements according to the approved design shall be given

Requirements for the inverter

- Installation as per manufacturer's instructions and compliance with IEC 62548
- Inverters properly fastened to the ground
- Inverter properly earthed
- Inverter incoming/outgoing cables properly isolated, labelled and connected
- The connections for phase sequence L1, L2, L3 and N in the correct order
- All cable terminations properly done
- Nameplate data. The minimum requirements for the production of a name plate are –
    - name and origin of the manufacturer; –
    - model or type name;
    - serial number;
    - electrical parameters: Vdcmax, Idcmax, Pac,rated, Vac,rated, fr , Iacmax;
    - degree of protection;
    - overvoltage category;
    - safety class.
- The displays - check / readout show plausible results
- The filters are clean and properly maintained
- The cooling outputs of the inverters are free from obstruction
- The DC circuit breaker/relay is functional
- The DC insulation monitoring correctly installed
- The fuses at the DC entrance correctly sized
- The location of the inverter(s) in the field matches the approved design
- Protection against self-loosening of clamps and screws
- The mechanical assembly is robust
- The inverters are fixed to non-flammable mechanical elements

Acceptance criteria

Each deviation from industrial best practices, norms, standards and good workmanship shall be documented in a punch list. The punch list shall represent a maximum budget of 1% of the construction price and all items shall be categorized as "critical", "important" or "minor".

3.2.2.2. Pre-Energizing Tests

Measuring instruments and monitoring equipment and methods shall be chosen in accordance with the relevant parts of IEC 61557 and IEC 61010. The following tests shall be carried out on the AC circuit forming the PV array:

- Continuity of conductors. The requirements in IEC 60364-6:2016 – 6.4.3.2 apply
- Insulation resistance of the electrical installation. The requirements in IEC 60364-6:2016 – 6.4.3.3 apply
- Insulation resistance testing to confirm the effectiveness of protection by SELV, PELV or electrical separation. The requirements in IEC 60364-6:2016 – 6.4.3.4 apply
- Insulation resistance/impedance of floors and walls. The requirements in IEC 60364-6:2016 - 6.4.3.5 apply
- Polarity test. The requirements in IEC 60364-6:2016 - 6.4.3.6 apply
- Testing to confirm effectiveness of automatic disconnection of supply. The requirements of the IEC 60364-6:2016 – 6.4.3.7 apply
- Testing to confirm the effectiveness of additional protection. The requirements of the IEC 60364-6:2016 – 6.4.3.8 apply.
- Test of phase sequence. The requirements of the IEC 60364-6:2016 – 6.4.3.9 apply
- Functional tests. The requirements of the IEC 60364-6:2016 – 6.4.3.10 apply
- Voltage-drop. The requirements of the IEC 60364-6:2016 – 6.4.3.11 apply

Acceptance criteria

The AC commissioning will be passed when the aforementioned verifications are successfully passed in 100% of the sample according to the IEC 62446: 2016 – 5 and IEC 60364 – 6.

3.2.2.3. Additional Pre-Energizing Tests

All of the below tests shall be conducted in accordance with the supplier's installation/commissioning manuals.

i. Distribution boards

Site testing on distribution boards shall include:

- Mechanical functional test of all components including mechanical interlocks
- Electrical functional test of all control and protection wiring against the

approved switchgear schematics

- Power frequency overvoltage test (flash test) on the switchgear including circuit-breakers in the test circuit
- Low resistance duct or test on the switchgear including circuit-breakers in the test circuit
- Visual inspection
- Verification of earthing

ii. Inverters

Site testing on inverters shall include:

- Full test procedure as defined by the inverter manufacturer
- A full mechanical functional test of all components including mechanical interlocks
- Verification that the inverter operational parameters have been programmed to local regulations
- Electrical functional test of all control and protection wiring against the approved switchgear schematics as per approved MQP/FQP
- Insulation resistance test and earth residual current monitoring test
- Anti-islanding functionality
- High Voltage overvoltage test
- SCADA and metering calibration & functionality test

iii. HT Switchgear

Site testing on outdoor circuit-breakers shall include:

- Functional check of all wiring, interlocks, auxiliaries and pressure devices
- Timing test and travel curve
- Visual inspection

iv. LV/MV transformers

Transformer commissioning shall include:

- Visual inspection, alignment, earthing and labelling
- Functional check of all wiring against the approved transformer schematics
- Testing and calibration of all transformer protection and monitoring devices
- Insulation resistance test
- Functional test of off-circuit/on Circuit tap changer and check of the continuity of all windings

v. Substation/Power Transformers

- Ratio measurement on all tap changer settings
- Winding resistance measurement on highest, lowest and nominal tap settings
- Insulation resistance between all windings, and each winding to earth
- Insulation resistance core-to-earth
- Oil sample tests: breakdown strength, moisture content, and dissolved-gas

content

- Transformer differential protection scheme testing

Acceptance criteria

The test results shall be aligned with the manufacturer specifications stated in the installation manual.

3.3. Hot Commissioning

3.3.1. Inverter Availability Test

Calculation of the Operation Time

It shall be calculated on inverter level. The operation time starts as soon as the inverter switches on. Therefore, only the logged irradiation values during the operation time of the inverter shall be considered. Irradiation values logged before or after the inverter running time shall be disregarded.

Calculation of the Downtime

The downtime relevant for the availability calculation is any time in which a part or a subpart of the system is not operational. The outage periods shall be considered again on inverter level. Only complete outages shall be taken into consideration. System black-out periods due to following reasons shall not flow into the calculation (i.e., excluded events):

- A failure in the distribution grid or the transformer substation, making it impossible to transmit the generated power
- Causes of Force Majeure.
- Occurrences of anomalies in the power supply system (frequency differences or voltage surges) that trigger the protective systems of the plant or the limit settings of the inverter
- Any forced disconnection shall be documented and recorded.

Acceptance criteria

The system availability shall be at least 99% during the testing period.

3.4. SCADA Reliability

- Installation of the communication system architecture diagram according to the specifications
- Functional Tests conducted during FAT for Pre-Dispatch Inspection shall be repeated.
- SCADA shall be linked to all protection relays, disturbance recorders and other substation equipment using the communications protocol
- Visual check on the assembly of all joints and on the as-installed condition of all components, including:

- Ambient temperature sensors are installed properly (Reference IEC 61724)
- Mechanical anchorage of the sensors is robust

- Complete calibration certificates of all the instruments shall be provided

Acceptance criteria

Each deviation from industrial best practices, norms, standards and good workmanship shall be documented in a punch list. The punch list shall represent a maximum budget of 1% of the construction price and all items shall be categorized as "critical", "important" or "minor".

3.5. **Functional test**

3.5.1. **Start and stop test**

Check start and stop operation of BESS system with the startup/shutdown command manually and automatically.

3.5.2. **Alarms Functional Test**

Alarms initiation from the BESS in case of following conditions:

- Emergency trip switch.
- Loss of the low-voltage AC or utility grid voltage.
- An AC circuit breaker trip (either side of transformer).
- Door interlock: Initiate shutdown when the door is opened (with appropriate provision for maintenance work). Interlocks shall be self-resetting.
- Smoke/fire alarm.
- A DC ground fault (simulated).
- Remote disable (no reset required).
- Grid system faults (balanced and unbalanced; line-to-ground, line-to-line, and three-phase).
- Abnormal voltage
- Islanding condition.
- Protection or control scheme failures, including the following:
  - Failure of local interconnection protection system
  - Failure of critical breaker trip coil or interrupting device
  - Loss of DC supply

3.5.3. **Load tripping test**

Check the interlock of BESS with the main

3.5.4. **Operating cycle test**

Check for any abnormalities such as rise in temperature, noise level and vibration in ESS system during rated input and output power operation.

3.5.5. **Storage Settings**

Verification of settings/control points and provision for modification of various set

points and fixed operation/control settings associated with the various control functions.

Operator Controls:

- Trip/reset for the BESS AC circuit breaker or contactor.
- Trip/reset for DC circuit breaker(s)/contactor(s).
- PCS on/off.
- Reset cut-out selector switch to disable remote or local reset signals.
- A selector switch to manually set the operating state (that is, the shutdown, disconnect, or operate state) and to have the control system set the operating state automatically.
- A selector switch to manually set the operating mode and to have the control system set the operating mode automatically.

3.5.6. **Communication test**

Verified that measuring, alarm, fault indication, message and control and monitoring system operations are correct transmitted and received by the SCADA system.

3.6. **System Rating Verification**

BESS rating including rated power, energy available at rated power, and the performance of the BESS associated with different performance metrics mentioned herein taken at the beginning of life shall be based on a set of ambient operating conditions specified by the BESS Original Equipment Manufacturer (OEM) for the Project site. The Contractor shall also provide an indication of how the performance of the BESS with respect to the metrics is expected to change over time, to account for time and use of the system, and report the same periodically.

3.6.1. **Energy Content Test**

Energy Content Test shall be performed in accordance with the following steps:

a) The BESS shall be charged to its full available energy level at rated input power in accordance with the system specifications and operating instructions.

b) The BESS shall be discharged at the rated power of the system in accordance with the system specifications and operating instructions. The system shall be discharged to the minimum available energy level associated with the system specification and operation instructions (including the needed rest times between input and output power operation).

c) The constant output power, output time and energy consumption of the auxiliary subsystem shall be measured and recorded during output. The actual energy capacity is calculated as follows:

Case I: If the auxiliary subsystem is fed internally, actual energy capacity is calculated by following equation.

$$E_O = \sum_{i=1}^{n} P_{O_i} \times \Delta t \quad (1)$$

where,

E_o is the calculated total output energy at the POC (kWh);

P_{Oi} is the active output power at time i, measured at the POC (kW);

Δt is the sampling time of the measurement (h);

n is the discharge time (h).

Case II: If the auxiliary subsystem is fed from other feeder, actual energy capacity is calculated by following equation.

$$E_O = \sum_{i=1}^{n} P_{O_i} \times \Delta t - E_{aux_o} \quad (2)$$

where,

E_o is the calculated total output energy at POC (kWh);

P_{Oi} is the active output power at time i, measured at the POC (kW);

Δt is the sampling time of the measurement (h);

E_{aux_o} is the energy consumption of the auxiliary subsystem measured at the auxiliary POC during the output operation (kWh);

n is the discharge time (h)

This test shall be conducted 3 times for 100% Rated Power, 1 time each for 75%, 50%, 25% of rated power. Data shall be collected from the Plant SCADA and the following data shall be tabulated in Table 1 for each case.

Case 1: Auxiliary subsystem is fed internally				**Power:** ___ % of Rated Value = _____ MW		
Parameter	**Observed during Charging**			**Observed during Discharging**		
	Power P_I	**Energy E_I**	**Duration T_I**	**Power P_O**	**Energy E_O**	**Duration T_O**
Unit	**kW**	**kWh**	**h**	**kW**	**kWh**	**h**
	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**
Actual Energy Content (kWh)		$E_O = \sum_{i=1}^{n} P_{O_i} \times \Delta t$				
Case 2: Auxiliary subsystem is fed from other				**Power:** ___ % of Rated Value = _____		

feeder					MW			
Parameter	**Observed during Charging**				**Observed during Discharging**			
	Power P_I	**Energy** E_I	**Duration** T_I	**Aux Con.** E_{aux_I}	**Power** P_O	**Energy** E_O	**Duration** T_O	**Aux Con.** E_{aux_O}
Unit	**kW**	**kWh**	**h**	**kWh**	**kW**	**kWh**	**h**	**kWh**
	(g)	**(h)**	**(i)**	**(j)**	**(k)**	**(l)**	**(m)**	**(n)**
Actual Energy Content (kWh)			$E_O = \sum_{i=1}^{n} P_{O_i} \times \Delta t - E_{aux_o}$					

Table 1: Actual Energy Content

Acceptance criteria

Dispatchable energy at the Point of Interconnection shall be at least equal to the dispatchable capacity for the first year specified by the Employer for:

(i) AC Terminals of Power Conditioning System (PCS)

(ii) Point of Interconnection at 220 kV

3.6.2. **Round-trip Efficiency**

The EES system shall be tested for its roundtrip efficiency following the test procedures a) to c) presented in Section I. This test shall be performed under the rated input active power and rated output active power.

The roundtrip efficiency ηrt shall be determined in accordance with Formulae (3) and (4) for at least 3 cycles for 100% of Rated Power) based on the data secured from the tests conducted in accordance with the provisions in 5.1.1, taking into account possible auxiliaries power consumption from auxiliary POC during idle/rest times.

Case I:

$$\eta_{rt} = \frac{E_{out}}{E_{in}} \qquad \text{.....(3)}$$

Where,

E_{out} is the Total Energy Discharged from BESS as recorded in the Energy Meter(s) at the POC.

E_{in} is the Total Charging Energy into the BESS as recorded in the Energy Meter(s) at the POC.

Case II:

$$\eta_{rt} = \frac{E_{out} - E_{aux,o}}{E_{in} - E_{aux,i}} \quad \text{……..(4)}$$

The roundtrip efficiency shall be reported as shown in Table 2. In case more than 1 cycle is performed, round trip efficiency shall be reported based on average values:

Table 2: Round Trip Efficiency

	Energy E_{in}	**Energy E_{out}**	**Aux Cons. $E_{aux,i}$**	**Aux Cons. $E_{aux,o}$**	**Roundtrip Efficiency**
	kWh	**kWh**	**kWh**	**kWh**	**%**
	(p)	**(q)**	**(r)**	**(s)**	**(t)**
Test 1					
Test 2					
…					
Test N					
Average					

Acceptance criteria

Round-trip efficiency of the BESS shall be more than or equal to, including auxiliary Consumption at 100% rated power:

(i) 86% at the PCS AC Terminals

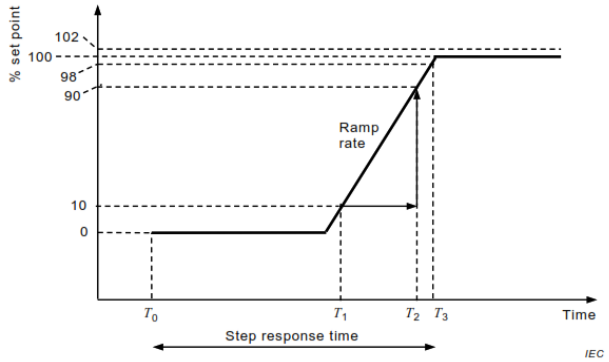
(ii) 82% at the 220 kV Interconnection Point

3.6.3. **Step Response Test: Step Response Time and Ramp Rate**

Step response time: Duration of the time interval between the instant T0, when the set point is received at the EES system, which is in stand-by mode, or when the grid parameter changes in a way to trigger the system response, and the instant T3 when the active power at the POC reaches within 2 % of the set point

Ramp Rate: Average rate of active power variation per unit of time between T2 and T1 as shown in Figure 5. T1 is the time when the active power at the POC becomes higher than 2 % of the set point value. T2 is the time when the active power at the POC becomes higher than 98 % of the set point value.

$$RR\ (W/s) = \frac{P(T_2) - P(T_1)}{T_2 - T_1}$$



a) The EES system shall be charged or discharged to a 50 % state of available energy.

b) The set point (power, kW) shall be zero. The set point value shall be retained until the output comes to within (0 ± 2) % of rated input power.

c) The set point shall be changed to rated input power. The set point value shall be retained until the active power at the POC reaches within 2 % of the range of rated input power. Step response time and ramp rate for step c) shall be recorded as SRT1 and RR1 respectively.

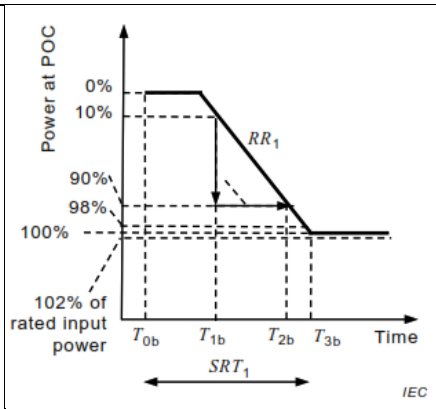
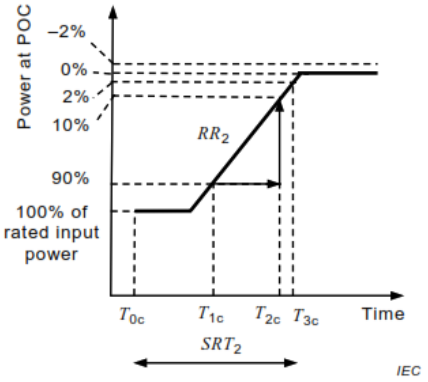
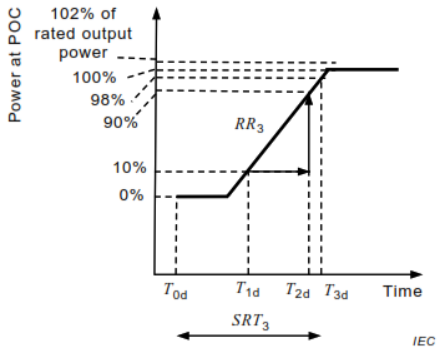
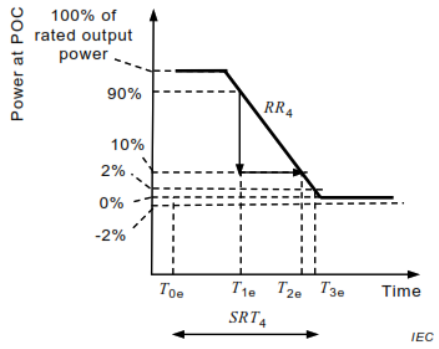
d) The set point shall be changed to zero. The set point value shall be retained until the active power at the POC reaches within (0 ± 2) % of rated input power. Step response time and ramp rate of step d) shall be recorded as SRT2 and RR2 respectively.

e) The EES system shall be charged or discharged to a 50 % state of available energy or specified capacity value agreed between the system supplier and user.

f) The set point shall be changed to rated output power. The set point value shall be retained until the active power at POC reaches within 2 % of the range of rated output power. Step response time and ramp rate for step f) shall be recorded as SRT3 and RR3 respectively.

g) The set point shall be zero. The set point value shall be retained until the active power at the POC reaches within (0 ± 2) % of rated input power. Step response time and ramp rate for step g) shall be recorded as SRT4 and RR4 respectively.

	Representative Figure	**Measured Parameters**	**SRT_n**	**RR_n**

(c)		SoC (%) Setpoint (kW) T_{0b} (sec) T_{1b} (sec) T_{2b} (sec) T_{3b} (sec)	SRT_1 =	$RR_1 = \frac{P(T_{2b}) - P(T_{1b})}{T_{2b} - T_{1b}}$
(c)		SoC (%) Setpoint (kW) T_{0c} (sec) T_{1c} (sec) T_{2c} (sec) T_{3c} (sec)	SRT_2 =	$RR_2 = \frac{P(T_{2c}) - P(T_{1c})}{T_{2c} - T_{1c}}$
(d)		SoC (%) Setpoint (kW) T_{0d} (sec) T_{1d} (sec) T_{2d} (sec) T_{3d} (sec)	SRT_3 =	$RR_3 = \frac{P(T_{2d}) - P(T_{1d})}{T_{2d} - T_{1d}}$
(e)		SoC (%) Setpoint (kW) T_{0e} (sec) T_{1e} (sec) T_{2e} (sec) T_{3e} (sec)	SRT_4 =	$RR_4 = \frac{P(T_{2e}) - P(T_{1e})}{T_2 - T_1}$

	Step Response Time (SRT)	**s**	
	Ramp Rate (RR)	**kW/ s**	

Acceptance criteria

Step Response time and Ramp Rate shall be at least the values committed to by the Supplier.

3.6.4. **Auxiliary Power Consumption Test**

Auxiliary Power Consumption shall be measured for Case 1 and 2 delineated in Section I, as per the following:

1. In case the auxiliary subsystem is fed from the POC, auxiliary power consumption shall be measured at the point of supply of the auxiliary subsystem.
2. In case the auxiliary subsystem is fed from the auxiliary POC, the auxiliary power consumption shall be measured as input power at the auxiliary POC.

Before measurement, the EES system shall be charged or discharged to a 50 % state of available energy capacity or specified energy capacity value agreed between the system supplier and user. Auxiliary Consumption shall be recorded at Rated Input Active Power, Rated Output Active Power, Rated Injected Reactive Power, Rated Absorbed Reactive Power, and Standby State.

The tolerance on Input and Output power must be within 2% of the Rated Power.

Table 4: Auxiliary Power Consumption Measurement

Point of Measurement of Auxiliary Power Consumption (*Select Applicable Case*)	Point of supply of the Auxiliary subsystem		
	Auxiliary PoC		
Operation at Rated Input Active Power			
SoC at start of measurement		%	
Measured Input Active Power		kW	
Measured Auxiliary Power Consumption		kW	
Operation at Rated Output Active Power			
SoC at start of measurement		%	
Measured Output Active Power		kW	
Measured Auxiliary Power Consumption		kW	
Operation at Injected Reactive Power (if the system has a rated value of reactive power)			
SoC at start of measurement		%	
Measured Output Reactive Power		kVAr	
Measured Auxiliary Power Consumption		kW	

Operation at Absorbed Reactive Power (if the system has a rated value of reactive power)		
SoC at start of measurement	%	
Measured Input Reactive Power	kVAr	
Measured Auxiliary Power Consumption	kW	
Stand-by state (i.e. PCS Active power = 0 W, Reactive Power = 0 VAr)		
SoC at start of measurement	%	
Measured Output Active and Reactive Power	kW, kVAr	
Measured Auxiliary Power Consumption	kW	

The Energy Content Test and Round Trip Efficiency Demonstration shall serve as the PG test as well and should meet the acceptance criteria. The measured auxiliary consumption data shall be recorded for information.

4. Liquidated Damages due to shortfall of Round-Trip Efficiency during PG Test: -

4.1. Performance Guarantee Requirement

The Contractor shall demonstrate compliance with the guaranteed Round Trip Efficiency (RTE) of the Battery Energy Storage System (BESS) during the Performance Guarantee Test conducted at the time of commencement of commercial operations, in accordance with the procedure and testing methodology specified in this Contract.

4.2. Non-Compliance and Liquidated Damages

In the event the Contractor fails to demonstrate the guaranteed Round Trip Efficiency during the Performance Guarantee Test, the Contractor shall be liable to pay Liquidated Damages (LD), not amounting to a penalty, to compensate the Employer for the Net Present Value (NPV) of the estimated annualized losses arising from the reduced efficiency of the BESS. Further, the new measured value of Round-trip efficiency shall be benchmarked for the Service Level Agreement.

4.3. Calculation of Liquidated Damages

The LD amount shall be calculated as follows:

$$LD = \sum_{i=1}^{n} \frac{\Delta \text{ E x R}}{(1+r)^i}$$

Where:

ΔE is $\left(\frac{E_i+E_{i+1}}{2}\right) x\ 365\ x\ A\ x\ 1.5\ x\ (\frac{1}{\eta_{\text{actual}}} - \frac{1}{\eta_{\text{guaranteed}}})$

E_i and E_{i+1} are the minimum dispatchable energy for year ***i*** and ***i+1*** as specified elsewhere in the document (refer Scope of Works)

A is the guaranteed availability as specified elsewhere in the document (refer Scope of Works)

$\eta_{\text{guaranteed}}$ is the guaranteed minimum round trip efficiency as specified elsewhere in

the document (refer Scope of Works)

η_{actual} is the round trip efficiency demonstrated during the Performance Guarantee Test

R is the reference rate of Rs 4.5 per kWh (INR/kWh)

r is the annual discount rate, i.e. 8.5%

N is the number of years over which the performance is evaluated as specified elsewhere in the document (refer Scope of Works)

4.4. **Reversal of LD**

In the event that the Contractor is able to demonstrate compliance with the minimum guaranteed Round Trip Efficiency (η_{min}) under the Service Level Agreement (SLA) during any two (2) distinct consecutive billing periods within the SLA monitoring window (post-commissioning), the LD amount levied under Clause 4 shall be subject to reversal. The reversal shall be calculated by deducting the energy arbitrage losses for the intervening period (between initial test failure and the second compliant billing period). Upon such compliance, the Round Trip Efficiency shall thereafter be deemed to be benchmarked to the guaranteed efficiency (η_{min}) for all further purposes of the Contract.

X. GENERAL ANNEXURE G: SCADA SCHEMATICS & I/O LIST (INDICATIVE)

SCADA Schematics & I/O List is attached as a separate document named as "GA-G_SCADA Schematics_1200 MWh BESS_AC Package from IDT"

XI. GENERAL ANNEXURE H: QUALITY ASSURANCE & INSPECTION OF CIVIL WORKS

1. Introduction

1.1. This part of the specification covers the sampling, testing and quality assurance requirement (including construction tolerances and acceptance criteria) for all civil and structural works covered in this specification.

1.2. This part of the technical specification shall be read in conjunction with other parts of the technical specifications, general technical requirements & erection conditions of the contract which covers common QA requirements. Wherever IS code or standards have been referred they shall be the latest revisions.

1.3. The rate for respective items of work or price shall include the cost for all works, activities, equipment, instrument, personnel, material etc. whatsoever associated to comply with sampling, testing and quality assurance requirement including construction tolerances and acceptance criteria and as specified in subsequent clauses of this part of the technical specifications.

1.4. The QA and QC activities in all respects as specified in the technical specifications/ drawings / data sheets / quality plans / contract documents shall be carried out at no extra cost.

1.5. The contractor shall prepare detailed construction and erection methodology scheme which shall be compatible to the requirements of the desired progress of work execution, quality measures, prior approvals from statutory authorities etc. if any and the same shall be got approved from the Engineer.

1.6. If required, work methodology may be revised/ reviewed at every stage of execution of work at site, to suit the site conditions, work progress commensurate with project schedule by the contractor at no extra cost to the Engineer

2. QA and QC Manpower

2.1. The contractor shall nominate one overall QA coordinator for the contract detailing the name, designation, contact details and address at the time of post bid discussions.

2.2. All correspondence related to Quality Assurance shall be addressed by the contractor's QA coordinator to the Engineer.

2.3. Employer/ Consultant shall address all correspondence related to Quality issues to the contractor's QA coordinator. The contractor's QA coordinator shall be responsible for co-ordination of Quality activities between various divisions of the contractor and their sub-vendors on one hand & with Engineer on the other hand.

2.4. The contractor shall appoint a dedicated, experienced and competent QA & QC in-charge at site, preferably directly reporting to the Project Manager, supported as necessary by experienced personnel, to ensure the effective implementation of the approved QAP.

2.5. The contractor shall finalize and submit a deployment schedule of QA & QC personnel

along with their details to Engineer for approval/ acceptance and further shall ensure their availability well before the start of the concern activity.

3. Laboratory and Field Testing

3.1. The contractor shall make necessary provisions to provide all facilities required for QA & QC activities by setting up a field laboratory for QA and QC activities in line with the indicative field QA & QC laboratory set-up.

3.2. The Laboratory building shall be constructed and installed with adequate facilities to meet the requirement of envisaged test setup. Temperature and humidity controls shall be available wherever necessary during testing of samples.

3.3. The quality plan shall identify the testing equipment/ instrument, which the contractor shall deploy and equip the field quality laboratory for meeting the field quality plan requirements.

3.4. The contractor shall furnish a comprehensive list of testing equipment/ instrument required to meet the planned/scheduled tests for the execution of works for Engineer's acceptance/ approval.

3.5. The contractor shall mobilize the requisite laboratory equipment and QA & QC manpower at least 15 days prior to the planned test activity as per the schedule of tests.

3.6. In case contractor desires to hire the services of any established laboratory nearby for any field tests then he shall ensure that the subject laboratory is well equipped with all requisite testing facilities and qualified QA & QC staff and this shall not affect in anyway the work progress.

3.7. All equipment and instruments in the laboratory/ field shall be calibrated before the commencement of tests and then at regular intervals, as per the manufacturer's recommendation and as directed by the Engineer. The calibration certificates shall specify the fitness of the equipment and instruments within the limit of tolerance for use. Contractor shall arrange for calibration of equipment and instruments by an NABL / NPL accredited agency and the calibration report shall be submitted to Engineer.

3.8. The tests which cannot be carried out in the field laboratory shall be done at a laboratory of repute. This includes selected IITs, NCB, CSMRS, reputed government / autonomous laboratories / organizations, NITs and other reputed testing laboratories. The test samples for such test shall be jointly selected and sealed by the engineer and thereafter these shall be sent to the concerned laboratory through the covering letter signed by Engineer. Test report along with the recommendations shall be obtained from the laboratories without delay and submitted to Engineer.

3.9. Based on the schedule of work agreed with the Engineer and the approved FQP, the contractor shall prepare a schedule of tests and submit them to the Engineer and organize to carry out the tests as scheduled/agreed.

4. Sampling and Testing of Construction Materials

4.1. The method of sampling for testing of construction materials and work / job samples

shall be as per the relevant BIS / standards / codes and in line with the requirements of the technical specifications / quality plans.

4.2. All samples shall be jointly drawn, signed and sealed wherever required, by the contractor and the engineer or his authorized representative.

4.3. The contractor shall carry out testing in accordance with the relevant IS standards/ codes and in line with the requirements of the technical specifications / quality plans. Where no specific testing procedure is mentioned, the tests shall be carried out as per the best prevalent engineering practices and to the directions of the Engineer.

4.4. All testing shall be done in the presence of Engineer or his authorized representative in a NABL accredited / Govt. Laboratory acceptable to Engineer.

4.5. The test samples shall be jointly selected and sealed and signed by the Site-in-charge and thereafter these shall be sent to the concerned laboratory.

4.6. The test report along with the recommendations shall be obtained from the laboratory without delay and submitted to Engineer.

5. Purchase and Service

5.1. All structural steel shall be procured only from main steel producers In case of non-availability of some of the sections with main steel producers, the contractor may propose to procure the sections from the re-rollers of the main steel producers, the name of such re-rollers will have to be cleared by the Engineer for which details such as BIS approval, main steel producer's approval, past experience for production of sections of specified material, details of machines, plant, testing facilities etc.

5.2. Confirmation that the process control and manufacturing of steel sections by re-rollers shall be same as that of main steel producers, that billets for re-rolling will only be sourced from main steel producers shall be furnished with regard to re-roller.

5.3. For Module Mounting Structures (MMS), sources of steel other than those specified under this clause may also be used subject to the condition that they otherwise meet the requirements of the Technical Specifications / Bid documents. Even after clearance of re-rollers, induction of billets with identified and correlated Mill test certificates (MTC) in the process of re-rolling, sampling of steel, quality checks thereof and stamping of final product for further identification and correlation with MTC prior to dispatch shall be the responsibility of the contractor and these shall be performed in presence of the authorized representative of the main Contractor.

5.4. Reinforcement steel shall be procured only from main steel producers and Mill test certificates (MTC) shall be obtained and submitted to the Engineer for correlation.

6. Field Quality Plan

6.1. Well before the start of the work, the contractor shall prepare and submit the Field Quality Plans to Employer for approval, which shall detail out for all the works, equipment, services, quality practices and procedures etc. in line with the requirement of the technical specifications to be followed by the contractor at site.

6.2. This FQP shall cover all the items / activities covered in the contract / schedule of items required, right from material procurement to completion of the work at site.

6.3. An Indicative Field & Manufacturing Quality Plan for civil and structural works is enclosed with this specification for reference as Annexure-D.

7. General QA Requirements

7.1. The contractor shall ensure that the works, BOIs and services under the scope of Contract, whether manufactured or performed within contractor's works or at his subcontractor's premises or at the project site or at any other place of work, are in accordance with Technical specification, applicable standards / codes, approved drawings / data sheets / quality plans and BOQ. All the works, BOIs and services shall be carried out as per the best prevalent engineering practices and to the directions of the Engineer.

Equipment	**UOM**	**Approx. Qty.**
Cube moulds for cement testing	nos.	4
Sieve shaker	nos.	1
Sieve for sand, coarse and fine aggregate	set	1
Sieve for coarse aggregate	set	1
Slump testing equipment	nos.	6
Oven	nos.	2
Physical balance	nos.	1
Thermometer	nos.	4
Burret	nos.	2
Measuring cylinder	nos.	9
Measuring flask	nos.	3
Compression testing machine	set	1
Cube mould for concrete	nos.	10
Mechanical weighing machine	nos.	1 (100kg capacity)
Drum type concrete mixer (for trial mixes)	nos.	1
Proctor testing equipment	set	1

7.2. Notes

The equipment listed above is indicative and minimum required. Additional equipment, if any, required for successful completion of work shall be provided /arranged by the contractor.

All test reports/ inspection reports shall be submitted in soft copy also and shall be available at site for easy access to the Engineer.

Based on the schedule (L2/L3 Network), Quality control & Quality Assurance Work plan shall

be finalized by the contractor and the same shall be submitted to Engineer for acceptance/approval.

XII. SPECIFIC ANNEXURE A: TENTATIVE PROJECT LAYOUT

The tentative project layout is attached as a separate document named as "S-XII-SA-A_Tentative Project Layout_1200 MWh BESS_AC Package from IDT"

XIII. OPERATION AND MAINTENANCE AGREEMENT

Operation and Maintenance Agreement is attached as a separate document named as "S-XIII_OM Agreement_1200 MWh BESS_AC Package from IDT"