

# Large BESS Integration



### The Challenge

Ergon Energy Network operates 33 isolated networks, which have historically relied on diesel generation to supply electricity. These networks are now experiencing a shift towards greater integration of renewable energy sources.

As renewable generation increases, there is a growing need for additional Battery Energy Storage System (BESS) capacity. This is particularly important when the amount of renewable energy produced exceeds the network's demand, as BESS units can store the surplus energy for later use.

The introduction of increased BESS capacity offers several benefits. It reduces the operating hours required for diesel generators, which in turn leads to lower overall network costs and a reduction in emissions from diesel generation. This supports more sustainable and cost-effective electricity supply across the isolated networks.

To ensure that the BESS and its associated control schemes can operate effectively alongside existing onsite diesel and distributed renewable generation, integration testing was carried out at the Microgrid and Isolated Systems Test (MIST) facility. This testing aimed to confirm that the batteries could coordinate seamlessly with other generation sources to support network stability and reliability.

After testing, the BESS will be installed at a site located in a remote part of Queensland that is often difficult to access for extended periods during the year. Because of this, it was essential to thoroughly validate system performance and resolve any design issues during the MIST testing phase. This approach helped build confidence in the system's reliability and ensured that any necessary adjustments could be made before deployment to the remote location.

### Test Procedures

The BESS, along with its coupling transformer and associated switchgear, was integrated into the MIST test environment to conduct a series of comprehensive tests. The primary objectives of these procedures were to ensure the stability of the BESS, its integration with the other power station controllers and to take highspeed measurements to allow validation of the BESS's model. The MIST test setup replicated the equipment at the BESS's final installation site as much as feasible with the same diesel generator and controllers used in the MIST as will be installed onsite.

### Stability Verification

A range of network operating scenarios were performed to verify the stability of the BESS. This involved assessing the BESS's performance under various load and generation conditions to ensure consistent and reliable operation across different modes of network demand and supply.

### Integration Testing

Integration testing was carried out between the BESS controller and the site's hybrid resource controller. This process aimed to confirm that both controllers could communicate effectively and operate in a coordinated manner, supporting seamless transitions and maintaining network reliability.

### Control Algorithm Tuning

The procedures also facilitated the tuning of the BESS control algorithms for both grid-following and grid-forming operating modes. This tuning was essential to ensure stable operation of the BESS when working alongside onsite diesel generation, allowing the system to adapt dynamically to changes in the network.

### Diesel-On to Diesel-Off Transition Testing

A key focus of the testing was the transition from diesel-on to diesel-off operation. These tests were conducted to ensure that the BESS could be brought online and take over as the sole source of power in the network. The procedure aimed to confirm that the BESS could manage this transition smoothly and maintain network stability throughout the process.

### Model Validation

Voltage and current waveform recordings were acquired during the tests to capture the BESS's performance in detail. This high-resolution data enabled validation of the BESS inverter's electromagnetic transient (EMT) model, providing further confidence in the system's operational characteristics.

### Our Approach

The BESS skid was connected to the MIST low voltage (LV) bus via the MIST's dedicated marshalling boxes. This setup provided a reliable interface for integrating various components necessary for the testing procedures. A single line diagram of the test setup is provided in Figure 1.

To assess the BESS's performance during operational transitions, a diesel generator and a load bank were also connected to the LV bus. These elements were essential for simulating the diesel-on to diesel-off transition and verifying the stable operation of the BESS when synchronised with the diesel generator.

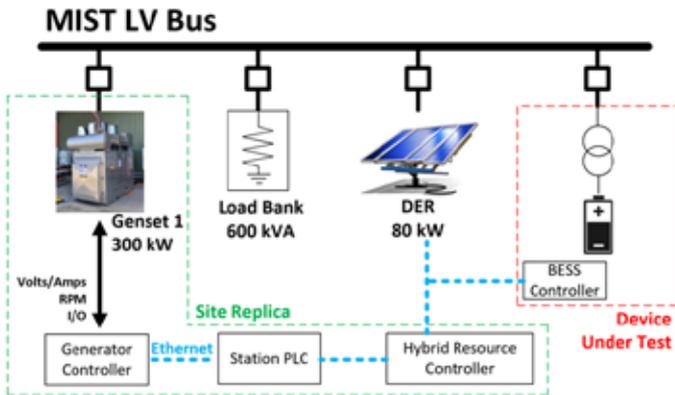


Figure 1: Test setup within the MIST facility.

To facilitate integration testing and to advance the development of the site's controller, the hybrid resource controller designated for the remote power station was installed within the MIST facility. A dedicated connection was established between this controller and the BESS's controller, supporting coordinated operations and enabling further refinement of control strategies.

High-speed monitoring equipment was installed at both the diesel generator and BESS connection points. This arrangement ensured that waveform-level data could be accurately captured during testing. The detailed data collected allowed for precise stability assessments and provided the necessary information to validate the EMT model of the BESS inverter.

The BESS installed at the MIST facility is shown in Figure 2.



Figure 2: BESS installed at the MIST Facility.

## Test Results and Analysis

### Control Design Improvements

Testing within the controlled environment of the MIST facility enabled significant enhancements to the control design. These improvements focused on achieving better integration between the BESS controller and the site's hybrid resource controller. By conducting comprehensive tests, the team was able to identify and resolve integration challenges, leading to more reliable and coordinated operations between the two controllers.

## Verification of System Stability

The testing process also served to verify the stability of both the BESS and the generator during critical operational transitions, specifically during the handover from diesel-on to diesel-off modes. In the diesel-on scenario, the diesel generator provides the grid-forming reference with the BESS in grid-following. In contrast in diesel-off mode, the BESS operates in grid-forming isochronous mode with the diesel generation switched off. A variety of load scenarios were tested to ensure that the BESS could transition smoothly from grid-following to grid-forming operation while maintaining stable performance. An example of the BESS synchronising to the generator and transitioning from grid-forming to grid-following is shown in Figure 3.

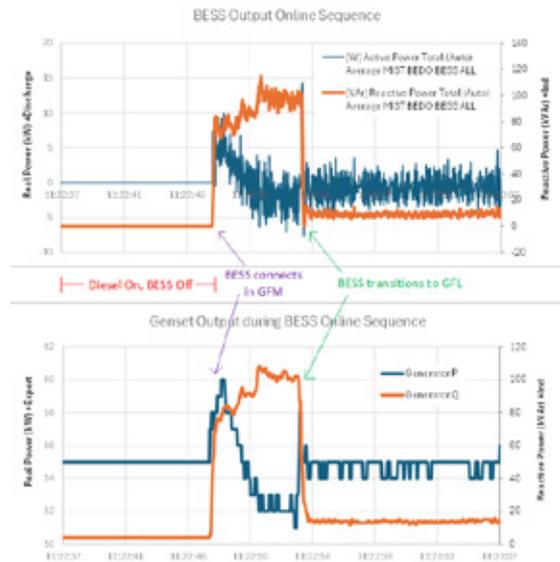


Figure 3: Active and reactive power recordings for the BESS and generator.

## Waveform Recordings and Data Analysis

During the tests, detailed recordings from both the BESS and the generator were captured using power quality analysers. These measurements provided valuable insights into the system's dynamic behaviour under different conditions. The data collected during these tests was instrumental in validating the EMT model of the BESS inverter.

## Model Validation and Scenario Simulations

In addition to supporting improved tuning of the BESS inverter's stability, the measurements taken during testing also enabled the modelling of additional site-specific scenarios. Some of these scenarios could not be physically replicated within the MIST facility, but by using the validated EMT model, these situations could be simulated with greater accuracy prior to installing the system onsite.

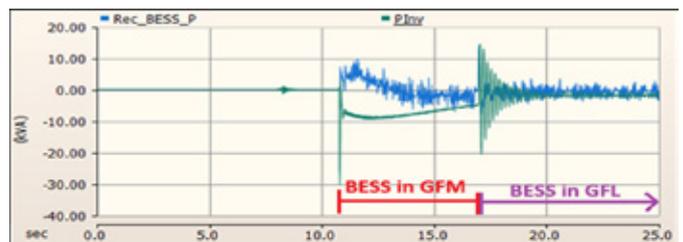


Figure 4: Comparison between BESS's measured response (blue) and modelled response (green).

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