ANNEXURE B

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A. SCOPE OF WORK

1. Battery Energy Storage System (BESS)

1.1. For the purpose of this RfS document, a Battery Energy Storage System (BESS) shall be defined as an AC Coupled energy storage system with electrochemical type accumulator subsystem, capable of receiving, storing and delivering electrical energy at specified rate(s) suitable for the application laid out in the specifications herein.

1.2. For the purpose of common reference in these specifications, BESS shall comprise of following subsystems/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) (PCS)
iii. Auxiliary sub-systems such as HVAC and fire suppression systems
iv. Data Acquisition and Communication sub-systems
v. BESS Energy Management System (EMS)

Note: The Accumulation system i.e. battery packs/modules/racks along with associated systems (BMS, HVAC, auxiliary subsystems etc.) deemed necessary to enable system operation shall be containerised.

1.3. **Battery Management System or BMS** is any electronic system that manages a rechargeable battery (cell or battery pack), including protecting the battery from operating outside its Safe Operating Area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it.

1.4. **Available or Dispatchable or Throughput energy** is the sum total of energy (kWh) delivered from the BESS at the PCS.

1.5. **Nameplate Energy** is the sum total of the rated energy capacity of the energy storage units i.e. battery packs/modules/racks.

1.6. **Unit battery** – A unit battery is the minimum field-replaceable stored energy component or assembly. It may consist of one or more electrochemical cells, electrically interconnected in any series and/or series–parallel configuration. A unit battery has one (and not more than one) set of positive and negative terminals, by which it is interconnected with the rest of the storage system.

1.7. **Point of Interconnection**:

i. **Point A:** Point A is the point of interconnection of the Project at 220 kV substation end.
ii. **Point B:** Point B is the point of interconnection of PCS with the BESS transformer i.e. AC terminals of PCS.

2. Project Particulars

Particulars	Description
Name of Package	DC Package for Design, Engineering, Supply, Manufacturing, Erection, Testing, Commissioning and Maintenance of 600 MW / 1200 MWh Battery Energy Storage System at Kolimigundla, Nandiyal, Andhra Pradesh
Design and Engineering	
BESS minimum nameplate DC Capacity (Cumulative), (MWh)	1400 MWh
BESS minimum dispatchable Capacity at Point of Interconnection at the Beginning of Life	1200 MWh
Cumulative BESS Power Conditioning System (PCS) Capacity	Cumulative Inverter Capacity shall be capable of delivering 600 MW AC Power with PF range -0.95 to +0.95 at POI at the design ambient temperature.
Design life of BESS Project	15 Years
Service and Maintenance Contract period	15 Years and 3 months
Site Location and Land Details	
Location	Kolimigundla
District	Nandiyal
State/UT	Andhra Pradesh
Latitude & Longitude	15°01'18"N 78°09'13"E
Altitude	283 m
Available Land Area	~ 40 acres
Type of Land	Government (Revenue Land)
Project Ownership	Solar Energy Corporation of India Limited
Access to Project Site	
Nearest Urban Area	Kolimigundla
Nearest Highway	Thimannayunipeta – Ankireddy Palli Road (adjacent to location)
Nearest Railway Station	Tadipatri Railway Station
Nearest Airport	Uyyalawada Narasimha Reddy Airport, Kurnool
Power Evacuation (Not in the Scope of the Bidder)	
Plant End Substation Power Transformer Capacity	640 MVA

<table>
<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>Metering Point</td><td>ABT Meter at the 220 kV Plant End Substation Line Bay.
Note: BESS Scope of Supply is limited to the DC Package up to and including accumulation sub-system, auxiliary sub-system, PCS and EMS.
However, the Supplier shall size the BESS Energy and Power rating, considering loss parameters for systems not in the scope of the Contractor under this Contract.</td></tr>
<tr><td>Losses Consideration</td><td>The BESS Supplier shall take into consideration following loss parameters while sizing the nameplate capacity of the BESS:
<table>
<tr><td>Storage/Shipment Loss (3 months)</td><td>As per OEM</td></tr>
<tr><td>DC Cable Efficiency</td><td>As per design</td></tr>
<tr><td>PCS Efficiency</td><td>As per OEM</td></tr>
<tr><td>LV Cable Loss
(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>Dispatchable Energy</td><td>To ensure the dispatchable energy at 220 kV Point of Interconnection in Point A, the BESS Supplier shall ensure and demonstrate minimum dispatchable energy at the PCS’s AC terminals given in Point B at the start of the respective year.
<table>
<tr><th>Year</th><th>Point A
(At 220 kV PoI)</th><th>Point B
(At Inverter AC Terminals)</th></tr>
<tr><td>Year 1</td><td>1200 MWh</td><td>1248.0 MWh</td></tr>
<tr><td>Year 2</td><td>1170 MWh</td><td>1216.8 MWh</td></tr>
<tr><td>Year 3</td><td>1140 MWh</td><td>1185.6 MWh</td></tr>
<tr><td>Year 4</td><td>1110 MWh</td><td>1154.4 MWh</td></tr>
<tr><td>Year 5</td><td>1080 MWh</td><td>1123.2 MWh</td></tr>
<tr><td>Year 6</td><td>1050 MWh</td><td>1092.0 MWh</td></tr>
<tr><td>Year 7</td><td>1020 MWh</td><td>1060.8 MWh</td></tr>
<tr><td>Year 8</td><td>990 MWh</td><td>1029.6 MWh</td></tr>
<tr><td>Year 9</td><td>960 MWh</td><td>998.4 MWh</td></tr>
<tr><td>Year 10</td><td>930 MWh</td><td>967.2 MWh</td></tr>
<tr><td>Year 11</td><td>900 MWh</td><td>936.0 MWh</td></tr>
</table></td></tr>
</table>

	Year 12	870 MWh	904.8 MWh
	Year 13	840 MWh	873.6 MWh
	Year 14	840 MWh	873.6 MWh
	Year 15	840 MWh	873.6 MWh
Design Parameters			
Design Ambient Temperature	50 °C		
Basic Wind Speed (IS 875-3)	39 m/s		
Seismic Zone (IS 1893-1)	Zone II		
Corrosion Class	C4		
Performance Guarantee			
For Operational Acceptance	1. Demonstration of System Round Trip Efficiency at the Point B i.e. PCS's AC terminal: 86% 2. Demonstration of Dispatchable energy at the Point B i.e. PCS's AC terminal: Dispatchable energy plus downstream losses considered		
During System Maintenance Contract Period			
BESS Availability	98%		
Other Details			
Water and Power for Construction	To be arranged by the Supplier		

3. Brief Scope of Work

3.1. Scope of Supply & Work includes Design & Engineering, Manufacturing of equipment and materials, Testing at manufacturers works, Inspections, Packing and Forwarding, Supply on FOR-Site basis, Receipt, Unloading and Storage at site, associated civil works, services, permits, licences, installation and incidentals, insurance at all stages, erection, testing and commissioning and interconnection works till the PCS output terminals of the BESS for **"DC Package of 600 MW / 1200 MWh Battery Energy Storage System (BESS)",** and Performance Demonstration with associated equipment and materials on turnkey basis along with 15 (Fifteen) years of comprehensive Service and Maintenance from the date of commissioning.

3.2. The Supplier shall provide Product Warranty and Performance Guarantee as per the Technical Specifications.

4. Responsibility Matrix

4.1. 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 DC 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.*

4.2. 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
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

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

4.4. **Design & Installation Coordination**: Supplier (DC Package) and Employer's Balance of Plant 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.

4.5. **Testing and Commissioning Interface:** Supplier (DC Package) shall perform functional testing of BESS, PCS, and EMS systems up to the AC terminals of the PCS. Employer's Balance of Plant Contractor (AC Package) shall perform testing from BESS transformer onward and overall plant synchronization. Joint testing protocols shall be developed and approved by the Employer.

5. Design and Engineering

5.1. The Supplier shall prepare the detailed Design Basis Report (DBR), and Master Drawing List (MDL). The Supplier shall submit a copy to Employer for review and approval prior to detail engineering.

5.2. The Supplier shall estimate the Plant Nameplate size (both Energy and Power), including accumulation, conversion and auxiliary sub-systems, considering the climatic conditions prevailing at site, loss parameters specified, if any, so as to deliver minimum performance parameters required as per the RfS document at the Point of Interconnection. Detailed Sizing Calculations report shall be submitted along with the DBR.

5.3. The design of the BESS shall be in accordance with grid code at Point A and the technical specifications provided in this document. The BESS Supplier shall effectively coordinate with Employer's AC Package Contractor for the works awarded under this Contract. On completion of DC Package awarded under this Contract and AC Package awarded by the Employer under separate Contract, the Facility shall be interconnected to the grid to allow the import and export of energy to and from the electricity network.

5.4. The design, execution and Testing of the interconnection works by the BESS OEM shall comply with the Technical Specifications, code requirements, Applicable Standards, Regulations and Applicable Laws.

5.5. 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 at SECI HQ Office at Delhi and one copy at the Project site. The drawings/documents shall be approved in any one of the following categories based on nature of the comments/ type of drawing or document.

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

(***Note:*** *Approval of document neither relieves the Supplier 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*)

5.6. Tender Drawings and/or Indicative Schematic drawings provided with Annexure B shall supplement the requirements specified in the Technical Specifications. These drawings are preliminary drawings for bidding purpose only and subject to necessary changes during the detailed engineering. Parameters specified in the tender drawing are the minimum required & any increase in these parameters, if required, to meet the system requirement shall be made by the Supplier without any additional cost implication to Employer.

5.7. The Supplier 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 (including all BESS sub- systems).
- GTP & G.A. drawings for all components.
- Test reports (for type, routine and acceptance tests).
- Design calculations and sheets.
- Quality assurance plans for Manufacturing (MQP), Standard Operating Procedure. (SOP) and Field Quality Plan (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).

- Installation drawings, manuals, electrical layouts, erection key diagrams, electrical and physical clearance diagrams, design calculations for earthing.

5.8. 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.

5.9. The Supplier shall submit technical connection data, inter alia, BESS discharge data to the Employer's AC Package Contractor for fault studies, dynamic simulation data, and details (as applicable).

5.10. The Supplier shall submit relevant inputs to the Employer's AC Package Contractor for preparation of the detailed and plant level Equivalent PSS/E Model of the Project/Plant to demonstrate performance under steady-state and dynamic state at the Point of Interconnection i.e. Point A.

5.11. The Supplier shall design the BESS with consideration to the "Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007" & subsequent amendments and "Central Electricity Authority (Grid Standards) Regulations, 2010" & subsequent amendments. The plant shall be capable of reactive power support in line with regulations & its amendments/clarifications.

6. Manufacturing & Supply

6.1. The scope of manufacturing and supply, testing at manufacturer's works, packing, transportation, transit insurance, receipt, unloading, storage at site of equipment and materials along with associated system shall include but not limited to the following:

6.1.1. Containerised BESS accumulation sub-system, along with necessary auxiliary sub-systems including HVAC system, Fire Suppression System, of appropriate rating. The rating of the Container shall be a minimum of 5 MWh.

6.1.2. Power Conditioning System (PCS) of appropriate rating.

6.1.3. DC Cables of appropriate size and rating from DC Block to PCS along with cable termination kits, ferrules / tags, conduits, cable ties and other materials required for cable laying and termination at both the ends. (not applicable if PCS is housed in the DC Block container)

6.1.4. Energy Management System comprising of both hardware and software, configurable for the operational modes/use cases specified in this document.

6.1.5. Control and communication cables, along with RTU and related accessories for communication with the BESS.

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

6.1.7. Earthing system including earth strip/cables, earth electrodes, earth enhancing compound and all other associated materials for earthing of BESS equipment (including PCS).

6.1.8. Testing instruments as specified.

6.1.9. Mandatory spares as specified/recommended by the OEM.

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

7. Installation

7.1. Installation, testing and commissioning of equipment procured and supplied under Clause 6 above, as per detailed specifications provided under Technical Specification.

7.2. Ownership of packing materials (except of mandatory spares) shall be of the Supplier. Responsibility of removal and disposal of the packing material shall be in the scope of the Supplier.

8. Plant Testing and Commissioning

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

8.2. Synchronization and Commissioning of plant.

8.3. Any other works related to installation, testing and commissioning of the equipment supplied and installed under this package not mentioned but required to complete the BESS Plant facilities in all respect.

8.4. All costs associated with the Plant Testing and Commissioning (for scope of work as per this package) shall be borne by the Supplier.

8.5. AC Package Contractor will ensure the compliance of requirements mentioned in procedure of First Time Charging (FTC) as applicable for other power system elements. The consolidated FTC procedure including the requirements for BESS is available in public domain in the below link.

https://posoco.in/wp-content/uploads/2021/04/Procedure_for_Integration_of_Power_System_Elements.pdf

Note: Please refer Clause 4 for Scope of Works under the Responsibility Matrix.

9. Warranties

9.1. Warranties for BESS Components, including augmentation of energy/power capacity as specified in the Technical Specifications.

10. Equipment Maintenance under Service Level Agreement

10.1. The Scope of Works for Plant Operation shall include deputing necessary manpower necessary to ensure plant availability and system performance (round-trip efficiency, energy and power ratings).

10.2. DC Package Supplier shall enter into a Service Level Agreement (SLA) with the Employer.

10.3. Total Operation & Maintenance of the Plant Facilities shall be with the AC Package Contractor under an O&M Contract as per the terms and conditions of the Operation and Maintenance Agreement. The AC Package Contractor shall enforce the SLA on behalf of the Employer.

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

B. TECHNICAL SPECIFICATIONS (TS) – ELECTRICAL SYSTEM

I. Battery Energy Storage System

Table 1-Codes and Standards

Standards	Description	Certification Requirements
IEC 62485-2	Safety requirements for secondary batteries and battery installations - to meet requirements on safety aspects associated with the erection, use, inspection, maintenance and disposal	Applicable only for Lead Acid and NiCd / NiMH batteries
UL 1642 or UL 1973, Appendix E (cell) or IEC 62619 (cell) + IEC 63056 (cell)	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications	Required for Cell
UL 1973 (battery) or (IEC 62619 (battery) + IEC 63056 (battery))	Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications / Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications	Required for Battery
IEC 62281 / UN 38.3	Safety of primary and secondary lithium cells and batteries during transport: Applicable for storage systems using Lithium Ion chemistries	Required for the unit transported
UL 9540 or (IEC TS 62933-5-1 + IEC 62933-5-2)	Electrical energy storage (EES) systems - Part 5-1: Safety considerations for grid integrated EES systems – General specification / Standard for Energy Storage Systems and Equipment	Either UL9540 or (IEC 62933-5-1 + IEC 62933-5-2) is required for BESS system level
UL 9540A	Standard for Thermal runaway	At cell/module/rack /system level, as required by standard

11. Technical Specification of Battery Energy Storage System

11.1. Project-Specific Ratings and Requirements: Table below specifies project-specific BESS capabilities and ratings for this Project.

Table 2-Project Specific Ratings and Requirements

Item Description	Requirement
Battery Technology	Any battery technology with totally Maintenance Free suitable for operation in site-specific climatic conditions.
Rated No of Cycles (Minimum)	8000 cycles at rated energy capacity at minimum 80% Depth of Discharge (DoD) at 25oC and 0.5 C Rate of Discharge
Power rating* (A)	600 MW, continuous
Energy rating* (B)	Minimum 1200 MWh dispatchable at the beginning of life and not less than 70% of this capacity at any point of time up to End of Battery Life.
BESS Availability	98%
System ac-dc-ac efficiency*:	>85%
Use case requirements	(i) Energy Shifting (ii) Ancillary Services – TRAS, SRAS
Charge-discharge cycles	Up to two cycles per day.
Ventilation System inside the Container	Should be such as to maintain minimum and maximum Temperature as recommended by the manufacturer for optimum performance of the batteries.
Grid Charging	No
***To be verified as per the procedure described in General Annexure-D to this Section for Plant Commissioning and Test Procedure and to be verified on annual basis as per Schedule. All measurement instruments for conducting the tests shall be maintained by the Supplier.** **System sizing shall be done to deliver Power and Energy Ratings at the Point of Interconnection considering minimum losses specified herein.**	

11.2. **System Ratings**

11.2.1. Overall System Real Power and Energy Ratings

During discharge, the BESS shall be rated to supply at the PCS, continuous net AC real power and AC energy output specified in *Table: Project-Specific Ratings and Requirements* above. The Power and energy ratings shall be achievable during discharge for the full range of stated environmental conditions, provided that the battery is fully charged and the HVAC system has stabilized. In any case, the BESS shall be capable of being discharged at reduced power levels from that specified above. The Supplier shall account for efficiencies of the BESS components up to the PoI (Point of Interconnection) as well as the expected losses from auxiliaries for system sizing.

11.3. The BESS shall be capable of operating over its entire life in one or more of the use cases described in this section to meet the system requirements specified in Table-2, and further detailed in the RfS.

12. Design, Fabrication, and Construction Requirements of BESS

12.1. General

The methods and materials specified in this technical specification are intended to represent minimum requirements. Reliance thereon shall not diminish the responsibility for meeting performance and other requirements stated herein. The design of the BESS shall incorporate the principle of modularity, with a view to reducing life-cycle costs and ease of replenishment of storage capacity while facilitating ease of maintenance, space requirements, and reliability. The design should also facilitate rapid and easy replacement of the unit batteries/battery packs/modules without significant downtime.

12.2. System-Level Design and Performance Requirements

The major equipment items shall include battery packs/modules, Battery Management System (BMS), PCS and BESS EMS which is to be integrated with the Plant SCADA system (in the scope of Employer's Balance of Plant/AC Package Contractor). Additional equipment shall include HVAC, wiring, connectors, protective devices, grounding, junction boxes and enclosures, instrumentation, enclosures, and all other items needed for a fully functional, grid-interactive BESS to meet the requirements set forth in this specification.

12.3. Containerization and Transportability

12.3.1. Containers for the accumulation subsystem shall comply with International Organization for Standardization (ISO) 668 shipping containers or custom-designed power equipment centres. The container or containers shall be designed to be drop-shipped onto a properly prepared pad or foundation (such as compacted soil, concrete pad or platform).

12.3.2. Containers shall be designed and constructed to meet IP54/NEMA 3R requirements.

12.3.3. All containers and packaging of separately shipped components shall be suitable for land or sea transport, including offering suitable protection of the equipment inside against damage from weather and vibration or shock from transportation.

12.3.4. The containers and their contents shall be designed to be easily prepared for transport, shipped, connected and operated at site. Containers shall be transported along with all requisite bracing and shipping stabilization equipment.

12.4. Design Life and Life-Cycle Costs

12.4.1. End of battery life – End of battery life is that point in time when the BESS can no longer meet the power and/or energy discharge requirements of this Specification due to age or non-repairable malfunction of the accumulation subsystem, and/or non-replaceable components. When the system is no longer able to provide these

requirements, the system has reached its end of life. End of Battery life shall not be less than the total period from the date of Commissioning to the expiry of the Service and Maintenance Contract period.

12.4.2. It shall be the responsibility of the Supplier to make periodic replacements/replenishments of unit batteries, if and when required, up to the End of Battery Life as described above. Outage time as a result of replacement will also be counted as an "Accountable BESS Outage" for the purpose of computing BESS Availability.

12.5. **Battery Subsystem Design Requirements**

12.5.1. **Electrochemical Cells**

Cell and module design shall accommodate the anticipated vibrations and shocks associated with the transportation of the BESS and shall resist deterioration due to vibrations resulting from the same. Associated hardware and paraphernalia should also be able to withstand the rigors of transportation. The transport plan shall be shared with the Employer and approved prior to dispatch.

Labelling of the unit batteries/battery packs shall include manufacturer's name, cell type, nameplate rating, and date of manufacture, in fully legible characters and traceable to the point of origin for purpose of addressing safety issues.

12.6. **Electrochemical Storage System**

12.6.1. The storage system may consist of one or more unit batteries/battery packs/racks. If the storage system consists of more than one unit battery, these may be electrically interconnected in any desirable series and parallel configuration to achieve the overall system storage and power rating requirements.

12.6.2. Each electrically series-connected string of unit batteries shall include a means of disconnecting the string from the rest of the system and of providing over-current protection (during a fault). The means of disconnect shall provide for a physical interruption of the string electrical circuit, which shall be visible and accessible to maintenance personnel and shall be capable of being locked or secured in an open position.

12.6.3. If the disconnect means consists of removal of a unit battery, the storage system shall be designed to allow maintenance personnel to determine that there is no current flowing in the string and provisions to ensure that the PCS is off before the unit battery is removed. Procedures for maintenance and/or field replacement of unit batteries shall neither require nor recommend removal of the unit battery without first ensuring that no current is flowing in the string circuit.

12.6.4. Over-current protection, whether on the AC or DC side, in paralleled unit battery strings shall be sized and coordinated so that currents from other strings do not contribute to a fault in any unit battery string.

12.6.5. Protection shall include a DC breaker, fuse, or other current-limiting device on the battery bus. This protection shall be coordinated with the PCS capabilities and battery string protection.

12.6.6. Cells, wiring, switch gear, and all DC electrical components shall be insulated for the maximum expected voltages plus a suitable factor of safety.

12.6.7. The BESS shall include appropriate self-protective and self-diagnostic features to protect itself and the battery from damage in the event of BESS component failure or from parameters beyond the BESS's safe operating range due to internal or external causes.

12.6.8. Temperature sensors shall be incorporated in critical components within the BESS. The BESS shall alarm and go to standby/fault mode when an over-temperature condition is detected.

12.6.9. Door interlock switches shall be provided for all BESS container doors, with a provision to be disabled for maintenance. The BESS shall alarm and go to shutdown mode when a BESS Container door is opened. Doors shall be fitted with provisions for external locks.

12.6.10. The battery system shall include a system to detect and alarm excessive ground leakage current levels. Ground fault detection shall be enabled for the container or, if more than one electrical series string is installed in the container, for each series string.

12.6.11. The battery system shall include a monitoring/alarm system and/or prescribed maintenance procedures to detect abnormal unit battery conditions and notify proper personnel of their occurrence.

12.6.12. The Battery Management System (BMS) shall have at least the following protection mechanisms for battery:

- Reverse Polarity
- Over/Under Voltage
- Over Temperature
- Over Charge

12.6.13. Unit battery monitoring should be specified to alert in a timely manner that an abnormal unit battery condition exists or may exist. All alarms shall be part of the control system and shall include remote display or annunciation capability.

12.6.14. The unit batteries shall be racked or shall be housed in stackable modules. The unit batteries or cells shall be arranged and installed to permit easy access for equipment and personnel. The moveable units shall be arranged and installed to permit easy access for equipment and personnel to carry out unit removal and replacement activities. For all systems, it shall be possible to remove and replace a prematurely

failed unit battery or cell (as appropriate), when system performance specifications cannot be met. The lengths and widths of all aisles and spaces into which personnel may enter in the field for operations and/or routine or unscheduled maintenance purposes, as well as egress routes from these aisles and spaces, shall conform to applicable codes and standards.

12.6.15. All racks and metallic conductive members of stackable modules shall be grounded to earth. Racks shall meet the seismic load requirements and shall include means to restrain cell movement during seismic events. The Contractor shall furnish analyses and/or other data that show that the rack and cell designs are designed to meet all potential seismic vibration requirements.

12.6.16. The cells and battery system shall be supplied with all required and/or recommended accessories. This includes inter-cell connectors and monitoring devices for cell temperature and cell voltage, if required.

12.7. **Power Conditioning System Design Requirements**

12.7.1. Standards and Codes

Power Conditioning System (PCS) shall comply with the following standards and codes:

Table 3-Codes and Standards

Standard	Description
IEC 62909-1	Bi-directional grid connected power converters - Part 1: General requirements
IEC 61000-6-2 Ed. 2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-4 Ed. 2.1	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEC 62116 Ed. 2	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures
IEC 60068-2-1:2007	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2:2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat
IEC 60068-2-14:2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-30:2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)
Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations with the latest amendments	

12.7.2. Power Conditioning System Rating

The PCS shall be bi-directional type, capable of delivering Real power as specified in Table-2. This rating shall be referred to in all project documentation, including this

specification, as the nameplate VA rating. Cumulative PCS rating shall be sized to deliver rated output active and reactive power at the POI at the design site temperature.

12.7.3. The PCS AC Output voltage shall be 690 V.

12.7.4. The PCS shall include provisions for disconnect on both its AC and DC terminals for maintenance work. The detailed maintenance procedure shall be addressed in the O&M manual.

12.7.5. **PCS Handover Point** - The handover point between DC Package (under this Contract) and AC Package (under Employer's separate Balance of Plant Contract) shall be the **AC output terminals of the Power Conditioning System (PCS)**. All cabling from these terminals to the BESS step-up transformer shall be under the scope of AC Package. Contractor (DC Package) shall terminate the PCS output cables inside the PCS cabinet and provide terminal drawings, cable schedules, and load data in advance to Employer's Balance of Plant Contractor (AC Package).

12.8. **Auxiliary Power**

12.8.1. Auxiliary AC power required for BESS auxiliary sub-system viz. container HVAC, fire protection, lighting, and control systems etc. **is not in the scope of the Supplier**. The same shall be provided by Employer's Balance of Plant Contractor. However, the Supplier shall provide the necessary interface for BESS Auxiliary Power supplied by the Employer's Balance of Plant Contractor, which shall be metered. Contractor shall furnish the auxiliary power load list and required connection points. Employer's Balance of Plant Contractor shall route power up to the defined terminals in the BESS containers.

13. Control and Communication

Control and communication functionalities as described in this section shall be implemented within the Energy Management System for the BESS.

13.1. **Control System General Requirements**

The control system shall be designed to provide for automatic, unattended operation. The control system design shall provide for local manual operation and remote operation or dispatch from a remotely located computer. The control system shall be programmable for establishing or adjusting all parameters, set points, algorithms, limits, and so on that are required for effective operation as described in this specification.

13.2. **Control Functions and Protocols**

13.2.1. All BESS control communications shall be built over MODBUS TCP/IP communication (Fast Ethernet or 802.11a/b/g/n).

13.2.2. There shall be provision of redundant communication channels.

13.2.3. Additional Control System Functions

13.2.3.1. Shutdown/Startup/Standby

The control system shall ensure orderly and safe shutdown, even in the absence of grid power; an orderly start up sequence, which shall provide for a safe system reset from any standby or operating condition so that the unit goes through a normal start up sequence in the same way it would when being powered up after loss of power or being in a shutdown state, and for a standby state (that is, BESS but not charging or discharging), which shall be the end result of a normal start up sequence.

13.2.3.2. Initiation of Shutdown

The control system shall initiate shutdown under the following conditions and shall remain in the shutdown state until a reset signal, either local or remote, is initiated. An appropriate alarm shall be set.

- 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 (adjustable setting)
- Remote disable (no reset required).
- Grid system faults (balanced and unbalanced; line-to-ground, line-to-line, and three-phase).
- Abnormal frequency
- Abnormal voltage
- Islanding condition.
- Communication Failure
- Protection or control scheme failures, including the following:
  - Failure of local interconnection protection system
  - Failure of critical breaker trip coil
  - Loss of Container DC control supply

13.2.3.3. Reset Alarms

For all system-generated alarms, the control system shall provide for the resetting of those alarms. This function is intended for alarms that, after they are set (for example, by a fault condition, as listed above and elsewhere in this specification), must be cleared by operator intervention to allow normal operation to be restored.

13.2.3.4. Modify Storage Settings

The control system shall provide for modification of various set points and fixed operation/control settings associated with the various control functions.

13.2.3.5. Event/History Logging

The control system shall provide for the automatic logging of the following information:

- All errors or failures
- All start-up and shutdown actions
- All control actions
- All responses to control actions
- All limit violations, including returns within limits

13.2.3.6. Status Reporting

The control system shall provide for reading and reporting of various BESS- supplied status information in accordance with the data collection and reporting requirements specified in this technical specification.

13.2.3.7. Time Synchronization

The control system shall provide for synchronization of its real-time clock with a GPS synchronized time source.

13.2.3.8. Change Operational Mode

The control functions are expected to be executed by command from a remote host, but may also be scheduled.

13.2.3.9. Perform Self Diagnostics

The control system shall provide for self-diagnostic functions.

13.2.4. Control System Hardware

All control and monitoring system components shall be housed in appropriate controlled environment enclosures either as separate arrangement or in conjunction with Plant SCADA system.

13.2.4.1. The BESS shall include, as a minimum, the following operator controls shall be provided in a local Control Panel or built into BESS EMS:

- Trip/reset for the BESS AC circuit breaker or contactor.
- Trip/reset for DC circuit breaker(s)/contactor(s).
- PCS on/off.
- Selector to select remote or local operation.
- Selector to manually set the operating state or have the control system set the operating state automatically.
- Meter readings, indicators, and displays.

14. Performance Monitoring and Data Acquisition

14.1. Data Acquisition and Performance Monitoring shall be achieved by means of the Energy Management System (EMS) of the BESS.

14.2. BESS EMS shall continuously monitor as well as permanently archive key operational parameters. The BESS EMS shall be connected to sensors, transducers, wiring, signal isolation and conditioning circuitry, and data acquisition and analysis hardware and software as required to perform the functions described in this section. All

interconnected components shall be suitable for operation in the climatic conditions prevailing at site.

14.3. The Data Acquisition System (DAS) shall measure operational data, as described in this Clause, and shall record all data points to a fixed and removable non-volatile memory. The DAS shall be capable of making all monitored data and events available through the DNP3 / IEC 61850 communication interface and shall permit display of current values and recent historical trends on a local screen for all recorded points. In addition, the DAS shall provide panel meter displays of certain operational parameters, as prescribed below.

14.4. Provision of monitoring and event data via the communication shall capture at least the following data points:

- Frequency at the AC bus
- AC real power
- Power factor
- Real energy delivered
- Real energy received
- Auxiliary power
- Auxiliary energy
- DC power
- DC voltage
- DC current
- Phase A voltage
- Phase A angle
- Phase B voltage
- Phase B angle
- Phase C voltage
- Phase C angle
- Battery state of charge
- Battery string currents
- Battery temperature

14.5. Digital displays of the above shall update at least once per second. The BESS EMS shall be integrated with the Plant SCADA.

14.6. The BESS EMS shall continuously measure or calculate the data points and make them available via the communication network as specified. All measured parameters shall also be permanently archived in all modes of operation. For continuously varying quantities, the Supplier shall propose for Employer’s review and approval, an approach to data archiving that is suitable for each quantity measured. The final approach will be decided during detailed engineering design.

14.7. The BESS EMS shall provide unsolicited message capability for reporting critical alarms. The Supplier and the Employer will agree on a list of alarms that are reported the instant they are detected. However, a minimum of following parameters shall be displayed on the Plant SCADA:

- Main temperature Alarm (on system temperature exceeding a predetermined threshold)
- Smoke/fire Alarm (on system detection of smoke/fire)
- DC leakage current (battery leakage current to ground exceeding a predetermined threshold)
- Breaker status (connect/disconnect switch)
- AC voltage OK (system ac voltage exceeding a predetermined threshold)
- Battery temperature alarm (battery temperature exceeding a predetermined threshold)
- Synchronization error shutdown
- PCS fault
- AC system fault
- DC fuse blown
- Container door open (BESS container door opening)

14.8. The BESS shall include provisions for determining and storing in non-volatile memory the sequence of abnormal events, trips, and/or alarms that cause the BESS to go the disconnect or shutdown state. It is preferable that this function be implemented separately from the normal operations data acquisition function of the DAS so that failures in the latter (hardware/software failures or power interruptions) will not prevent the permanent logging of abnormal event sequences. The BESS shall include provisions to transmit, at a minimum, the data displayed on the panel meters and the alarm/status indicators to the remote computer.

15. **Earthing**

15.1. Earthing of individual BESS enclosures and PCS units shall be done by Supplier (DC Package) as per OEM guidelines. The overall earthing grid, earthing pits, and lightning protection shall be provided by Employer's Balance of Plant Contractor (AC Package). Interface connection drawings shall be developed jointly and submitted during detailed engineering. Supplier scope shall be limited to providing the earthing connections to the earthgrid provided by the AC Package Contractor.

15.2. <u>Tests</u>

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.

16. Wiring

16.1. All wiring shall be continuous for each wiring run; splices are not acceptable.

16.2. Wiring that may be exposed to mechanical damage shall be placed in conduit or armoured.

16.3. Wires shall have identifying labels or markings on both ends. The labels or markings shall be permanent and durable. Stick-on labels will not be allowed. All field wiring between separate equipment items supplied by the Supplier shall be color-coded according to appropriate standards.

16.4. In general and where practicable, 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 within a common enclosure.

16.5. BESS and PCS control and instrumentation system wiring shall be bundled, laced, and otherwise laid in an orderly manner. Wires shall be of sufficient length to preclude mechanical stress on terminals. Wiring around hinged panels or doors shall be extra flexible and shall include loops to prevent mechanical stress or fatigue on the wires.

16.6. Insulation and jackets shall be flame retardant and self-extinguishing.

16.7. Wiring to terminal blocks shall be arranged as marked on wiring diagrams. Terminal groupings shall be in accordance with external circuit requirements.

16.8. Raceway and cable systems shall not block access to equipment by personnel. There shall be no exposed current-carrying or voltage-bearing parts.

17. Communication Cables

17.1. Optical Fibre Cables

17.1.1. 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.

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

17.1.3. 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.

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

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

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

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

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

17.2. 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.

18. Fire Alarm System

18.1. 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	

18.2. The Supplier 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.

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

19. Fire Protection

19.1. The Supplier shall design and install a fire protection system that conforms to good engineering practice, CEA guidelines and considering thermal runaway fire characteristics of the Battery Unit/Packs provided by the OEM.

19.2. The fire protection system design and associated alarms shall take into account that the BESS will be unattended. If required by the type of fire protection system provided, the Contractor shall calculate and consider the heat content of the battery cell materials in designing an appropriate fire protection system. Separate fire protection systems may be used in the battery, PCS, and control areas.

20. Toxic Materials

If any toxic substance can be emitted from the equipment during a failure, fire, or emergency or protective operation, description of the toxic nature of the substances as well as treatment for exposure to it shall be included in the O&M manual. Their treatment and disposal shall be in accordance with the New Hazardous Waste Management Rules 2016 notified by the Government of India and subsequent amendments.

21. Spare Parts and Equipment

The Supplier shall evaluate the design with regard to expected failure rates, modes, and effects; overall BESS reliability; and planned mode of servicing. Based on this evaluation, the Supplier shall recommend and furnish an initial complement of spare parts that are not readily available. For example, these spare parts may include spare unit batteries and a small rectifier to maintain the unit batteries, as well as fuses, printed circuit boards, and minimum field replaceable switching devices.

22. Maintenance and Repair

22.1. The Supplier shall supply all labour, equipment, and materials needed to maintain the BESS performance and safe operation, including all maintenance required to satisfy the warranty terms and conditions.

22.2. The Supplier shall list all maintenance activities to be carried out under the maintenance contract. For each maintenance item, the list shall include a description of the item, the expected frequency (maintenance interval), the time required to perform the maintenance, any anticipated parts replacement, and any potential problems in carrying out the maintenance.

23. Factory Acceptance Testing (FAT) of BESS

23.1. The Supplier shall develop and submit to the Employer for its review and approval a comprehensive FAT plan that shall demonstrate that the BESS will meet the requirements of the specification. The Employer shall have the right to request reasonable changes to the test plan.

23.2. Where full-scale testing of larger systems at the factory may be difficult or impossible due to the large system, the FAT shall be carried out at a subsystem or module level and shall consist of tests of 100% of the subsystems or modules that comprise the complete BESS, to the extent possible. In the FAT plan, the Supplier shall clearly state what is being tested and shall fully explain any features or functions of the fully assembled BESS that would not be fully tested in the reduced-scale testing proposed. In such a case, the SAT plan shall further describe how the tests that could not be carried out in the factory will instead be carried out at the site.

23.3. After the Supplier determines that the BESS is fully operational, the Supplier shall conduct a FAT, witnessed by the Employer and/or the Employer’s representative. The FAT shall consist of the Supplier demonstrating to the Employer that the BESS is fully operational and performs as specified. This includes but is not limited to the following:

- Visual inspection of all provided equipment, including dimensions and overall design.
- Verification of proper mechanical construction such as electrical connection torques.
- Verification of sensors, metering, and alarms.
- Verification of all control functions, including remote control and monitoring, and communications interfaces.
- Verification of BESS performance at full and partial power and energy ratings.
- Verification of maintenance and replacement features for unit batteries and other key components.
- Verification of compliance with specifications.

23.4. During the FAT, the BESS shall meet the following:

- Be operated and function as specified and designed in all the operating states, use cases, and duty cycles specified herein
- Meet the power and energy requirements specified herein
- Be demonstrated to meet the safety and response to catastrophic failure requirements specified herein
- Have the efficiencies, response capabilities, and other features specified herein and/or proposed by the Contractor

Note: *The methodology for measurement of procurement specifications is provided in the Annexure-GA-D to this Section.*

23.5. Operation of all control, protective relaying, and instrumentation circuits shall be demonstrated by direct test, if feasible, or by simulating operating states for all parameters that cannot be directly tested. Automatic, local (control console), and remote operation of the controls shall be demonstrated.

23.6. The Supplier shall perform any and all system modifications required during start-up and testing. The testing may be suspended as a result of a BESS malfunction and resumed only on rectification of problem items. Such suspension and resumption will occur at the sole discretion of the Employer.

23.7. The BESS will not be accepted for shipment until all FATs have been successfully completed. In addition, the Employer will verify that all provisions of the contract have been met, including verification of all required submittals, any spare parts delivery, and any required system modifications.

24. Commissioning and Functional Guarantee test procedure

24.1. The Supplier shall develop and submit to the Employer for its review and approval a comprehensive Site Acceptance Test (SAT) plan that shall demonstrate to the Employer that the BESS will perform as specified at the Employer's site. The Employer shall have the right to request reasonable changes to the test plan.

24.2. The Supplier shall develop and perform SAT procedures to ensure that the BESS will perform as designed and that the system meets the performance criteria specified elsewhere in these specifications. The SAT plan shall include procedures to test operating scenarios described in the specification. These procedures may involve special requirements and/or witnessing by the local independent system operator. To the extent achievable, all use cases and operating modes described in the specification shall be tested.

24.3. After the Supplier has determined that the BESS is fully operational, the Supplier shall conduct the SAT, witnessed by the Employer and/or the Employer's representative. The tests shall include, as a minimum, the following:

- Verification of sensors, metering, and alarms
- Verification of all control functions, including automatic, local, and remote control
- Verification that the performance criteria in the specification can be met or exceeded
- Demonstration of all of the intended uses
- Demonstration of interface protection circuits and functions and control interfaces

24.4. Tests shall demonstrate that the BESS capabilities, efficiencies, response, and features are as proposed by the Contractor.

24.5. Testing shall include, as a minimum, measurement of harmonic content and power factor at full and partial power levels for both charge and discharge.

24.6. Operation of all control, protective relaying, and instrumentation circuits shall be demonstrated by direct test, if feasible, or by simulating operating states for all parameters that cannot be directly tested. Automatic, local, and remote operation shall be demonstrated.

24.7. The SAT shall also specifically address discovery of problems or failures that may have occurred during or as a result of shipment.

24.8. The Supplier shall perform any required modifications and repairs identified by the testing, before acceptance by the Employer.

24.9. The Employer will not accept the BESS for commissioning until all acceptance tests have been successfully completed and all provisions of the contract have been met.

24.10. <u>Functional Guarantee - Actual Operating Experience</u>

Since it may not be possible, due to system constraints, to test all facets of the BESS function as part of the performance verification tests specified in the preceding sections the actual operating experience of the BESS during the performance guarantee period after initial start-up shall be deemed an extension of the performance verification tests. The performance guarantee period shall not be construed as a substitute for the warranty requirements, as specified in the subsequent Clause. Actual operating experience will be documented through Supplier-furnished records, and other system monitoring

equipment and associated BESS performance. Documented failure or malfunctions of any BESS component during the performance guarantee period shall be deemed a failure of the system commissioning test. The Supplier shall, at no cost to the Employer, make the necessary repairs, replacements, modifications, or adjustments to prevent the same failure or malfunction from occurring again. The replacement of certain BESS components in response to a system failure may necessitate, at the discretion of the Employer, the duplication of certain performance verification tests, which shall be performed at the Supplier's expense.

25. Warranty

25.1. The Supplier shall provide a warranty for the entire BESS and its constituent equipment.

25.2. At a minimum, the Supplier shall provide an unconditional, 5 (five) -year parts and labour warranty on all BESS equipment except battery (unit or racks). For the battery storage, the warranty shall cover parts warranty including battery nominal capacity ratings in order to meet the End of battery Life condition described in this specification.

25.3. Warranty replacement shall be required for individual unit batteries that degrade in performance to the point at which the BESS cannot meet the requirements specified in this specification up to the End of Battery Life and/or for unit batteries that materially degrade the availability, reliability, safety, or functionality of the BESS.

25.4. The warranty shall guarantee the availability of battery replacements delivered to the site within 2 weeks of notification during the battery warranty period. This period, shall, however, not be considered part of the Accountable Outage period for assessing BESS availability.

25.5. Additional warranty requirements are as follows:

- The warranty shall specify the terms and conditions of the warranty, including operating conditions requirements, procedures that must be followed, and all maintenance requirements.
- The warranty shall provide an explicit statement as to the warranted cycle life and the warranted calendar life of the battery.
- The warranty shall include a simple and easy to understand proration formula, if any, to be used in crediting the Employer for unused life or capacity of equipment replaced or repaired.
- The warranty shall specify the scope of service associated with software updates.
- The warranty shall specify the scope of service included in replacement or repair of the equipment.
- The warranty shall specify all labour, materials, shipping charges, and other Employer expenses not included in the warranty.

26. Documentation and Submittals

26.1. The Supplier shall furnish complete documentation that will be used for determination of contract compliance, as well as O&M of the BESS.

26.2. Review and acceptance of submittals shall not encumber the Employer or the Host Utility with responsibility for the adequacy or safety of the Supplier's design.

26.3. Titles shall clearly indicate the function of the document, the Employer and location of the facility.

26.4. At a minimum, Supplier's documentation shall consist of the following:

- Construction and installation drawings
- Equipment drawings and specifications
- Operation and maintenance manual
- Quality Assurance Plan
- Quality assurance manual
- Software documentation
- Test reports

II. Energy Management System (EMS)

27. General Requirements

27.1. Energy Management System (EMS) system shall be a controller based system along with required accessories and communication links for integrated, real-time monitoring, efficient operation and control of active power, reactive power as well as voltage at the interconnection point (Point B).

27.2. EMS shall be integrated with the Plant SCADA to acquire/monitor real time data of various equipment of Plant facilities and have in built logic/programming to monitor, control, and optimize the performance of Plant facilities as per specification. Supplier shall provide complete EMS system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation of entire Plant facilities and its auxiliary systems. Supplier shall include in its proposal all the Industrial Grade Hardware, Software, Panels, Power Supply, HMI, Gateway, Networking equipment and associated Cable etc. needed for the completeness even if the same are not specifically appearing in this specification.

28. EMS functionality for the BESS Control

28.1. The following operation modes of BESS can be set from the EMS system.

- Automatic mode: This means that a part of the power quantity of the BESS behaves according to the selected operation mode.
- HMI mode or manual mode: in this mode, the operator has the possibility to:
  - Select the operation point
  - Direct control of active and reactive set points of the PCS.
  - Command of the balance of plants

- OFF-mode: A BESS is not producing any power. The system is disconnected form the grid.
- STANDBY-mode: the BESS is connected to the grid, but the IGBTs in the PCS system are in an off-state (i.e. open switching)

Also, the performance of every application mode will be controlled by this system.

28.2. This energy management strategy will be operated by the SCADA in Main Control Room. Any failure in the process or the control system including instrumentation must be detected and logged. This means that the instrumentation, electronic and electrical equipment shall include those failure detections.

28.3. A communication with the SCADA system must be possible to receive set points and transmit set points for each application mode. The SCADA should be able to remotely control the BESS. The EMS should allow the SCADA at least the following:

- Change the operation mode of each BESS independently
- Start/Stop each application mode appointed to a BESS.
- Change the application mode of each BESS (multiple modes can be selected together)
- Select the amount of power dedicated to each selected application mode.
- Specifically, for following use cases:
  - Power ramp rate control
  - Power Curtailment
  - Change the set points for the SOC management
  - Direct control of active and reactive set point of a PCS
- Adapt the parameters needed for the operation of every application mode

28.4. The Communication protocol shall be MODBUS TCP. Other solutions can be proposed but are subjected to the approval of the client.

29. BESS Handover Point

29.1. Plant SCADA is not in the scope of the Supplier (DC Package). However, the Supplier under these specifications shall be responsible for the design and supply of the Energy Management System (EMS) and communication architecture within the BESS. Employer's Balance of Plant Contractor shall provide all required connectivity (LAN/fiber) from BESS EMS to the plant-level SCADA and grid interfacing systems. Interface protocols shall be mutually agreed during design stage.

C. GENERAL ANNEXURE A: TECHNICAL SPECIFICATIONS FORMAT

The Appendix-II for Format 7.1 submitted by the Successful Bidder/Supplier shall be the part of this General Annexure A.

D. GENERAL ANNEXURE B: 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 BESS Supplier.

Category	Stake holder	Pre-dispatch inspection
Category – A	SECI	Yes
	BESS Supplier	Yes
Category – B	SECI	No
	BESS Supplier	Yes
Category – C	SECI	No
	BESS Supplier	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.	BESS	Battery Containers
2.	PCS	Power Conditioning System
3.	EMS	Energy Management System
Category – B		
1.	DCC	DC Cable
2.	BESS-S	Battery (Spares)
3.	BCDK	Battery Charging and Discharging Kit
Category – C		
1.	LDC	LT Distribution Cable
2.	UPS	Uninterrupted Power Supply
3.	EES	Earth Electrode and Accessories
4.	CMC	Communication Cable
5.	CPC	Control and Power Cables

1. **Category – A**

The BESS Supplier 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.

2. **Category – B**

For Category – B equipment, the BESS Supplier 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 pre-dispatch 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 be issued by SECI. In case SECI does not participate in the pre-dispatch inspection, the Contractor shall submit the Inspection Report signed by BESS Supplier and Manufacturer/Supplier Representatives to SECI for issuance of Material Dispatch Clearance Certificate (MDCC).

3. **Category – C**

For Category – C equipment, the BESS Supplier 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 his observations, if any. In case of any observation reported by Inspector, then BESS Supplier shall submit compliance report for the same to SECI. SECI shall review the inspection report, along with the compliance report submitted by BESS Supplier, 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	BESS Supplier (SECI optional)	SECI	BESS Supplier 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	BESS Supplier will verify the CoC and issue the MDCC and submit to SECI

E. GENERAL ANNEXURE C: MANDATORY SPARES

S. No.	Equipment/Material	Quantity (For each type and rating)
1.	**Battery Energy Storage System**	
1.1	**Battery Module**	
	Battery Packs	0.3% of Supply
	Connector (Each Positive and Negative)	0.30% of supply
	Fuse	0.20% of supply
	Socket	0.20% of supply
	Plug	0.30% of supply
	Fan (module)	0.30% of supply
1.2	**Control Panel/Control Unit**	
	MCB	0.30% of supply
	MCCB	0.30% of supply
	Switching supply	0.10% of supply
	Flood Sensor	0.10% of supply
	Intermediate relay	0.10% of supply
	Fan (control box)	0.10% of supply
	Surge Protection Device (SPD)	0.30% of supply
	Electricity meter	0.10% of supply
	Current Transformer	0.10% of supply
	Emergency stop button	0.10% of supply
	UPS	0.10% of supply
	UPS battery	0.10% of supply
	Indicator	0.10% of supply
	Fuse	0.20% of supply
	Internal Communication Cable of the Rack	0.20% of supply
	DC cable for internal rack	0.30% of supply
	AC/DC Power Source	0.20% of supply
	Main Control box	1
	E_CAN Driver	1
	Debug wiring harness including the connector	1
1.3	**High Voltage Box**	

S. No.	Equipment/Material	Quantity (For each type and rating)
	Connector (Each Positive and Negative socket)	0.30% of supply
	High Voltage relay	0.30% of supply
	Pre-charge resistor	0.20% of supply
	Fuse	0.20% of supply
	DC disconnector	0.30% of supply
	Indicator	0.10% of supply
	Hall Sensor	0.10% of supply
	Pre-charge contactor	2
	Current Transducer	2
1.4	**Fire Suppression System**	
	Fire Alarm Control Panel	0.30% of supply
	Battery	0.10% of supply
	Manual release button	0.10% of supply
	Emergency stop button	0.10% of supply
	Horn/Strobe/Annunciator	0.10% of supply
	Alarm bell	0.10% of supply
	Smoke detector	0.20% of supply
	Thermal detector	0.20% of supply
	Aerosol	0.30% of supply
	Aerosol Bracket	0.30% of supply
	Hydrogen detector (H2)	0.20% of supply
	Electric ventilation louver	0.10% of supply
	Exhaust fan	0.10% of supply
	Ventilation system emergency start/stop button	0.10% of supply
	Sprinkler	0.10% of supply
	Quick connector	0.10% of supply
1.5	**Liquid Cooling System**	
	Anti-freeze Coolant	0.30% of supply
1.6	**Battery Management System**	
	Master Battery Management Unit	0.30% of supply
	Slave Battery Management Unit	0.30% of supply
	Central Battery Management Unit	0.30% of supply

S. No.	Equipment/Material	Quantity (For each type and rating)
1.7	**Power Conditioning System**	One set of spares for each type / rating of inverter subject to a minimum of spares corresponding to 10% of each type / rating of inverter rounded off to the next higher integer for the following items - IGBT modules for one complete inverter - AC and DC fuses - air filters - cooling fans - electronic cards of each type - harmonic filter units - digital display units - switches, push buttons and indication lamps - diodes of each type & rating resistors of each type & rating
2.	**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
	(x) Indicating lamp	10% of total supply
	(xi) Rotary switch	10% of total supply
3.	**DC Cables**	**1 Drum**
4.	**Communication Cables**	**1 Drum**

Spares, if used, during the Service and Maintenance period shall be replenished by the BESS Supplier. All the mandatory spares shall be handed over to the Employer in working condition at the end of Service and Maintenance period along with list of utilized items and replaced items.

F. GENERAL ANNEXURE D: 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 Section VII B: 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.

3.3 AC Commissioning

3.3.1 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".

3.3.2 **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.

3.3.3 **Additional Pre-Energizing Tests**

All of the below tests shall be conducted in accordance with the supplier's installation/commissioning manuals.

3.3.3.1 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

3.3.3.2 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

3.3.3.3 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

3.3.3.4 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

3.3.3.5 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.

3.4 Hot Commissioning

3.4.1 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.

3.5 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”.

3.6 Functional test

3.6.1 Start and stop test

Check start and stop operation of BESS system with the startup/shutdown command manually and automatically.

3.6.2 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

3.6.3 Load tripping test

Check the interlock of BESS with the main

3.6.4 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.

3.6.5 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.

3.6.6 Communication test

Verified that measuring, alarm, fault indication, message and control and monitoring system operations are correct transmitted and received by the SCADA system.

3.7 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.

3.7.1 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,

$\mathbf{E_o}$ is the calculated total output energy at the POC (kWh);

$\mathbf{P_{Oi}}$ is the active output power at time i, measured at the POC (kW);

$\Delta \mathbf{t}$ 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,

$\mathbf{E_o}$ is the calculated total output energy at POC (kWh);

$\mathbf{P_{Oi}}$ is the active output power at time i, measured at the POC (kW);

$\Delta\mathbf{t}$ is the sampling time of the measurement (h);

$\mathbf{E_{aux\_o}}$ 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 feeder					**Power:** ___ % of Rated Value = _____ 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

3.7.2 **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,

$\mathbf{E_{out}}$ is the Total Energy Discharged from BESS as recorded in the Energy Meter(s) at the POC.

$\mathbf{E_{in}}$ is the Total Charging Energy into the BESS as recorded in the Energy Meter(s) at the POC.

Case II:

$$\eta_{rt} = \frac{E_{out} - E_{aux,o}}{E_{in} - E_{aux,i}} \qquad \text{……..(4)}$$

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

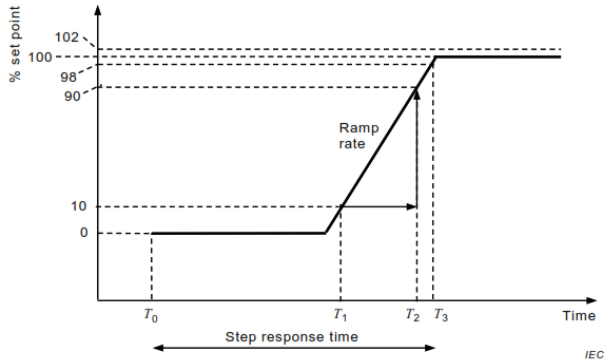
(ii) 82% at the 220 kV Interconnection Point

3.7.3 **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.

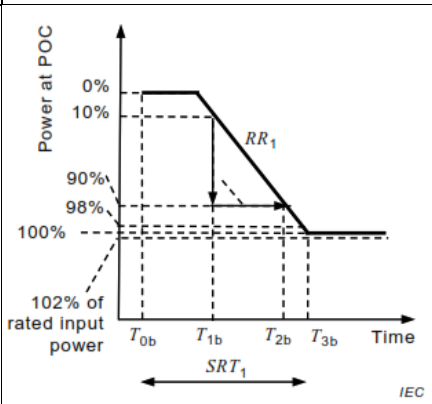
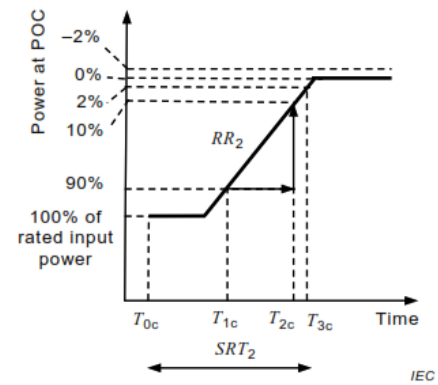
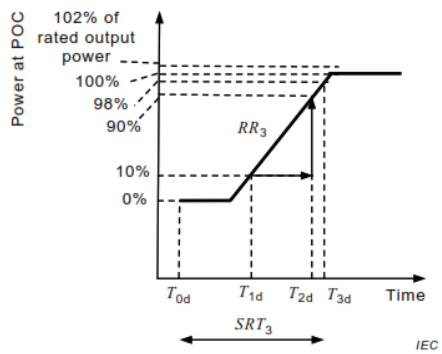
c) The set point shall be changed to rated input power. The set point value shall be retained until the active power at the POC reaches within 2 % of the range of rated input power. Step response time and ramp rate for step c) shall be recorded as SRT1 and RR1 respectively.

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.

<table>
<tr><th></th><th>Representative Figure</th><th>Measured Parameters</th><th>SRT_n</th><th>RR_n</th></tr>
<tr><td>(c)</td><td> 
</td><td><table><tr><td>SoC (%)</td><td></td></tr><tr><td>Setpoint (kW)</td><td></td></tr><tr><td>T_{0b} (sec)</td><td></td></tr><tr><td>T_{1b} (sec)</td><td></td></tr><tr><td>T_{2b} (sec)</td><td></td></tr><tr><td>T_{3b} (sec)</td><td></td></tr></table></td><td>SRT₁ =</td><td>RR₁ = $\frac{P(T_{2b}) - P(T_{1b})}{T_{2b} - T_{1b}}$</td></tr>
<tr><td>(c)</td><td> 
</td><td><table><tr><td>SoC (%)</td><td></td></tr><tr><td>Setpoint (kW)</td><td></td></tr><tr><td>T_{0c} (sec)</td><td></td></tr><tr><td>T_{1c} (sec)</td><td></td></tr><tr><td>T_{2c} (sec)</td><td></td></tr><tr><td>T_{3c} (sec)</td><td></td></tr></table></td><td>SRT₂ =</td><td>RR₂ = $\frac{P(T_{2c}) - P(T_{1c})}{T_{2c} - T_{1c}}$</td></tr>
<tr><td>(d)</td><td> 
</td><td><table><tr><td>SoC (%)</td><td></td></tr><tr><td>Setpoint (kW)</td><td></td></tr><tr><td>T_{0d} (sec)</td><td></td></tr><tr><td>T_{1d} (sec)</td><td></td></tr><tr><td>T_{2d} (sec)</td><td></td></tr><tr><td>T_{3d} (sec)</td><td></td></tr></table></td><td>SRT₃ =</td><td>RR₃ = $\frac{P(T_{2d}) - P(T_{1d})}{T_{2d} - T_{1d}}$</td></tr>
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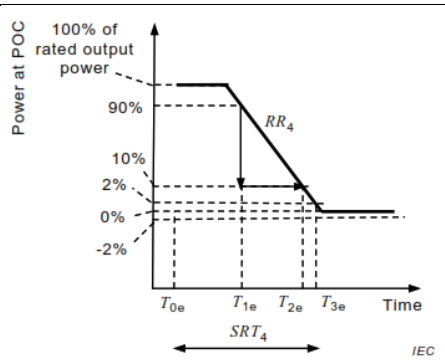
(e)		SoC (%) Setpoint (kW) T_{0e} (sec) T_{1e} (sec) T_{2e} (sec) T_{3e} (sec)	SRT_4 =	$RR_4 = \frac{P(T_{2e}) - P(T_{1e})}{T_2 - T_1}$
	Step Response Time (SRT)		**s**	
	Ramp Rate (RR)		**kW/s**	

Acceptance criteria

Step Response time and Ramp Rate shall be at least the values committed to by the Supplier.

3.7.4 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 Supplier 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 Supplier fails to demonstrate the guaranteed Round Trip Efficiency during the Performance Guarantee Test, the Supplier 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 $\left(\frac{E_i+E_{i+1}}{2}\right) x\ 365\ x\ A\ x\ 1.5\ x\ (\frac{1}{\eta_{actual}} - \frac{1}{\eta_{guaranteed}})$

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)

$\eta_{guaranteed}$ 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 Supplier 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 billing periods within the SLA monitoring window (post-commissioning), the LD amount levied under Clause 2 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.

G. SPECIFIC ANNEXURE A: TENTATIVE PROJECT LAYOUT

The tentative project layout is attached as separate document named as “1 SA A_Tentative Project Layout_1200 MWh BESS_DC Package till PCS”