Employer's Requirements

Battery Energy Storage System (BESS)

Project: Engineering, Procurement and Construction of Hybrid PV-Diesel-Energy Storage System

Location: Pulau Tiga, Maluku, Indonesia

1. Intended purpose

The purpose of the Battery Energy Storage System (BESS) is to store electrical energy for nighttime use or during periods of low solar generation. The BESS shall also work with diesel generators to optimise loading and operate the generators at the highest fuel efficiency.

Solar PV inverters and/or MPPT charge controllers will feed solar energy from the PV arrays into the BESS. Bidders may install dedicated battery and solar PV inverters, or install hybrid PV/BESS inverters. In either case, the BESS must be able to be "grid-forming" when the generators are not running.

As well as charging the batteries, the inverters will draw power from the batteries to supply electrical power at any time during the day and night. The objective shall be to reduce or remove the need to run the diesel generator as much as possible considering the available solar generation and load.

Figure 1: Existing defunct Lead-acid battery in P. Tiga site

1.1 Recommended Sizing

- Bidders are required to determine the size of the BESS in order to provide a minimum Renewable Fraction of 95% throughout the project's lifetime (i.e. the average renewable fraction over 20 years must be at least 95%).
- Details of how to assess the BESS sizing are outlined in Attachment L: Load and modelling assumptions.
- The Employers LCOE optimisation using HOMER has indicated that:
    - The BESS capacity at 100% Depth of Discharge shall be 200 kWh when measured at the AC terminals on commissioning.
    - The total installed battery inverter capacity should be minimum 30kW continuous in the given tropical environment. The peak capacity should be minimum 50kW. This shall be measured on the AC output of the inverters.

1.2 Topology

- Bidders can recommend either operational module systems or kiosk based systems
    - If modular systems are presented then the BESS must be both operationally modular (all systems required for operation included), and physically modular. Modular units should be easily disassembled for safe transportation to site and installed in a way which minimises site BESS assembly work as much as possible.
    - If kiosk-based systems are recommended, then Bidders must consider the difficulty of logistics associated with the site.

2. Specific Equipment Requirements

2.1 General Requirements

2.1.1 Capacity

- The usable capacity of the BESS shall be measured at the connection point to the AC switchboard. It is the total energy that the BESS can discharge in kWh from 100% to 0% State of Charge.
- The operational minimum and maximum State of Charge (SOC) must be defined, and any potential movement detailed, in the bid documents. This is the usable range. In normal operation, the BESS is expected to operate down to 20% state of charge before the generator is switched on.

2.1.2 Power

- The BESS units must achieve the rated power output performances across its usable range.
- Power performance is measured at the BESS connection point to the AC switchboard i.e. is inclusive of inverter losses.
- The continuous (rated) power must always be available, even following overloads.
- The following overload power ratings must be available at least once per 24 hours without any warranty impact:
    - 160% of the specified continuous power requirement must be continuously maintained for at least 1 second
    - 120% of the specified continuous power requirement must be continuously maintained for at least 60 seconds
- The rated power must be achievable at a power factor of 0.8 leading to 0.8 lagging (typical power factor of the load). Outside this range, full four quadrant capability needs to be provided (including overload) to an apparent power at least equal to the rated power requirement.
- The power performance of the BESS must have no degradation over the design life.

2.1.3 Efficiency and Self-Discharge

- The BESS must have a Round trip Efficiency (RTE) of at least 85% in STC. Below the kW round trip efficiency must be as high as practical by minimising parasitic loads. The RTE is measured as total energy generated divided by total energy consumed at all connections.
- Self-discharge must be no more than 5 % of storage capacity discharged per month. A 2% self-discharge is preferred.

2.2 Configuration

For all configurations:

- The BESS must have at least two 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.

- The BESS shall manage all internal system functions required for operation and all internal loads should be self-powered. The BESS shall be able to communicate with the system monitoring and control system (see Section 7).
- 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:
    - Temperature
    - Solar irradiance and heating
    - Humidity
    - Altitude
    - Corrosive/saline environments
    - Rainfall
    - Wind
    - Dust levels
    - Ventilation
    - Seasonal variation
    - Storms
    - Risk of site inundation from flood
    - Risk of seismic events

2.3 Temperature Management

- The BESS must have an active temperature and humidity management system (HVAC) to maintain the required performance and warranty conditions in the expected environmental conditions.
- If BESS has its own internal cooling system, a clear depiction of its operation and maintenance needs must form part of the offer, with a method statement on how to ensure the manufacturer's warranty.
- Bidders must demonstrate that the HVAC is suitable to allow the BESS to continually be able to operate in a high-temperature high-humidity tropical environment on the site without any additional air-conditioning requirement and maintain environmental conditions in accordance and ensuring the manufacturer's warranty performance limitations.
    - Temperature calculations must be submitted in order to demonstrate that the offered HVAC can maintain the required temperature.
- The Contractor must configure any BESS HVAC system and enclosure insulation to minimise running costs and ensure the BESS meets the performance limited warranty.
- If the BESS is to be installed inside the powerhouse then:
    - Bidders must ensure Battery Room has the proper HVAC to ensure the warrantied lifetime and usable energy in BESS after 10 years.
    - The HVAC system shall also have an N-1 redundancy so that in the event of failure of an individual HVAC unit, the Battery Room shall maintain climatic conditions as required by the warranty.
- Contractors may only provide temperature management for the batteries (and excluding the battery inverters) only where the performance and lifetime of the entire BESS can be guaranteed.

- The BESS shall not be derated in any way due to ambient environmental conditions that have historically been encountered at the Project site.

2.4 Safety

- The BESS must have practical and lockable isolation points at the following locations to allow all installation, commissioning, and O&M tasks to be conducted safely without excessive personal protection equipment:
    - DC terminals of each battery or at the end of each battery string
    - DC input to the battery inverter
    - AC terminals of the battery inverter
- 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.
- The BESS shall be configured so that it cannot be operated outside warranty conditions, unless for explicit cases as agreed with the Employer.
- The BESS shall enter a safe and controlled failsafe/passive mode and electricity shall be provided by the diesel generator and solar if:
    - The environmental conditions exceed the warranty conditions, UNLESS the shutdown is intentionally taken out of the failsafe mode, OR
    - Communications to the power station is disconnected or becomes unresponsive, OR
    - There is a major power system fault such as complete power system outage and loss of all electrical supply.
- The BESS will include a high-quality early warning fire detection system and at least two handheld fire extinguishers suitable for all of the equipment installed (evidence that this is not required shall be at the Employers discretion).
- 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.
- Appropriate safety signage shall be installed and must be approved by the Employer.

2.5 Battery inverters

The BESS shall have dedicated or hybrid inverters to provide an AC output as well as allowing the batteries to charge:

- The total installed battery inverter capacity should be minimum 30kW continuous in the given tropical environment. Peak capacity should be minimum 50kW. This shall be measured on the AC output of the inverters.
- The battery inverters must be able to operate in parallel to the diesel generator and also be able to accept diesel generator input to charge the batteries through an in-built AC-DC rectifier.
- The battery inverters must be able to operate without a diesel generator. In zero diesel mode, the battery inverter should be responsible for setting grid frequency and voltage.

- Overall control of the battery inverters as well as the BESS generally must be handled by a system controller (refer to Attachment F: Monitoring & Control).
- For redundancy reasons, a minimum of two three phase sets of battery inverters are required. Each set must operate in parallel. A set of three phase inverters can be made up of one three phase inverter or three, separate single-phase inverters.
- All battery inverters shall be of the exact same make, model, and size across the whole BESS.
- If a hybrid DC coupled topology is used:
    - More than one DC-DC charge controllers, which directly charge the BESS from the solar panels must be included.
    - The controller(s) should be able to communicate as well as log and exchange monitoring data with the overall system controller (refer to Attachment F: Monitoring & Control). This includes the capability for the charge controllers to be monitored remotely (via the overall system controller) on an online portal.
    - The charge controller(s) should be fully programmable and able to charge the lithium-ion batteries chemistry.
    - Charge controllers must be able to communicate with each other and synchronize their charging.
    - It is recommended that the DC-coupled part of the system takes care of no more than 20% of the overall charging of the BESS, with the rest coming from the AC-coupled side.
- The battery inverters should be able to regulate the flow of electricity to the PV inverters, that is coming from the PV arrays through grid frequency-shifting or by communication.
- The Total Harmonic Distortion injected onto the grid by the inverter shall be less than 3%, and the output of the inverter shall be a true sine wave.
- The power conversion efficiency of the battery inverters shall be at least 94%.

Bidders are encouraged to highlight and detail their reasoning for topology preference, e.g. does it achieve a higher efficiency, lower cost, and/or other justifications.

2.6 Standards

- The BESS shall be installed and all work shall be carried out in accordance with relevant Indonesian government statutory requirements.
    - Recognising that OEM products in the international market may not be certified against Indonesian standards, such products will not necessarily be excluded.
    - However, bidders must demonstrate product compliance with ANSI, IEC or ISO standards providing coverage of the same requirements (in particular, including earthing, fire detection, lightning protection, switchgear, signage, and protection).
- If local standards for BESS is not available, an equivelant international standards shall be referenced. Ie; AS/NZS 5139:2019, Electrical installations Safety of battery systems for use with power conversion equipment
- If a requirement included in the Employer Requirements exceeds the applicable standard then the requirement within the Employer Requirements shall be adhered to.

- Non-OEM products and custom installations should be built to the specified standards. These includes standards such as:
    - Technical requirement for parallel connections of installations with distribution networks EN 50549-1:2019 or equivalent
    - Electromagnetic emission EN 55011:2016
    - Interference immunity IEC 61000-3-2:2014
    - Device safety IEC 62109-1:2010, 62109-1:2011
    - Health and safety IEC 62311:2007
- Earthing of the BESS shall be provided in accordance with the requirements of ENA EG0:2010, ENA EG1:2006.
- Lightning and surge protection shall be provided in accordance with Peraturan Umum Instalasi Listrik 2011 (PUIL 2011), IEC:62305 and IEC 60364 Lightning protection.

2.6.1 Operation

- The BESS must be capable of automated restart once the issue causing the BESS to enter the failsafe mode is no longer occurring for enough time (subject to safe restart procedures).
- 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 the frequency or number of charge or discharge cycles per day.

2.7 Location and Installation Requirements

- The BESS shall be installed either:
    - In a dedicated kiosk within the PLTS site.
        - In this case, Bidders shall be required to install all necessary foundations and with a design life in excess of the design life of the BESS.
    - Inside the existing powerhouse with refurbishment requirements outlined in **Section 4**.
- The Contractor must ensure that the BESS configuration is appropriate for the site.
- The BESS must be laid out in such a way as to ensure sufficient and safe access to the BESS for O&M activities and in accordance with a defined maintenance procedure.
- Efforts should be made to minimise the use of space through an efficient layout, with the final site configuration subject to approval by the Employer. Contractors shall provide a drawing showing the layout of the BESS within their Bids.
- The Contractor is required to undertake all civil works required for the site, including (if necessary) the refurbishment of the existing powerhouse to make it suitable for installation of the BESS and all Power Conditioning Equipment (PCE).
- More details on necessary works on the Powerhouse and battery room are included in Attachment B: Remediation and Decommissioning ERQ.

2.8 Battery Lifetime, Operation and Maintenance Considerations

2.8.1 Design life and workmanship

- The design life of the BESS should be at least 10 years in the proposed operating environment.
- Tendered 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.
    - To be clear, it is anticipated that BESS cells/modules may require replacement within this design life, and to that effect may be treated as a consumable.
- Tendered O&M procedures include maintenance of the HVAC system. Sufficient spare parts and consumables for 20 years of operation of the HVAC system must be required.
- The BESS shall be designed and installed such that all components will remain safe, operational and maintainable for the entire design life using tendered 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 tendered O&M procedures.
- 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.

2.8.2 Battery life

- A manufacturer backed warranty must be provided for the inverters and batteries. If a kiosk system is proposed then a manufacturer backed warranty must be provided for the whole kiosk.
- The BESS warranty should guarantee at least 60% of original nameplate capacity and with no battery replacements:
    - After 10 years of operation and;
    - After an energy throughput equivalent to one full cycle per day.
- Any conditions or operations that tend to accelerate BESS degradation beyond the nominated amount must be detailed in the tender documents.
- In order to ensure warranty e.g. 60% output after 10 years, the BESS must be kept at a specific temperature.

- Bidders must indicate the expected capacity and energy throughput at the end of lifetime

2.9 Reliability

- The Mean Time Between Failure (MTBF) should be > 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.
- No more than 10% of cells should require replacement due to faults during their warranty life.
- During the defects liability period, cell replacement shall not exceed a pro-rata rate based.

2.10 Decommissioning and waste management

- Tenderers should identify potential waste management procedures for recycling or disposing of the energy storage system and its components at the end of their lifetime.

2.11 Performance Monitoring

The BESS must achieve the energy storage performances assuming the specified usage profile (including capacity and round trip efficiency), with the following requirements:

- The BESS shall be charged to 100% SoC to start the test.
- The BESS is then discharged at rated power to 20% SoC before being immediately charged to 100%.
- Measurements shall be taken at the switchboard connection point and inclusive of all BESS loads. I.e. BESS energy storage capacity is inclusive of all HVAC and parasitic loads.
- For the purpose of any tests, the SOC can be the reported SOC from the BESS control system rather.
- The total capacity (from 0% to 100% SoC) and round trip efficiency will be determined based on these measurements.
- Contractors may repeat this test up to five times.

2.11.1 Specified Usage Profile

The charge and discharge profile of the BESS is heavily dependent on evolving demand and generation. The Employer requires that the BESS and its warranties achieve the required performance and life in a wide range of usage scenarios.

The following usage profile shall be used when the Employer Requirements requires reference to a usage profile including evaluation of warranties:

1. Start at 20% SoC at 6am local solar time;
2. Over next 10 hours, the BESS:
   a. Performs a solar smoothing role (partial cloud) to maintain supply
   b. Opportunistic charging from solar when the solar generation exceeds load and the generator is off.
   c. Charging from the generator if the generator is switched on and the BESS is not isolated.

   d. During this period, the BESS will operating in grid forming mode when the generator is switched off
   e. At the end of this period, the BESS will be at 100% SoC.
3. Discharge at 25-100% rated power for 14 hours until:
   a. 6am when the SoC shall be 20%. OR
   b. The BESS SoC is 20% and the generator is started.
4. Repeat each day for the life of the BESS.

The daily energy throughput (measured on discharge) equals the energy across the usable range of the BESS (i.e. one full cycle per day).

3. Scope of Works

Contractors shall complete the following Scope of Work:

- Supply and install all BESS components in accordance with the specific equipment requirements.
- Supply and installation of a thermal management system (HVAC) in accordance with the specific equipment requirements.
- Installation of all civil structures/foundations as needed for all components of the BESS.
- Supply and install all cabling and switchgear required, rated at the appropriate sizes.
- Specify cable length and diameter carefully to optimise system efficiency.
- Supply and install all interfaces and connections to the existing network.
- Supply and install all system lightning and surge protection as required.
- Supply and install all system earthing and equipotential bonding as required.
- Supply and install all terminations between batteries and battery inverters in accordance to manufacturer specifications. No installation practices or terminations shall be used that may void manufacturer warranties
- Training and capacity building for local staff for operation and maintenance.

4. Optional Items

4.1 Local content optional (TKDN)

- Tenderers are encouraged to submit and propose an alternative energy storage system that complies with Indonesia's TKDN regulation Permenperin No. 5 tahun 2017 for renewable energy projects.
- BESS should be Li-ion technology. Tenderers should specify any deviations/differences that the TKDN BESS has with this technical specification and also in comparison to the non-TKDN option selected.