Section 6 Employer Requirements
Attachment B – BESS

1. Technical definitions

Unless explicitly stated in this document, definitions are as per IEC 62933.

The following technical definitions are included and are referenced throughout these bidding documents.

Name	Definition	Units	Notes
State of charge (SOC)	Amount of energy stored in the BESS relative to its upper and lower limits.	kWh, %	See definitions of 0% and 100% SOC for more details.
0% SOC	The condition where no more energy can be discharged from the BESS at the time without damage.	-	Charging or discharging the BESS to its physical limits may mean it does not meet other parts of the Employer Requirements.
100% SOC	The condition where no more energy can be stored in the BESS at the time without damage.	-	
Minimum operational SOC	The condition where the energy stored in the BESS is the minimum that allows the BESS to meet the full Employer Requirements (must be greater than or equal to the 0% SOC)	kWh, %	
Maximum operational SOC	The condition where the energy stored in the BESS is the minimum that allows the BESS to meet the full Employer Requirements (must be less than or equal to the 100% SOC)	kWh, %	
Energy storage (kWh)	The operational range of SOC, equal to the difference between the maximum and minimum operational SOC (or otherwise nominated SOC range).	kWh, %	
Round trip efficiency	The ratio of energy output from the BESS to energy input to the BESS in a full charge and discharge cycle (minimum operational SOC to maximum operational SOC) at full rated power. $\frac{Energy\ output\ from\ BESS}{Energy\ input\ to\ BESS}$ Auxiliary / parasitic loads shall not be excluded from round-trip efficiency.		To be measured at the AC connection to the switchboard, using an approved Class 1 (or better) power meter to be installed between the AC output of the BESS and the switchboard and fully integrated into

Name	Definition	Units	Notes
	Measured at the LV side of the transformer.		the BESS output data stream.
Availability	The ratio of time that the BESS is able to meet all Employer Requirements. To allow for short term part performance, the system shall be deemed to be available if, and only if: ● Rate of charge / discharge > 80% required level ● Energy storage > 80% required level	%	Availability will be determined by BESS self-reporting status, except in cases where this is shown to be inaccurate (either determined through performance tests or operational data)
Lifetime throughput capacity	The total energy discharged by the BESS while its Energy storage exceeds End of Life Capacity under the usage cycle specified in Employer Requirements-Appendix B and C. End of Life Capacity to be nominated by the Bidder but must exceed 50% of the Energy storage at commissioning.		To be measured by an approved Class 1 (or better) power meter to be installed at the AC output of the BESS and fully integrated into the BESS output data stream.
Local conditions	Means any environmental conditions that may be encountered on site during operations. An indication of the local conditions is included in Supplementary Information.		
Grid forming	A feature of modern inverters which allows battery energy storage systems to act in a manner that mimics synchronous generators response to rapid changes in load.		
Service life	The number of years where the BESS can meet the full Employer Requirements, when operated as per the Duty Cycle.	Year	

2. Standards

All equipment shall be installed and all work shall be carried out in accordance with AS/NZS 3000, Solomon Power regulations, relevant Solomon Islands government statutory requirements (including amendments), and all applicable Australian/New Zealand and international standards.

Recognising that OEM products in the international market may not be certified against local Standards, such products will not necessarily be excluded. However, bidders must demonstrate product compliance with AS/NZS, ANSI, IEC or ISO standards providing coverage of the same requirements (in particular, including earthing, substation design for access and safety, fire detection, fire safety, lightning protection, switchgear, signage, and protection). Non-OEM products and custom installations should be built to the specified standards. If a requirement included in the Employer Requirements exceeds the applicable standard then the requirement within the Employer Requirements shall be adhered to. Standard(s) referred to shall mean the current Edition / Revision together with Amendments issued.

The following standards should be satisfied:

- Those listed in *Attachment A –General and Electrical* where appropriate
- AS/NZS 3000 Electrical Installations
- AS/NZS 5139 Safety of battery systems for use with power conversion equipment
- UNIFI-2022-2-1 Specifications for Grid-forming Inverter-based Resources
- IEC 61936-1:2002 Power Installations Exceeding 1kV
- IEC 60905 Loading guide for dry-type power transformers
- IEC 61000.3 Electromagnetic compatibility
- IEC 60076 Power transformers – dry type transformers
- IEC 60688 Electrical measuring transducers for converting AC and DC electrical quantities to analogue or digital signals
- IEC 60439-1:1999 Low Voltage Switchgear
- IEC 60529 Degrees of protection
- IEC 62109 Safety performance of power converters
- IEC 62933 electrical energy storage (EES) systems
- IEC 62305 Standard for lightning protection
- ENA EG0:2010 Power System Earthing Guide
- ENA EG1:2006 Substation Earthing Guide
- ISO 14520 Gaseous fire-extinguishing systems
- “Grid code: high and extra high voltage”, E.ON Netz GmbH, 1st April 2006[1]
- IEEE Standard 80 (2000): Guide for Safety in AC Substation Grounding

[1] http://www.nerc.com/docs/pc/ivgtf/German_EON_Grid_Code.pdf

- IEEE Standard 837 (2002): Qualifying Permanent Connection Used in Substation Grounding
- IEC 60027.4 Letter symbols for use in electric technology
- IEC 60848 Specification language for sequential function charts

3. Intended Purpose

This section details the Intended Purpose of the Battery Energy Storage System (BESS) by listing general features that are required for the BESS to fulfil its role. The supplied BESS must meet all of these requirements, noting that other parts of the Employer Requirements provide additional context and specification.

3.1 Functionality

The primary purpose of the **Subproject 2 - Honiara Substation BESS and Subproject 3 – Honiara East Substation BESS** is to provide spinning reserve and have a grid forming capability. Both batteries will have enough capacity to provide ramping capabilities to absorb fluctuations from solar generation and to avoid starting of another diesel generator, minimising diesel use by maintaining longer periods where the system can run in the lower diesel schedule. It shall have multiple modes including a minimum of; fast acting voltage and frequency support functions which can be selected as either active or disabled and operate in parallel to other operating modes, local energy smoothing to manage fluctuations and minimise the diesel schedule index, real/reactive power set-point mode where the BESS responds to a central controller commands at settable ramp rates, and a manually settable output daily profile with hourly slots.

The purpose of **Subproject 4 - Ambu Solar PV and BESS Hybrid System** is to provide grid support and load shifting, absorb fluctuations from solar generation and to avoid starting of another diesel generator, minimising diesel use by maintaining longer periods where the system can run in the lower diesel schedule. The BESS, in conjunction with the solar farm, will be capable of grid forming.

The purpose of **Subproject 5 – Solar School Systems BESS** is to provide grid forming capabilities to ensure that the system can operate without a diesel generator, load shifting of solar daytime generation for night-time output, an autonomy time to manage days of low solar generation, and overall system control and SCADA functionality.

The functionality of the BESS for Subprojects 2, 3 and 4 shall also include:

1. Operation of the battery inverter in parallel with at least one diesel generator, and in the absence of any diesel generators (zero diesel mode)[2].
2. Micro-grid and Energy Management System (EMS) managing and controlling the entire grid for on-grid and off-grid applications.
3. Charge and discharge of real and reactive power to support the loads on the grid and manage frequency and voltage.
4. Ensuring smooth and reliable operation of the power station, with high renewable penetration as required under this project.
5. Metering and monitoring the performance and operation of the BESS.
6. Management of all internal system functions required for operation.

[2] Subproject 2 & 3 is only expected to operate in zero diesel mode when hydropower output is available. That is, the Honiara Grid is not expected to operate on solar PV-battery alone.

7. Visual presentation of system status and operational information to local system operators
8. Ease of maintenance and long operational life.
9. Communication with the SCADA and power station control.
10. Functions to minimise parasitic loads while the BESS is in standby or not in use.

3.2 Usage Profile

The charge and discharge profile of the BESS is heavily dependent on new evolving power system conditions, and particularly the introduction of solar energy generation. However, primarily the BESS will be used to provide ramp rate control in order to provide spinning reserve, minimise the diesel schedule index for the Honiara grid to smoothen fluctuations from solar generation and to provide grid forming capabilities. To this end, the defined usage profile for the BESS shall be as follows:

a. At dawn, start at SOC_{min_EOL}
b. Over next 10 hours, charge at varying power to $SOC_{max\_EOL.}$ Includes zero charge and charge at rated solar generation maximum (≥1000 kW) for at least 10 minutes when very near $SOC_{max\_EOL.}$
c. Over next 8 hours, discharge at varying power to $SOC_{min\_EOL.}$ Includes zero discharge and discharge at rated solar generation maximum (≥1000 kW) for at least 10 minutes when very near $SOC_{min\_EOL.}$
d. SOC_{min_EOL} held for remainder of day
e. Repeat each day. Daily energy discharge equals the BESS Usable Energy Capacity at EOL.

Where: SOC_{min_EOL} and SOC_{max_EOL} are the respective SOC_{min} and SOC_{max} selected to limit BESS range to simulate BESS capacity at EOL.

Because the power system is evolving, in practice it is expected that initial throughput will be lower, increasing over time, and there may be instances where the total daily throughput exceeds the energy storage capacity (EOL rating). As such, this specification requires that the BESS and its warranties robustly achieve the required performance and longevity in a wide range of usage scenarios.

Note that there should be no idle time restrictions on the BESS (i.e. it may be called upon to operate at any time). Nor should there be any restrictions on continuity of charge or discharge cycles.

3.3 Topology

The BESS shall be both operationally modular (all systems required for operation included), and physically modular. To satisfy the physically modular requirement, the BESS should be supplied housed in one (1) or more physical enclosures of weight and dimensions suitable for transport to site. The enclosures should provide the required protection from the environment and be able to be simply installed on footings prepared on site. Where there is more than one enclosure, an electrical and communications connection (only) shall be made between enclosures. Additional electrical connections required for earthing and lightning

protection are acceptable. All enclosures types shall have an adequate IP for the site, not less than IP65.

The BESS shall include sufficient space, as may be required under battery module warranty conditions, for the addition of modules in the event of failure to meet warrantied performance or functional guarantees.

For information that may assist in logistics for delivery of the BESS, including shipping information, please refer to Section 6 Employer Requirements: Supplementary Information

3.3.1 Topology of Honiara BESS and Honiara East BESS (Subproject 2 & 3)

Particular requirements apply to the Honiara BESS and Honiara East BESS in terms of modularity. The design, equipment selection, and implementation must be sufficient to ensure that the there are multiple independent units of BESS, each of which may be relocated and installed at other sites with an available equivalent point of connection. Such relocation and installation must be achievable with minimum effort, minimal impact on other BESS units, full ongoing manufacturer support (as applicable), and generally continuing to meet the requirements of this specification.

Each BESS unit shall include: Battery rack(s); inverter(s); controller; transformer; switchgear (noting that switchgear is not required to be relocatable).

4. Site and construction requirements

For **Subproject 2**, the BESS will be located at the Honiara Power Station. A proposed location has been identified adjacent and to the north-east of the Honiara Substation in the eastern area of the power station boundaries. There is land area available for future modest expansion as more renewable energy is installed on the Honiara grid.

For **Subproject 3**, the BESS will be located at the Honiara East Substation. A proposed location has been identified adjacent and to the north of the Honiara East Substation in the north-eastern area of the property boundary. The site is currently being developed with several storage warehouses under construction. The BESS will be located adjacent to the new buildings in an area that has been previously cleared and levelled.

For **Subproject 4**, the BESS will be located on the Auki grid adjacent to the proposed solar farm in this renewable energy development project in Ambu. The area requires vegetation clearance There is significant area for future expansion of the BESS. **Subproject 5** sites are two schools in one or two of either Malaita or Guadacanal provinces of the Solomon Islands. The sites consist of a school with multiple classrooms within a village community context. Installation on site must adhere to AS/NZS 5139 including fire barriers and protection. The BESS must be contained adjacent to the solar farm.

The Contractor is required to undertake all civil works as required for the sites.

Please note the following:

1. Environmental and social safeguards as noted in *Section 6: Employer Requirements*.
2. Work practices, as described in *Section 6: Attachment A –General and Electrical*.
3. Geotechnical and soil resistivity data for the site are not available and the contractor is expected to carry out necessary testing as part of its design.
4. To protect the BESS against inundation of the site, the footings for the BESS must be at least 500 mm above the 0.1%AEP flood level.
5. BESS housing to be provided with marine resistant coating as specified for mounting structure and cabinets.
6. There are existing concealed and underground services on-site that may not be fully mapped. The Contractor shall undertake its own investigations to confirm.

The Contractor must ensure that the BESS configuration is appropriate for the site. This includes due consideration of impacts to other activities at the site, such as access to other equipment and safety. Placement must ensure sufficient access to the BESS for O&M activities.

5. Design Requirements

5.1 General Considerations for Design

5.1.1 Subproject 2,3 and 4

- The BESS is required to operate in true grid-forming (V/F) mode, in conjunction with the existing diesel generators and the planned renewable generation. Grid forming is as follows:
    - The BESS must have a full grid forming capable inverter (i.e. voltage sourced – voltage controlled operation) irrespective of number of online diesel generators. It should not change the control mode to current controlled (i.e. grid following) during the normal operation or under any network faults conditions. This will be the main mode of operation for this BESS facility. For Subproject 4, the grid forming function of the BESS inverter shall be sufficient to support system strength requirement of solar PV inverter(s) and to provide fault response for various contingency events. Contactor shall provide sufficient documentary or modelling evidence to support the above requirement.
    - BESS must be capable of operating in parallel with other diesel generation, renewable energy generation, and BESS systems also operating in a voltage-controlled mode.
    - BESS must be capable of receiving real power, reactive power, power factor and voltage set points or targets for charging/discharging or reactive power control while in grid forming mode depending on the excess solar PV generation or load balance in the network.
- The BESS will be required to provide a reliable source of instantly available active and reactive power to support the grid through abnormal or fault conditions, or unplanned variation in generation output.
- Speed response is pivotal to the successful operation of the BESS.
- The storage levels specified are the minimum requirements and the Company has the option to provide higher storage levels if it is a requirement to achieve the desired active power levels at the inverter terminals.
- Diesel generator online capacity may be lower than grid load (shortfall made up by renewable energy, sudden increase in load, or genset trip). The BESS must contribute with frequency and voltage regulation and to fault currents within its capability.
- Islanded grids have very low inertia compared to traditional grids and can become unbalanced in timeframes of tens of milliseconds. The BESS is required to operate robustly to meet this characteristic and rapidly react to regulate the system.

5.2 Environment

The BESS shall be designed and installed such that the specified performance (including internal environmental requirements) is achieved for full range of environmental conditions at

site for the full design life. This should have due consideration for site conditions as mentioned in Section 6:

- Temperature
- Solar irradiance and heating: this is not specified, but bidders should assume high irradiation level and make provisions for appropriate enclosures and also shades to allow the reading of equipment data as well as to perform O&M tasks
- Humidity
- Altitude
- Corrosive/saline environments
- Rainfall
- Wind
- Dust levels
- Ventilation
- Seasonal variation
- Storms and cyclones
- Risk of site inundation from flood, storm surges and overtopping wave events
- Risk of seismic events

5.3 Operation and maintenance

The BESS should be designed to allow for safe and easy maintenance by local operators. This should be achieved through adherence to the following principles:

1. Major equipment of the BESS must have plug-and-play capability, allowing for replacement of faulty components by local staff by following O&M manuals and without requiring onerous removal of other components for access. It is essential that nearly all maintenance tasks are undertaken without complex procedures, reprogramming, specialist skills or high-risk activities. Except in rare circumstances, all components must be replaceable through a standard procedure of shut-down, isolation, disconnection, removal, replacement, reconnection, removal of isolation and start-up.
2. As much as possible, the requirement for on-site high-level technical expertise should be limited. Maintenance processes must be designed for completion by local staff with appropriate training.
3. Full sets of operation and maintenance manuals to be provided on-site in physical and digital format.
4. Full set of electrical, civil and mechanical drawings to be provided on-site in physical and digital format.
5. The BESS should have the capacity to identify all potential warning and fault events and communicate these to Solomon Power’s SCADA in a standard format.
6. Troubleshooting and fault rectification processes must be clearly laid out in system operation and maintenance manuals.

7. Complete and comprehensive labelling of all electrical components, wiring, and connections to be provided in English, for ready reference to system schematics and electrical drawings. All labels shall be permanent (not stickers).
8. Comprehensively support isolation and ‘lock and tag’ procedures.
9. Appropriate lockable isolation points for all sources of energy.
10. Solomon Power-acceptable access and egress provisions, including aisle widths, emergency exits, clearances around cabinet doors and adequate lighting and ventilation.
11. Safe access, such as equipment that is properly designed for arc flash and eliminating exposed live equipment (including within cabinets if they need to be opened without first being isolated).

The BESS, including all sub-systems and components, will present relevant information concerning system status, operation mode and fault events in a format that is well labelled, in English, and is clear and easy to read and interpret by local operators. The BESS shall allow sufficient local operator control for O&M works. This is in addition to SCADA interfaces. All HMI will be located so that it is safe to use and sufficiently accessible for its role.

Comprehensive training in all operational and maintenance requirements for the BESS and control systems shall be provided as described in Section 6, Appendix A.

5.4 Design life and workmanship

The design life of the BESS should be achieved in the proposed operating environment. O&M procedures must list all items that require replacement to achieve this life, including indicative replacement/repair intervals with consideration of site conditions and usage profile as per Section 3.2 and 3.3.

The BESS shall be designed and installed such that all components will remain safe, operational, and maintainable for the entire design life using O&M procedures. The design and installation must be sufficient to meet specified performance throughout the design life without any refurbishment that is not nominated in the O&M procedures.

Fits and tolerances shall be given in accordance with AS/NZS Standards. Fits shall be selected for the smooth functioning of the components for the design life.

While selecting materials and their finishes, due regard shall be given to the humid, saline, tropical conditions under which equipment is to operate. Material specifications, including grade or class shall be shown on drawings submitted for approval. The BESS shall incorporate all necessary passive corrosion protection sufficient to achieve the design life in the site environmental conditions. Corrosion protection will include all internal systems (taking into account levels of atmospheric moisture, salt, dust, etc). Corrosion protection will not require major maintenance, such as replacement of major components or surface protections (sacrificial materials designed for replacement is acceptable). Electronic equipment should be suitably coated.

Any evidence of corrosion, degradation or leakage during defects liability period will be treated as a defect if it has potential to impact expected life or may introduce O&M challenges or additional work.

6. Scope of Works

The Scope of Work for the BESS is the design, documentation, certification, supply, delivery, installation, testing and commissioning of a modularised BESS. The scope shall also include training and capacity building of local staff to operate and maintain the system as well as provide warranties for equipment and workmanship and functional guarantees and defects liability for the complete system as a whole.

Works shall include but not be limited to the following:

1. Supply and installation of new modular BESS that meets the Employer Requirements.
2. Interface and connection to the Solomon Power power station control systems.
3. Connection to new and existing switchboards, switchgear and distribution systems.
4. All system lightning and surge protection as required.
5. All system earthing and equipotential bonding as required.
6. Interface to conduits, ducting or cableways existing or installed under other works packages.
7. Supply and install all cable management equipment, supports, trays, ladder and conduit etc. including trenching, ducting and catenary wires.
8. Provision of data and communications cabling for interface of BESS with Employer SCADA.
9. Supply, installation and testing of communications cabling, outlets, frames etc.
10. Label all circuits and provide a complete updated circuit schedule for the entire new and existing electrical distribution system.
11. Co-ordination with the Electrical Supply and Distribution Authority for provision and approval of services to the site.
12. Co-ordination and liaison with the Employer's Representative and Owner's Engineer at the outset and throughout the entirety project.
13. Submission of a full set of system design drawings and associated design documentation for review and approval prior to any equipment procurement or commencing works on site.
14. Subproject 2, 3 and 4 only: Submission of a suitable Power Factory model of the BESS to assist the Employer in integrating the BESS into the network and examine future operational scenarios when additional RE generation is connected
15. Submission of a project programme including witness and hold points for review and approval prior to commencing works onsite.
16. Submission of a testing plan for review and approval prior to commencing factory acceptance tests. Testing plan to be based on Employer requirements provided during detailed design.
17. Submission of a testing and commissioning plan for review and approval prior to commencing works onsite. Testing plan to be based on Employer requirements provided during detailed design.
18. Submission of shop drawings, equipment datasheets and vendor data for review and approval prior to the commencement of works onsite.
19. Submission of Operations and Maintenance Manuals for review and approval prior to practical completion.

20. Submission of As-Built Drawings and other construction drawings for approval and verification prior to practical completion.
21. Provide training and capacity building of local staff in the operation, maintenance and safety of the system.
22. Supply of mandatory spares, which are all spares expected for the initial period of operation.
23. Supply of a full set of tools and instruments required for the maintenance and operation of the system.

7. Specification

This Specification lists the technical features that the BESS must satisfy within the Scope of Work in meeting the Intended Purpose. The other Employer Requirements provide additional detail.

7.1 General and electrical

The BESS will comply with general and electrical requirements as described in *Attachment A – General and Electrical* and the additional requirements detailed in this document.

7.2 Connection points

When connecting the BESS to its Connection points the Contractor will provide all necessary equipment, including cable and cable supports, and will undertake all civil and installation works associated with the connection. The Contractor will terminate all cables and make proper connection to the connected devices.

7.3 Electrical arrangement

As well as meeting other Employer Requirements, the design of the BESS must appropriately address the following:

1. BESS transformer must be independently mounted, separate and external from the PCS.
2. BESS transformer may be dry or ONAN type, but must be in general compliance with the intent of *Attachment A – General and Electrical.*
3. BESS must allow its transformer to be energised with practical in-rush currents.
4. BESS must have considerable redundancy to equipment faults. Small or frequent faults should not lead to BESS outage or unpredictable operation.
5. BESS must have at least **two (2) separate strings of cells** so that the BESS will operate without interruption or limitation (other than a proportional loss of energy storage capacity and power capability) if any string was to fault or trip.
6. BESS should have modularity to allow altered configurations for self-testing (i.e. so can act as a number of smaller BESS to allow one to discharge into another and vice versa).
7. BESS must have energy metering at LV side of transformer and separate metering for any internal or external auxiliary circuits. Metering should be sufficient for measuring whole of system round trip efficiency.
8. BESS must have practical and lockable isolation points on all energy sources to allow all installation, commissioning and O&M tasks to be conducted safely without excessive personal protection equipment.
9. BESS must have suitable circuit breakers and/or fuses to protect equipment and limit arc flash and other safety risks. The DC bus should have sufficient fuses/protection to address arc flash risk without requiring excessive personal protection equipment.

10. BESS must be configured and include sufficient UPS (uninterruptable power supply) to allow safe and controlled shutdown without any operator intervention when external supplies are lost. It is expected that UPS should allow for at least eight (8) hour operation.
11. All BESS internal loads should be self-powered. Contractor may consider installing a separate LV supply from the mains grid if this can be shown to offer performance advantages. This connection must be metered as per a standard LV customer connection and any consumption included in efficiency calculations.
12. The BESS shall continuously maintain a suitable internal air temperature and humidity that complies with all warranty requirements and design provisions. The Contractor will configure the HVAC system and enclosure insulation to minimise running costs. This includes avoiding unnecessary heating in cool ambient conditions.
13. The BESS shall be configured so that it cannot be operated outside warranty conditions, unless for explicit cases as agreed with the Employer.

For Subproject 2, the Honiara BESS transformer shall be a Star/Delta (Ynd) 11/0.6kV. The Contractor shall determine how an earth reference is established and maintained for all auxiliaries on the LV side.

For Subproject 3, the Honiara East BESS transformer shall be Delta/Star (Dyn) 33/0.6kV.

The Contractor is to confirm the adequacy of its transformer designs and selection, including impedance, and present this to Solomon Power for endorsement prior to procurement.

7.3.1 Conceptual Functional Layout

Figure 7-1 depicts an example BESS configuration that illustrates the envisioned functional arrangement. The Contactor's design may be different but demonstrate the same or better functionality.

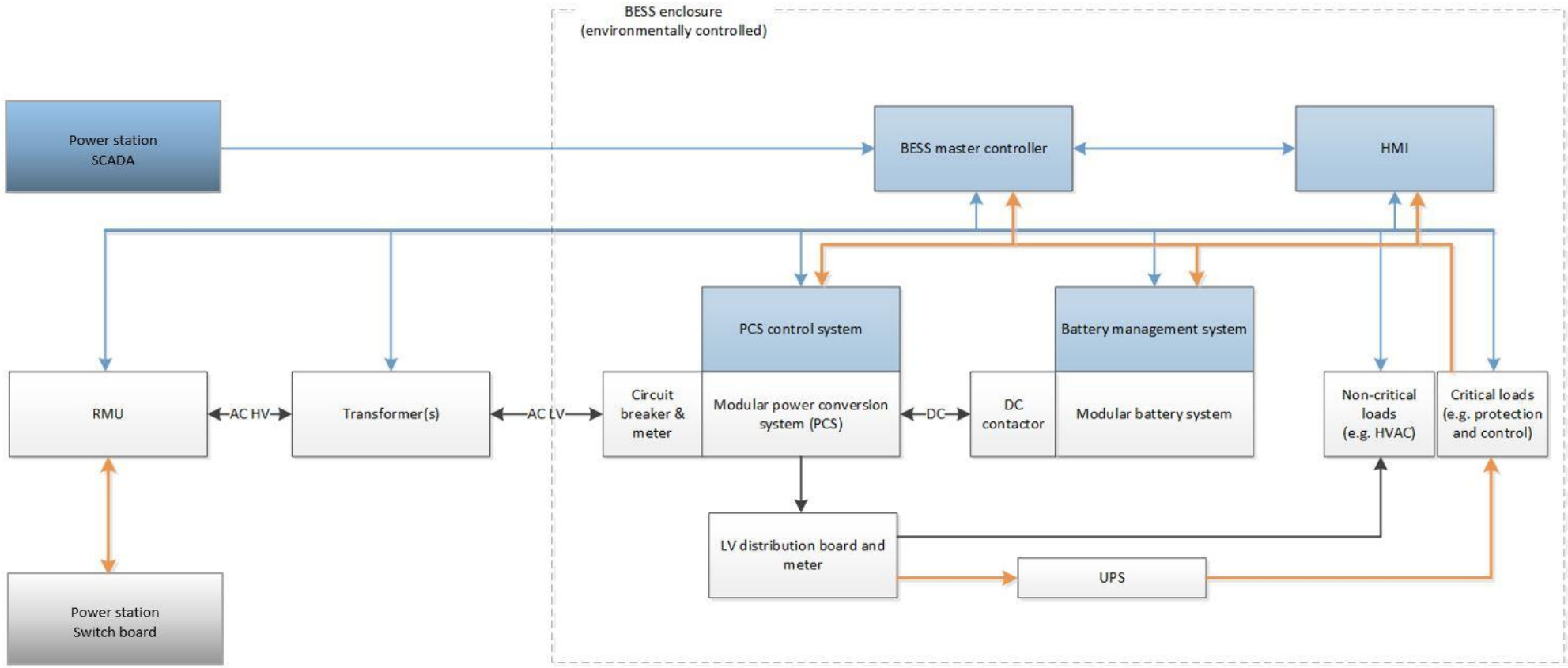


Figure 7-1 Subproject 2, 3 and 4 BESS concept layout

Notes:

- Blue paths show communications and control links for SCADA system, orange is for critical supplies and black is primary electrical.

7.4 Equipment arrangement

The following requirements shall be met. Note that where personnel access inside the BESS is not possible, corresponding requirements do not apply.

Table 6-1 Equipment arrangement detail

Item	Requirement
[a] Modular	BESS must be designed as modular unit(s), such as containerised systems or kiosks, which have been fully factory assembled. Modular units should be able to be comprehensively factory tested as a complete BESS, easily disassembled for safe transportation to site and installed with minimal on-site work. A shade is to be provided for the BESS kiosks, if containers are not proposed, to ensure proper visualisation of the screens and other monitoring tools available.
[b] Building code	BESS enclosure(s) must meet relevant provisions for safe access and egress, and other applicable regulations as a permanent structure at the project site. The BESS will be installed outside at the project site and will be exposed to all weather.
[c] AS/NZS 3000	BESS must fully comply with AS/NZS 3000 when treated as a switch room, including all minimum access requirements, clearances for cabinet doors, access to lift heavy equipment and sufficient emergency exits. For any areas not covered by AS/NZS 3000, the design shall generally meet the level of safety and design philosophies intended by AS/NZS 3000 and, where appropriate, the requirements of IEC 61936-1.
[d] Panels	BESS must meet IEC 60439-1:1999 with panels built to Form 3.b. or higher.
[e] General access	BESS must not interfere with or reduce access to other nearby equipment or buildings. Refinement of the layout will occur during detailed design.
[f] BESS access	BESS configuration and internal layout must provide suitable safe access to all equipment for installation, commissioning, O&M (including emergency repair) in all weather conditions. BESS must include all landings and stairs external to the BESS so that it can be safely accessed in all conditions for all purposes.

Item	Requirement
[g] Flood	BESS must be sufficiently above ground level to eliminate water run-off and flood risks. Minimum height of the footings above existing ground level is 500 mm
[h] Security lighting	Security lighting (sensor activated) will be installed on the BESS to illuminate surrounding areas. This will be done in a way that minimises light pollution for neighbouring residents.
[i] Access lighting	Lighting will be provided at entrance point(s) to the BESS, and in internal access areas of the BESS. Lighting must be sufficient to allow full operation and maintenance, including at night.
[j] Emergency exits	Emergency exits must comply with relevant standards. Safety bars will be provided on doors. Floor surface, step dimensions and handrails must provide safe exit. Aisle widths, protrusions into aisles and panel door clearances must provide unobscured access. Emergency exit lighting must be sufficient. Generally, at least two emergency exits are required for containerised modules.
[k] Security	The BESS will be able to be secured against unauthorised access. Doors shall be lockable using a common key (no padlocks).
[l] Access for authorised persons	Safe access and egress of the BESS will be provided for O&M. This shall ensure separation of pedestrians and vehicles, and provision of stairs and handrails for elevated access points. Provision shall also be made for an awning or other sheltered area directly outside the BESS to facilitate access in wet conditions. Internal configuration will be designed to safely allow all required operations and maintenance activities, including replacement of cells. The internal ambient conditions must be appropriate for the types of work to be undertaken.

<table>
<tr><th>Item</th><th>Requirement</th></tr>
<tr><td>[m] Human Machine Interface (HMI)</td><td>The BESS shall have a physical HMI located within the BESS envelope in a position where is it safe to use while the BESS is in operation. The HMI shall also be available (remote access) on a supplied PC installed in the power station control room.

The BESS HMI must be configured so that the Employer can operate, control and interrogate the BESS at the BESS location (i.e. locally). This includes:

a. Displaying all detailed alarms
b. Displaying BESS system data suitable for operation and fault finding
c. Locally controlling the BESS, such as providing charge and discharge set points
d. Locally enter BESS operation modes, such as charge to a target SOC, charge to a string target voltage and cell state of heath checks.
e. Setting configurable parameters, such as adjusting ramp rates
f. Providing detailed performance and system data logs

The Contractor will provide remote access to the HMI at a separate PC located in the power station control centre.</td></tr>
<tr><td>[n] Degree of ingress protection</td><td>At least IP65 (or otherwise demonstrated that site conditions, including cyclones and insects, will not affect equipment operation).
Appropriate measures will be applied to all penetrations to ensure the required degree of ingress protection is maintained.
Ingress protection shall meet the requirements of IEC 60529. Degrees of protection provided by enclosures for electrical equipment.
BESS shall have sufficient drainage to prevent any water pooling.</td></tr>
<tr><td>[o] Corrosion protection</td><td>Enclosures and all exposed equipment should satisfy Category 5M conditions ISO 12944. All enclosed equipment must be suitably protected from corrosion. HVAC systems should be designed to minimise entry of salt laden air.
Contractors shall describe their corrosion prevention design in their bid documents.</td></tr>
<tr><td>[p] Noise</td><td>Contractors may use appropriate shield barriers or earthworks designs to meet noise limitations and obtain compliance at the urban receivers.
Contractors must adhere to SP HSE SOP02 Hearing Conservation Procedures as well as World Bank EHS Noise Level Guidelines, as defined:

<table>
<tr><th rowspan="2">Receptor</th><th colspan="2">One Hour LAeq (dBA)</th></tr>
<tr><th>Day time 07:00 - 22:00</th><th>Night time 22:00 - 07:00</th></tr>
<tr><td>Residential, institutional, educational</td><td>55</td><td>45</td></tr>
<tr><td>Industrial, commercial</td><td>70</td><td>70</td></tr>
</table>
</td></tr>
</table>

Item	Requirement
[q] Materials	Presence of all hazardous material must be clearly documented. The BESS shall be configured to prevent escape or personal contact of hazardous material. The BESS will include appropriate first aid equipment for contact with hazardous materials. All hazardous material shall have a clear documented method of safe disposal. Hazardous materials with potential for significant environmental or safety impacts (for instance, loss of life) shall not be included in the BESS design.
[r] Fire	The BESS shall include certification to UL9540A, and provision for venting of explosive gasses. A fire safety assessment shall be carried out and findings implemented. The BESS will include a high-quality early warning fire detection system and sufficient hand-held fire extinguishers at a minimum. The fire detection system shall be appropriate for early detection and isolation of all credible fires and be suitable for integration into a standard fire detection system (with fire indication panel) for the power station. Depending on the fire risk a fire suppression system may be required. All fire-fighting chemicals must be suitable for use in Solomon Islands. The BESS will be configured such that if there is a fire that all hazardous materials are suitably contained. This includes release of the contaminated or hazardous fire-fighting materials into the environment. BESS to be installed must adhere to all requirements of AS/NZS 5139. **Subproject 5** must include fire protection and barriers which meet AS/NZS 5139.
[s] Fabrication	Designs shall eliminate any requirements for on-site fabrication and welding.
[t] External colour	The external colour of the BESS shall be agreed with the Employer, taking into account that managing solar heat gain in accordance with the BESS design shall be the overriding factor.
[u] Signage	Safety signage shall be installed in accordance with relevant Solomon Power requirements and applicable standards.
[v] Branding	Any branding applied to the BESS or its surroundings requires approval by the Employer. Generally, low profile branding only to identify the supplier / manufacturer of the BESS will be acceptable.
[w] Storage of spares	Sufficient storage facilities for supplied spares shall be included within the BESS.
[x] Cell replacement	Where the BESS cells have a different life to the BESS, the BESS shall be configured to ensure cells can be replaced without disassembling or significant alteration to the BESS.

Item	Requirement
[y] Disposal	Should any BESS component fail (including damage by fire) during the warranty period, the OEM shall be responsible for removing and safely disposing of the failed part. Any failed parts shall not be left at the site.
[z] Bunding	BESS containers and infrastructure must be provided with appropriate spill containment (bunding or otherwise) that includes provision for management of firewater run-off. Any designs must minimise contamination and damage to the nearby environment. It is recommended that the design adheres to AS4681-2000 Section 7.3.9

7.5 Performance

7.5.1 Power

The BESS must achieve the power performances across its Usable Range:

1. Continuous (rated) power must always be available, even following overloads.
2. Overload power must always be available and be maintained for at least the set time limit, unless there has been a separate overload within the previous 10 minutes.
    a. Overload (2 second) must allow the BESS inverter to operate at 1.5 times (150%) of the BESS's rated inverter power capacity and meet the requirements of UNIFI Consortium's UNIFI-2022-2-1 standard for grid-forming inverter-based resources.
    b. Overload (60 second) of 120% of the BESS inverter capacity must be continuously maintained for at least 60 seconds.
    c. Access to intermediate overloads, such as 120% of rated for 10 minutes (or similar) should be offered if supported by the proposed equipment.
3. Full four quadrant capability is maintained at all power levels (including overload). Four quadrant capability at or below continuous power rating must be without restriction (i.e. when charted as kW vs kVAr the capability is circular).
4. The power performance of the BESS must have no degradation over the design life.
5. SOC_{min} and SOC_{max} must be defined, and any potential movement detailed, in the tender documents. This is the Usable Range.
6. Predictable power performance, based on BESS capability and design limits, will be provided for use of the BESS between 0% SOC to SOC_{min} and between SOC_{max} to 100% SOC.
7. The BESS shall not be de-rated in any way due to ambient environmental conditions that have historically been encountered at the Project site.

Where bidders offer a different power capability under the functional guarantee, these levels shall be adjusted accordingly.

7.5.2 Energy storage

The BESS must achieve the energy storage specified assuming the specified usage profile, with the following requirements:

1. For the purpose of any tests, SOC will be the reported SOC from the BESS control system.
2. BESS energy storage capacity must be inclusive of all site ambient conditions and discharge conditions.
3. BESS energy storage capacity degradation (loss of storage capacity over time) must be robust to the wide variety of operating conditions possible at the site.

7.5.3 Miscellaneous

Table 6-3 provides further performance requirements.

Table 6-3 Performance detail

Item	Requirement
[a] Round trip efficiency (RTE)	Round trip efficiency shall be maximised through the minimisation of auxiliary loads, including during standby. All batteries must have a round trip efficiency of more than 90%. Suitable proof shall be submitted.
[b] Availability	As per functional guarantee.
[c] Self-discharge	Self-discharge must be a no more than 5 % of storage capacity discharged per month. 2 % self-discharge is preferred.
[d] Reliability	MTBF > **90 days**. Failures include any fault that requires the BESS to be removed from service, de-rated or interrupted in any way or requires an O&M action that was not scheduled.
[e] Cell replacement	No more than 10 % of cells should require replacement due to faults during their design life. During the defects liability period, cell replacement shall not exceed a pro-rata rate based on this requirement.
[f] BESS models	**Subproject 2, 3 and 4:** Powerfactory models will be supplied to assist the Employer in integrating the BESS into the power system.

7.6 Protection

The BESS must have sufficient capability to operate effectively on the grid at its connection. This includes ability to ride through grid instability, self-protection, compatible harmonics and SCADA communications of developing faults. Table 6-4 provides specific detail.

Table 6-4 Protection detail

Item	Requirement
[a] Local circuit breaker	The BESS shall include electrical protection in the form of circuit breakers on the low voltage side of the transformer suitable for BESS self-protection and isolation. The BESS shall be capable of remote operation of the local circuit breaker, for both connection and disconnection. Remote operation shall include operation via a command issued from the Employer SCADA, and operation via a manual start / stop button (with e-stop capability) located at the BESS site (but away from the immediate location of the local circuit breaker).
[b] Voltage fluctuations	Voltage fluctuations shall comply with the current standard IEC61000.3.7:2012. Compatibility levels defined in Table 1 of the standard.
[c] Voltage imbalance	Voltage unbalance shall be less than 2% as a 30 minute average and less than 3% as a 1 minute average.
[d] Faults	The BESS shall detect and isolate all credible faults or hazardous conditions that may affect safety, security or result in asset damage. The BESS shall activate any internal systems that are intended to reduce severity (e.g. fire suppression).
[e] Protection response	The BESS must detect and isolate all credible faults or hazardous conditions that may affect safety, security or result in asset damage. The BESS shall activate any internal systems that are intended to reduce severity (e.g. fire suppression). Internal faults should be isolated as close as practical to the affected equipment so that the BESS will still operate without interruption at a reduced capacity if safe to do so (i.e. if a string has a fault, then it is isolated and the BESS continues with the remaining strings). Unpredictable BESS operation will cause power system instability and has considerable potential to cause the entire power system to fail (e.g. black out). The BESS must be configured so that if an error with the BESS is developing (e.g. equipment over-temperature) the BESS shall notify the Employers controller via the SCADA so that the Employers controller can command the BESS to idle (i.e. zero charge and discharge) after it has activated additional equipment to ensure the power system will remain stable. This will typically occur within 60 seconds.

Item	Requirement
	a. If an error occurs that does not have an immediate risk to safety or plant (e.g. power station controller communication loss) then the BESS will: i. Send the appropriate fault code to the SCADA; ii. Override the power station controller and ramp down in a controlled manner; and iii. Disconnect, shut down or remain at idle as appropriate. iv. The ramp rate will configurable across a wide range. b. In rare circumstances the BESS may have a fault that requires it to trip immediately for safety or to protect plant (e.g. e-stop). In these cases the BESS shall: i. Disconnect or shut down as rapidly as possible; and ii. Send the appropriate fault code to the SCADA.
[f] Protection study	The Contractor shall undertake a protection study (including review of existing equipment settings for the coordination of protections systems) to demonstrate suitability of BESS protection settings in the network.
[g] Emergency stop	Hard wired and fail-safe emergency stops must be included.

7.7 Grid support functionality

7.7.1 Frequency support

(a) The BESS must be capable of responding independently on a configurable droop curve in response to frequency deviations, without receiving external control signals.

(b) Droop set point will be set based on studies conducted by the Contractor as part of the design of the Facility for the purpose of maintaining network stability.

(c) In addition, during a sudden frequency drop (high ROCOF) situations BESS shall mimic an inertia response of a synchronous machine through its grid forming control system. This synthetic inertia response shall be configured by the Company as part of the design of the Facility for the purpose of maintaining network stability.

7.7.2 Frequency withstand capability

(a) Under frequency variations, the solar PV and BESS must remain connected and fully operational for duration as shown in the following table.

Frequency		Time
Hz	p.u.	
> 55.0	> 1.10	Automatic disconnection allowed if so desired by the VRE Operator after 1 second
> 53.0 – 55.0	> 1.06 – 1.10	10 seconds
> 52.0 – 53.0	> 1.04 – 1.06	2 minutes
> 51.5 – 52.0	> 1.03 – 1.04	10 minutes

48.5 – 51.5	0.97 – 1.03	Continuous operation
48 – < 48.5	0.96 – < 0.97	60 minutes
47 – < 48.0	0.94 – < 0.96	2 minutes
45.0 – < 47.0	0.90 – <0.94	10 seconds
< 45.0	< 0.90	1 second

(b) Frequency ride through settings must be configurable in at least six bands between 45 Hz and 55 Hz. If default capability of equipment exceeds this requirement, the default capability must be maintained and accessible to the Employer without restriction.

7.7.3 Rate of change of Frequency

(a) RoCoF withstand capability mentioned does not mean that equipment manufacturer or developer intentionally set the unit to trip with RoCoF protection. For BESS rate of change of frequency (RoCoF) protection should be disabled unless absolutely essential and agreed with the Employer.

(b) At a minimum, the Facility should be able to remain synchronised to the system during rate of change of system frequency of up to and including 4.0 Hz per second measured at a rolling average over 500 milliseconds.

7.7.4 Active power recovery after a fault

(a) The BESS is required to provide a ramp rate in response to a fault that mimics an inertia response of a synchronous generator. This synthetic inertia response shall be configured by the Company as part of the design of the Facility for the purpose of network stability, and subject to approval by the Employer.

(b) Active power shall be recovered to 95% of the pre-fault value within 100 ms after the fault.

7.7.5 Voltage support

(a) The BESS must be capable of responding on a configurable droop curve to local voltage deviations, without receiving external control signals.

(b) Droop set point will be set based on studies conducted by the Company as part of the design of the Facility, for the purpose of maintaining network stability.

7.7.6 VOLTAGE WITHSTAND CAPABILITY

(a) Under voltage variations, the solar PV and BESS must remain connected and fully operational for duration as shown in the following table.

Voltage (p.u.)	Time	Voltage (p.u.)	Time
≥ 1.30	20 milliseconds	= 0	500 milliseconds
≥ 1.25	200 milliseconds	≤ 0.70	Linear between 500 milliseconds and 2 seconds
≥ 1.20	2 seconds	≤ 0.80	2 seconds
≥ 1.15	20 seconds	≤ 0.90	10 seconds
≥ 1.10	20 minutes	> 0.90	Continuous operation
< 1.10	Continuous operation		

(b) Voltage ride through settings must be configurable in at least six bands between 1.1 and 1.3p.u.. If default capability of equipment exceeds this requirement, the default capability must be maintained and accessible to the Employer without restriction.

7.7.7 Reactive current injection during the fault

(a) Solar PV and BESS inverter shall inject reactive current during the fault (within their capability) based on the amount of remaining system voltage. Amount of reactive current during the contingency shall be equal to 2% for every 1% drop in voltage at the connection point. Reactive current of 2% per 1% drop in voltage is a default setting but it must be capable of setting from 0% - 4% subject to request from the Employer for the purposes of maintaining Network stability following changes in the Network.

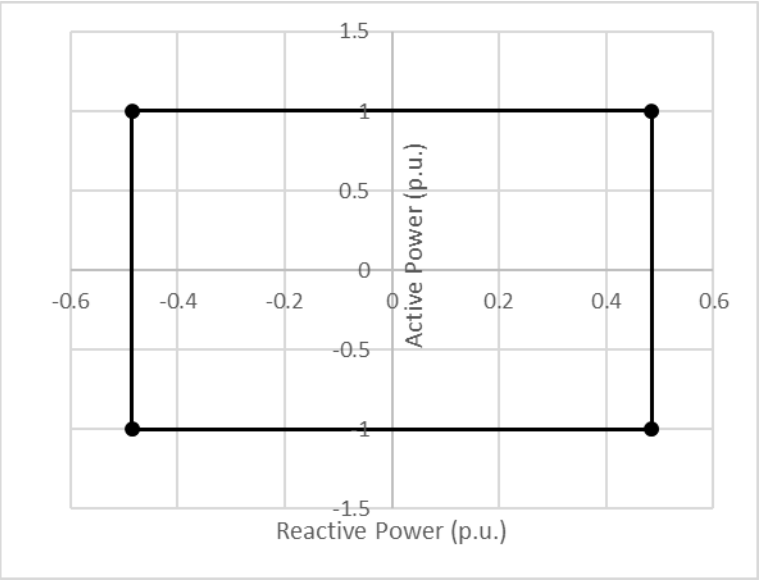
7.7.8 Harmonics

(a) Harmonic mitigation of the BESS is required such that harmonic emissions to the network meet 20% of the MV planning limits provided in AS61000.3.6:2012 for both total harmonic distortion (THD) and individual harmonic limits. The design of the harmonic mitigation measures (including filters if required) shall be demonstrated through a harmonic study.

7.7.9 Reactive power capability

(a) BESS four quadrant operation: The BESS must be capable to operate in any combination of exporting or importing active and reactive power, otherwise known as four quadrant operation.

(c) The minimum operating requirements are shown in the figure below.



7.7.10 Set point response

(a) The BESS inverter must be able to respond to separate command set points from the Employer's SCADA system for the following performance characteristics:

(i) MW

(ii) Mvar

(iii) Power factor

(iv) Voltage

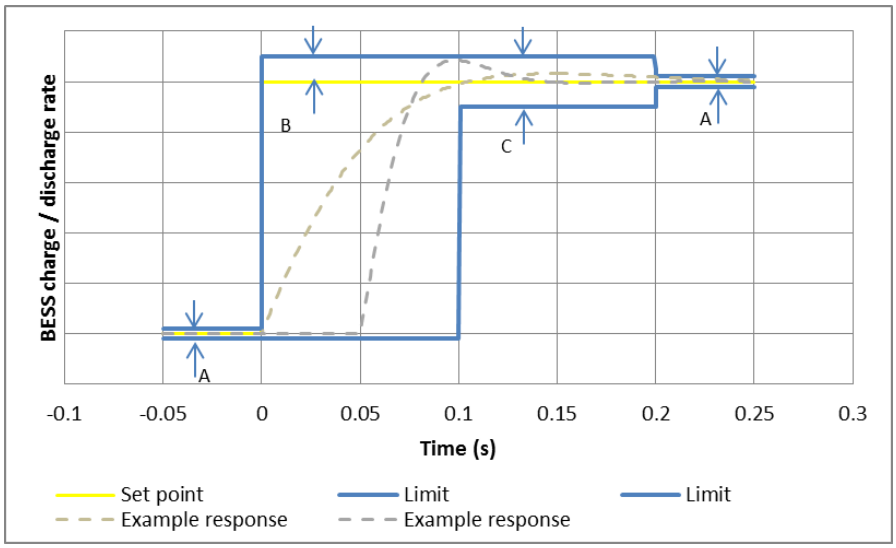
(d) Set point response shall be by bias of the relevant droop curve and grid support functionality shall be maintained, within the active and reactive power capability limits of the BESS and solar PV.

(e) The behavior of the relevant performance characteristic following receipt of a set point command at the Facility SCADA, is subject to any pre-set ramp rate limitations, and limitations on the active and reactive power capability limits of the BESS.

For Subprojects 2 & 3, the BESS must have an overall response time of no more than 50ms to initially reach its reach set point, and no more than 100ms including settling time to allow it to control its power flows sufficiently to follow this set point. The response time is defined as the time that will elapse from when the BESS receives a command at the SCADA connection point to charge or discharge occurs and is stable (measured at output of BESS).

The response time shall be achievable for all charge and discharge combinations and magnitudes.

7.7.11



A – Tolerance on steady state output: 50 kW
B – Maximum overshoot: 10 % of the change in set point
C – Maximum of 20 % of the change in set point

This response time includes, but is not limited to, delays from all signal conversions (including the time to receive the signal), any signal processing or algorithms, cell chemistry, power electronics and transformers.
The BESS shall be capable of achieving any set point commands that are within the operation limits detailed in the Employer Requirements.
The BESS shall override or limit commands that may cause BESS damage (e.g. that exceed the rate of charge).

7.7.12 Loss of communications

(f) In the event of loss of communications, the set point response of the BESS and Solar PV shall automatically revert to a state as agreed with the Employer during design of the Facility.

(g) Upon restoration of communications, the solar PV and BESS plant shall not automatically restore operations but shall assess and issue ready status. Restart of operations shall only be commenced following instruction from the Employer.

7.7.13 Safe shutdown

(h) In the event network fault that leads to power system conditions outside the requirements of this specification, the solar PV plant and BESS must automatically execute a safe and controlled shutdown.

(i) Upon restoration of standard operating conditions, the solar PV and BESS plant shall not automatically restore operations but shall assess and issue ready status. Restart of operations shall only be commenced following instruction from the Employer.

(j) Subject to the limits of the backup power supply of the Facility, communications and essential functions shall remain operational throughout a safe shutdown event.

7.7.14 Black start capability

(k) Black start capability is not mandatory, however may be offered as an option by the tenderer (for Subproject 2 & 3)

7.8 Communications and control

The BESS must have sufficient control functionality and communications to operate effectively on the grid and allow the control system at the power station to schedule and control other equipment in response to BESS state. This includes responding to control signals, SCADA interface, HMI, fail-safe operation and useful control modes. Table 6-5 provides additional specific detail.

Table 6-5 Communication and control detail

Item	Requirement
[a] Wireless communications	No wireless communications are allowed either internal or external to the BESS. If internet access is required as part of warranty conditions and Contractor prefers 4G (or similar) connection, this can be negotiated with appropriate security provisions.
[b] Physical interfaces	**Subproject 2, 3 and 4**: Communications shall be provided using fibre optic cable from the BESS to the SCADA Connection point, and fibre patch to existing infrastructure. The Contractor is responsible for inspecting existing infrastructure at the point of connection and proposing a method of physical connection for review in the design stage. Note: bidders may inspect the point of connection during the site visit or make provisions to allow for possible connection requirements in their design.
[c] BESS master controller	The BESS master controller shall be configured so that the BESS can achieve all Employer Requirements. Additionally, the BESS controller shall: a. Report estimated remaining life of each replaceable battery module b. Individually control battery strings and/or inverters so it can manage string SOC and power capabilities c. Frequently balance individual cell voltages

Item	Requirement
[d] Network inputs	The BESS will receive commands sent by SCADA. The BESS shall act on those commands within appropriate timeframes. As a minimum this will include commands to: a. Connect, energise and start the BESS b. Control charge and discharge power flows to set points c. Control reactive power d. Change BESS modes e. Stop (idle), standby, shut down and disconnect the BESS
[e] Network outputs	The BESS will make available parameter data to the power station controller via the network communication system at appropriate intervals. The power station controller will use these to optimise the power system and manage risk, and requires accurate and frequent updates. The data will also be used for continuous data logging at a one (1) second interval. As a minimum this will include outputs of: a. Alarms to an appropriate level of detail, including of when approaching warranty limits. These alarms will also be summarised in a master alarm that will be communicated to the power station controller for operator alerts. b. Measured charge and discharge power flows c. Maximum available charge and discharge power flows d. BESS mode e. BESS state, including SOC, relevant equipment condition indicators (e.g. string voltages and cell temperature and voltage ranges) and parameters which may affect BESS warranties f. Notification when BESS operation is at or near any warranty limits The maximum available charge and discharge power flows shall be provided with sufficient detail for the BESS to operate within its intended purpose. Failure to set appropriates limits has considerable potential to cause the entire power system to fail (e.g. black out). This requires the BESS to: a. Continually update power maximums based on current system state b. Forecast of power flow limits for the next 60 seconds c. Have high confidence that all indicated power flows are achievable

Item	Requirement
[f] Internet and cloud services	The BESS must operate with full functionality without continuous internet connection or cloud-based data services. Any required (intermittent) connection must demonstrate security.
[g] Idle, standby and shutdown modes	**Subprojects 2,3 and 4**: The BESS must respond to any command when it is 'idle' without any limitations. Idle means that the BESS is fully active but is currently commanded to zero power. The BESS will enter a 'standby' mode when commanded by the power station controller. When commanded, the BESS must automatically restore itself into full service within (1) one second. Standby means that the BESS is active but has shut down some systems for the purpose of reducing energy consumption and/or wear. The BESS will enter a 'shutdown' mode when commanded by the power station controller. When commanded, the BESS must automatically restore itself into full service within (10) ten minutes. Shutdown means that the BESS is inactive and has opened all appropriate breakers/contractors on the LV side of the transformer, but still has active communications.
[h] Uninterruptable power supply (UPS)	The BESS must be configured and have sufficient UPS to achieve safe and controlled shutdown from when any supply or electrical connection is lost. The UPS size will be sufficient to ensure the BESS can restart in a controlled and safe manner, such that no operator intervention is required, for at least (8) eight hours since the major fault if external power is not restored. This includes preventing PLC signals that may unnecessarily trip power system circuit breakers or other undesirable actions. The UPS shall automatically reconnect to the external power supply when the supply is re-activated. This includes when power is solely supplied by the power station backup diesel generator.

7.9 Energy management system

7.9.1 EMS scope of work

The BESS shall include an Energy Management System (EMS) which shall manage BESS operation and have capability to schedule dispatch of different generators and energy storage within the network it is connected to. In respect of the EMS, the Contractor has responsibility for:

Guadalcanal (Subproject 2 & 3): The Contractor must supply an EMS with the BESS. The EMS shall have the functionality described in this section. The EMS shall monitor data available from the SCADA, provide information to the SCADA (and/or via HMI) about the BESS, and make decisions about the best operating mode and charge / discharge of the BESS that support network stability and reduce diesel consumption, to the extent practical. However, the Contractor is not responsible for physical or software interface with, or issuing dispatch instructions to generators and automated energy systems in the grid.

For clarity, since the dispatch and control decisions will rely on a range of third-party systems and will be impacted by ongoing developments such as network SCADA upgrade, development of the Tina River Hydropower facility, and other solar PV plants, the Contractor will not be responsible for full integration and scheduling of systems in the grid.

The Contractor is required to work closely with the Employer during system development, to implement suitable operating states of the BESS applicable to the current state of the grid, to provide capacity building and to allow the Employer necessary control (either via static / manual commands or via SCADA and future dispatch and control systems) of the BESS. The EMS shall be capable of reconfiguration and reprogramming of dispatch functions to support future changes in operation, including potentially the issuance of dispatch commands to other generators in the network. The final functionality of the EMS shall be decided during the design and development phase, in consultation with the Employer, and be documented by the Contractor in the Functional Specification.

Without limitation, and by way of example, the EMS may initially implement, in both BESS, a ramp rate smoothing with a scheduled storage bias during the day to enable better network operation and reduce spill from variable solar PV. At night, it may advise to the network operator its availability and capacity to provide spinning reserve, which the network operator may use to schedule diesel generation. At times when sufficient solar PV and hydropower capacity is available, the BESS may advise capability to operate in diesel off mode, which may then be manually activated and deactivated through operating procedures.

Auki (Subproject 4): The Contractor is fully responsible for dispatch of all generation systems in the Auki grid. The EMS supplied by the contractor must monitor data and issue dispatch and scheduling commands as necessary to minimise diesel consumption while maintaining reliability and safety of the grid. The Contractor must also complete all physical and software interfaces to all generation and automated energy systems in the grid, and undertake commissioning, including testing to ensure correct operation of all systems.

Solar Schools (Subproject 5): As for Auki, the Contractor is fully responsible for dispatch of all generation systems at each school. The EMS may be a proven, proprietary embedded EMS that

automatically manages BESS and Solar PV in an integrated manner suitable for the proposed application, and is not explicitly required to fully meet this specification.

In each system, the Contractor's scope includes: design, documentation, certification, supply, delivery, installation, testing and commissioning of an EMS, including all associated balance of plant, meeting the functional requirements of this specification.

The scope shall also include training and capacity building of local staff to operate and maintain the system as well as provide warranties for equipment and workmanship and performance guarantees and defects liability for the complete system.

The works shall include but not be limited to the following:

- Design of the EMS.
- Supply and installation of EMS including:
    - PLCs.
    - Software packages to allow plant operators to interrogate (and troubleshoot) the system.
    - Racking and cabinets.
    - Power supply converters.
    - Cables and communications and media converters as required.
        - All local communications at the power station, including any supporting infrastructure such as power supplies, cabinets, etc.
        - Communications to remote solar PV plants will be via fibre optic cables, with backup radio communications to a single interface switch and will be provided by others. Contractor is responsible for interfacing to this communications infrastructure.
    - Configuration settings and application backup (in native file format).
- Supply and installation of any required structures, footings, cable management.
- All system lightning and surge protection as required.
- All system earthing and equipotential bonding as required, including interface to existing earth grids as relevant.
- Co-ordination with the site owner for access and coordination of activities.
- Co-ordination and liaison with the Employer's Representative and Owner's Engineer at the outset and throughout the entirety project.
- Submission of documentation as per the documentation deliverables list.
- Provide training and capacity building of local staff in the operation, maintenance and safety of the system.
- Installation of all required temporary facilities.
- Supply of all required spares as per the contract, including storage cabinet or equivalent.
- Supply of a full set of tools required for the maintenance and operation of the system.

- Ensuring compatibility with existing equipment and other plant supplied by the Contractor – especially ensuring that the existing controllers, meters and subsystems are also compatible with the procured equipment.

7.9.2 EMS functionality

The purpose of the EMS is to monitor the system state, issue status information and, where applicable, issue scheduling instructions for dispatch of generating subsystems (thermal plant, solar PV plant, hydropower and BESS, as applicable). The instructions must ensure that system safety requirements, reliability, and power quality requirements are maintained, while minimising use of fuel (diesel), minimising generator run-time and starts.

In particular, the EMS must identify, based on the available renewable energy in the network and the BESS state of charge, when a change in the number of operating diesel generators is required, and when output of solar PV generators shall be curtailed (and when such curtailment shall be released). This information shall be provided to the network SCADA. In Ambu (Malaita) and for Solar School (Guadalcanal / Malaita) systems, curtailment of solar PV where required be automatically actioned by the EMS via the solar PV controller. Otherwise, information provided by the EMS will be acted on by the network operator.

The EMS must:

- Operate proven and configurable algorithms demonstrating reliable operation of hybrid energy systems of a similar scale and providing for optimal dispatch of solar PV and BESS to minimize cost of energy. Capabilities should include:
    - Capability to adapt BESS SoC limits when load shifting to ensure full grid support functionality at all times.
    - Ability to control BESS and solar PV plant under all their intended control modes.
    - Capability to adapt to different configurations of thermal generators (including outages for maintenance) while ensuring redundancy requirements are met.
    - Capability to curtail solar based on grid state.
    - Capability to use real-time local irradiance data to estimate capacity of curtailed solar PV and utilize this in dynamically allocating spinning reserve.
    - Provision for accommodating typical response times of connected generators to dispatch commands, including thermal generator start-up.
    - User configurable (tuneable) settings for inputs to dynamic spinning reserve calculation, ramp times, delays, limits, and conditions for state transition.
- Be operable as a stand-alone system, even when the BESS and solar PV is offline.
- Be separable, such that the existing thermal power plant can continue to operate if the EMS is offline.
- Include an HMI, with remote web access capability, also accessible on the power station operator workstation.
- Provide expansion capability to add or reconfigure BESS, solar PV, or thermal generators over the EMS life.

- The EMS must provide flexibility for future upgrade requirements including new generators or configuration changes. EMS vendor will be required to offer support for such requirements (which may include remote support and site visits if needed). EMS vendor will be required to provide fully documented open-source code on standard industrial hardware or other make other provisions to ensure the EMS is not stranded / left unsupported under any circumstance.
- EMS to have a design life of at least 15 years. O&M procedures must list all items that may require replacement to achieve this life.
- Be designed and installed to ensure all components remain safe in the design life.
- Be accessible to O&M personnel without need for PPE or other special equipment and accessible in all weather conditions. EMS shall not be co-located in DC, LV or MV panel or other location with personnel safety risk.
- Be lockable using a common key (no padlock).

7.9.3 EMS Operation

The EMS is intended to be a PLC based dispatch style controller, issuing instructions and updating data input typically on a time scale of one (1) to two (2) seconds. The EMS is not expected to act as a low-level unit controller (operating at millisecond time scale to balance load or respond to system dynamic events) – these functions are expected to be autonomously performed by the subsystems.

For example, following a thermal generator trip event, the grid forming BESS autonomous controller would instantly provide frequency support, exporting active power to compensate independent of the EMS. Meanwhile, the EMS would register this event, monitor BESS SoC, adjust curtailment limits on solar PV, and flag start of another thermal generator (or potentially forecast planned load shedding).

The EMS should consider credible generation combinations including (where applicable):

- Diesel only
- Diesel + BESS
- Hydro only
- Hydro + BESS
- Solar + BESS
- Diesel + Solar + BESS
- Hydro + Solar + BESS
- Diesel + Hydro + Solar
- Diesel + Hydro + Solar + BESS

7.9.4 EMS robustness to failure

The EMS must utilise high quality, industrial standard equipment including PLCs in compliance with IEC 61131 (or similar with higher quality – to be approved by the employer). Power supplies,

cabinets, cables, connections, switches etc. must also be specified for low failure rates and continuous operation for the design life.

The EMS is not strictly required to have dual redundancy (2N). The EMS must implement failsafe actions to ensure controlled and conservative response to all plausible failure modes, including of the EMS.

7.9.5 EMS safety, reliability and power quality requirements

Requirements for safety, reliability and power quality take precedence over requirements to minimise fossil fuel use or thermal generator runtime and starts.

The EMS, or associated systems monitored by the EMS, must ensure the following requirements are met for operation of the power system:

- All sub-system protections and safety systems not compromised or conflicted.
- Safety interlock system for switching, operation, or shutdown of subsystems.
- Provision for operator initiated controlled and emergency shutdown.
- Provision for safe operation of the EMS, remotely or locally, at any time.
- Inclusion of failsafe automatic response where required for various fault scenarios.

The required system to remain operational under the following contingency events:

- Loss of any single operational generator (single thermal generator, solar PV plant, BESS).
- Loss of any single feeder.
- 80% reduction in solar PV plant output (relative to rated AC capacity) within 10 seconds, as well as a corresponding increase to rated AC capacity.
- Note that if curtailed below rated AC capacity, proportionally less change applies.
- 20% variation in load within 10 seconds.

Each event shall be considered in isolation, however:

- System shall be restored and able to respond to a subsequent contingency event within 300 seconds.
- In the 300 seconds immediately following the loss of any single thermal generator, reliability should be maintained with variation in solar PV output of up to 40% (reduced proportionally if solar PV plant output is constrained) or rated AC capacity and 10% of load.
- Inter-trip operations are not normally expected as part of the EMS but may be required to be implemented in conjunction with the EMS if required to meet these requirements (for example, trip of a large solar plant if the BESS trips when charging).

7.9.6 System states of the EMS

The EMS must demonstrate maintenance of the required system safety, reliability and power quality under plausible system states, transitions between system states, and failure modes.

Where necessary, sub-states may be used to reflect different load conditions, BESS SoC, or different solar resource conditions / forecast.

Under each system state, additional sub-states for failure modes shall be considered. During a failure mode, the intended purpose shall be adhered to the extent possible. Failure modes shall include:

- Action on loss of communications:
    - Specific actions shall be considered for each communication pathway that may experience a loss of communications.
    - Any associated / required automatic response at the subsystem side experiencing loss of communications must be included in the design of the relevant subsystem and made fail-safe.
- Action on subsystem alarm or partial functionality:
    - Alarm response to be consistent with sub-system design for safe operation.
    - To the extent practical, partial functionality shall be dealt with by proportionally reducing contribution of the hybrid sub-systems to the thermal plant operation. Where this is not practical, shutdown of hybrid subsystems may be required.

Typical action in a failure situation may include:

- Increase/decrease online thermal generation or start-stop thermal generation.
- Reduce system variability by curtailing solar PV plant.
- Alter operating mode and grid support functionality of part of the system.
- Altering the BESS SoC target and normal operating limits.
- Controlled shutdown of part or all of the system.

Actions on failure modes and state transitions shall be fully described in a cause-and-effect matrix and/or state diagram to be supplied by the Contractor.

7.9.7 EMS interfaces

The Contractor shall provide full parameter lists for:

- Input data parameters required from thermal plant, BESS, solar PV plant, hydro power or other (e.g. time signal).
- Output data parameters to thermal plant, BESS, solar PV plant, hydropower or other.
- Configurable parameters governing EMS operation, including:
    - Nominal values
    - Recommended values for non-standard operations if applicable (e.g. system test, conservative contingency operation).

All parameters shall specify:

- Data type
- Units
- Allowable range

The Contractor shall provide all required support to the Employer to configure and test data tables in the Employer's SCADA and advise on recommended parameters to archive on the Employer's historian.

7.10 Earthing

Table 6-6 provides earthing detail.

Table 6-6 Earthing detail

Item	Requirement
[a] Earthing	Earthing of the BESS shall be provided in accordance with the requirements of earthing standards (ENA EG0:2010, ENA EG1:2006), and as set out in *Section 6: Attachment A – General and Electrical*
[b] Lightning protection	Lightning protection shall be provided in accordance with IEC 62305 Standard for lightning protection.

7.11 Footings

Table 6-7 provides footing detail.

Table 6-7 Footings detail

Item	Requirement
[a] Footings	Footings will be provided on which to mount the BESS (including the transformer). Footings shall be designed for: ● Adequate elevation for the BESS as per these requirements. ● Sufficient hold-down force for the BESS withstand all site conditions. ● Negative buoyancy in the event of site inundation. ● A safe and stable platform for operation of the BESS, including access and egress as required. ● Cable entries as required.
[b] Drainage	Footings shall make adequate provision for site draining, for both rainfall events and wave inundation events. In particular, footings should not prevent discharge of water from the power station, and should not create any ponding of water on site.

Item	Requirement
[c] Vegetation	Footings shall allow for easy maintenance of vegetation around the BESS and power station. The footing design shall minimise any requirement for maintenance staff to operate gardening machinery (e.g. weed eaters) under the BESS, around cable entry points, in narrow spaces between BESS modules, etc.
[d] Bunding	Transformers shall be bunded in accordance with IEC 61936.
[e] Height	Sufficient to ensure Minimum height of the above flood levels are achieved

8. Inspection and testing

8.1 Quality control

The Contractor shall provide a Quality Management Plan (QMP) that describes the quality control methods for manufacture of all major equipment and equipment installation and testing.

When major equipment relies on manufacturing quality to lessen physically testing (e.g. battery cells) the Contractor will detail the quality control methods, provide evidence of conformance and quantify the expected failure rates.

8.2 Testing

The Facilities must perform according to the Employer Requirements. The Facilities must pass any element of the Employer Requirements if tested, including under worst case conditions within the defined operating envelope.

This specification should be read in conjunction with the testing and commissioning requirements in Section 6.

The facilities shall be subjected to comprehensive acceptance testing in factory and at the project site. The Contractor must ensure the Facilities are able to perform according to the Employer Requirements when tested and must provide appropriate measurement equipment to suitably quantify facilities' performance while under test. Facilities performance must better the Employer Requirements by the declared accuracy of measurement equipment. The following acceptance tests will be performed:

- Factory acceptance test (FAT)
- Mechanical test (MT)
- Functional guarantee test (FGT)

The Contractor will provide detailed Inspection Test Plans (ITPs) for the Employer to review and approve at the appropriate times prior to the tests. The ITPs will detail testing arrangement, test procedures (including pre-conditions), measurement devices (including accuracy and specification sheets) and logging configurations. The ITPs will also detail clear pass/fail criteria that demonstrate compliance with the Employer Requirements inclusive of measurement error.

The Employer will reject ITPs that do not comprehensively prove the capability of the Equipment against the Employer Requirements.

Prior to commencing any acceptance test, the Contractor shall undertake sufficient pre-test checks to be reasonably confident of test success. During acceptance test the Contractor shall have all design information, appropriate tools and experienced personnel on-hand so that the Contractor can rapidly respond to queries and rectify minor issues. The Employer will only supply those raw materials, utilities, lubricants, chemicals, catalysts, facilities, services, and other matters required that have been clearly described in the Contract.

Following completion of each test the Contractor will provide a certified Acceptance Testing Report for Employer review and approval that proves Equipment performance compliance with the associated ITP and lists all known non-conformances. The Contractor will also provide all notes and clearly detailed full records of data logging obtained during tests so that the Employer can independently assess performance.

8.3 Factory acceptance tests (FAT)

The BESS shall be subjected to a comprehensive Factory Acceptance Test (FAT), and demonstrate satisfactory performance, before it is delivered to site.

It is preferable that the BESS be configured as it would be installed for the FAT. However, this testing may also take a modular approach, in which case the proposed FAT must comprehensively assure the Employer that the BESS will function when integrated on site. A modular approach may, for example, be:

- FAT of BESS battery modules and separate FAT of fully integrated BESS excluding modules, provided that a suitable equivalent DC power source is used, and availability of necessary battery management system (BMS) data (including warnings and alarms) to the SCADA can be effectively tested.
- FAT of fully integrated BESS but with only a limited subset of modules (sufficient to supply rated power). Other modules must be separately subject to FAT. Full depth of discharge for the integrated unit may be verified during site commissioning tests.
- FAT of fully integrated BESS units of lower capacity, which are then electrically connected at a high level to provide full required capacity on site, provided that the necessary control functionality can be demonstrated at the module level and that a proven track record exists for integration of the same types of units into a larger system.

Substitution of equipment for testing (such as type testing) may be allowed, but only if the Contractor has adequately demonstrated that the Employer’s intent for FAT is met. If this is

offered, the Employer must be satisfied with all FAT departures, the rigor of their justification and the completeness of the tender response.

Shipment to the Project site will be prohibited until Employer approves the Acceptance Testing Report and the conclusions meet the Employer's requirements.

The Contractor will provide detailed Inspection test plans (ITPs) for the Employer to review during detailed design. The Contractor will perform additional tests that the Employer requests where they are reasonable. The Employer will reject ITPs that to not comprehensively prove the capability of the BESS against the Employer Requirements. FAT must not proceed until all ITPs are agreed.

The scope of the FAT shall be sufficient to:

1. Comprehensively ensure that the equipment operates as agreed in the Employer Requirements
2. Ensure that the equipment operates as intended
3. Allow the Employer to observe operation characteristics that may impact integration to the power station

8.3.1 Power and overloads

Between SOC_{min} and SOC_{max}, measure the overload capability of the BESS to any reasonable precondition. Highly controllable loads and generation are required to run this test.

8.3.2 Capacity and efficiency

The measurement of capacity and round-trip efficiency will be based on the following procedure:

1. Testing is conducted under representative conditions for the site;
2. SOCmax is held for 10 minutes;
3. BESS is discharged at a stated rate until SOCmin is reached;
4. BESS is held at idle for 10 minutes;
5. BESS is charged at the same rate until SOCmax is reached;
6. BESS is held at SOCmax for 10 minutes (or more if required for the BESS to remain within operation limits).
7. BESS is discharged at a stated rate until SOCmin is reached.

Test will be completed for at least continuous rated power. Energy meters are required for all loads.

8.3.3 Other tests

The following, non-exhaustive, tests are also required:

1. Voltage and frequency ride through
2. Harmonics
3. Measure of energy absorbed by ancillary loads
4. Test of HVAC ability to maintain ambient conditions

5. Test of UPS

8.4 Mechanical Test (MT) - commonly referred to as site acceptance testing

The Employer requires pre-commissioning of the complete BESS. Tests may occur during pre-commissioning, commissioning and functional guarantee tests as appropriate and agreed.

The tender response must include a method statement for MT, including concept Inspection test plans (ITP).

The Contractor will provide detailed Inspection test plans (ITPs) for the Employer to review during detailed design. ITPs must include consideration of the limitations of the power system and associated risks. The Contractor will perform additional tests that the Employer requests where they are reasonable. The Employer will reject ITPs that do not comprehensively prove the capability of the BESS against the Employer Requirements, or introduce undue risks to the power station or continuity of power supply. The MT must not proceed until all ITPs are agreed.

The scope of the MT shall be sufficient to:

1. Ensure that the equipment was not damaged in transit
2. Ensure that the equipment was installed correctly
3. Complete tests against the Employer Requirements
4. Confirm operation of integrated system (if integrated system test with all components was not undertaken at the FAT)
5. Observe correct BESS operation in coordination with control inputs for its intended purpose

The Contractor will have sufficient supervision and technical experience on site during MT to undertake works and to rapidly overcome BESS equipment faults, documentation errors and miscommunications.

The Contractor should be aware of the following limitations of the islanded grid issues when compiling the MT ITP:

1. BESS charge and discharge rates are limited by the capacity of the network. High power commands and commands that require rapid changes in power will cause unacceptable power system instability.
2. The power station must be specially configured to prevent instability during specific tests. Factors such as renewable energy generation and system load may prevent appropriate configurations from time to time.
3. Most BESS operations are large enough to change the dynamics of the power station which can affect the validity of many tests.
4. Local manufacturing facilities are limited.
5. Delivery of equipment can be time consuming.
6. Assembling the required specialised personnel can be difficult at remote sites. Significant delay and cost can be incurred if the equipment does not function as intended in the agreed timeframes.

8.5 Functional Guarantee test (FGT)

The Facilities shall be subjected to guarantee testing during and after Commissioning. The grid at the installation site imposes various limits on FGT scope, and some tests may not be possible without introducing undue risks to other equipment or continuity of power supply. The FGT ITP must include consideration of the limitations of the power system and associated risks. The Employer will advise these limits as part of FGT ITP review, and will reject ITPs that introduce undue risks to other equipment or continuity of power supply.

The Contractor is made aware of the following issues common to islanded grids:

1. Facilities charge and discharge power may be limited by the capacity of the power system. High power commands and commands that require rapid changes in power may cause unacceptable power system instability.
2. The power system may need to be specially configured to prevent instability during specific tests. Factors such as renewable energy generation and system load may prevent appropriate configurations from time to time.
3. Facilities operations are large enough to change the dynamics of the power system, affecting the validity of certain tests.
4. Significant delay and cost can be incurred if the Facilities does not function as intended on its first attempt because:
    a. Local manufacturing facilities are very limited
    b. Delivery of equipment can be very time consuming
    c. Assembling specialised personnel can be difficult

The scope of FGT acceptance testing shall be sufficient to:

1. Comprehensively ensure that the Facilities operates as agreed in the Specification (FAT results may replace certain testing if the tests are very likely to pass FGT); and
2. Quantify performance against Functional Guarantees in agreed test conditions.

FGT will be split into the following phases. Separate Acceptance Testing Reports are required at completion of testing for each phase.

Operational Acceptance will be prohibited until Employer approves all Acceptance Testing Reports and the conclusions meet the Employer’s requirements.

9. Documentation

Documentation is to be submitted for the design, quality assurance and final construction of the BESS.

Where noted, documents are to be provided in local language as well as English and on a per installation basis.

Typical deliverables are listed below. These are specific to the BESS.

	Deliverable	**Typical revisions (IFU=issued for use; IFC=issued for construction)**	**Local language version**	**Per installation**
1	**DESIGN**	**Within One (1) month after EFFECTIVE DATE**		
a	Basis of design report, including as attachments, detailed functional specifications for the ESS and BMS	80%		YES
b	AC and DC electrical single line diagrams	30% / 80%		YES
2	**DESIGN**	**Within four (4) months after EFFECTIVE DATE**		
a	Design drawing package to include, at a minimum:			YES
b	Basis of design report, including as attachments, detailed functional specifications for the ESS and BMS	IFU		YES
c	Site layout	30% / 80% / IFC		YES
d	Sub-surface works layout	80% / IFC		YES
e	Earthworks	30% / 80% / IFC		YES
f	Drainage and stormwater management	30% / 80% / IFC		YES
g	Detailed drawings the BESS	30% / 80% / IFC		YES
h	BESS Container Drawings and General Arrangement	80% / IFC		YES
i	Detailed layout drawings of switchboards and panels and electrical fit-out	80% / IFC		YES
j	AC and DC electrical single line diagrams	IFC		YES
k	Electrical schematics of all systems	80% / IFC		YES
l	BESS footing / mounting designs	30% / 80% / IFC		YES
m	Protection details	80% / IFC		YES
n	Earthing drawings	30% / 80% / IFC		YES

	Deliverable	**Typical revisions (IFU=issued for use; IFC=issued for construction)**	**Local language version**	**Per installation**
o	Cable tray section drawings	30% / 80% / IFC		YES
p	Details of interconnection	80% / IFC		YES
q	Details of auxiliary power distribution	30% / 80% / IFC		YES
r	Communications network drawing	30% / 80% / IFC		YES
s	Electrical, Mechanical and Civil Specifications documents, including detailed installation and materials compliance requirements	80% / IFC		YES
t	Protection single line diagram	30% / 80% / IFC		YES
u	Equipment schedules for the following, at a minimum	80% / IFC		YES
v	Cable schedule, including terminations	80% / IFC		YES
w	EMC Report	80% / IFC		YES
x	Protection equipment and ratings schedule	80% / IFC		YES
	Studies:			
a	Arc Flash	80%		
b	Insulation Coordination	80%		
c	Protection and Coordination	80%		
d	Earthing study	30% / 80%		
e	Cable sizing calculations	30% / 80% / IFC		
f	Short circuit study	80%		
g	Safety in Design	30% / 80% / IFC		
h	Fire safety study	30% / IFC		

10. Supplied spares and tools

The Contractor will locally hold a quantity of additional spares during commissioning. These will be selected to prevent long delays during commissioning.

All supplied spare parts shall be of same material / workmanship and interchangeable with the corresponding parts of the executed work, protected against corrosion, have identification labels and marked ‘Approved’. Provision shall be made within the BESS to store any spare parts that require a controlled environment for adequate longevity, such as spare cell modules.

Supplied tools shall be of high quality and fit for purpose. The following tools shall be supplied:

1. All tools and accessories required for maintenance of the system
2. Any customary and special tools, as well as auxiliary devices i.e. lifting devices, ropes, etc. necessary for assembly and disassembly of all parts.
3. Special tools designed and supplied for the project.

Supplied tools can be used by the Contractor during installation and commissioning, however they must be handed over to the Employer in good working condition without any wear and tear.