

Model Technical Specifications

For

**Energy Management System (EMS)
with SCADA**

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1. General

- 1.1. SCADA system shall be part of Energy Management System (EMS) system and it shall be a computerized system with capability for monitoring, operation & control, locally as well as remotely from control centre. Necessary software at remote and local end shall be under scope of Bidder.
- 1.2. Monitoring & control system shall comprise of hardware & software for managing BESS for specified applications and shall have capability for establishing or adjusting all parameters, set points of algorithms, limits etc. required for effective operation for the applications mentioned in the specification. It shall support the necessary functions and operating modes.
- 1.3. EMS shall be able to acquire real time data of various equipment of BESS system, have in built logic/programming to monitor, control, and optimize the performance of BESS as per specification.
- 1.4. The system shall incorporate the specified control and monitoring functions, self-monitoring features, signalling and testing facilities, measuring as well as memory functions, event and disturbance recording. The control system design shall be based on single fail criterion i.e. failure of any one component in the system should not result in to outage of the complete system.
- 1.5. Parameter visualization at 100% capacity level is also required for performance measurement of total BESS Plant.
- 1.6. Contractor shall provide complete EMS system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation of entire BESS Plant and its auxiliary systems. The Contractor shall include all the Industrial Grade Hardware, Software, Panels, Power Supply, HMI, Gateway, Networking equipment and associated Cable, Laser Printer etc. needed for the completeness even if the same are not specifically appearing in these specifications.
- 1.7. EMS system includes the supply and integration of redundant Power Quality Meters (Min. 02 nos) at grid interconnection point. Interconnection with optical fiber communication cables through IEC 61850 to EMS shall also be in Contractor's scope. Also Supply of necessary Ethernet switches at HT switchgear and communication cable from EMS to individual numerical relays and its integration with required accessories is under Contractor's scope.
- 1.8. EMS Panels and EWS/OWS systems shall be located in Control room building which in contractor's scope.

2. Functional Requirements

- 2.1. BESS operation shall be possible by only one operator at a time positioned locally or at local control centre by providing suitable interlock. Local control shall be highly placed in control hierarchy. The operation shall depend on the conditions of other functions, such as interlocking, synchro-check etc. Functional requirement of the BESS shall be as per section project. Apart from the project specific requirements following requirements shall also be provided in the control system.
- 2.2. Select-Before-Execute: For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.
- 2.3. Command Supervision: Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear does not take place. Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

- 2.4. User Configuration: The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.
- 2.5. Analog data and Digital status data (reported by exception) shall be updated and displayed at the control centre in real time. An integrity scan of all analog / digital data shall also be made regularly and any discrepancies between field status and database shall be reported by an alarm message. Monitoring & Control system shall monitor & display at least following parameters in control centre:
 - 2.5.1. Operation Mode
 - 2.5.2. Application Mode
 - 2.5.3. Measurements (V, I, P, Q, f, Energy Export / Import)
 - 2.5.4. Events
 - 2.5.5. Alarms
 - 2.5.6. Display of status of major equipment in Single Line Diagram (SLD) format showing Breaker position / operation of all the LV/MV Switchgear Equipment
 - 2.5.7. Condition monitoring of PCC & PCS Transformers
 - 2.5.8. Incomer and bus coupler breaker of LT Panel.
 - 2.5.9.
 - 2.5.10. Parameters from Battery Management System
 - 2.5.10.1. Individual cell temperature
 - 2.5.10.2. Individual cell voltage
 - 2.5.10.3. Cluster voltage
 - 2.5.10.4. Cluster current
 - 2.5.10.5. Cluster wise charge/discharge current
 - 2.5.10.6. Cluster wise SOC
 - 2.5.10.7. Overall SoC
 - 2.5.10.8. Remaining time for charge / discharge
 - 2.5.10.9. Max charging current
 - 2.5.10.10. Max discharging current k.
 - 2.5.10.11. Battery Management Unit (BMU) device status
 - 2.5.10.12. Charge current limit in case of protection operated
 - 2.5.10.13. Discharge current limit in case of protection operated
 - 2.5.11. Parameters from Power Conditioning System
 - 2.5.11.1. Converter voltages (Phase wise)
 - 2.5.11.2. Current (Phase wise)
 - 2.5.11.3. Active power
 - 2.5.11.4. Reactive power
 - 2.5.11.5. Power factor
 - 2.5.11.6. Frequency
 - 2.5.11.7. Individual IGBT temperatures
 - 2.5.11.8. Energy charge / discharge data
 - 2.5.11.9. Efficiency
 - 2.5.11.10. Running status
 - 2.5.11.11. Normal run / Normal stop
 - 2.5.11.12. Fault stop
 - 2.5.11.13. AC contactor status
 - 2.5.11.14. DC contactor status
 - 2.5.11.15. Modulation pulse status
 - 2.5.11.16. Air conditioning of PCS container – running status
 - 2.5.11.17. Heater on / off & power management system
 - 2.5.12. Parameters from Energy Meters
 - 2.5.12.1. MVA, MW, MVA_r

- 2.5.12.2. MWh, MVAh, MVArh (import & export both)
- 2.5.12.3. Phase wise voltage & current
- 2.5.13. Estimated time for charging
- 2.5.14. Estimated discharge time at ongoing discharge rate
- 2.5.15. Fault information and status of Numerical relays
- 2.5.16. Protection operation information
- 2.5.17. Status of air-conditioning system (Fan status & Compressor Status for each air conditioning unit)
- 2.5.18. Status of fire protection system (Active/Faulty/Operated)
- 2.5.19. Ambient temperature
- 2.5.20. Temperature of Containers
- 2.5.21. Status of UPS of Controller
- 2.5.22. GPS Time Synchronization unit
- 2.5.23. Numerical relay & fire alarm panel
- 2.5.24. Any other equipment required to complete monitoring of BESS plant upto 33kV level.
- 2.5.25. Any other information required for proper monitoring / display of the system
- 2.6. At least following control from control centre shall be possible
 - 2.6.1.1. Provision to operate the BESS as per following minimum application requirement including Ancillary services but not limited to:
 - 2.6.1.1.1. Integrated control in case of multiple BESS plant
 - 2.6.1.1.2. Standalone operation based on the grid schedule/requirements.
 - 2.6.1.1.3. VAR support to Grid / voltage Regulation
 - 2.6.1.1.4. Black Start application
 - 2.6.1.1.5. Frequency Regulation /Grid support f. Ancillary Services (PRAS, SRAS, TRAS)
 - 2.6.1.1.6. Energy Arbitrage/energy shifting operation
 - 2.6.1.1.7. Ramp rate support
 - 2.6.1.1.8. Power Quality Application to Grid
 - 2.6.1.1.9. Interaction on real-time with IEX for schedule of charging and discharging.
 - 2.6.1.1.10. Inertia Support to Grid as virtual Synchronous
 - 2.6.1.2. Emergency stop
 - 2.6.1.3. Control of switchgears and PCS in hard or soft signal
 - 2.6.1.4. Change of operating mode
 - 2.6.1.5. Allow local/remote control of the BESS, such as providing charge and discharge set points and setting of ramp rates
 - 2.6.1.6. Change in parameters for different applications
 - 2.6.1.7. Protection relay parameter setting
 - 2.6.1.8. Battery over / under voltage alarm/ tripping setting
 - 2.6.1.9. Battery over current alarm / tripping setting
 - 2.6.1.10. Temperature rise alarm / tripping setting
- 2.7. Display and storage of measured values
- 2.8. Historical storage of important data
- 2.9. Display and storage of derived/calculated/integrated values
- 2.10. Display and Storage of Alarm, Event and Trends
- 2.11. Generate, store and retrieve user configurable Sequence of Event (SOE) Reports
- 2.12. Generate, store and retrieve user configurable periodic Reports

- 2.13. Remote monitoring of essential parameters of plant on the web using popular web browser without requirement of additional software. Same shall be authorized with user id and password using standard modem. User ID and password for remote view can only be changed by EMS/SCADA Administrator. Internet connection for transferring data to web shall be taken by Contractor in the name of PESL/POWERGRID Site for O & M period.
- 2.14. Communication with Pooling Substation SCADA at PCC. All necessary software and hardware (both end) including laying of Communication/Fiber optic cable as required for communication SCADA shall be provided by the contractor.
- 2.15. System self-supervision and diagnostic functions.
- 2.16. Security of Data from authorized access using Hardware Firewall and software access privileges/rights.
- 2.17. Auto logging of all O & M evaluation parameters like availability, daily capacity used etc. in report form.
- 2.18. Auto generated reports to evaluate the performances of BESS for all functions like smoothening, time shift operations etc. as mentioned elsewhere in this specification.
- 2.19. The control system shall provide safe operation under all plant disturbances and on component failure so that under no condition the safety of plant, personnel or equipment is affected. Control system shall be designed to prevent abnormal swings due to loss of Control System power supply, failure of any Control System component, open circuit/short circuit. On any of these failures, the controlled equipment/parameter either shall remain in last position before failure or shall come to fully open/close or on/off state as required for the safety of plant/personnel/equipment and as finalized during detailed engineering. These operations shall be demonstrated by vendor/contractor during Factory Acceptance Testing (FAT)
- 2.20. The SCADA (including EMS) system shall be provided with two processors (Main processing unit and memories) one for normal operation and one as hot standby. In case of failure of working processor, there shall be an appropriate alarm and simultaneously the hot standby processor shall take over the complete plant operation automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. In the event of both processors failing, the system shall revert to fail safe mode. It shall be possible to keep any of the processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor. The memory shall be field expandable.
- 2.21. Manual intervention shall be possible at any stage of operation. Protection commands shall have priority over manual commands and manual commands shall prevail over auto commands. A forcing facility shall be provided for changing the states of inputs and outputs, timers and flags to facilitate fault finding and other testing requirements. It shall be possible to display the signal flow during operation of the program.
- 2.22. In addition, following requirements shall also be fulfilled,
 - 2.22.1. Where required by the equipment listing in accordance to this specification with Hazard Mitigation Analysis, an approved EMS shall be provided for monitoring operating conditions and maintaining voltages, currents and temperatures within the manufacturer's specifications.

- 2.22.2. The EMS shall electrically isolate the components of the BESS or place it in a safe condition if potentially hazardous temperatures or other hazardous conditions are detected.
- 2.22.3. When required by the EMPLOYER, visible annunciation shall be provided on the cabinet exterior or in an approved location to indicate potentially hazardous conditions associated with the BESS exist.
- 2.23. SCADA shall provide real-time performance monitoring according to IEC 61724 standard. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail.
- 2.24. All the power supply module, Ethernet switches and network accessories for nonair conditioned area shall be suitable for operating in ambient temperature of 50 Deg C minimum.
- 2.25. Performance Monitoring
 - 2.25.1. As part of the performance monitoring, the following shall be carried out:
 - 2.25.1.1. The Contractor must install necessary equipment to continuously measure BESS operating parameters (including but not limited to voltage, current, ambient conditions etc.) as well as energy input into and energy output from the BESS along with Metering arrangement in accordance with extant regulations. They will be required to submit this data to Employer, CTUlland Grid -India online and/or through a report on regular basis every month for the entire duration of contract.
 - 2.25.1.2. The plant SCADA should be OPC UA compliant and implement appropriate OPC-UA server as per the specification of OPC Foundation. All data shall be accessible through the OPC server to provide real-time BESS parameters for remote monitoring/RLDC. The Project SCADA system shall make time-series data available for performance monitoring, covering key parameters required to facilitate preparation of daily, monthly, and annual reports.
 - 2.25.1.3. Web-based monitoring should be available, which should not be machine dependent. The web-based monitoring should provide the same screens as available in the plant. Also, it should be possible to download reports from a remote web-client in PDF or Excel format.
- 3. Time Synchronization
 - 3.1. GPS based Time synchronising equipment complying with NTP /SNTP protocol shall be provided and integrated with Monitoring & Control system. All devices having real-time clock (RTC) with time synchronization facility and are communicating with BESS EMS/SCADA shall be synchronized with GPS Clock through SCADA or directly with GPS Clock.
- 4. Type of signal
 - 4.1. Type of signal from equipment (Hard wired or Soft) shall be as per specification of the equipment mentioned in the respective chapter and approved during detail engineering.
- 5. Power Plant Controller
 - 5.1. Power plant controller (PPC) shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby.

In case of failure of working PPC processor, there shall be an appropriate alarm and simultaneously the hot standby PPC processor shall take over the plant control function automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. It shall be possible to keep any of the PPC processors as master and other as standby. The standby processor shall be updated in line with the

changes made in working processor. The BESS plant SCADA and PPC networks shall be suitably designed, so that PPC shall directly and independently be able to control the individual PCS. Detailed control logic in the PPC shall be finalized during detailed engineering stage as per grid requirement to support voltage and frequency with suitable droop characteristic as per CEA standard.

- 5.2. The Contractor shall supply a separate hot standby redundant Power Plant Controller (PPC) or part of the EMS to act as redundant PPC, along with associated equipment.
 - 5.3. The PPC shall be compliant with the latest CEA Technical Standards for Connectivity to Grid (hereafter referred to as CEA Connectivity Standards) and RLDC requirements.
 - 5.4. The PPC network shall be designed to directly and independently control/communicate with:
 - 5.4.1. Individual PCS units (dual/multi-master)
 - 5.4.2. Redundant Power Quality Meters (IEC 61000-4-30 Class A) at the Pol (400/220/132/33 kV, as applicable)
 - 5.5. It shall support two-way communication using IEC 104 protocol with:
 - 5.5.1. SLDC/RLDC
 - 5.5.2. Local control room
 - 5.6. PPC shall be monitored for health status via SCADA.
 - 5.7. Installation and integration of Power Quality Meters with PPC/EMS shall be under the Contractor's scope.
6. SCADA
- 6.1. The SCADA controller of SCADA/EMS at control room shall be of redundant & PLC based as per specification given hereunder. For other locations such as Inverter/Battery containers Room, PLC/ 10 modules/RTUs are acceptable

Main control room SCADA shall have the following feature:
 - 6.1.1. Facility for implementation of all logic functions for control, protection and annunciation of the equipment and systems.
 - 6.1.2. Main control room SCADA shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby. In case of failure of working processor, there shall be an appropriate alarm and simultaneously the hot standby processor shall take over the complete plant operation automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. In the event of both processors failing, the system shall revert to fail safe mode. It shall be possible to keep any of the processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor.
 - 6.1.3. Processor and RAM shall be selected in such a manner that during normal operation not more than 80% capacity of processing and memory are used. Supplier shall demonstrate these features.
 - 6.1.4. The memory capacity shall be sufficient for the complete system operation and have a capability for at least 20% expansion in future. Programmed operating sequences and criteria shall be stored in non-volatile semiconductor memories like EPROM. All dynamic memories shall be provided with buffer battery backup for at least 360 hours. The batteries shall be lithium or Ni-Cd type.
 - 6.1.5. A forcing facility shall be provided for changing the states of inputs and outputs, timers and flags to facilitate fault finding and other testing

requirements. It shall be possible to display the signal flow during operation of the program.

6.1.6. The memory shall be field expandable. The memory capacity shall be sufficient for the complete system operation and have a capability for at least 20% expansion in future. Programmed operating sequences and criteria shall be stored in nonvolatile semiconductor memories like EPROM. All dynamic memories shall be provided with buffer battery backup for at least 360 hours. The batteries shall be lithium or Ni-Cd type.

6.1.7. A forcing facility shall be provided for changing the states of inputs and outputs, timers and flags to facilitate fault finding and other testing requirements. It shall be possible to display the signal flow during operation of the program.

7. Data Communication System (DCS)

The Data Communication System shall include a redundant Main System Bus with hot back-up. Other applicable bus systems like cubicle bus, local bus, I/O bus etc shall be redundant except for backplane buses which can be non- redundant.

7.1. The DCS shall have the following minimum features:

7.1.1. Redundant communication controllers shall be provided to handle the communication between I/O Modules (including remote I/O) and PLCs and between PLCs and operator workstation.

7.1.2. The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station/module connected to the system bus shall not result in loss of any communication function to and from any other station/module.

7.1.3. If the system bus requires a master bus controller philosophy, it shall employ redundant master bus controller with automatic switchover facility

7.1.4. Built-in diagnostics shall be provided for easy fault detection. Communication error detection and correction facility (ECC) shall be provided at all levels of communication. Failure of one bus and changeover to the standby system bus shall be automatic and completely bump less and the same shall be suitably alarmed/logged.

7.1.5. The design and installation of the system bus shall take care of the environmental conditions as applicable.

7.1.6. Data transmitting speed shall be sufficient to meet the responses of the system in terms of displays, control etc. plus 25% spare capacity shall be available for future expansion vii. Cat 6 UT P or fiber optic cables shall be employed.

7.1.7. The Contractor shall furnish details regarding the communication system like communication protocol, bus utilization calculations etc.

7.1.8. Contractor shall setup Gigabit Ethernet based Plant Local Area Network (LAN) to connect to different communication nodes at Inverter /Switchgear location etc. with redundant backbone using ring or better topology. Each Modbus cable shall be provided with Surge protection device at SCADA Panel End. Specification of OFC and Modbus cable has been given elsewhere in this specification.

7.1.9. Provision of monitoring and event data via the communication interface shall adhere to DNP3 AN201 1-001 / IEC 61850 to the extent possible and capture at least the following data points:

7.1.9.1. Frequency at the AC bus

- 7.1.9.2. AC real power
 - 7.1.9.3. Power factor
 - 7.1.9.4. Real energy delivered
 - 7.1.9.5. Real energy received
 - 7.1.9.6. Auxiliary power
 - 7.1.9.7. Auxiliary energy
 - 7.1.9.8. DC power
 - 7.1.9.9. DC voltage
 - 7.1.9.10. DC current
 - 7.1.9.11. Phase A voltage
 - 7.1.9.12. Phase A angle
 - 7.1.9.13. Phase B voltage
 - 7.1.9.14. Phase B angle
 - 7.1.9.15. Phase C voltage
 - 7.1.9.16. Phase C angle
 - 7.1.9.17. Battery state of charge
 - 7.1.9.18. Battery string currents
 - 7.1.9.19. Battery temperature
- 7.1.10. The DAS shall provide unsolicited message capability for reporting critical alarms. The list of alarms shall be finalized during detailed engineering. However, a minimum of following parameters shall be displayed on BESS local control panel, console, or SCADA computer:
- 7.1.10.1. Main temperature Alarm (on system temperature exceeding a predetermined threshold)
 - 7.1.10.2. Smoke/fire Alarm (on system detection of smoke/fire)
 - 7.1.10.3. DC leakage current (battery leakage current to ground exceeding a predetermined threshold)
 - 7.1.10.4. Breaker status (connect/disconnect switch)
 - 7.1.10.5. AC voltage OK (system ac voltage exceeding a predetermined threshold)
 - 7.1.10.6. Battery temperature alarm (battery temperature exceeding a predetermined threshold)
 - 7.1.10.7. Synchronization error shutdown
 - 7.1.10.8. PCS fault
 - 7.1.10.9. Weak Unit Battery Alarm
 - 7.1.10.10. AC system fault
 - 7.1.10.11. Control logic problem (problem with the BESS control logic)
 - 7.1.10.12. DC fuse blown
 - 7.1.10.13. Container door open (BESS container door opening)
8. Human Machine Interface System (HMIS)
- 8.1. HMIS shall be configured around latest state-of-the art servers/Workstations with open architecture supporting OPC/TCP/IP protocols, etc.
 - 8.2. The SCADA shall be OPC UA compliant and implement a OPC-UA server as per the specification of OPC Foundation. All data should be accessible through this OPC server.
 - 8.3. For communicating with the generation data of plant with pooling substation, the SCADA system shall be interfaced/ connected with PI server of pooling substation on OPC Protocol. The details of pooling substation PI server shall be furnished during the detailed furnished.
 - 8.4. Graphical Interface Unit (GIU) / Operator workstation (OWS) shall perform control, monitoring and operation (as applicable) for plant equipment's connected with SCADA system.

- 8.5. Engineering workstation (EWS) shall work as a programming station both for controller and SCADA. It shall be possible to use same EWS as programming station and the Human Machine Interface System.
- 8.6. SCADA System shall be provided with redundant OWS. Operator shall be able to access all control/information related data under all operating conditions including a single processor and computer failure/hardware failure at Control room in the HMIS.
- 8.7. In addition to a desktop based EWS, vendor shall also provide dedicated portable (laptop) based EWS.
- 8.8. All frequently called important functions including major displays shall be assigned to dedicated function keys on a soft keyboard for the convenience of the operator for quick access to displays & other operator functions.
- 8.9. The mimic shall be configured on the HMI and it shall be possible to control, monitor and operate the plant from the same.
- 8.10. The SCADA System shall have ability to perform operator functions for each OWS / GIU as a minimum, include Control System operation (A/M selection, raise/lower, set point/bias change, on/off, open/close operation, mode/device selection, bypassing criteria, sequence auto, start/stop selection, drive auto selection, local-remote/other multi-position selection etc.); alarm acknowledge; call all kind of displays, logs, summaries, calculation results, etc.; printing of logs & reports; retrieval of historical data; and any other functions required for smooth operation, control & management of information as finalized during detailed engineering.
- 8.11. The display selection process shall be optimized so that the desired display can be selected with the minimum no. of operations. Navigation from one display to any other should be possible efficiently through paging soft keys as well as through targets defined on the displays. There should be no limitation on number of such targets.
- 8.12. The display selection process shall be optimized so that the desired display can be selected with the minimum no. of operations. Navigation from one display to any other should be possible efficiently through paging soft keys as well as through targets defined on the displays. There should be no limitation on number of such targets.
- 8.13. The system shall have built-in safety features that will allow/disallow certain functions and entry fields within a function to be under password control to protect against inadvertent and unauthorized use of these functions. Assignment of allowable functions and entry fields shall be on the basis of user profile. The system security shall contain various user levels with specific rights as finalized by the Employer during detailed engineering. However, no. of user levels, no. of users in a level and rights for each level shall be changeable by the programmer (Administrator).

Wherever Graphical Interface Unit is envisaged, it shall meet the minimum functional requirements of monitoring, operating & controlling the process and displaying information related to process locally. GIU shall be provided with TFT active matrix or LED display and keypad for operation. GIU shall be ruggedly designed to withstand hard environments like high temperature, shock and vibration.
- 8.14. Bidder has to provide suitable hardware DMZ network firewall to restrict unauthorized access to HMM SCADA system. Details specification of hardware firewall is provided elsewhere in the specification.

- 8.15. SCADA shall have facility to provide real time reporting of alarms and statistical data through SMS and e-mails.
9. Programming Functionalities
- 9.1. Programming of the PLC Processor/controller as well as programming of HMIS shall be user friendly with graphical user interface and shall not require knowledge of any specialized language.
- 9.2. The programming of HMIS (like development and modification of data base, mimics, logs / reports, HSR functionalities etc.) shall also be possible through user-friendly menus etc.
- 9.3. All programming functionalities shall be password protected to avoid unauthorized modification.

10. Software Requirements

- 10.1. All necessary software required for implementation of control logic, operator station displays / logs, storage & retrieval and other functional requirement shall be provided. The programs shall include high level languages as far as possible. The contractor shall provide sufficient documentation and program listing so that it is possible for the Employer to carry out modification at a later date.
- 10.2. The Contractor shall provide all software required by the system for meeting the intent and functional/parametric requirements of the specification.
- 10.3. Industry standard operating system like WINDOWS (latest version) etc. to ensure openness and connectivity with other systems in industry.
- 10.4. SCADA system shall include the following standard protocols as a minimum:
- a. Modbus (TCP/IP, RTU, ASCII).
 - b. Sub Station Protocol (IEC-61850 and IEC 60870 -5-101/104).

Any other protocol on which the offered equipment (by Contractor) will communicate with SCADA

- 10.5. The system shall have user friendly programming language & graphic user interface.
- 10.6. All system related software including Real Time Operating System, File management software, screen editor, database management software, On line diagnostics/debug software, peripheral drivers software and latest versions of standard PC-based software, Antivirus software and latest WINDOWS based packages (MS Word, Excel and PowerPoint) etc. and any other standard language offered shall be furnished as a minimum.
- 10.7. All application software for SCADA system functioning like input scanning, acquisition, conditioning processing, control and communication and software for operator interface of monitors, displays, trends, curves, bar charts etc. Historical storage and retrieval utility, and alarm functions shall be provided.
- 10.8. The Contractor shall provide software locks and passwords to Employer's engineers at site for all operating & application software so that Employer's engineers can take backup of this software and are able to do modifications at site.
- 10.9. The Contractor shall provide software license for all software being used in Contractor's System. The software licenses shall be provided for the project (e.g. organization or site license) and shall not be hardware/machine specific. That is, if any hardware/machine is upgraded or changed, the same license shall hold good and it shall not be necessary for Employer to seek a new license/renew license due to up gradation/change of hardware/machine in Contractor's System

at site. All licenses shall be valid for the continuous service life of the plant (CAMC period).

- 10.10. All SCADA software along with license keys shall be handed over to POWERGRID in secure USB drive media. All the hardware and software shall be licensed to POWERGRID.

11. Parametric Requirements

The control system shall be designed such that under worst case loading conditions the response time shall not be worse than the following:

- i) On/Off Command: The response time for screen update after the execution of the control command from the time the command is issued shall be one second (excluding the drive actuation time).
- ii) Adjustment Command: 0.5 to 1 second.
- iii) On screen Updating and All Control related displays: 1 second.
- iv) Bar Chart displays, Plant Mimic displays, Group review displays, X-T Plot Displays and Plant Summary Displays: 1 to 2 seconds.
- v) All the Analog data shall be scanned at the resolution of 1 (one) second and refreshed on screen however, recording of data shall be as finalized during detail engineering

12. Input / Output Modules

- 12.1. The SCADA system should be designed according to the location of the input/output cabinets as specified.
- 12.2. Input Output modules, as required in the Control System for all type of field input signals (4-20 mA, non-changeover/change over type of contact inputs etc.) and outputs from the control system (non changeover/change over type of contact, output signals for energizing interface relays at suitable DC voltage as decided during detail engineering, 4-20 mA output etc.) are to be provided by the Contractor.
- 12.3. Electrical isolation of 1.5kV with optical couplers between the plant input/output and controller shall be provided on the I/O cards. The isolation shall ensure that any inadvertent voltage or voltage spikes (as may be encountered in a plant of this nature) shall not damage or mal operate the internal processing equipment.
- 12.4. The Input/output system shall facilitate modular expansion in fixed stages. The individual input/output cards shall incorporate indications on the module front panels for displaying individual signal status.
- 12.5. Individually fused output circuits with the blower fuse indicator shall be provided. All input/output points shall be provided with status indicator.
- 12.6. The I/O Module shall have the following features:
 - 12.6.1. Power supply monitoring
 - 12.6.2. Contact bounce filtering
 - 12.6.3. Optical isolation between input and output signals with internal circuits.
 - 12.6.4. In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode. The fail-safe mode shall be finalized during detailed engineering.
 - 12.6.5. Binary Output modules shall be rated to switch ON/OFF coupling relays of approx. 3 VA. Analog output modules shall be able to drive a load impedance of 500 Ohms minimum.

- 12.7. Electrical isolation of 1.5kV with optical couplers between the plant input/output and controller shall be provided on the I/O cards. The isolation shall ensure that any inadvertent voltage or voltage spikes (as may be encountered in a plant of this nature) shall not damage or mal- operate the internal processing equipment.
- 12.8. Requirement of Nos. of channel in each type of Module (Analog Input, Analog Output, Binary Input, Binary Output, RTD) and Modbus link at Inverter and main control room shall be calculated based on the Input/output signal list to be submitted by the contractor for approval during detail engineering.
13. System Spare Capacity
- 13.1. Over and above the equipment and accessories required to meet the fully implemented system as per specification requirements, Control System shall have spare capacity and necessary hardware/ equipment/ accessories to meet following requirement for future expansion at site.
- 13.2. 10 % spare channels in input/output modules fully wired up to cabinets TB. ii. Wired-in "usable" space for 10% modules in each of the system cabinets for mounting electronic modules wired up to corresponding spare terminals in system cabinets.
- 13.3. Empty slots between individual modules/group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice of Contractor shall not be considered as wired-in "usable" space for I/O modules.
- 13.4. Terminal assemblies (if any in the offered system), corresponding to the I/O modules shall be provided for above mentioned 10 % blank space
- 13.5. Each processor / controller shall have 20% spare functional capacity to implement additional function blocks, over and above implemented logic/ loops. Further, each processor / controller shall have spare capacity to handle minimum 20% additional inputs/ outputs of each type including above specified spare requirements, over and above implemented capacity. Each of the corresponding communication controllers shall also have same spare capacity as that of processor/controller.
- 13.6. The Data communication system shall have the capacity to handle the additions mentioned above
- 13.7. Ten (10) percent spare relays of each type and rating mounted and wired in cabinets TB. All contacts of relays shall be terminated in terminal blocks of cabinets.
- 13.8. The spare capacity as specified above shall be uniformly distributed throughout all cubicles. The system design shall ensure that above mentioned additions shall not require any additional controller/processor/ peripheral drivers in the system delivered at site. Further, these additions shall not deteriorate the system response time / duty cycle, etc. from those stipulated under this specification.
14. Operator Interface Displays / Logs / Reports
- 14.1. Suitable Operator Interface Displays/Logs/Reports for control operation & monitoring shall be provided. The details shall be finalized during detailed Engineering stage.
- 14.2. Minimum quantities shall be as follows:-

Various displays on the OWS shall as a minimum include P&ID displays or mimic, bar chart displays, X-Y & X-T plot (trend) displays, operator guidance message displays, group displays, plant start-up/shutdown message displays, system status displays etc. Number of displays and the exact functionality shall be on as required basis and as finalized during detailed engineering subject to the

minimum quantities as given in subsequent clauses. For X-T & X-Y plots, the facility of providing a background grid on operator request shall be variable with adequate no. of divisions in both coordinates.

15. Historical Storage and Retrieval System (HSRS)

- 15.1. The HSRS shall collect, store and process system data from MMIPIS data base. The data shall be saved online and automatically transferred to nonerasable long term storage media once in every 30 Days periodically for long term storage.
- 15.2. The data to be stored in the above system shall include alarm and event list, periodic plant data, selected logs/reports.
- 15.3. The system shall provide user-friendly operator functions to retrieve the data from historical storage. It shall be possible to retrieve the selected data on OWS in form of trend/report by specifying date, time & period. Further, suitable index files/directories shall also be provided to facilitate the same.
- 15.4. In addition to above, the system shall also have facility to store & retrieve important plant data for a very long duration on portable external long term storage media. Bidder shall provide two numbers of portable external hard drive of 2TB each.
- 15.5. For long term plant performance analysis, the following plant data as a minimum with time stamping and interval as indicated in below table but not limited to shall be stored daily on historian.
Important plant data for a very long duration (plant life) Storage on Historian

	Parameter	Time Interval
1	Power Conditioning System (PCSs):- DC Voltage, DC Power, DC Current,, AC Active & Reactive Power, Power factor, AC Current & Voltage, Energy, PCS room temp, PCS Cabinet tem and Modules Tem	1 (One) Minute
2	MFM, Energy meter and Numerical Relay data:Active & Reactive Power, Energy (day), Current and Volta e	1 (One) Minute
3	Export feeder/s Energy Meter Data:- Active & Reactive Power, Energy import and export, Current and Voltage and Grid Frequency	1 (One) Minute
4	Daily energy export from each PCS	24 (Twenty Four) Hours
5	Total sum of daily energy export from all PCS	(Twenty Four) Hours
6	BESS Parameter for different application functionl assessment: (i) Active & Reactive Power (ii) Reference Target Active & Reactive power	(one) second
7	BESS Battery Voltage, SOC (upto Module and String level) and other Important Battery and BMS data.	1 (one) second

8	Any other parameter (s) as per POWERGRID/Grid Controller requirement	As per requirement
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16. Coloured Laser Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.

17. The printer shall have in built testing facility. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc. It shall have LAN port. SCADA Panel / Cabinet / Control Desk / Furniture

17.1. The SCADA cabinets shall be IP-22 protection class.

17.2. The Contractor shall ensure that the packaging density of equipment in these cabinets is not excessive and abnormal temperature rise, above the cabinet temperature during normal operation or air-conditioning failure, is prevented by careful design. The Contractor shall ensure that the temperature rise is limited to 10 deg. C above ambient and is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets. Ventilation blowers shall be furnished as required by the equipment design and shall be sound proof to the maximum feasible extent. If blowers are required for satisfactory system operation, dual blowers with blower failure alarm shall be provided in each cabinet with proper. Suitable louvers with wire mesh shall be provided on the cabinet.

17.3. The cabinets shall be designed for front access to system modules and rear access to wiring and shall be designed for bottom entry of the cables for Main control room.

17.4. The cabinets shall be totally enclosed, free standing type and shall be constructed with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per supplier's standard practice for similar applications, preferred height of the cabinet shall not higher than 2200mm. The cabinets shall be equipped with full height front and rear doors. The floor mounting arrangement for other cabinets shall be as required by the Employer and shall be furnished by the Contractor during detailed engineering. Wall mounted cabinet is acceptable for Inverter room/subpooling switchgear.

17.5. Cabinet doors shall be hinged and shall have turned back edges and additional bracing where required ensuring rigidity. Hinges shall be of concealed type. Door latches shall be of three-point type to assure tight closing. Detachable lifting eyes or angles shall be furnished at the top of each separately shipped section and all necessary provisions shall be made to facilitate handling without damage. Front and rear doors shall be provided with locking arrangements with a master key for all cabinets. If width of a cabinet is more than 800 mm, double doors shall be provided.

17.6. Two spray coats of inhibitive epoxy primer-surface shall be applied to all exterior and interior surfaces. A minimum of 2 spray coats of final finish colour shall be applied to all surfaces. The final finished thickness of paint film on steel shall not be less than 65-75 micron for sheet thickness of 2 mm and 50 microns for sheet thickness of 1.6 mm. The Preferable finish colors for exterior and interior surfaces shall conform to following shades:

17.6.1. Exterior:- As per RAL 9002 (End panel sides RAL 5012),

17.6.2. Interior:- Same as above

Paint films which show sags, checks or other imperfections shall not be acceptable.

As an alternative, single coat of anodic dipcoat primer along with single textured powder coating with epoxy polyester meeting the thickness requirement is also acceptable.

- 17.7. Control desk shall be free standing table top type with doors at the back and shall be constructed of 2 mm thick CRCA steel plates. A 19 mm thick wooden top shall be provided on the desk to keep the monitors at top and computers inside. Control desk shall consist of vertical, horizontal and base supports with their coverings for work surface, keyboard trays, mouse pads, monitor shelf and concealed cable and wire way management, perforated trays with covers in both horizontal and vertical directions. ASCII Keyboard shall be capable of being pulled out through a tray.
- 17.8. Contractor shall provide the two power supply feeders (DC supply or UPS AC) and one raw supply feeder of suitable rating to cater all the load requirements of SCADA panel/cabinet/control desk. System remain in service in case of single power supply failure/power supply module failure. Suitable alarm shall be generated in case of any power supply failure.
- 17.9. The cabling / wiring between OWS & CPU'S, power supply cables etc. shall be aesthetically routed and concealed from view.
- 17.10. Chairs — Industry standard revolving chairs with wheels and with provision for adjustment of height (hydraulically/gas lift) shall be provided for the operators and other personnel in control room area. These shall be designed for sitting for long duration such that these are comfortable for the back. Armrests in one piece shall be of poly-urethane and twin wheel castor of glass filled nylon.
- 17.11. One Printer Table made of Laminated Wood or Heavy Duty MDF shall be provided for printer.
- 17.12. All the furniture shall be of reputed **make (Godrej or Equivalent)**
18. Human Machine Interface System Hardware (HMISH)
- 18.1. The HMISH as specified shall be based on latest state-of-the-art Workstations and Servers and technology suitable for industrial application & power plant environment.
- 18.2. The Workstation/Servers employed for HMISH implementation shall be redundant based on industry standard hardware and software which will ensure easy connectivity with other systems and portability of Employer developed and third-party software.
- 18.3. Redundant sets of communication controllers shall be provided to handle all the communication between the HMISH and redundant system bus and to ensure specified system response time and parametric requirements. Each communication controller shall have message checking facility. Power Fail Auto Restart (PFAR) facility with automatic time update shall be provided.
- 18.4. All the peripherals shall conform to the following minimum requirement but the exact make & model shall be as approved by Employer during detailed engineering. The LAN to be provided under HMISH shall support TCP/IP protocol (Ethernet connectivity) with OPC RD' for interface with PLCs/ Owners PI System/other systems and shall have data communication speed of min. 100 MBPS. All network components of LAN and Workstations shall be compatible to the LAN, without degrading its performance.
19. Engineering Workstations/ Operator Workstations/ Historian/ Portable EWS

No.	Features	Industrial Grade Engineering Cum Operator Workstations/ Operator workstations/ Other workstations/ Documentation station
1	Processor	Engineering Cum Operator Workstations: 64 bit Server Grade (Xeon or Equivalent), Octa core minimum For other Workstation: 64 bit i5 or Equivalent
2.	Memory	Engineering Cum Operator Workstations: 16 GB RAM upgradable to 24 GB minimum For other Workstation: 8 GB RAM upgradable to 16 GB
3.	Hard Disk/SSD	Engineering Cum Operator Workstations: 1 TB RAID1 For Historian: 1 TB ultra-wide RAID1 For other Workstation: 500 GB ultra-wide RAID1 for OWS/ 500 GB for Portable EWS
4.	Communication port	Engineering Cum Operator Workstations: 2 Serial bus. Expansion slot=2 For other Workstation: 4 Serial bus, Expansion slot=2 Portable EWS: 2 Serial bus.
5.	Monitor (Color)	Min 32" TFT Flat Monitor with non-interfaced refresh rate min. 75 Hz, Graphic Memory = 16 MB
6.	Removable bulk storage drive	2 TB (minimum) NAS Logs for all the events (for all the devices) shall be maintained for a minimum duration of 6 months.
7.	Network Connectivity	Engineering Cum Operator Workstations: 4 Nos. Built-in Ethernet Network Port For other Workstation: 2 Nos. Built-in Ethernet Network Port Portable EWS: 1 No. Built-in Ethernet Network Port and 1 No. Wifi
8.	Additional general purpose software (for using over network by servers/work stations/PCs	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/antivirus, etc. antivirus subscription shall include definition updates
9.	Power Supply Unit	Redundant Power Supply Units for Server grade workstations

20. Time Synchronisation Equipment

- 20.1. Time Synchronization equipment shall be provided and shall be located in the Control Room. It shall receive Coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite (GPS) for time synchronization of all components of the SCADA.
- 20.2. It shall be complete in all respects including antenna, all cables, processing equipment, etc.
- 20.3. All auxiliary systems and special cables required for synchronization of the equipment shall be supplied and commissioned by the Contractor.
- 20.4. It shall work from DC supplies only and the Contractor to clarify if any built-in battery backup is provided, in which case, same shall be of long life lithium batteries.
- 20.5. It shall be immune to hostile electrical environment. Suitable protections are to be provided against lightning surges and over-voltages in power supply systems and antenna feeders.
- 20.6. The system shall be fully tested to the relevant international standards such as IEC: 801 and IEC: 255
- 20.7. All components of the SWYD SAS, including Substation Controllers, Workstations, Bay Control Units (BCU) and Bay Protection units (BPU) and all numeric protection relays, PCS, BMS and all network components etc. covering all equipment of BESS shall be synchronized with an accuracy of 1 ms.
- 20.8. The GPS shall be synchronized with the SCADA system to be supplied under this contract. Necessary software and Hardware (including laying of communication cable) required for time synchronization with SCADA and all other devices shall be in scope of contractor.
- 20.9. The system should be able to track more than 1 satellite at a time to ensure no interruptions of synchronization signals.
- 20.10. The system shall have provisions for combination of any of the following output signals:
 - 20.10.1. PTP (Precision time protocol) 100Mbits Ethernet port
 - 20.10.2. IRIG-B00x (TTL, pulse width modulated signal)
 - 20.10.3. 2 x Pulse per half-hour/ Pulse per minute/ Pulse per second outputs via potential free contacts
 - 20.10.4. Any other output port as may be required for the offered system.
 - 20.10.5. Alarm status contact indicating healthy status of system
- 20.11. These output ports shall be compatible with the requirement of the equipment to be synchronized i.e. BCUs/ BPU's/Numerical Relays/LEDs etc. as per scope of the specification. The master clock in control room shall also be synchronized with the time synchronization system. The actual port requirements (no./type) in line with the system offered shall be finalized during detailed engineering.
- 20.12. The equipment should have a periodic time correction facility of one-sec. periodicity. The equipment shall also have real time display in hour, minute, second (24-hour mode) and have a separate time display, having display size of approx. 144mm height.

21. Power Quality Meter

- 21.1. Class-A Power Quality Meter, which is fully compliant to IEC61000-4-30, shall be provided and shall be located at grid integration/metering points.
 - 21.1.1. It shall have a facility for time synchronization on the NTP protocol from the existing GPS clock in the BESS SCADA network.

- 21.1.2. PQM at the minimum shall measure three-phase voltage & current, power factor, active power, reactive power, harmonics (amplitude and phase), voltage sag and swell, flicker, disruptions. It should have capability of recording 10 second fault recording during LVRT and HVRT phenomenon as per CEA Regulation
- 21.1.3. It shall be able to communicate with PPC on Modbus TCP/IP protocol
- 21.1.4. Selected PQM shall be able to measure grid frequency with a minimum of two digit after the decimal point.
- 21.1.5. All associated software to be supplied for configuration, monitoring & maintenance of PQM to be installed on the EWS cum OWS.
- 21.1.6. Relay shall monitor power quality parameter including DC Injection, create automated daily /event wise reports as per CEA, Grid India, regulatory compliance i.e. IEEE519-2014, EN50160, LVRT/HVRT etc. and provide real time alarms for all power quality measuring parameters.
- 21.1.7. The PQM supplied shall be in compliance to RLDC requirement of daily/monthly automatic generation of Power Quality Report as per IEEE/IEC formats. These reports need to be submitted weekly to RLDC. Bidder to refer the RLDC website of required format of the various power Quality reports for renewable plants.

22. EMS Functionality

22.1. BESS Control

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

- 22.1.1. Automatic mode: BESS behaves according to the selected operation mode.
- 22.1.2. I-IMI mode or manual mode: in this mode, the operator has the possibility to:
 - 22.1.2.1. Select the operation point
 - 22.1.2.2. Direct control of active and reactive setpoints of the PCS.
 - 22.1.2.3. Command of balance of Plant
 - 22.1.2.4. OFF-mode: BESS is not producing any power. The system is disconnected from the grid.
 - 22.1.2.5. STANDBY-mode: BESS is connected to the grid, but the IGBT's in the PCS system are in an off-state (i.e. open switching).
- 22.1.3. Also, the performance of every application mode will be controlled and adaptable by this system. 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.
- 22.1.4. 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:
 - 22.1.4.1.1. Change the operation mode of each BESS independently
 - 22.1.4.1.2. Start/Stop each application mode appointed to a BESS.
 - 22.1.4.1.3. Change the application mode of each BESS (multiple modes can be selected together)
 - 22.1.4.1.4. Select the amount of power dedicated to each selected application mode.
 - 22.1.4.1.5. Control of control modes based on application for BESS use separately for capacity at each Thermal plant.

- 22.1.4.1.6. Adapt the parameters needed for the operation of every application mode
- 22.1.5. The Communication protocol will be IEC 61850. Other solutions can be proposed but are subjected to the Employer's approval.
- 22.2. Plant Control
 - 22.2.1. The EMS monitors grid and Plant facility variables and should be programmable for selecting the optimum-operating mode of the whole plant through PPC or directly w.r.t. active and reactive power, grid voltage, grid frequency, etc. Additionally, it can receive external set points and automatically adapt the Plant Facility behaviour to the new settings.
 - 22.2.2. The EMS shall perform the following functionality to Control the Plant facilities:
 - 22.2.2.1. Communication with grid or SCADA
 - 22.2.2.2. Communications with BESS and other power units
 - 22.2.2.3. Measuring and processing of the electrical magnitudes at EMS (voltage, current, PF)
 - 22.2.2.4. Control capability of BESS Inverters, BESS and other power units
 - 22.2.3. The EMS shall allow the following operation modes for the Plant facilities:
 - 22.2.3.1. Reactive Control (Q Control, setting point of reactive power Q at EMS)
 - 22.2.3.2. Power Factor Control (PF Control, setting point of $\cos(L)$ at EMS)
 - 22.2.3.3. Voltage Control (V closed loop control, setting point of V at EMS)
 - 22.2.3.4. Voltage Droop (Reactive power vs Voltage programmable curve or droop)
 - 22.2.3.5. Apparent Power Control (S Lim, setting point of S Lim at EMS)
 - 22.2.3.6. Active Power Limitation (P Lim, setting point of P Lim at EMS)
 - 22.2.3.7. Power Ramp Rate Control (setting point of maximum %Pn/min)
 - 22.2.3.8. Frequency Regulation (Power vs Frequency programmable curve or droop)
 - 22.2.4. In addition to these operating modes, the EMS shall be prepared to work under voltage dips, allowing the PCS to inject the corresponding reactive power to provide the corresponding voltage support at the EMS. The EMS can receive the target values specified by grid operators using a standard protocol (i.e. Modbus TCP/IP) and over different communication media.
- 22.3. Measurements
 - 22.3.1. To perform the application modes described above, measurements are needed at the Point of Common Coupling (PCC). The measurements are (but not limited to):
 - 22.3.1.1. Voltage measurement: This is needed to perform voltage regulation and reactive power compensation.
 - 22.3.1.2. Output power (Active and Reactive): This will be measured with an accuracy précised by the supplier. The measurement equipment should be class 0.2s.

23. Control & Power Supply Scheme

- 23.1. Contractor shall provide the UPS of suitable rating with N-1 contingency to cater all the load requirements of EMS system and its auxiliaries. Rating of UPS shall be finalized during detailed engineering.

24. Software Documentation & Listings

- 24.1. All technical manuals, reference manuals, user's guide etc. in English required for modification/editing/addition/deletion of features in the software of the EMS System shall be furnished.

24.2. The Contractor shall furnish a comprehensive list of all system/application software documentation after system organization for Employer's review and approval. All The software listings for application software, Project data files etc. shall be submitted by the Contractor.

24.3. All the EMS Software with license Key shall be handed over to the Owner on USB media.

24.4. All the hardware and software shall be licensed to POWERGRID. License shall be for design life of BESS (CAMS Period).

25. Next Generation Firewall

Next generation firewall requirement will be as mentioned in document C/ENGG/SPEC/SEC-PROJECT/SPECIFIC REQUIREMENT REV NO 10.

26. Factory Acceptance Test (Fat)

FAT procedure shall be submitted by bidder for POWERGRID approval and after approval of FAT procedure, FAT will be witnessed by POWERGRID Engineering or authorized representative of POWERGRID. SCADA shall communicate with all third party devices which are part of BESS System and the same shall be demonstrated during the FAT.