ESCRI-SA Battery Energy Storage Project Operational Report #1

First six months (14/12/2018 – 14/6/2019)

July 2019

In partnership with:

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This activity received funding from ARENA as part of their Advancing Renewables Program.

ARENA
Australian Government
Australian Renewable Energy Agency

Contents

Glossary of Terms

Term	Description
AEMO	Australian Energy Market Operator
ARENA	Australian Renewable Energy Agency
BESS	Battery Energy Storage System
BOA	Battery Operating Agreement
CPP	Consolidated Power Projects Australia Pty Ltd
EPC	Engineering, Procurement, and Construction
ESCOSA	Essential Services Commission of South Australia
ESCRI-SA	Energy Storage for Commercial Renewable Integration, South Australia
ESD	Energy Storage Device
FCAS	Frequency Control Ancillary Services
FFR	Fast Frequency Response
GPS	Generator Performance Standards
Hz	Hertz
Hz/s	Hertz per second
IDS	Island Detection Scheme
ITR	Inspection Test Report
kV	Kilovolts
MGC	Micro Grid Controller
MVP	Minimum Viable Product
MW	Megawatts
MWh	Megawatt hours
MWs	Megawatt seconds
NEM	National Electricity Market
NER	National Electricity Rules
PSSE	Power System Simulator for Engineering
RoCoF	Rate-of-change-of-frequency
SA	South Australia
SCADA	Supervisory Control And Data Acquisition
SIPS	System Integrity Protection Scheme
SOC	State of Charge
SRMTMP	Safety, Reliability, Maintenance and Technical Management Plan
WPWF	Wattle Point Wind Farm

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1. Document Purpose and Distribution

1.1 Purpose of Document

This document is a public report issued as part of the Knowledge Sharing commitments of Phase 3 of the Energy Storage for Commercial Renewables, South Australia (ESCRI-SA Project), in accordance with the Funding Agreement between ElectraNet and the Australian Renewable Energy Agency (ARENA), which has contributed funding support through its Advancing Renewables Programme.

ESCRI-SA involves the installation of a 30 MW, 8 MWh Battery Energy Storage System (BESS) at Dalrymple on the Yorke Peninsula of South Australia. Phase 1 of the Project completed in 2015 involved preliminary business case work, Phase 2 was the actual procurement, installation, and commissioning and Stage 3 is the operation of the asset.

Two public reports on Phase 2 have been published:

- The “Project Summary Report – The Journey to Financial Close”, which was published in May 2018 detailing the approach and resolution of issues required to commence the Project, which is referred to herein as the “Project Summary Report”
- The “ESCRI-SA Battery Energy Storage Project Commissioning Report – From Financial Close to Commissioning”, which was published in October 2018 detailing the journey and lessons learnt in project delivery through to commissioning, which is referred to herein as the “Project Commissioning Report”

This Project Operational Report is the first of four six-monthly Operational Reports required under Phase 3 and focusses specifically on core components of the Project operation, and lessons learnt on the journey from commissioning to full operation, including:

- Close out/update on final Commissioning items
- Listed system defects at commercial handover, and their resolution
- Current operational status and key storage metrics for the reporting period
- Overview and analysis of key events for the reporting period
- Portal operation and usage
- Demonstration of key BESS regulated services, including analysis of unserved energy events, modelled reduction of interconnector Rate of Change of Frequency (RoCoF) constraint and test response rates for participation in the System Integration Protection Scheme (SIPS)
- Demonstration of key BESS market services, including revenue from energy arbitrage and Frequency Control Ancillary Services (FCAS)
- Overview of system maintenance, faults and resolutions

Over the course of the Project a wide range of Knowledge Sharing work is being undertaken, including delivery of a range of reports, presentations, meetings and site visits.

Access to the full list of Knowledge Sharing resources as well as operational information and data is available at the Project Portal (the Portal), at http://escri-sa.com.au/, which is described in Section 4.4.

1.2 Intended Distribution

This document is intended for the public domain and has no distribution restrictions.

2. Introduction

2.1 Project Context

The ESCRI-SA Project has been part funded by ARENA and began as a concept in 2013 to explore the role of energy storage in a future with more variable renewable energy-based generation within Australia's larger interconnected energy system.

This concept evolved into a consortium consisting of ElectraNet, AGL and WorleyParsons (the Consortium[1]), that jointly explored the business case for a non-hydro energy storage device (Phase 1). This was followed by the installation and commissioning of a BESS (Phase 2) and now operation of the BESS (Phase 3).

This Operational Report (Report) covers the first six months of operation of the ESCRI-SA Project and represents one of the key Knowledge Sharing deliverables required under Milestone 4 of the Funding Agreement between ElectraNet and ARENA and follows on from the Project Commissioning Report which was published in October 2018.

The intention of this Operational Report is to describe the journey and lessons learnt from project commissioning and the first six months of operation. To do this, the Report covers the final components of commissioning and the first six months of commercial operation from 14 December 2018 to 14 June 2019.

Section 1 describes the Report's purpose, the intended audience and any distribution restrictions. This section also includes a link to the on-line portal where all Project Knowledge Sharing information is located.

Section 2 provides context for the Project including a description of the system, configuration, operational priorities and key project objectives.

Section 3 covers the close out of commissioning of the system, including updates on remaining commissioning testing, the status of the Engineering, Procurement and Construction (EPC) contract and the resolution of defects listed at commercial handover.

Section 4 provides a summary of the BESS operation over the reporting period including key storage metrics, key events and operation and usage of the portal.

Section 5 outlines the key BESS regulated services that have been demonstrated over the reporting period, covering un-served energy, any reduction of the interconnector RoCoF constraints and participation in the System Integration Protection Scheme.

Section 6 outlines the key BESS market services that have been demonstrated over the reporting period covering the revenue from energy arbitrage and FCAS services as well as consideration of future revenue streams.

Section 7 provides information on general operational issues including maintenance, safety incidents, stakeholder issues and any market non-compliance incidents.

Section 8 summarises the key lessons learnt in the journey from commissioning through the first six months of commercial operation.

[1] The parties and their roles are described in Section 9 along with a contact for Project enquiries

2.2 Overview of ESCRI-SA BESS System and Operation

The ESCRI-SA BESS system, a 30 MW, 8 MWh large-scale battery system, is connected to ElectraNet's Dalrymple substation, seven kilometres south-west of Stansbury on the lower Yorke Peninsula in South Australia, about 200 km from Adelaide.

Figure 2-1: Aerial photograph of Dalrymple BESS and the Dalrymple substation looking south

The Dalrymple substation is radially supplied via Hummocks and Ardrossan West substations. The BESS connection point is at a two 25 MVA 132/33 kV transformer substation.

In some ways Dalrymple's local electricity supply system can be considered a smaller version of the South Australian power system, as it includes significant local renewable energy generation at the nearby Wattle Point Wind Farm (90 MW) and has solar PV (about 3.4 MW total inverter capacity) installed on local customer rooves.

The local maximum demand at Dalrymple is about 8 MW, but the average demand is significantly lower at about 3 MW.

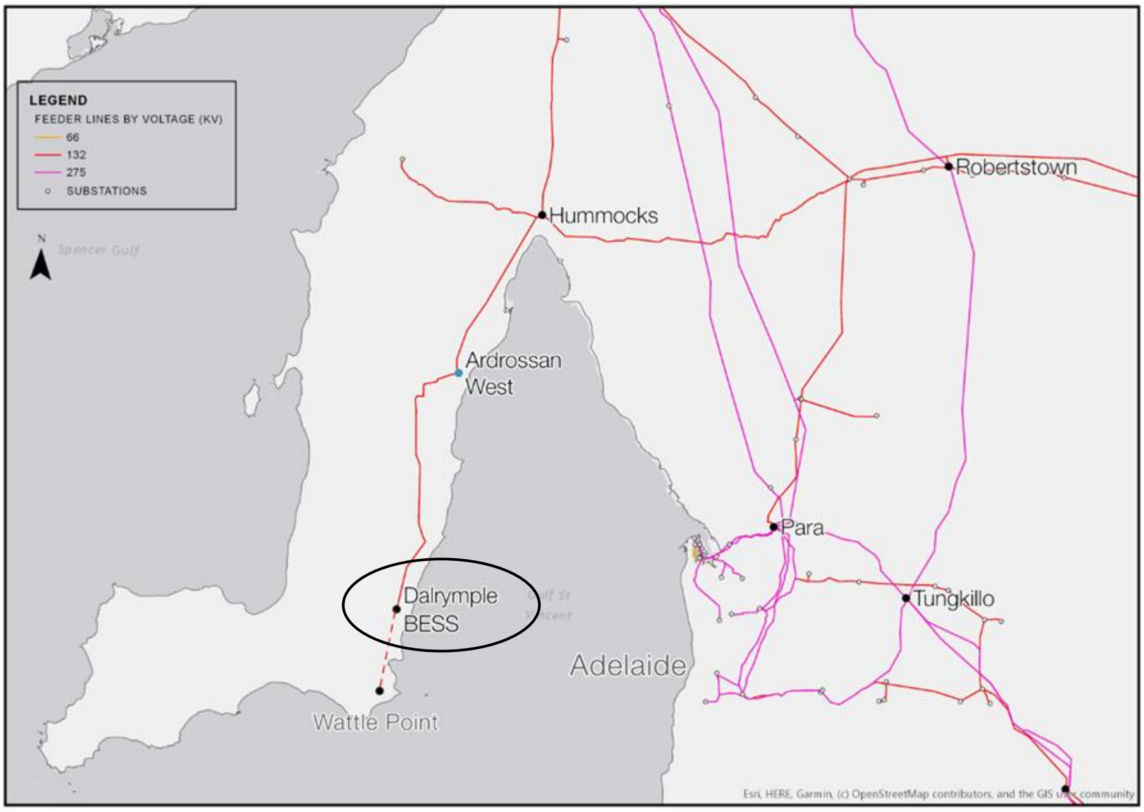

Figure 2-2: Dalrymple connection point relative to existing transmission assets

The Wattle Point Wind Farm, as is normal for wind farms, is only able to operate if a reference frequency is available from the power system. This means that if either the Hummocks to Ardrossan West 132 kV line or the Ardrossan West to Dalrymple 132 kV line is out of service, the local Dalrymple demand will be unsupplied, and the Wattle Point Wind Farm (WPWF) will also be out of service.

The installation of the BESS has provided the ability to supply the local Dalrymple demand in such situations and allow the WPWF to contribute – this means it can run in island mode with the wind farm as part of that island.

Analysis of the Dalrymple connection point performance for the period from 2006 to 2014, indicated that there were 22 interruptions to supply, totalling 35.18 hours. This equates to an average yearly loss of supply of 3.52 hours and 9.46 MWh.

Our analysis indicated that 8 MWh of energy storage, if operated in conjunction with a small part of the WPWF, would enable the local Dalrymple demand to be supplied during 96-98% of unplanned outages of the relevant 132 kV lines.

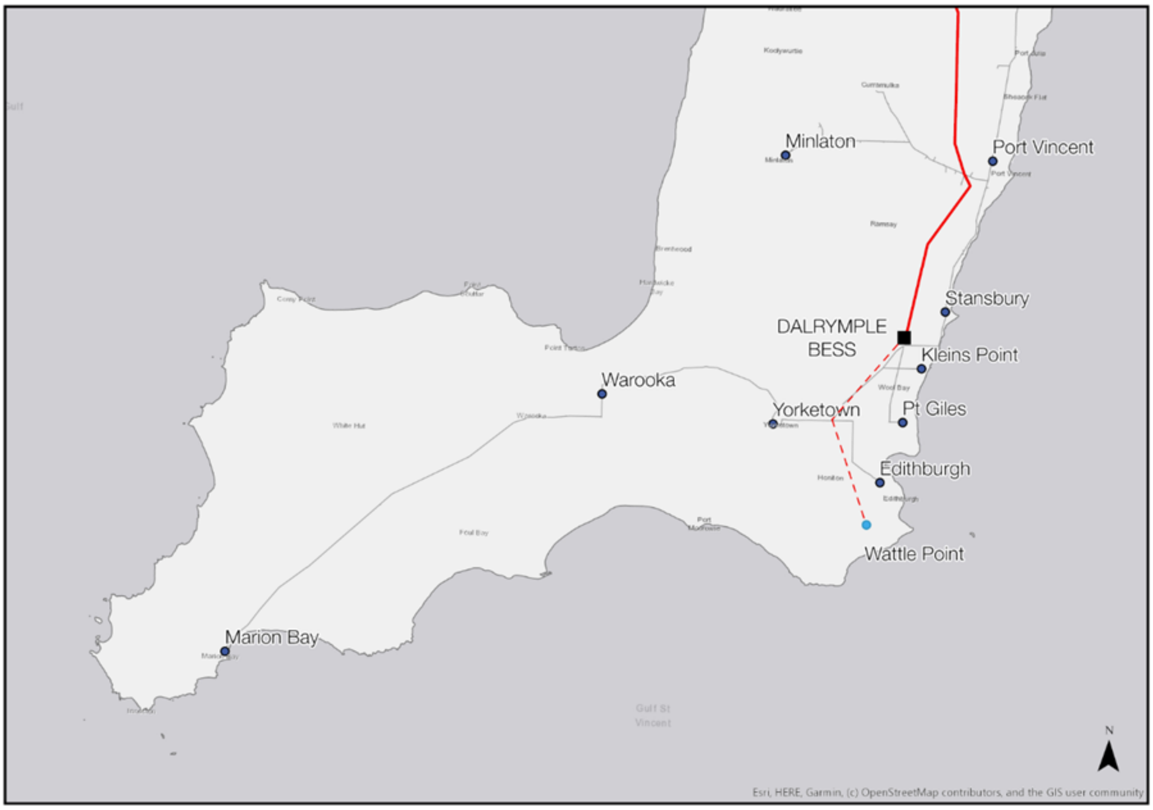

Figure 2-3: Region supported by the Dalrymple battery during an islanding event

During an islanding event, the Dalrymple battery supplies townships in the lower Yorke Peninsula region including Yorketown, Edithburgh and Stansbury. It also supplies communities, business and farms that are located south and southeast of Stansbury as shown in Figure 2-3

The BESS has been designed and commissioned to provide the following services in the priority order listed below.

1. Islanded operation to enhance local reliability of supply
2. Fast Frequency Response (FFR)
3. Network support
4. Frequency Control Ancillary Services (FCAS)
5. Energy arbitrage (previously referred to as Cap trading)

AGL operates the BESS and trades in the FCAS and Energy markets. During a network event where the BESS is required to respond, the system has been configured to automatically switch to one of the higher priority services.

During commercial operation, AGL is required to operate the BESS between 10% and 90% of the installed battery capacity. This is to ensure that the BESS always has the capacity to respond to a network event.

At the commencement of commercial operation, completion of the Wattle Point Wind Farm (WPWF) islanding integration testing had been delayed due to AGL's need to assess the effectiveness of the WPWF protection system.

To ensure commercial operation was not delayed, AGL and ElectraNet agreed to a modified BESS reserved energy discharge limit of 4.8 MWh until the WPWF islanding integration could be achieved.

The limit was applied to ensure that sufficient energy would be available to support the islanding of the lower Yorke Peninsula region during a system event.

2.3 Key Project Objectives

The key project outcomes, as defined in the Funding Agreement, include:

- Demonstrate the deployment and operation of a large-scale BESS to deliver a combination of network and market benefits
- Demonstrate a contracting and ownership model to maximise the value of a BESS
- Test the regulatory treatment for the ownership of large-scale BESS by regulated transmission network service providers
- Provide price discovery for the deployment of a large-scale grid-connected BESS
- Highlight and address technical and regulatory barriers in the deployment of large-scale batteries

Specific services and capability of the ESCRI-SA BESS, include:

- Supply of Fast Frequency Response (FFR) ancillary services into South Australia to reduce constraints on the Heywood interconnector, resulting in increased flows on the interconnector.
- Reduction of expected unserved energy to Dalrymple following loss of supply, involving islanding of the BESS with the local load, the Wattle Point Wind Farm at reduced output, and local rooftop PV to supply local load until grid restoration.
- Market trading of electricity within the South Australian National Electricity Market (NEM) region and provision of Frequency Control Ancillary Services (FCAS) services.

Since commencement of the Project, the BESS has also been incorporated into the System Integration Protection Scheme (SIPS) to support the existing Heywood interconnector by injecting real power into the system following a system event causing substantial loss of generation in South Australia.

3. Close out of Commissioning Items

3.1 Outline of Major Commissioning Items

Commissioning tests started in June 2018 and are covered in the Project Commissioning Report published in October 2018.

The major commissioning items which were completed prior to October 2018 are:

- Hold Point 1 Testing at 15 MW
- Hold Point 2 Testing at 30 MW
- Inspection Test Report (ITR) 38 Testing – ESCRI-SA Isolated BESS Testing
- ITR 40 Testing – ESCRI-SA Grid-connected and Islanded Operation
- ITR 41 Testing – ESCRI-SA Black Start

R2 model validation tests and ITR 39 testing (ESCRI-SA Partial and Full Island with WPWF) were not completed by October 2018 and progress on these items is included in Section 3.2. These items did not prevent the start of commercial operation on 14 December 2018.

3.2 Final Commissioning Items

3.2.1 R2 Model Validation Testing

As part of the National Electricity Rules (NER) requirements under S5.2.4, R2 model validation tests must be completed within 3 months following the successful completion of all commissioning tests. ElectraNet and its consultant started R2 model validation tests on 9 April 2019 and completed testing on 14 April 2019.

Based on observations during the R2 tests, the BESS model responded very well within its technical performance expectations and all test raw data was captured for analysis and validation of the models according to the test plan.

ElectraNet plans to submit the R2 model validation report soon for the Australian Energy Market Operator (AEMO) to review and approve.

3.2.2 ITR 39 Testing – ESCRI-SA Partial and Full Island with Wattle Point Wind Farm

The purpose of the ITR 39 test was to commission and verify connection of the BESS when it transits from Grid to Islanded operating condition with and without the Wattle Point Wind Farm.

Tests for planned and unplanned islanding, and resynchronisation of the BESS have been successfully completed with the WPWF output set at low output (up to 5 MW) for unplanned tests and up to 15 MW for planned tests. Further details of these tests are included in Section 3.2.2.1.

Unplanned islanding tests at high output (>5 MW) have not been successful to date due to the WPWF turbines tripping on the over-frequency protection setting currently applied at WPWF. This should be addressed once the wind farm over-frequency protection setting changes have been successfully applied at the wind farm site.

Further details of the tests are included in Section 3.2.2.2.

3.2.2.1 Islanded System Operation with Wattle Point Wind Farm set at Low Output

Planned islanding tests of the BESS have been successfully completed with zero and up to 15 MW output from Wattle Point Wind Farm (WPWF). In addition, unplanned islanding tests of the BESS have been successfully completed with up to 5 MW output from WPWF.

Figure 3-1 and Figure 3-2 show active power and frequency for the successful planned islanding test (at 15 MW WPWF output) and unplanned islanding test (at 5 MW WPWF output).

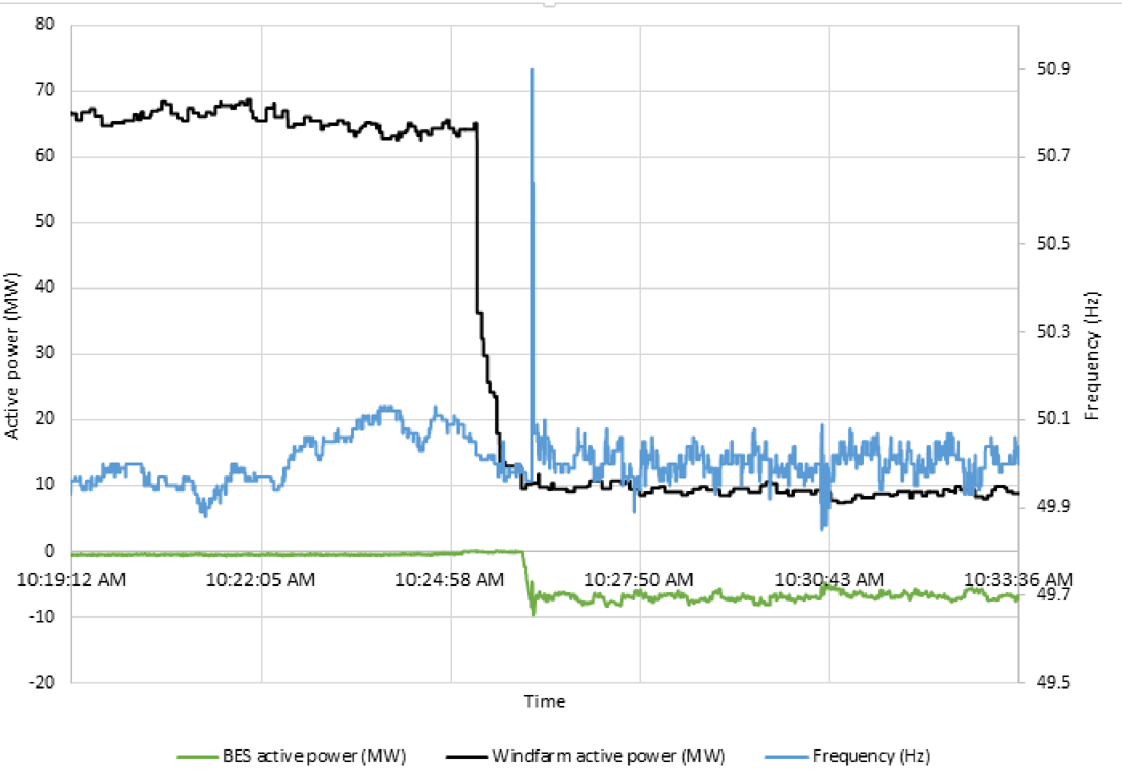

Figure 3-1: Planned islanding test with Wattle Point Wind Farm output limit set to 15 MW

Figure 3-1 shows that the BESS successfully transitioned to islanded operating mode and the WPWF stayed connected with WPWF output limit set to 15 MW during the planned islanding test.

The islanded network frequency remained within its normal operating frequency band, reaching 50.9 Hz during the transition.

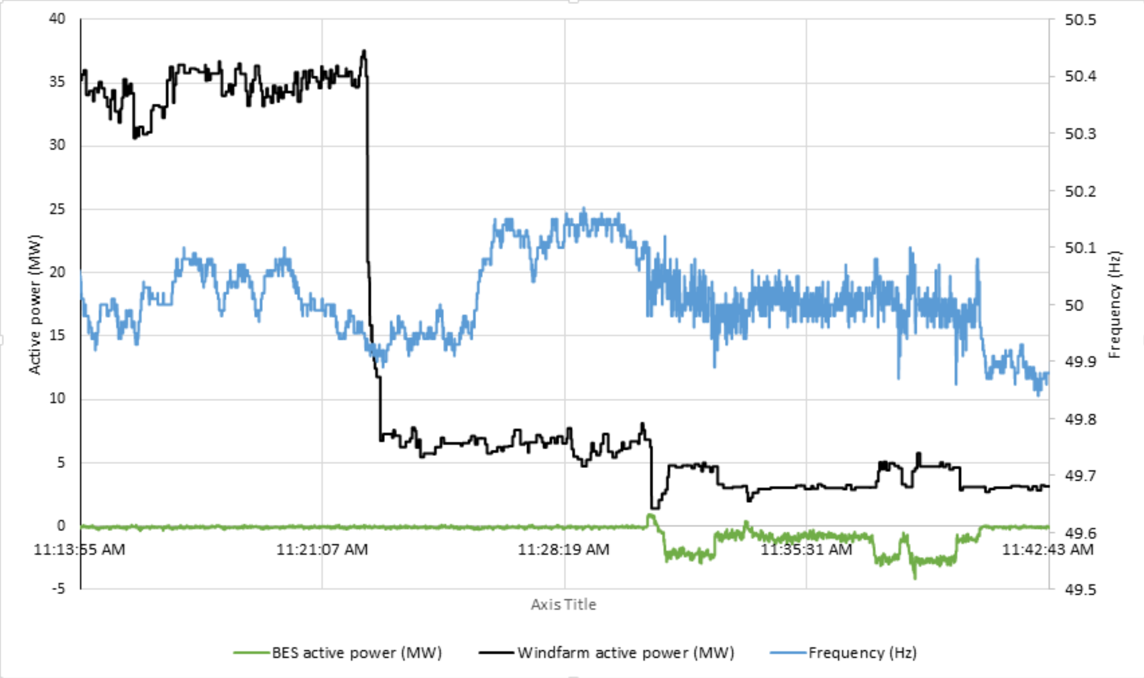

Figure 3-2: Unplanned islanding event with Wattle Point Wind Farm output limit set to 5 MW

Figure 3-2 shows that the BESS successfully transitioned to islanded operating mode and the WPWF stayed connected with the WPWF output limit set to 5 MW during the unplanned islanding test.

During this event the islanded network frequency remained within its normal operating frequency band.

3.2.2.2 Island System Operation with Wattle Point Wind Farm set at High Output

Unplanned islanding tests with the WPWF set at high output (>5 MW) have not yet been successful. While customers have not lost supply, wind farm output was lost. The underlining reason for this appears to be a minor Generator Performance Standards (GPS) non-compliance at the wind farm that, when addressed, should overcome this issue.

As an example, network islanded tests with the WPWF output limit set to 25 MW demonstrated that the Wattle Point wind turbines tripped as soon as the 33 kV network at Dalrymple went into islanded operating mode. This was due to the wind farm over-frequency protection scheme picking up an over-frequency event.

Figure 3-3 and Figure 3-4 show that during this test the BESS successfully transitioned to island operating condition, but WPWF tripped as the islanded network frequency rose beyond the normal operating frequency band.

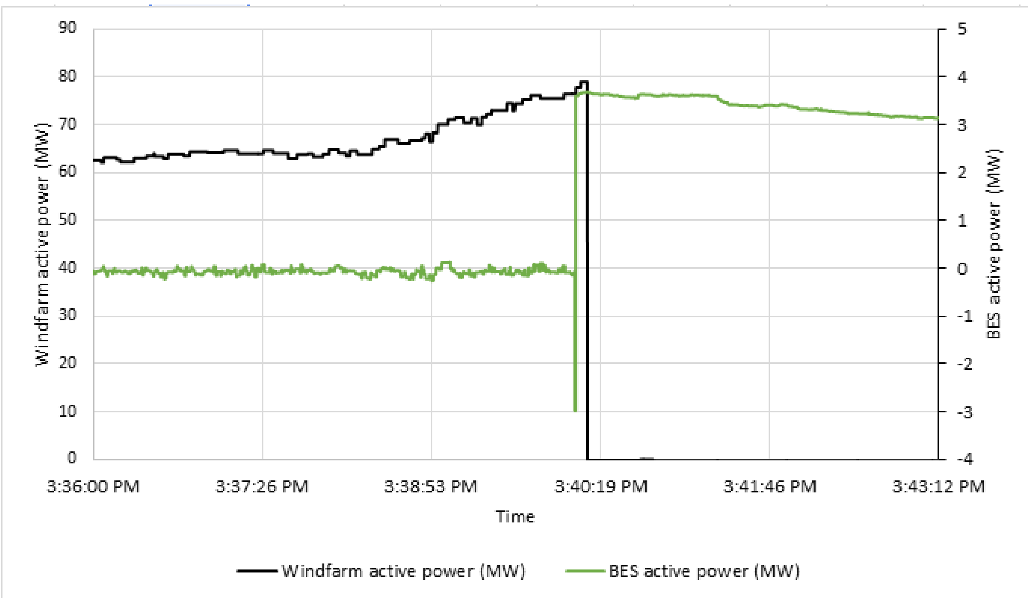

Figure 3-3: Unplanned islanding test with Wattle Point Wind Farm output limit set to 25 MW

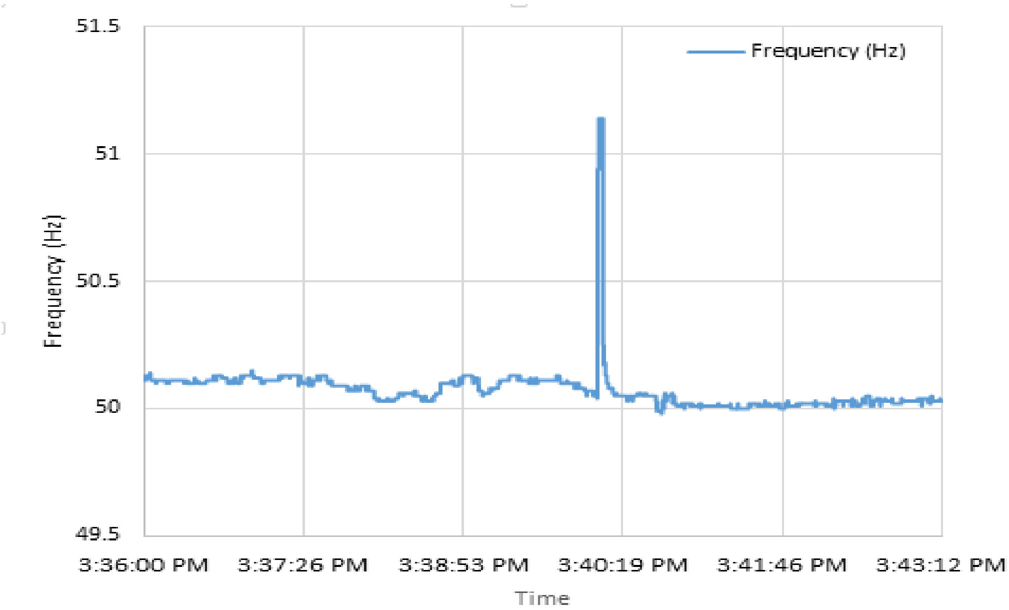

Figure 3-4: Islanded network frequency rise above 51 Hz during transition and Wattle Point Wind Farm over frequency protection trip

These results indicated that the Wattle Point wind turbines tripped when the frequency in the islanded network reached 51 Hz with delay time of approximately 100ms. This result was also replicated in the PSCAD modelling, as shown in Figure 3-5.

The Wattle Point wind turbines over-frequency protection settings appear to be set at a lower level than they should be, based on the WPWF registered Generator Performance Standards (GPS).

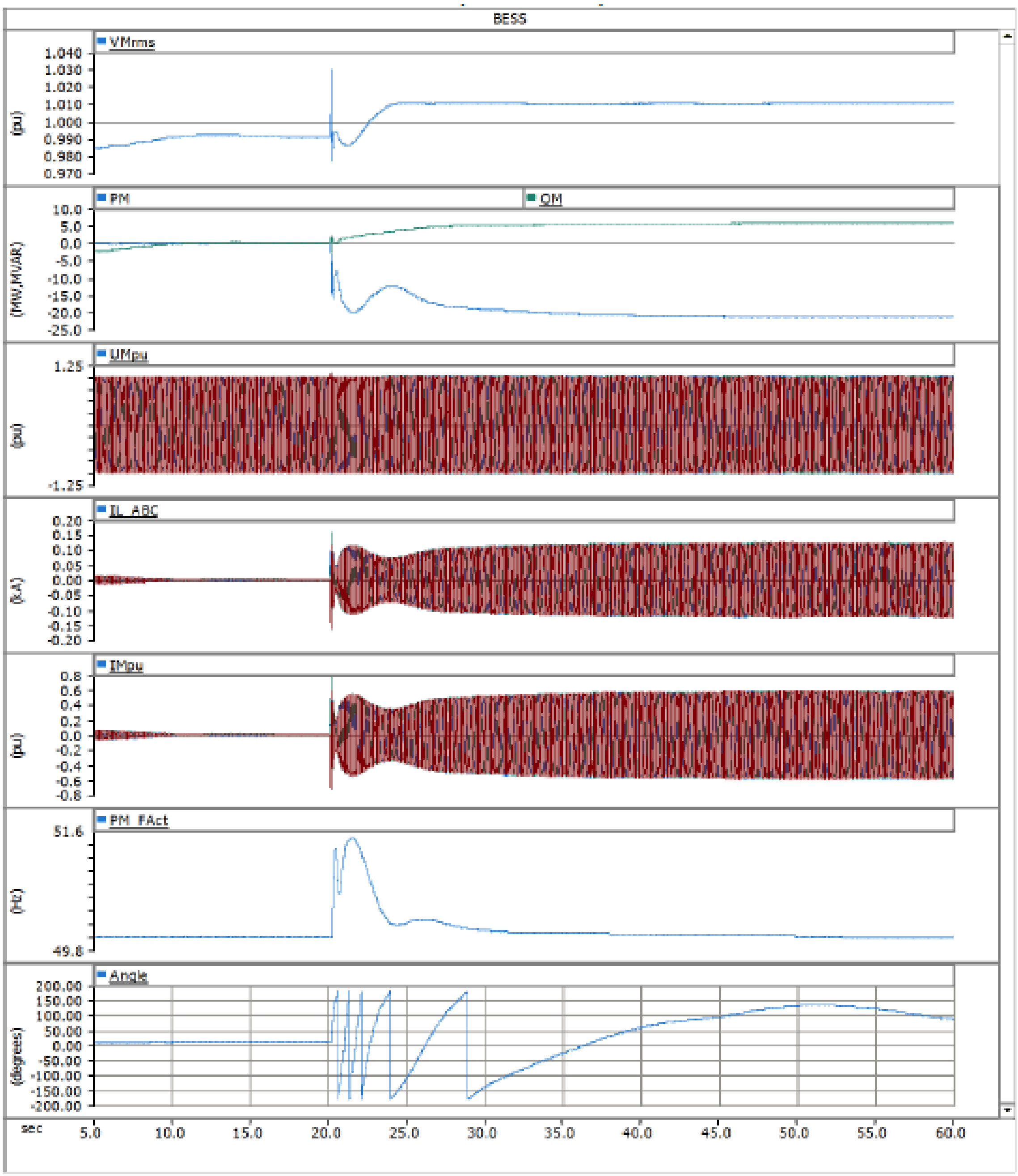

Figure 3-5: PSCAD study result for 3 MW load and 90 MW output from Wattle Point Wind Farm

AGL has submitted the WPWF non-compliance issue with AEMO and has agreed with AEMO to address the GPS non-compliance by 15 November 2019.

At this stage ElectraNet does not anticipate any further issues regarding islanded operation of the BESS with the WPWF in service.

3.3 EPC Contract

The EPC contract reached practical completion on 14 December 2018.

At handover, 11 listed defects were agreed between all contractual parties. The detail and resolution of the key defects is covered in Section 3.4.

Delays to the original program stemmed from difficulties with BESS model development, leading to delays with BESS registration, as well as commissioning.

Some delays with the BESS registration reflected that the Dalrymple BESS was the first large-scale battery storage system providing both regulated and non-regulated services seeking registration in the National Electricity Market (NEM).

Additional delays were experienced with development of the BESS software models by the contractor. These delays were in part caused by the need to develop models originally developed for BESS application in micro-grids/ distribution networks for the increased level of requirements applicable for the connection of such systems to the transmission network in the NEM. Following registration, these same challenges affected the timeline up to contractual completion.

Outstanding design and performance defects have now been largely resolved. The functionality of the ESCRI-SA BESS is now as committed, with only minor outstanding defects relating to the SCADA system and logging the system performance.

3.4 Defect resolution

At commercial handover of the BESS on 14 December 2018 there were 11 listed defects with the system. Of these, four remain outstanding as of mid-June 2019. Significant items on this list are covered below. In addition to this, completion of the outstanding R2 and ITR-39 commissioning tests was required.

3.4.1 Additional Cooling Requirements

Excess heat generated from the battery modules during maximum charge and discharge, combined with high ambient temperature, has been an ongoing issue that is currently being resolved.

The original BESS system included ten, 150 kW (cooling power) air conditioning units to maintain the temperature within the desired operational target of 26ºC in the battery rooms and 35ºC in the inverter rooms. An additional two, 150 kW air conditioning units were installed in February 2019 however, the extra capacity is still not sufficient to fully resolve the over-temperature issues.

A further two, 150 kW air conditioning units are on order and are due to be installed in August 2019. In addition, duct work is being installed within the rooms to better deliver air flow to the hot sections of system. It is expected that these two actions should be sufficient to fully resolve the over-temperature issues.

3.4.2 BESS Capability to Maintain Maximum Discharge at 30 MW

The capability of the BESS to maintain maximum discharge at 30 MW was restricted due to a temperature de-rating factor which reduces the 15 minute, full capacity discharge to approximately 28 MW by the end of a 15 minute discharge during onerous conditions (high ambient temperatures or usage).

The installation of the two additional air conditioning units and associated circulation fans and duct work changes, as detailed in Section 3.4.1, is expected to address the risk of temperature de-rating under maximum discharge.

3.4.3 BESS Overload Capability under Fast Charging Conditions

Within the limits of normal operation there was a risk that under certain conditions the BESS may not be able to meet the Generator Performance Standards for continuous, uninterrupted operation. When the BESS is performing a 30 MW fast charge and is called on to provide Fast Frequency Response to respond to an event on the network there is a risk that the system is driven into overload. If this overload is too much the BESS may trip to protect itself. This is particularly onerous on the BESS for an overload in the charge direction.

The probability of this situation occurring is extremely low as system operation is limited to 35 fast charge events per year, each taking 15 minutes, and one of these charging events would need to occur at the same time as a network event.

However, to address the issue the inverter parameters have been changed to make the BESS response less aggressive. In addition, ABB has negotiated with Samsung to change the protection settings to delay tripping of the batteries, while still achieving the warranty performance.

This issue is now resolved and has been confirmed by overload testing.

3.4.4 Island Detection Capability using Vector Shift Relay

ElectraNet operates a topology-based Island Detection Scheme (IDS) which examines the status of all relevant switches and will perform all the necessary actions to create an island when required.

As part of the specification the contractor was required to also include a separate local island detection system to provide a level of redundancy. The vector shift relay system used for this has not proved to be successful as there are both conditions where there is false operation (indicating the creation of an island when it is not required) and areas where islanding is not detected when it should.

The Vector Shift relay has since been disabled with the IDS relied upon to carry out the island detection function. In situations where the IDS is out of service the BESS is also to be taken out of service.

4. Summary of ESCRI-SA Operation

4.1 Current Operational Status

The BESS has been in commercial operational since 14 December 2018 following the completion of the Hold Point 2 tests, but prior to ITR-39 testing of partial and full islanding capability with the Wattle Point Wind Farm.

Since then, the BESS has been operational and continues to meet performance expectations within its design specification. The only outstanding functionality remains the ability to transition into islanded mode with the WPWF limit set at above 5 MW. This issue is outlined in detail in Section 3.2.2.2 and should be resolved once the wind farm over-frequency protection settings have been addressed.

The BESS is designed to be operated as a power battery and is capable of providing FCAS and FFR services as well as normal energy discharge.

4.2 Key Storage Metrics for Reporting Period

ElectraNet monitors the performance of the BESS, ensuring that operational data is captured and analysed to demonstrate its ability to operate as per its design specifications.

Key performance metrics for the first six months of operation from 14 December 2018 to 14 June 2019 are shown in Table 4-1.

Table 4-1: Key Performance Metrics for First Six Months of Operation

Key Performance Metric	Value for Reporting Period
Average BESS Availability	98.01%
Total Energy Consumed	1,370 MWh
Total Energy Exported	160 MWh
Average auxiliary load and losses (% of 30 MW rated capacity)	2.19%
Number of Charge and Discharge Cycles	2
BESS Charging Cost	$120,000
BESS Discharge Revenue	$116,000
FCAS Revenue	$1.33m

The average BESS availability for the period was 98.01%, which is greater than the 96% Guaranteed Annual Availability under Schedule 7 – Availability Guarantee of the Battery Operating Agreement.

The energy consumed by the BESS is significantly higher than the energy exported to the grid. The high energy use is because the BESS is designed as a power battery, rather than an energy battery, and therefore needs to be available all the time to be able to respond to system events. This means higher auxiliary load losses from transformers, inverters and the battery management system.

Two cycles of charge and discharge have been completed. The number of charge and discharge cycles is defined by the number of times the BESS state of charge (SOC) falls below 2.4 MWh and is more a reflection on how the BESS is being operated and how many significant unserved energy events have been avoided. Overall for a power battery the number of charge and discharge cycles is expected to be low.

The main source of revenue for the period was approximately $1.33 million for FCAS, compared to $116,000 for energy discharge. This is consistent with the BESS operating as a power battery. The BESS market services are discussed in more detail in Section 6.

4.3 Overview of Key Events for Reporting Period

Since 14 December 2018 the BESS has been through a total of nine operational system events. Six of these events were single-line trips as outlined below and in each case Power System Performance Monitor (PSPM) data confirmed that the BESS successfully rode through the fault.

The other three events were more significant and led to the BESS supplying load to prevent or reduce the duration of an unserved energy event. There are outlined below and are covered in more detail in Section 5.1 – Unserved Energy and Islanding.

In addition, in late January 2019, high ambient temperatures along with air conditioning failures, led to both automated derating and manual operator intervention to switch off parts and/ or all of the BESS for periods of time during a window of a few days.

4.3.1 Unplanned Outage at Dalrymple Substation – 29 March 2019

On 29 March 2019 switching at Ardrossan West resulted in maloperation of the IDS due to incorrect logic in the Ardrossan West IDS unit. This caused tripping of the 132 kV and 33 kV circuit breakers at the Dalrymple substation. The BESS was able to supply the 33 kV load for the 30 minutes until the 132 kV supply network was restored, thereby preventing a customer outage.

4.3.2 Planned Outage of Yorke Peninsula 132 kV system - 7 April 2019

On 7 April 2019 the BESS supplied the 33 kV distribution system for approximately seven hours of a seven and a half hour planned outage of the Yorke Peninsula 132 kV system. During this time the BESS maintained supply for the southern Yorke Peninsula region.

4.3.3 Unplanned Outage of the Dalrymple – Wattle Point 132 kV line - 13 June 2019

On the 13 June 2019, during protection tests at WPWF, a direct inter-trip signal to Dalrymple was accidentally initiated. This resulted in tripping of the Dalrymple 132/33 kV TF2 and subsequent maloperation of the IDS resulted in tripping of Dalrymple 132/33 kV TF1.

The BESS successfully transitioned to islanded operation and continued to supply the local load until the System Operator restored all outage elements approximately 30 minutes later. No load was lost as a result of the incident.

4.3.4 Transmission Network Faults from 14 December 2018 – 14 June 2019

Over the past six months from 14 December 2019 – 14 June 2019, the BESS has been through six transmission network fault events in the vicinity of the Dalrymple substation as summarised below:

- On 4 March 2019 at 3:19, the Para – Angas Creek 132 kV line tripped due to a 2 phase – ground fault
- On 4 March 2019 at 5:29, the Mintaro – Waterloo 132 kV line tripped due to a 2 phase – ground fault
- On 4 March 2019 at 6:20, the Clare North – Mintaro 132 kV line tripped and reclosed on a single phase due to a single phase – ground fault
- On 2 April 2019 at 2:06, the Templers West - Brinkworth 275kV line tripped due to a 2 phase – ground fault
- On 14 May 2019 at 12:10, the Hummocks - Bungama 132 kV line tripped due to a 3 phase – ground fault
- On 19 May 2019 at 17:00, the Hummocks – Kadina East 132 kV line tripped due to a 2 phase – ground fault

High speed data recorded at Dalrymple substation has been downloaded by ElectraNet and plotted for the transmission network fault events up to the end of April 2019. These are shown in Figure 4-1 to Figure 4-8. High speed data for the two faults in May has yet to be downloaded at the site.

This data demonstrates that the BESS successfully rode through the network fault events and its voltage, active power and reactive power response are in line with its design and technical performance expectations.

The BESS responds almost instantly to the system voltage dip during the fault and injects a significant amount of active and reactive power into the network to support network voltage recovery.

4.3.4.1 Para – Angas Creek 132 kV line, 2 phase to ground fault

Figure 4-1 and Figure 4-2 show the network voltage dip and the BESS active and reactive power response during the Para – Angas Creek 132 kV line, 2 phase to ground fault, successfully riding through the fault.

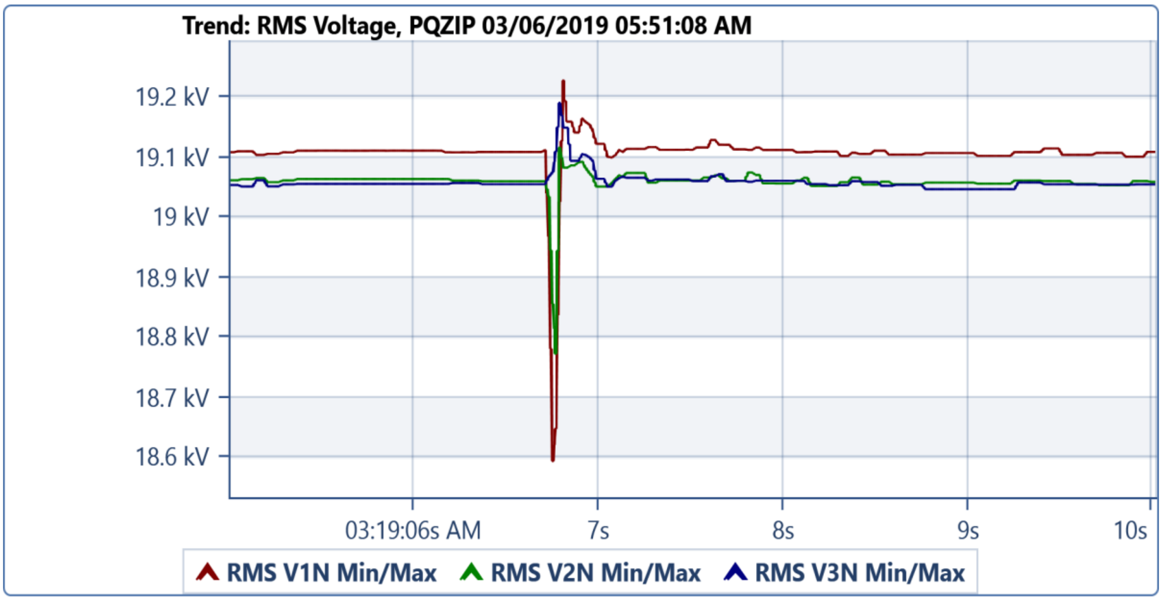

Figure 4-1: Para - Angas Creek 132kV line, Network voltage dip during 2 phase to ground fault

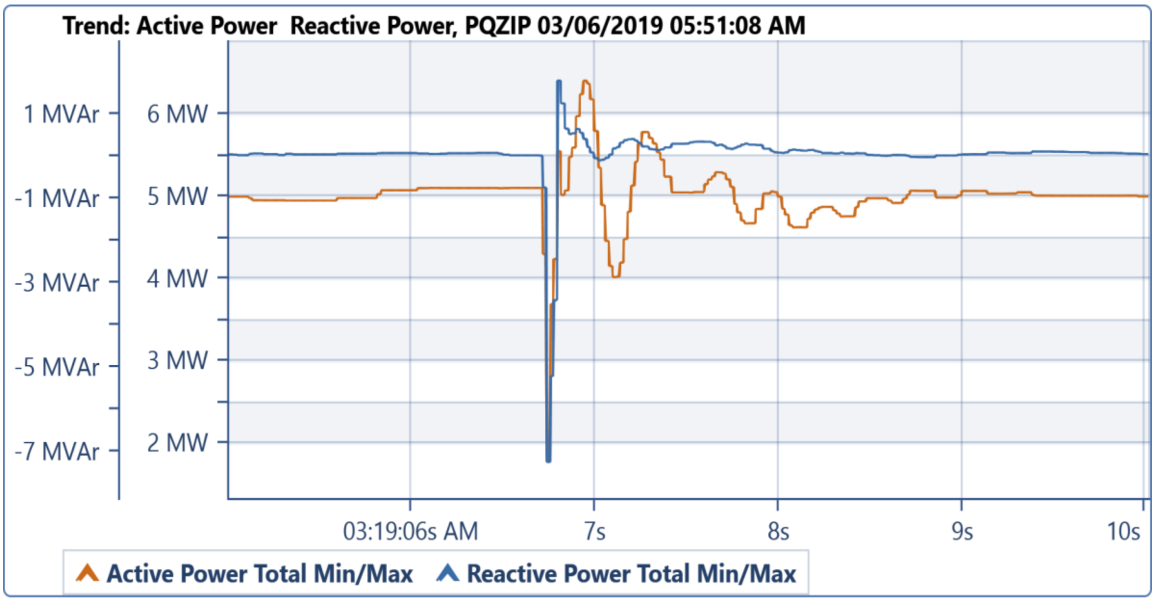

Figure 4-2: Para - Angas Creek 132kV line, BESS active and reactive power response during 2 phase to ground fault

4.3.4.2 Mintaro - Waterloo 132 kV line, 2 phase to ground fault

Figure 4-3 and Figure 4-4 show the network voltage dip and the BESS active and reactive power response during the Mintaro – Waterloo 132 kV line, 2 phase to ground fault, successfully riding through the fault.

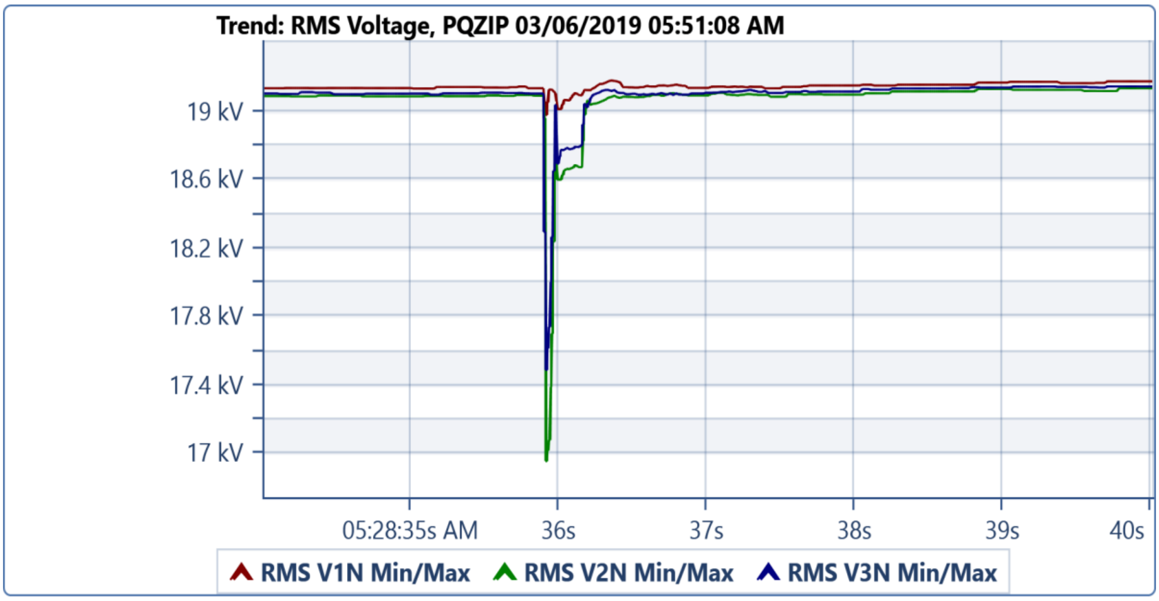

Figure 4-3: Mintaro - Waterloo 132 kV line, Network voltage dip during 2 phase to ground fault

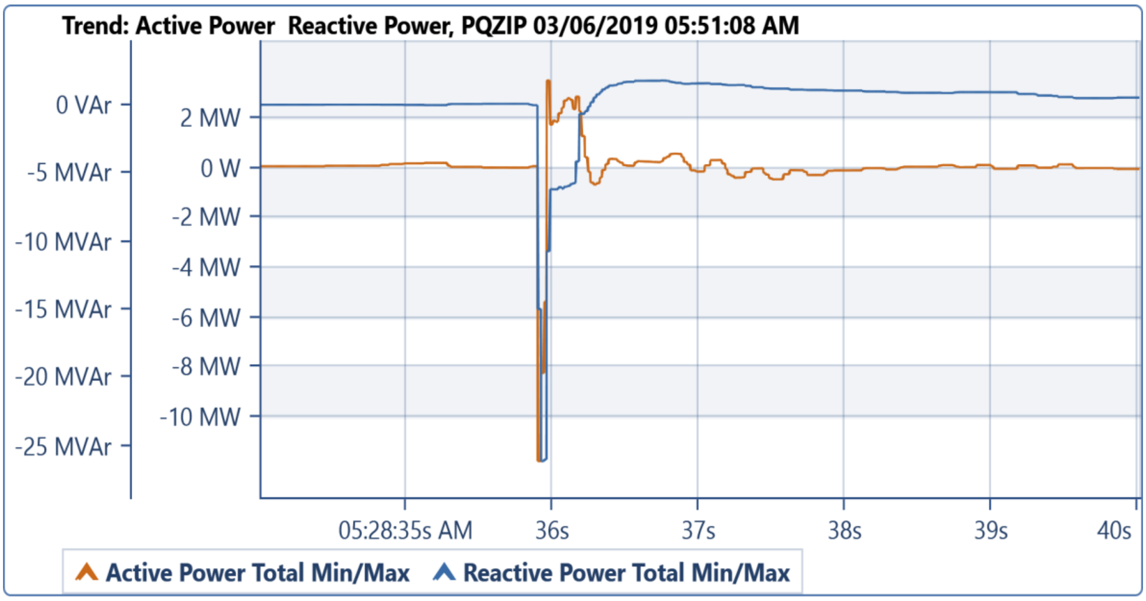

Figure 4-4: Mintaro - Waterloo 132 kV line, BESS active and reactive power response during 2 phase to ground fault

4.3.4.3 Clare North - Mintaro 132 kV line, 1 Phase to Ground Fault

Figure 4-5 and Figure 4-5 show the network voltage dip and the BESS active and reactive power response during the Clare North – Mintaro 132 kV line, 1 phase to ground fault, successfully riding through the fault.

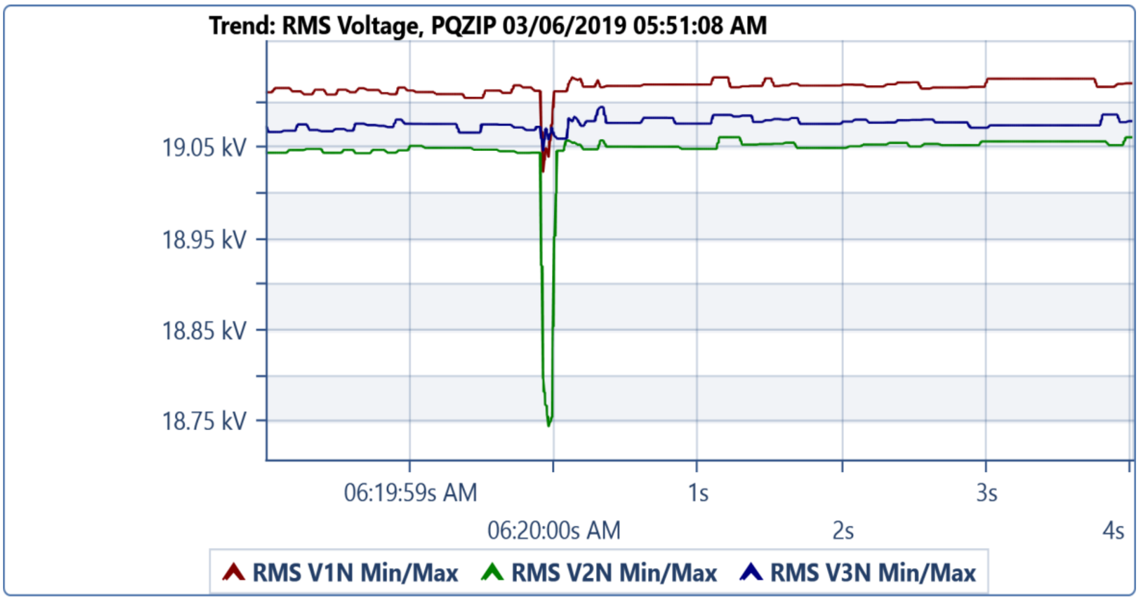

Figure 4-5: Clare North – Mintaro 132 kV line, Network voltage dip during 1 phase to ground fault

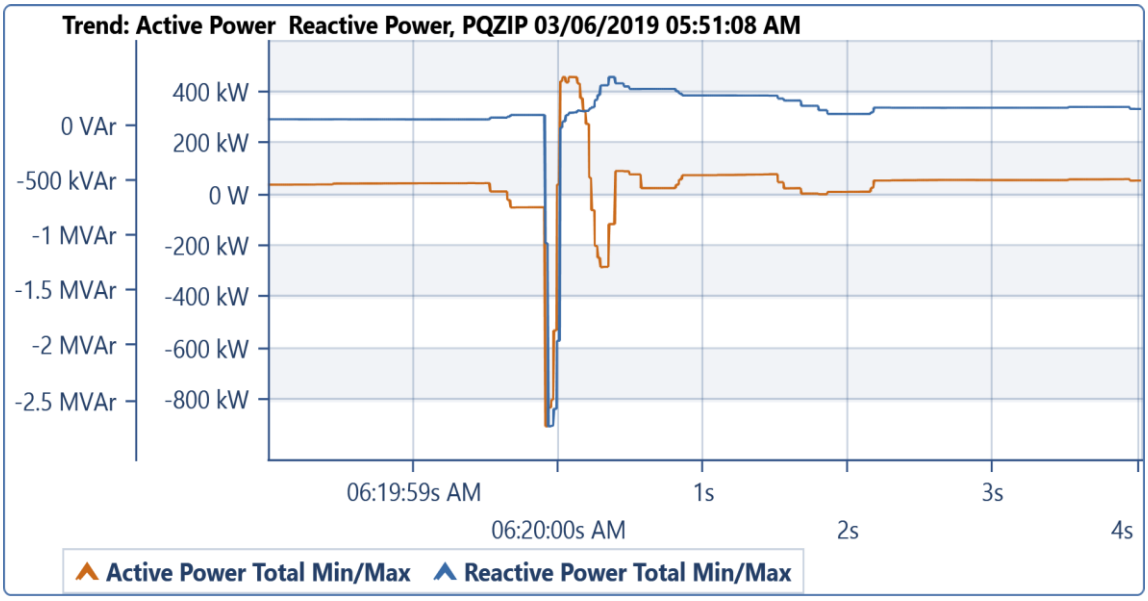

Figure 4-6: Clare North – Mintaro 132 kV line, BESS active and reactive power response during 1 phase to ground fault

4.3.4.4 Templers West - Brinkworth 275 kV line, 2 Phase to Ground Fault

Figure 4-7 and Figure 4-8 show the network voltage dip and the BESS active and reactive power response during the Templers West – Brinkworth 275 kV line, 2 phase to ground fault, successfully riding through the fault.

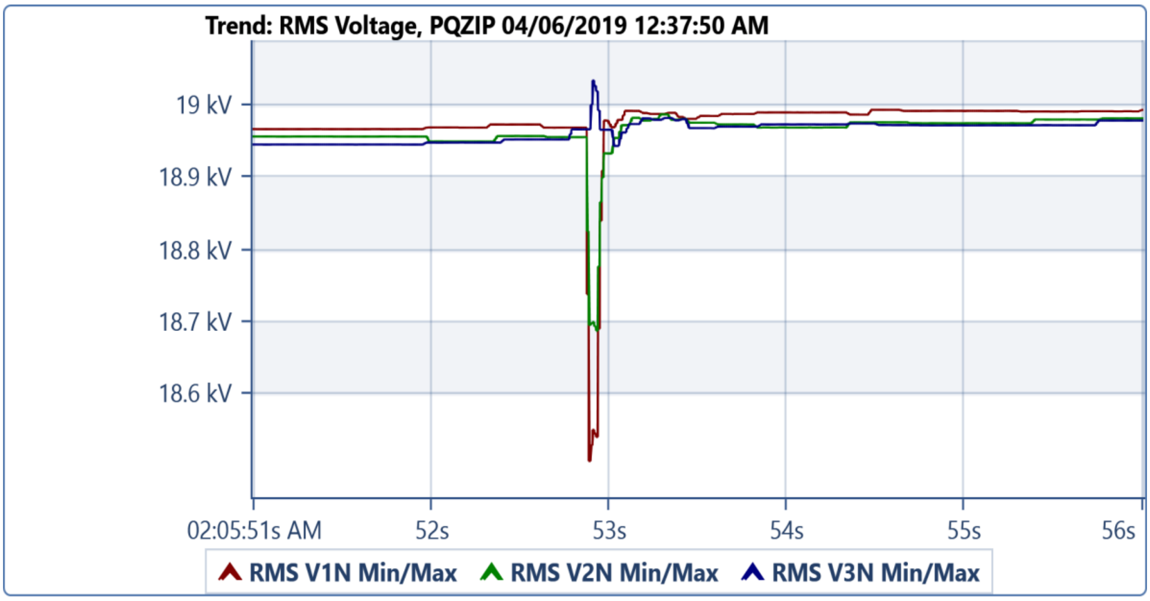

Figure 4-7: Templers West – Brinkworth 275 kV line, Network voltage dip during 2 phase to ground fault

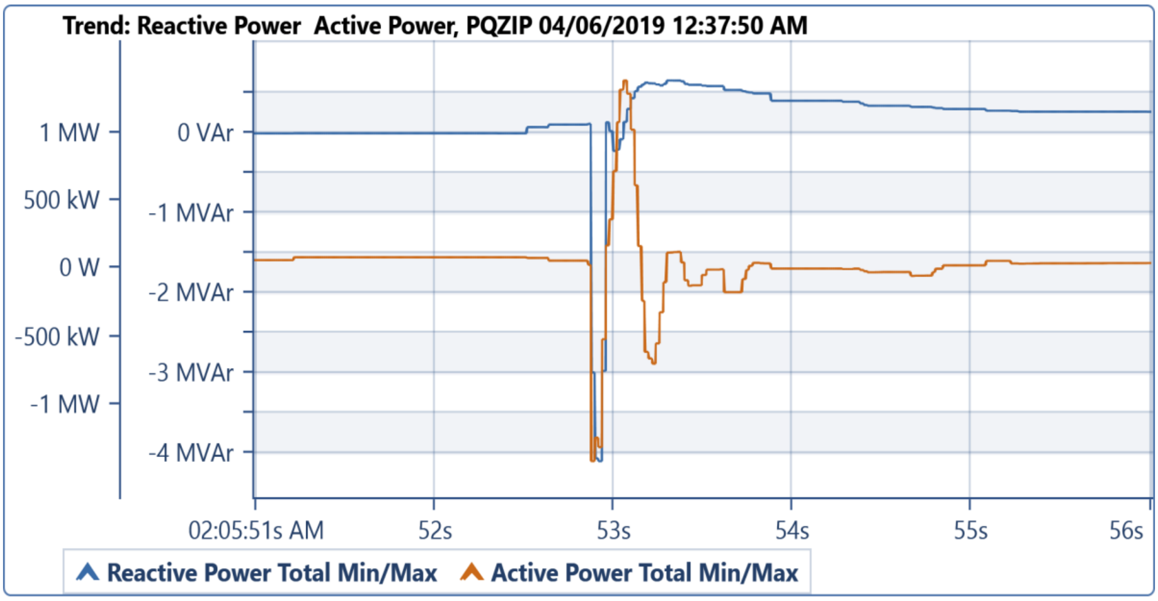

Figure 4-8: Templers West – Brinkworth 275 kV line, BESS active and reactive power response during 2 phase to ground fault

4.4 Portal Operation and Usage

The ESCRI-SA web portal is one of the primary knowledge sharing tools for the Project and provides the public with access to key information, including a real-time dashboard that shows the performance of the battery, Wattle Point Wind Farm, Dalrymple substation, the incoming transmission line and the Lower Yorke Peninsula network.

Figure 4-9: ESCRI-SA Portal Dashboard

This data is available for download directly from the portal. The portal also contains copies of ElectraNet's industry presentations and public reports on the Project.

The portal went live in February 2018 and was upgraded to show real time data in May 2018. Access to the web portal is available at http://escri-sa.com.au/.

Since May 2018, Google Analytics shows that the site has been visited 2,654 times from interested parties from 26 countries, with the number of views peaking in June 2018 and January 2019. The majority of portal views were through direct access to the website, rather than LinkedIn, Empired, Google or other sources or channels. Further details are shown in Figure 4-10 to Figure 4-12.

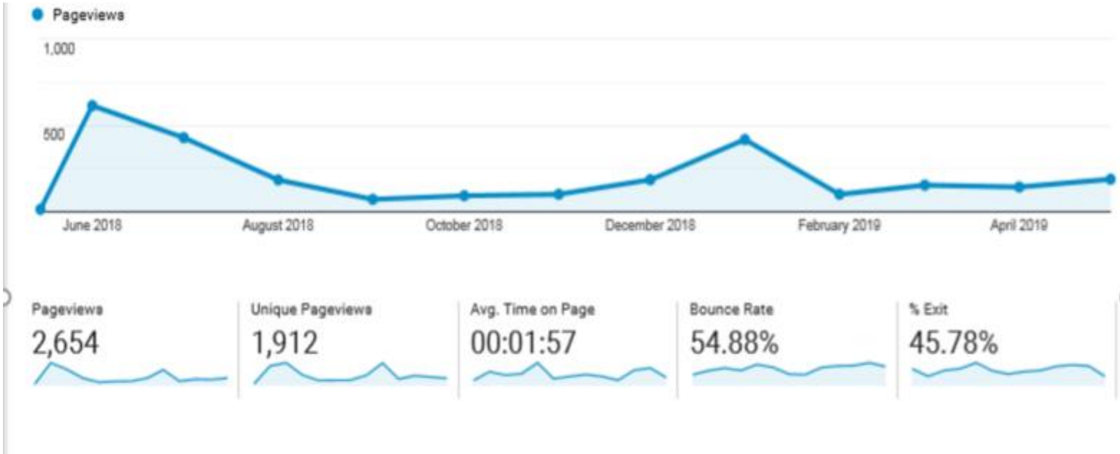

Figure 4-10: ESCRI-SA portal page views

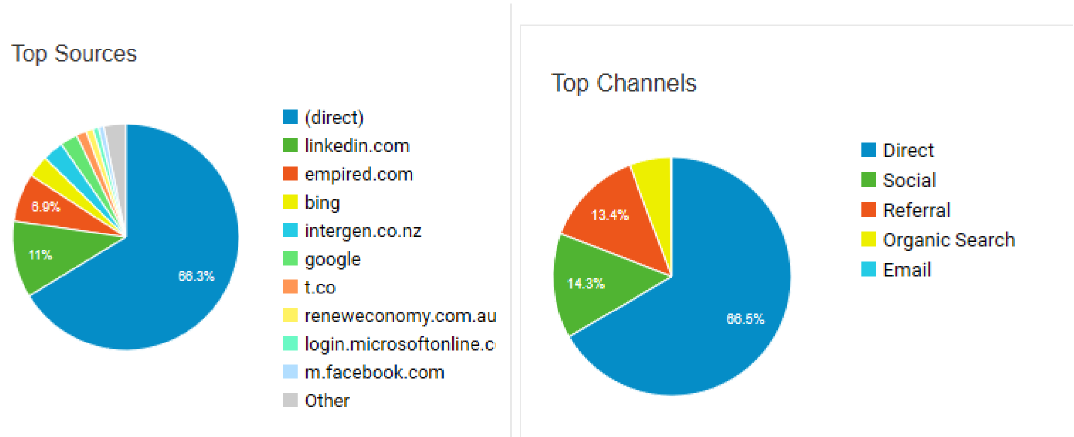

Figure 4-11: Top sources and channels used to locate ESCRI-SA portal

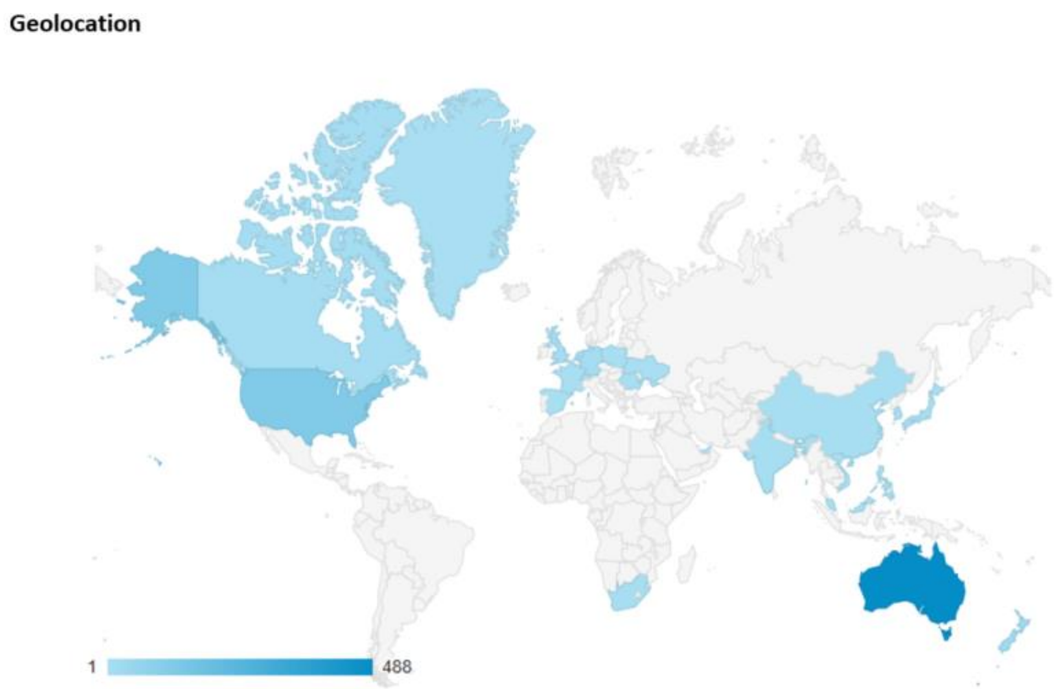

Figure 4-12: Geolocation of ESCRI-SA portal users

5. Demonstration of Key BESS Regulated Services

5.1 Reducing Expected Unserved Energy/ Islanding

From 2006 to 2014 there was an average yearly loss of supply of 3.52 hours and 9.46 MWh for the Dalrymple connection point.

Since the start of commercial operation of the BESS, there have been two instances where the BESS has prevented or reduced the duration of an unserved energy event. In combination, these events reduced the loss of supply from around 8 hours to around half an hour. Further details on these events are included in Section 5.1.1 and Section 5.1.2.

The benefits of being able to continue to supply the local load from the BESS island network during an outage are significant and go beyond reducing the duration of a loss of supply. For example, planned outages are able to be scheduled during normal hours rather than overnight and live line techniques need not be used, resulting in higher levels of safety for work crews.

5.1.1 Unplanned Outage at Dalrymple Sub-Station – 29 March 2019

On 29 March 2019 at 8:45, switching at Ardrossan West resulted in IDS maloperation due to incorrect logic in the Ardrossan West IDS unit. This caused tripping of the 132 kV and 33 kV circuit breakers at the Dalrymple sub-station leaving the BESS to supply the 33 kV load for about 30 minutes until the 132 kV supply network was restored.

ElectraNet's EMS SCADA data for this event is shown in Figure 5-1 and clearly shows the Dalrymple 33 kV local active power supply being switched from the network (red trace) to the BESS (green trace) at around 9am.

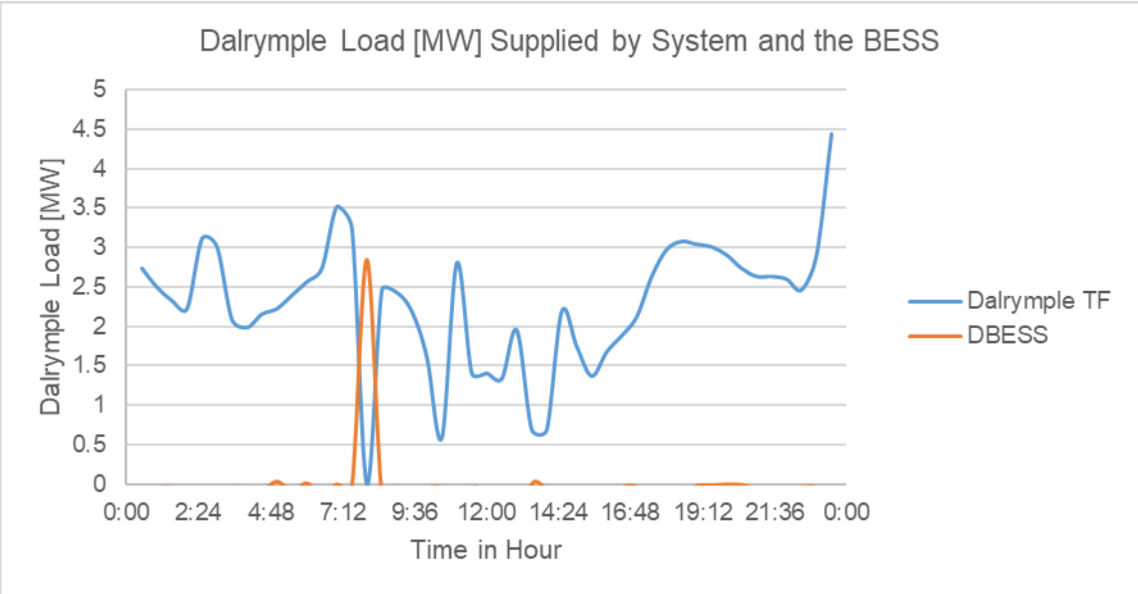

Figure 5-1: Dalrymple 33 kV local active power switching from network (blue) to BESS supply (orange)

High speed data recorded at Dalrymple substation for the bus voltage change, active and reactive power and network frequency is shown in Figure 5-2 to Figure 5-4.

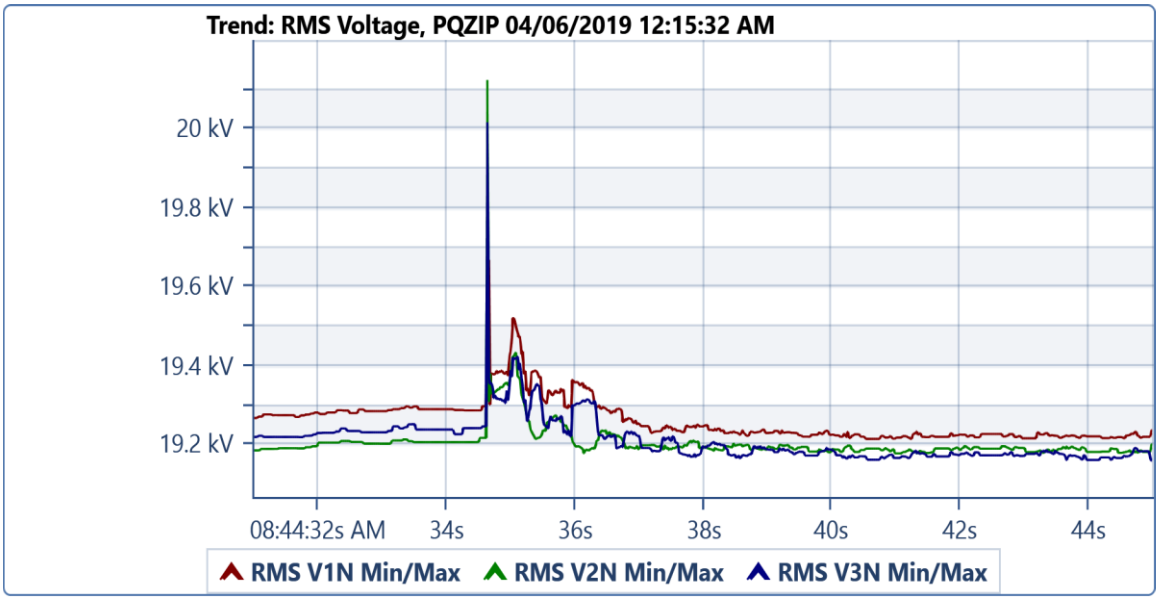

Figure 5-2: Dalrymple 33 kV bus voltage change from grid connected to island operating condition

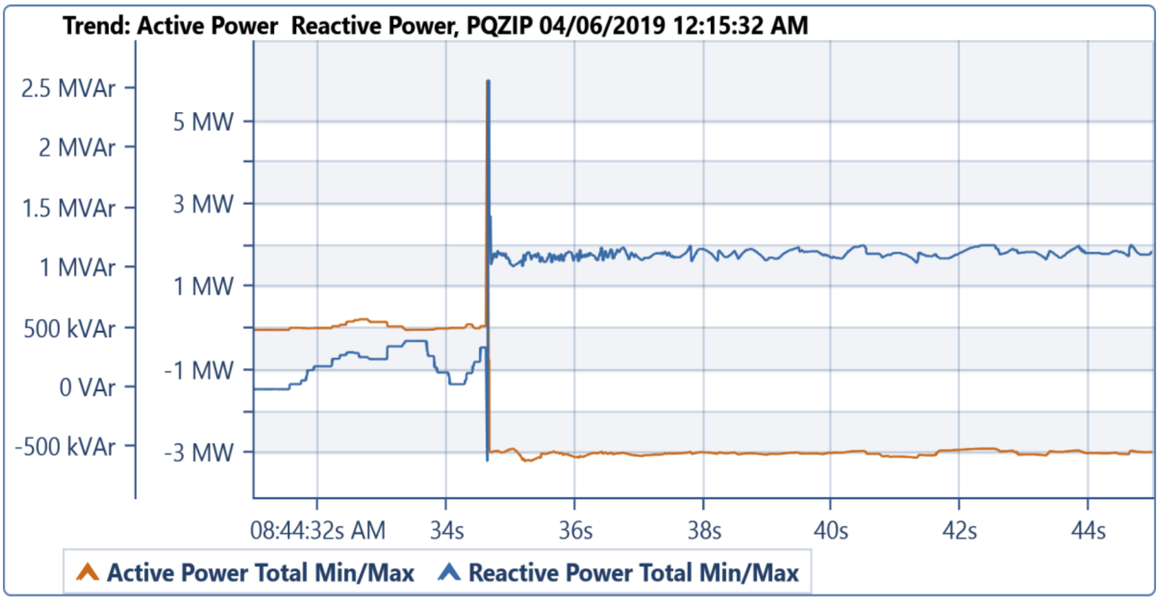

Figure 5-3: Active and reactive power supplied from the BESS to local 33 kV network under island operation

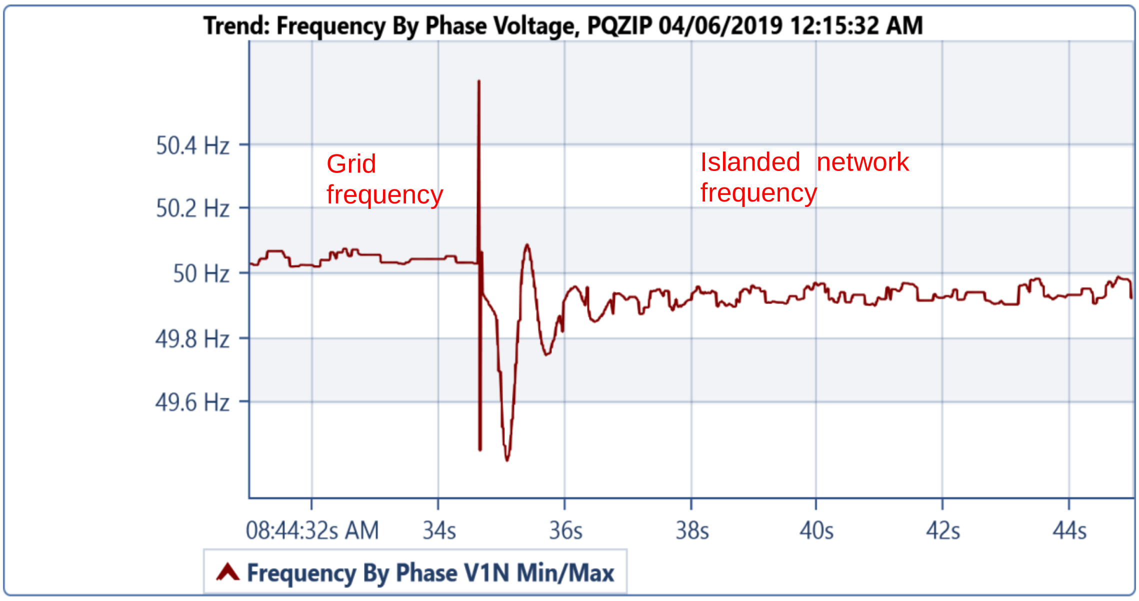

Figure 5-4: Local Dalrymple 33 kV network frequency controlled and regulated by the BESS

This event demonstrated that the BESS can successfully transition to islanded operating mode and supply the local load to prevent an outage.

This is the first system event to confirm that under unplanned conditions the BESS operated correctly and complied with its primary technical performance requirement.

5.1.2 Planned Outage of Yorke Peninsula 132 kV system – 7 April 2019

On 7 April 2019 the BESS supplied 33 kV for approximately seven hours of a seven- and-a-half hour planned outage of the Yorke Peninsula 132 kV system. During this time the BESS maintained supply for the lower Yorke Peninsula region.

After around 7 hours, at 9:50, some switching on the 33 kV network supplied by the BESS caused operation of Vector Shift (island detection) relay resulting in a trip of the BESS. The Vector Shift relay has since been disabled with the IDS relied upon to provide the island detection function.

ElectraNet's EMS SCADA data for this event is shown in Figure 5-5 and clearly shows the Dalrymple 33 kV local active power supply being switched from the network (blue trace) to the BESS (orange trace) at around 3am until around 10am.

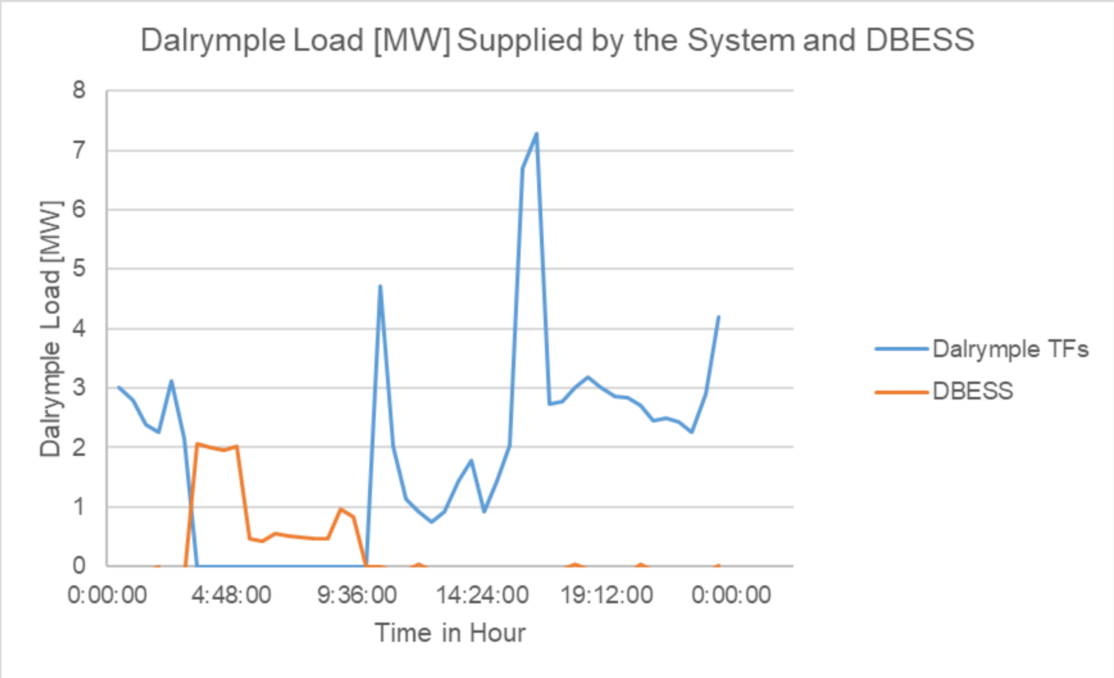

Figure 5-5: Dalrymple 33 kV local active power switching from network (blue) the BESS supply (orange)

During this planned outage the local load was approximately 1 MW. Figure 5-6 shows the state of charge of the BESS dropping from around 90% to around 20% while supplying the lower Yorke Peninsula load, before the BESS tripped offline.

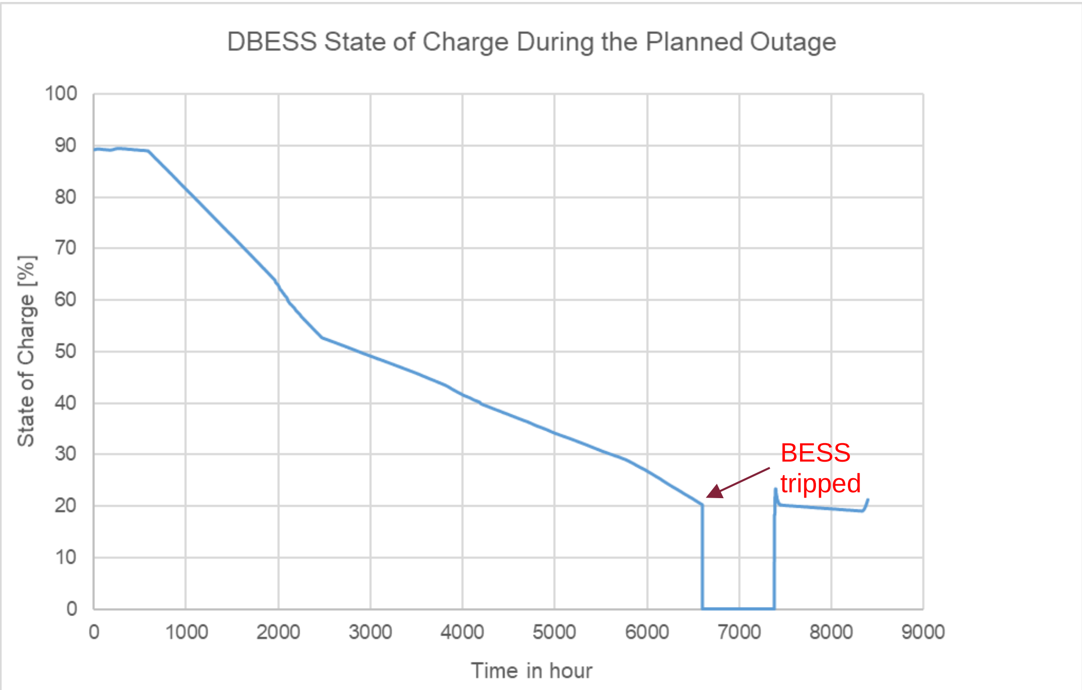

Figure 5-6: BESS State of Charge (%) during discharge to islanded network

High speed data has been recorded at Dalrymple substation. Figure 5-7 shows the Dalrymple 33 kV islanded network voltage being controlled and regulated by the BESS before it was tripped by the vector shift relay.

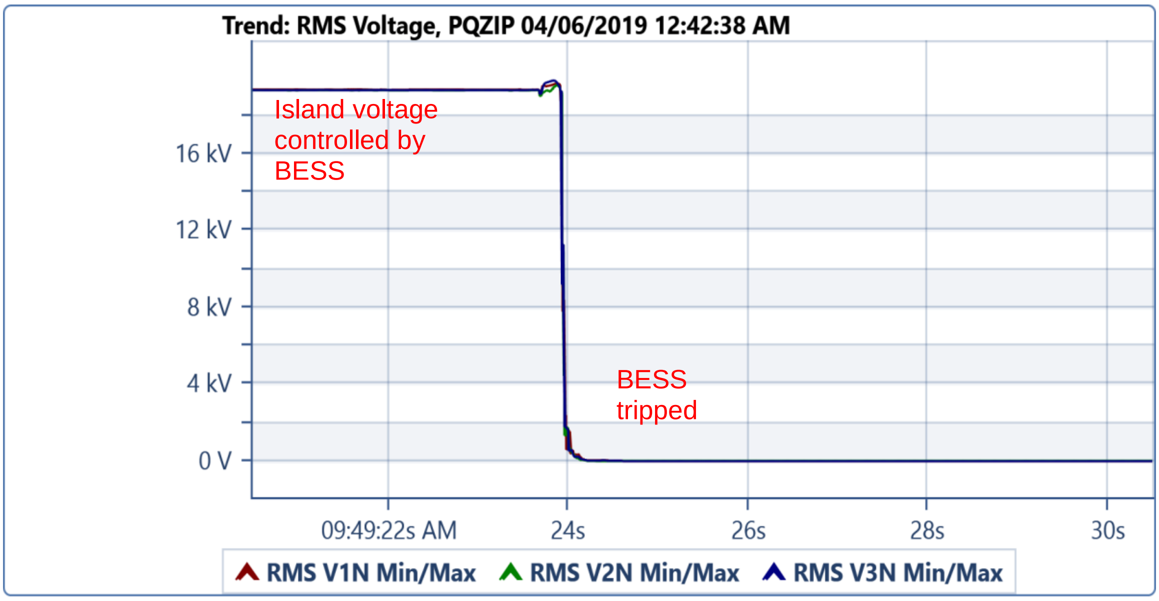

Figure 5-7: Dalrymple 33 kV island network voltage

Figure 5-8 and Figure 5-9 show the active and reactive power supplied by the BESS to the local 33 kV islanded network and the island network frequency prior to the BESS tripping.

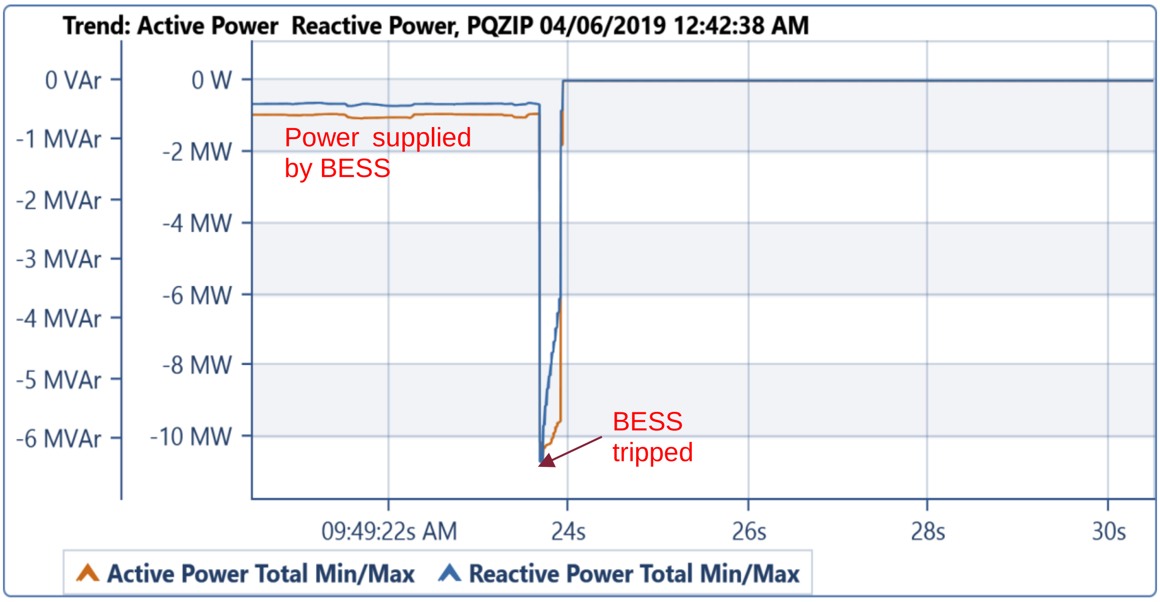

Figure 5-8: Dalrymple 33 kV island network active and reactive power supplied by BESS

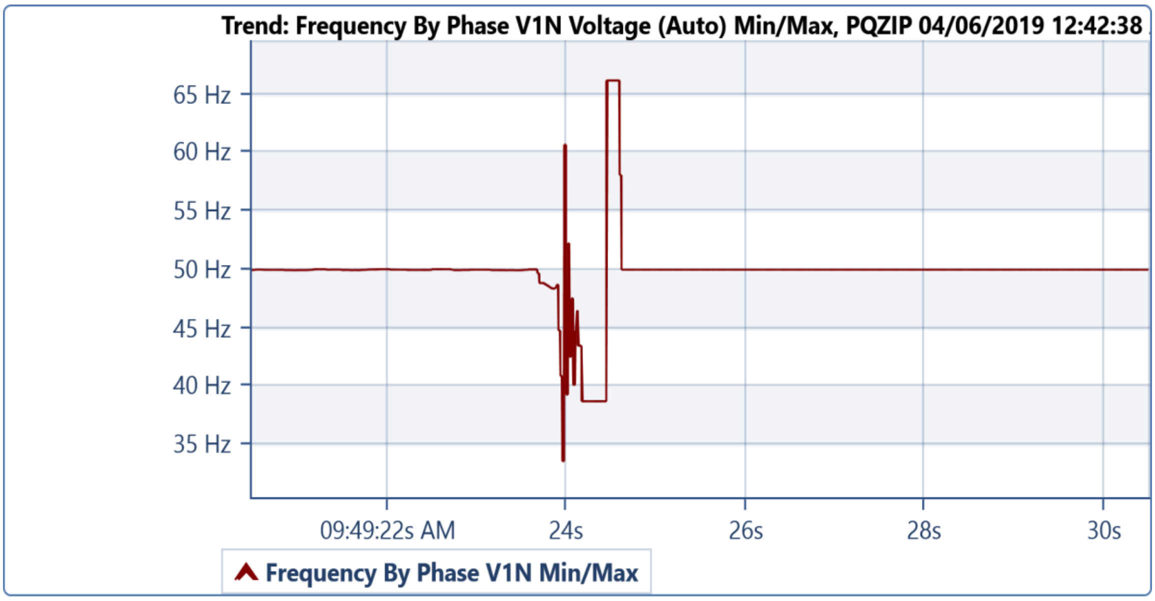

Figure 5-9: Dalrymple 33 kV island network frequency controlled by the BESS prior to tripping

This system information demonstrates that the BESS successfully supplied all local Dalrymple 33 kV network demand for around seven hours during the outage.

The BESS was tripped by the vector shift relay during the load restoration process and as a result local Dalrymple 33 kV supply was lost for approximately half an hour. Based on the status of charge of the BESS, if this incident had not occurred, the BESS would have had sufficient power to be able to supply local demand for the whole period of the planned outage.

5.2 Fast Frequency Response (FFR) to reduce constraints on the Heywood interconnector

Currently a 3 Hz/s RoCoF constraint is applied to the Heywood Interconnector. The constraint defines the maximum import/ export limit allowed based on the amount of synchronous system inertia online in South Australia at any point in time.

To achieve 650 MW transfer across the Heywood Interconnector based on the 3 Hz/s RoCoF, approximately 5,400 MWs of inertia is required to be available in South Australia.

5.2.1 BESS Reduction of Synchronous System Inertia required

Detailed power system analysis and test results have demonstrated that the FFR from the ESCRI-SA BESS results in an increase in the Heywood Interconnector transfer capability which is equal to a total 200 MWs of equivalent inertia contribution from the BESS.

This 200 MWs 'offset' has been implemented in the RoCoF constraint equation. As a result, when the BESS is in service, the total inertia requirement in SA for a 3 Hz/s RoCoF is reduced from 5,417 MWs to 5,217 MWs.

Since the BESS has been in commercial operation there has been no system frequency event to confirm the actual operation of the FFR function of the BESS.

Any additional increment on the existing Heywood Interconnector transfer capability will improve system security of the SA transmission network following a frequency disturbance event and directly benefits all network users in South Australia.

During the first six months of operation the RoCoF constraint has bound for 20 minutes. Without the BESS in service, the RoCoF constraint is estimated to have bound for about four and a half hours.

5.2.2 BESS Response Time to RoCoF Events

Based on the latest PSSE model for the Dalrymple BESS, the BESS will generate or absorb real power as soon as the frequency measured at Dalrymple 33 kV bus deviates from the fundamental system frequency of 50 Hz. The rate of real power generation/ absorption depends on the RoCoF value.

For a RoCoF of 3 Hz/s, study results indicated that the BESS will take approximately one second to go from zero to 30 MW maximum output level. The one second delay time is within the time taken for the SA system frequency to reach the top or bottom of the first system frequency swing cycle. Therefore, the injection of the 30 MW into the system will help to arrest the system frequency changes when South Australia is in an islanded condition.

For any RoCoF level lower than 3 Hz/s, the BESS will inject 30 MW into the system, but with a slower response. Figure 5-10 shows the BESS response due to a slow system frequency drop as simulated in PSSE.

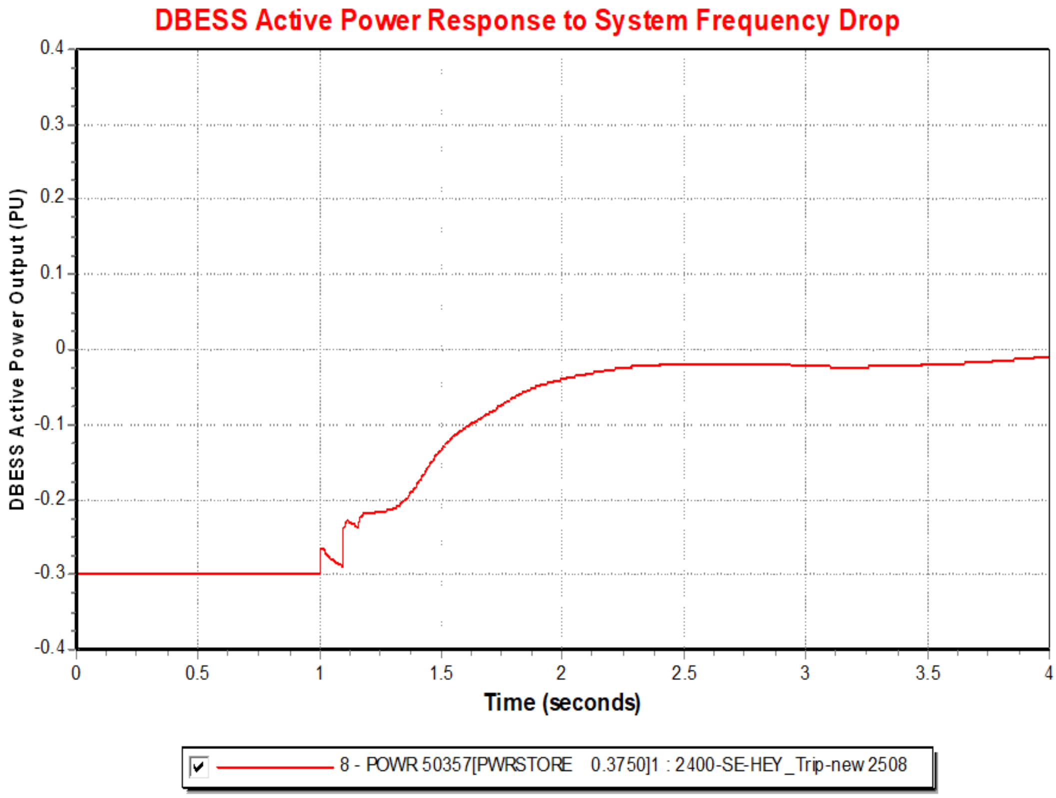

Figure 5-10: BESS response due to frequency drop in the system based on PSSE simulated result

As part of the ITR 39 Test, the BESS has been tested for FFR response with RoCoF of 1 Hz/s and 3 Hz/s. Test results, shown in Figure 5-11, indicate almost instant response from the BESS when system frequency deviates beyond the continuous operating frequency band.

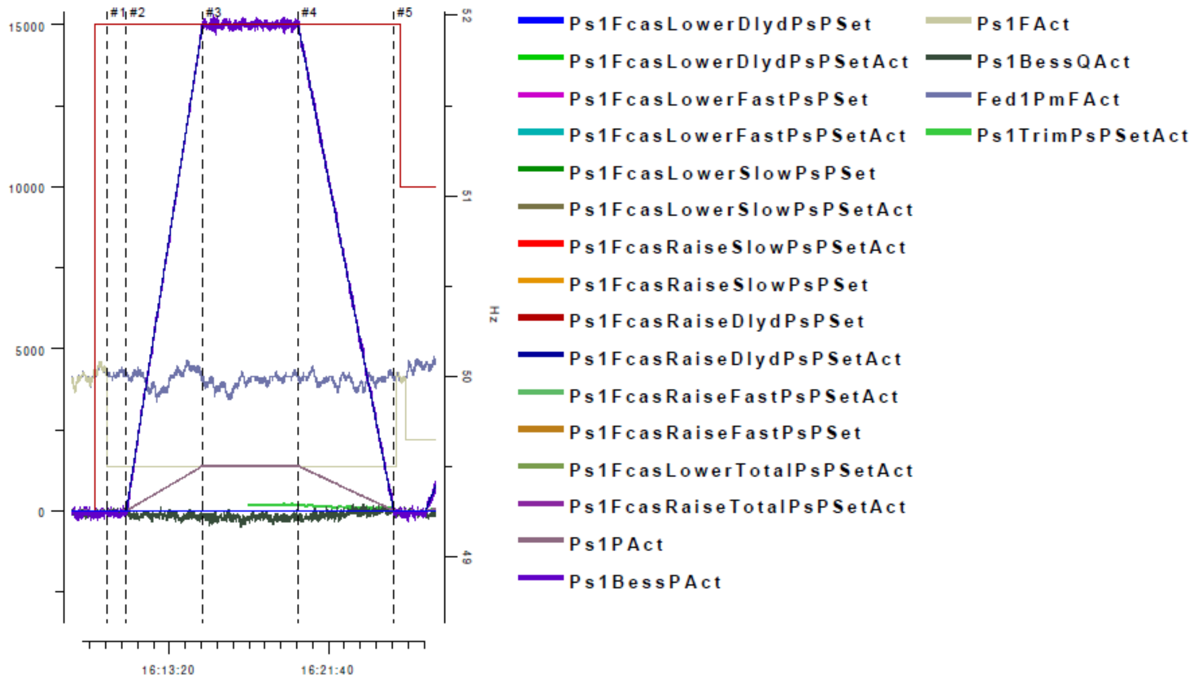

Figure 5-11: Fast frequency response test result from BESS

5.3 System Integration Protection Scheme

Following the SA power system black event in September 2016, maintaining the connection of the Heywood Interconnector during a system event that results in significant generation loss in South Australia has been identified as a high priority.

The System Integration Protection Scheme (SIPS) was introduced to address this risk and is designed to rapidly identify conditions that could otherwise result in a loss of synchronism between South Australia and Victoria. The SIPS is designed to correct these conditions by rapidly injecting power from batteries or shedding sufficient load to assist in re-balancing supply and demand in South Australia, and prevent a loss of the Heywood interconnector.

The BESS has been incorporated into the System Integration Protection Scheme (SIPS) and is able to provide rapid response on receipt of a SIPS command.

The BESS response to the SIPS external command performed during testing is shown in Figure 5-12 and Figure 5-13.

Test results have demonstrated that the BESS can achieve 100% output within 250 ms of a signal from the South East substation (SEAS), 400 km away. This response time is made up of the signal propagation delay from SEAS (30 ms), the BESS co-ordinated control action (120 ms) and the BESS time to respond from 0 to 100% discharge (100 ms). This performance is in line with the SIPS design response time of 250 ms.

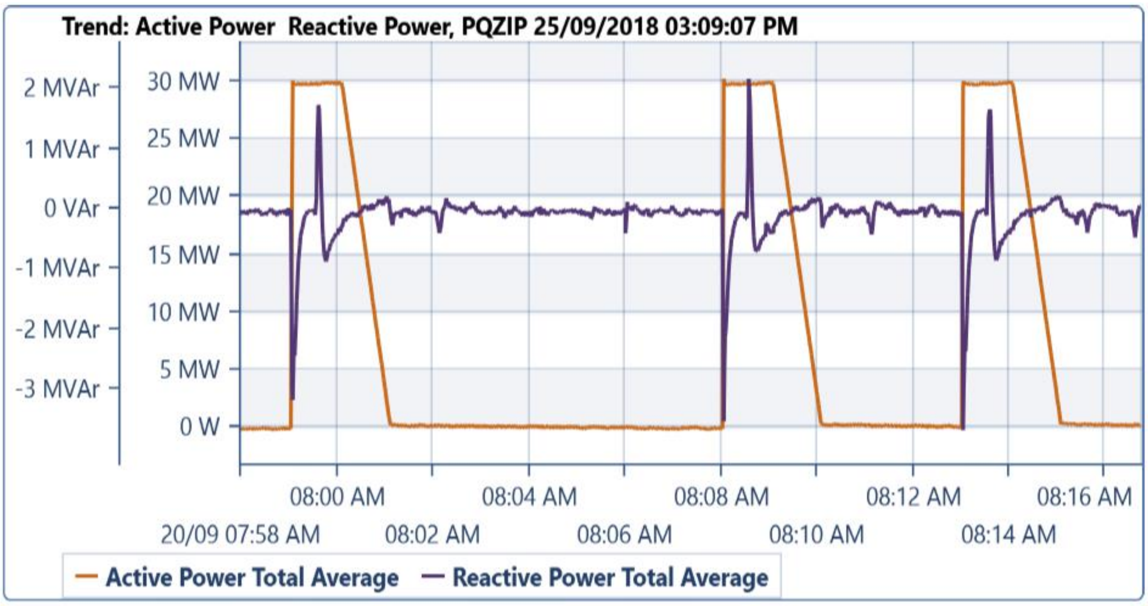

Figure 5-12: BESS response to external SIPS command test

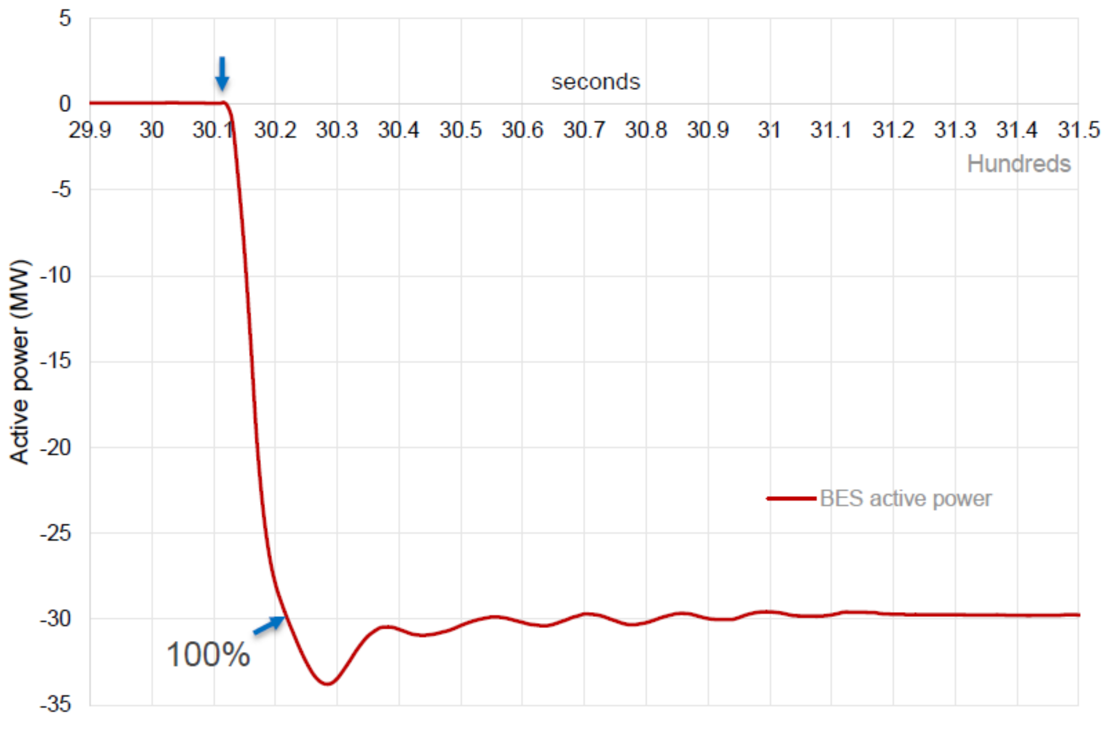

Figure 5-13: BESS active power in response to SIPS command

The SIPS function of the BESS has been tested and operated correctly.

However, since the BESS has been in operation there has been no system incident resulting in a significant amount of generation loss in SA to trigger the BESS response to the SIPS command.

6. Demonstration of Key BESS Market Services

6.1 General Financial Performance

AGL took over operational control for the BESS on 14 December 2018. After some initial commissioning issues related to faulted cells and aging communications infrastructure, the BESS has been performing well over the past few months, and generally autonomously. There has seldom been a need for AGL or ElectraNet to take operational action in response to a fault, meaning the battery has been highly available and well placed to perform its market services, primarily the provision of contingency FCAS.

For the six month reporting period since commercial operations commenced (14 December 2018 to 14 June 2019):

- The charging cost for the BESS was approximately $120,000
- Discharge revenue earned by the BESS was approximately $116,000
- The BESS required an average daily charge of approximately 7.5 MWh
- Average charge cost was approximately $700 per day
- FCAS revenue was approximately $1.33 million. Average daily FCAS revenue was approximately $7,200
- FCAS recovery paid was approximately $12,000. Average daily FCAS recovery paid was approximately $70

6.2 BESS Value Streams

The two market revenue streams for the BESS utilised in the first six months of operations are energy arbitrage and provision of FCAS services to the market. In this period, the majority of revenue earned from the BESS was through provision of FCAS services.

The total revenue earned from energy arbitrage and FCAS services combined was nearly double that expected when compared to this period in the business case. However, energy arbitrage revenue is around half of what was expected under the business case, while FCAS revenue is significantly higher than expected. Charging costs for the battery were around $120,000 overall for the first six months – this is required both for energy arbitrage opportunities (being able to discharge at times of high prices), and for providing FCAS services (see further 6.2.2 below).

6.2.1 Energy Arbitrage

Since taking operational control of the BESS, revenue through energy arbitrage opportunities was approximately $116,000. The delay in establishing effective control system coordination with Wattle Point Wind Farm has resulted in contractual limitations which have limited the value of energy arbitrage (due to increased capacity reserved for network services) over this period.

While this amount represents trading over the first six months of operational control only and is subject to the constraints noted above, continuation of this trend would result in significantly lower than projected energy arbitrage revenue when compared to this period of the business case.

6.2.2 FCAS Services

The majority of the BESS's current financial value arises from trading in the FCAS markets. During the six-month operational period, FCAS trading revenue was approximately $1.33 million. If a similar amount of FCAS revenue is earned over the remainder of the Contract Year, this will result in significantly higher than anticipated FCAS revenue when compared to the business case.

Of the FCAS services, the majority of revenue earned by the BESS has been in the offering of contingency raise services. However, in order to be physically capable of maximising enablement of those FCAS services (especially the delayed raise service), the BESS requires maintenance of a high charge state.

Accordingly, value trade-offs are continually being made as to whether the greater value lies in discharging the BESS for energy arbitrage activities (and thereby reducing the capability of maximising raise service enablement), or actively participating in the FCAS raise markets. To date, AGL has observed that the greater value has been in providing FCAS services.

6.2.3 Future Revenue Streams and Rebidding

While future revenue streams could include selling cap derivative products, AGL has not offered these products from the BESS to date.

AGL has developed an automated rebidding system which ensures timely and accurate information is sent to AEMO regarding the physical capabilities of the BESS.

The rebidding system was the Minimum Viable Product (MVP) required for National Electricity Rules (NER) compliance whilst trading in the NEM. The MVP software does not optimise energy arbitrage value (energy versus FCAS). It is anticipated that a comprehensive optimisation module will be required prior to the commencement of five-minute settlement in July 2021.

7. General Operational Issues

7.1 ElectraNet - AGL Battery Operating Agreement

The Battery Operating Agreement (BOA) is structured as an energy storage services agreement, which requires the parties to also enter into an Operating Protocol for the asset. The Operating Protocol sits behind the BOA and may be updated or amended if required to ensure the facility operates in accordance with the terms of the BOA, without amendment of the BOA. The BOA and Operating Protocol provide the ongoing contractual basis for AGL's operation of the BESS as well as the regime of payments and an availability guarantee.

Under the BOA an annual User Fee payment is due, which may be adjusted for performance/ non-performance of the asset. The first payment is due in December 2019.

The original BOA has been varied, as the parties realised that amendments were required in order to allocate responsibility for items arising under the state jurisdictional licensing regime managed by the Essential Services Commission of South Australia (ESCOSA) and some matters covered by the National Electricity Rules.

Accordingly, the varied BOA now sets out a responsibility matrix for the various licensing and regulatory obligations. A number of obligations have been adopted by ElectraNet (Owner), rather than AGL (User) as ElectraNet has the existing technical knowledge and experience with the asset to be able to fulfil the obligations and has the ongoing leverage to resolve any defects.

The BOA now explicitly specifies that the User wishes to rely on the Owner's compliance with the relevant obligations to support an exemption from the User to meet these same obligations.

The obligations on ElectraNet under this arrangement include:

- Development of a Generator Performance Standard compliance testing program, and undertaking compliance testing as required under that program
- The preparation, maintenance and periodic revision of the Safety, Reliability, Maintenance and Technical Management Plan (SRMTMP), to be approved by the South Australian Office of the Technical Regulator
- The preparation, maintenance and periodic revision of the switching manual

7.2 Facility Maintenance Contract

On 14 December 2018 the ESCRI-SA facility maintenance contract commenced with Consolidated Power Projects Pty Ltd (CPP). Under the contract, CPP is required to carry-out routine maintenance of the system, provide a first call response service, as well as respond to all breakdowns and other maintenance requirements.

Routine maintenance carried out under the contract to date has comprised of monthly visits to the site to inspect and test the on-site diesel generator and check and test the BESS fire suppression system.

CPP's maintenance team is based in Adelaide, around 200 km and a 2.5 hour drive from the ESCRI-SA system at Stansbury. As a result, each maintenance call-out requires significant response time.

In the period from 14 December 2018 to the 14 June 2019 a total of approximately 25 non-planned maintenance events (alarms from site) have occurred. ElectraNet recorded these events, raised a notification in their system and these were assigned to CPP to action under the maintenance contract.

These events were initially investigated via remote access and the majority were found to have reset once a 'Master Alarm Reset command' was issued and they cleared in the system. Included within these events were four call-outs between the 14 December 2018 and 1 January 2019 where site attendance was required, mainly due to cooling issues from operational load and high ambient temperatures. These non-planned maintenance events are covered in sections 7.2.1 to 7.2.5 below.

7.2.1 Communications

The ESCRI-SA micro grid controllers (MGC's) are all connected via the Ethernet. On 26 December 2018 these controllers lost communication with each other and the batteries. Technicians attended site, investigated and power cycled all the controllers.

Communication was re-established and the BESS put back into service.

Further investigation from ABB found there was an issue with a recent firmware update. Another update was applied to the firmware and the issue was resolved.

7.2.2 Air Conditioning Operation

The ESCRI-SA system has struggled to maintain temperature within the desired operational band.

The air conditioning units in the ESCRI-SA system are an inverter type with a 3-phase compressor. In general, the more efficient inverter mode is used to hold the temperature at the set point, while the compressor mode kicks in to provide extra cooling power when the temperature strays further from the set point.

CPP are refining the air conditioner controls with the supplier with a solution likely to be implemented when the additional air conditioner units are installed in August 2019. This is expected to resolve the cooling capacity of the system.

7.2.3 Air Conditioning Alarms

Over-temperature alarms are likely to continue to occur until an additional two air conditioning units are installed (due August 2019), although the lower ambient temperatures during autumn and winter is expected to reduce their frequency of operation.

ElectraNet, in conjunction with CPP and ABB, is currently working to develop self-resetting alarms on the BESS and air conditioning units. BESS alarms can presently be reset remotely but at this stage this is not available on the air conditioning units.

7.2.4 Suspect data

The Remote Terminal Unit (RTU) has at times flagged the BESS availability (plausible) and BESS availability (max capacity) as suspect data. This is due to the analogue values in the BESS system sometimes slightly exceeding 100%, probably due to floating point conversions. As a result, the points were flagged as “over-range” in the DNP3 protocol, which is why the EMS was receiving them as suspect quality.

ABB has proposed a change to the PLCs on site to cap the values in the system to 100%, which should prevent the over-range flag being applied to the points.

7.2.5 Component Failure and Changeover

Since commencement of the facility maintenance contract on 14 December 2018, four components have been changed over due to failure.

One BESS inverter failed soon after 14 December 2018 and was replaced by CPP under warranty. The inverter was sent back to ABB to determine the cause of failure along with three that failed during commissioning. CPP has been informed by ABB that failure of a small number of inverters during commissioning and initial start-up is not uncommon.

One battery module (22 cells, 78Ah, 6.35 kWh) which failed during commissioning was changed out in April 2019. There was a delay due to the long lead time (three months) to receive a replacement module from South Korea. In the meantime, the BESS system was able to operate with only a very minor de-rating on the maximum battery capacity.

One battery module cooling fan failed and was replaced using the fan module from the faulty module.

7.2.6 Spare Parts Inventory

Under the facility maintenance contract, CPP is required to carry a spare parts inventory, covering inverter, battery interface, panel and container spare parts. This does not currently include carrying spare parts for the SCADA system or spare battery modules.

ElectraNet is currently considering a proposal from CPP to carry spare parts for the ABB SCADA system, as recommended by ABB.

CPP is currently in discussions with Samsung around holding battery spares. The lead time for battery modules is at least 7-8 weeks as they are sourced from South Korea via sea freight. They could not be air freighted for safety reasons. There is the possibility that AWR Group (the Australian distributor for Samsung batteries), may be able to hold batteries at their Sydney facility to significantly reduce the lead time.

CPP is also exploring the possibility of holding some hot spare battery modules on-site. Replacing battery modules is not as simple as a direct replacement as the float level needs to be balanced (equalised) to the bank voltage, the battery module is charged and continually monitored as the voltage is increased to the acceptable voltage limit.

CPP is finalising their recommendations with Samsung on the management of hot-spares, potentially including a strategy of rotating hot-spares to ensure that the wear level of the spares is consistent with the active batteries.

7.3 Safety Incidents

There have been no safety incidents in the period from October 2018 to June 2019.

Three minor material handling accidents and one vehicle accident, all occurring in the construction phase, were reported within the Project Commissioning Report.

7.4 Stakeholder Issues

There has only been one complaint from a stakeholder regarding any aspect of the BESS system. One noise complaint was lodged with a Government department in June 2019. Preliminary field measurements of noise appear to be acceptable, but the testing will need to be repeated day and night over a period of time once all of the air conditioning units have been installed.

Initial concern shown in the early stages of the Project, relating to the possibility of acid spills from the batteries, was due to misinformation about the batteries containing sulphuric or hydrochloric acid. This was addressed by the provision of information. Other queries have mostly been generated by people wanting to find out more about the BESS.

7.5 Market Non-Compliance Incidents

All market performance requirements such as FCAS and energy trading functionality of the BESS have been tested as part of the commissioning test program. Test results confirmed that the BESS can respond to market dispatch signals as required by the Rules.

The technical performance requirements of the BESS under the NER have been tested and it has been confirmed that correct operations have been achieved. Since the BESS has been in commercial operation, no system event has occurred to indicate any non-compliance with market dispatch signals.

Based on test results to date it is not anticipated that the BESS would fail to comply with any market dispatch signal. Therefore, non-market compliance issues in the BESS system are not expected to occur.

Up to this point in time, the BESS appears to be compliant with its technical performance specifications and it operates in line with its design.

Due to the BESS Overload Capability under Fast Charging Conditions defect discussed in Section 3.4.3 a self-imposed limit was applied by AGL to limit charging to < 7.5 MW until the issue was resolved, and this was notified to AEMO.

During a loss of communications event this level was breached for a short time and there was a small risk of a non-compliance to performance standards if a number of co-incident events occurred (high charge and a RoCoF event), but this did not eventuate.

8. Key Lessons Learnt

Key lessons learnt from the first six months of operation (from 14 December 2018 to 14 June 2019) are outlined in Sections 8.1 to 8.5 below.

8.1 Project Objectives Achieved

The ESCRI-SA Project is now fully delivered and achieved key project outcomes, as defined in the Funding Agreement:

- Demonstrate the deployment and operation of a large-scale BESS to deliver a combination of network and market benefits
- Demonstrate a contracting and ownership model to maximise the value of a BESS
- Test the regulatory treatment for the ownership of large-scale BESS by regulated transmission network service providers
- Provide price discovery for the deployment of a large-scale grid connected BESS
- Highlight and address technical and regulatory barriers in the deployment of large-scale batteries

The following specific services and capability of the ESCRI-SA BESS are operational and performing well:

- Supply of Fast Frequency Response (FFR) ancillary services into South Australia to reduce constraints on the Heywood interconnector, resulting in increased flows on the interconnector.
- Reduction of expected unserved energy to Dalrymple following loss of supply, involving islanding of the BESS with the local load, the Wattle Point Wind Farm at reduced output, and local rooftop PV to supply local load until grid restoration.
- Market trading of electricity within the South Australian National Electricity Market (NEM) region and provision of Frequency Control Ancillary Services (FCAS) services.

Since commencement of the Project, the BESS has also been incorporated into the System Integration Protection Scheme (SIPS) to support the existing Heywood interconnector by injecting real power into the system following a system event causing substantial loss of generation in South Australia.

8.2 Air Conditioning Specification

The installation of additional air conditioning units to maintain the temperature of the battery rooms and inverter rooms within the desired operational target under extreme conditions is discussed in Section 3.4.1

The BESS is a comparatively large indoor installation of batteries and under rapid discharge the temperature can reach 50ºC in 1-2 minutes. The ESCRI-SA tender was not prescriptive around how cooling was applied to the battery modules and inverters. While liquid cooling is a potentially more efficient alternative to deliver cooling to the required areas, the application depends on how the inverters and battery modules are configured and designed and is not an off-the-shelf solution. In comparison to this, the cost of installing and operating additional air conditioning systems is low.

For a future project, rather than specifying a different cooling system, the knowledge gained from this Project would be to work with the contractor to pay closer attention to the air conditioning design and ducting of air flow to optimise the performance of the cooling system.

8.3 Auxiliary Loads and Losses

The BESS system accumulates losses from auxiliary loads (e.g. air conditioning), transformer energisation, inverters and the battery management system in order to keep the system available at all times and ready to respond to system events. This is discussed in Section 4.2.

Average auxiliary load and losses were 2.19% of the 30 MW rated capacity over the six month reporting period. These losses accumulate over time and can become a significant component of energy throughput for a “power battery”.

A key learning from this project is that it is important to consider how the battery is intended to be used and consider the various aspects that comprise the auxiliary loads and losses. This information is a key input to inform how the commercial arrangements then need to be setup.

8.4 Lead Time for Spare Battery Modules

The lead time for spare battery modules is discussed in Section 7.2.6. The lead time for BESS battery modules is at least 7-8 weeks as they are sourced from South Korea via sea freight and cannot be air freighted for safety reasons. CPP is working with the Australian distributor for Samsung batteries to try and reduce this lead time by holding batteries at their Sydney facility and are also exploring the possibility of holding some hot spare modules on-site to enable quick changeover of battery modules is required. Understanding the lead time, and management of spare battery modules is an important consideration for future projects.

8.5 Value of Future Battery Systems

Batteries are currently difficult to justify as a standalone investment. The key challenges facing future battery system projects are expected to include reduced FCAS value as FCAS competition increases, and the ability to capture regulated network benefits, including the turnaround time for applying the regulated economic cost benefit test (the RIT-T process).

The FCAS value is expected to reduce as more batteries and other technologies with similar profiles come online. This is a significant issue as FCAS is currently the primary income stream for battery installations – for the BESS this formed over 90% of the competitive market revenue over the six month reporting period. Battery installations are generally price takers within the FCAS market.

In addition, grid-scale battery systems inherently provide support to the system, in the form of active and reactive power to assist in the restoration of system voltage during faults. However, this service is currently unmonitored and is typically unable to be monetised, mostly because this support improves a regulated service, as opposed to rectifying a regulated service obligation that has been breached.

Increasing network constraints, potential increases in price volatility due to a decrease in dispatchable supply over time, and the introduction of five minute settlement may result in battery systems gaining in value over time.

9. Associated Parties & Project Contact Details

ElectraNet	ElectraNet powers people's lives by delivering safe, affordable and reliable solutions to power homes, businesses and the economy. As South Australia's principal Transmission Network Service Provider (TNSP), we are a critical part of the electricity supply chain. We build, own, operate and maintain high-voltage electricity assets, which move energy from traditional and renewable energy generators in South Australia and interstate to large load customers and the lower voltage distribution network. ElectraNet owns and maintains the 30 MW 8 MWh battery, which provides both regulated network services and competitive market services.
agl	AGL operates the country's largest electricity generation portfolio and is its largest ASX-listed investor in renewable energy. Our diverse power generation portfolio includes base, peaking and intermediate generation plants, spread across traditional thermal generation, natural gas and storage, as well as renewable sources including hydro, wind, landfill gas, solar and biomass. AGL operates the battery to provide competitive market services.
Advisian WorleyParsons Group	Advisian is the advisory and specialist consulting arm of WorleyParsons, who have been involved with the ESCRI-SA Project since its inception in 2013. This work included significant input into the technical and project management components of Phase 1. In Phase 2 and 3 Advisian is the Knowledge Sharing Partner for the Project.

For more information on the Project, please log into the ESCRI-SA Project Portal located at the following address: www.escri-sa.com.au.

The portal contains the ability to ask questions of the project team. It also contains relevant information including:

- Access to live and historical data from the operational BESS
- Images of the Project construction and operation
- All publicly published Knowledge Sharing material, including key reports, operational updates and presentations
- Information from the ESCRI-SA Knowledge Sharing Reference Group, which has been formed to share information about the Project, to discuss issues relevant to large scale batteries in the NEM, and to inform key stakeholders

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