ESCRI-SA Battery Energy Storage Project Operational Report #4

Fourth six months (14/06/2020 – 14/12/2020)

February 2021

In partnership with:

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The purpose of this document is to provide a summary of the fourth six months of commercial operation of the ESCRI-SA Battery Energy Storage Project.

This activity received funding from ARENA as part of their Advancing Renewables Program. The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

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
CBF	Circuit Breaker Fail
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 Integration, South Australia (ESCRI-SA Project), in accordance with the Funding Agreement between ElectraNet and the Australian Renewable Energy Agency (ARENA). ARENA 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 Phase 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”, published in May 2018. This detailed the approach and resolution of issues required to commence the Project. It is referred to herein as the “Project Summary Report”
- The “ESCRI-SA Battery Energy Storage Project Commissioning Report – From Financial Close to Commissioning”, published in October 2018. This detailed the journey and lessons learnt in project delivery through to commissioning. It is referred to herein as the “Project Commissioning Report”

Three public reports on Phase 3 have been published:

- The “ESCRI-SA Battery Energy Storage Project Operational Report No. 1 – First six months (14/12/2018 – 14/6/2019), published in July 2019. This detailed the journey and lessons learnt from commissioning to full operation
- The “ESCRI-SA Battery Energy Storage Project Operational Report No. 2 – Second six months (14/6/2019 – 14/12/2019), published in February 2020. This detailed the key operational events and lessons learnt during the second six months of operation
- The “ESCRI-SA Battery Energy Storage Project Operational Report No. 3 – Third six months (14/12/2019 – 14/06/2020), published in August 2020. This detailed the key operational events and lessons learnt during the third six months of operation

This Project Operational Report is the final of four six-monthly operational reports required under Phase 3. It focuses specifically on core components of the Project operation, and lessons learnt on the journey of full operation, including:

- 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), and
- Overview of system maintenance, remaining defects, faults and resolutions

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

Access to the full list of Knowledge Sharing resources is available at the Project Portal (the Portal), at http://escri-sa.com.au/, as described in Section 3.4.

1.2 Intended Distribution

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

2. Introduction

2.1 Background and Report Overview

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 Worley (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) is a key requirement under Milestone 6 of the Funding Agreement between ElectraNet and ARENA. It covers the journey and lessons learnt for the fourth six months of the Project's commercial operation.

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 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 4 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 5 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 6 provides information on general operational issues including maintenance, safety incidents, stakeholder issues, any market non-compliance incidents, the status of the remaining Engineering, Procurement and Construction (EPC) contract and an update on the resolution of defects listed at commercial handover.

Section 7 contains observations about activities and engagements related to the BESS and summarises new lessons learnt during the last six months of commercial operation.

[1] The parties and their roles are described in Section 8 along with contact details 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 roofs.

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

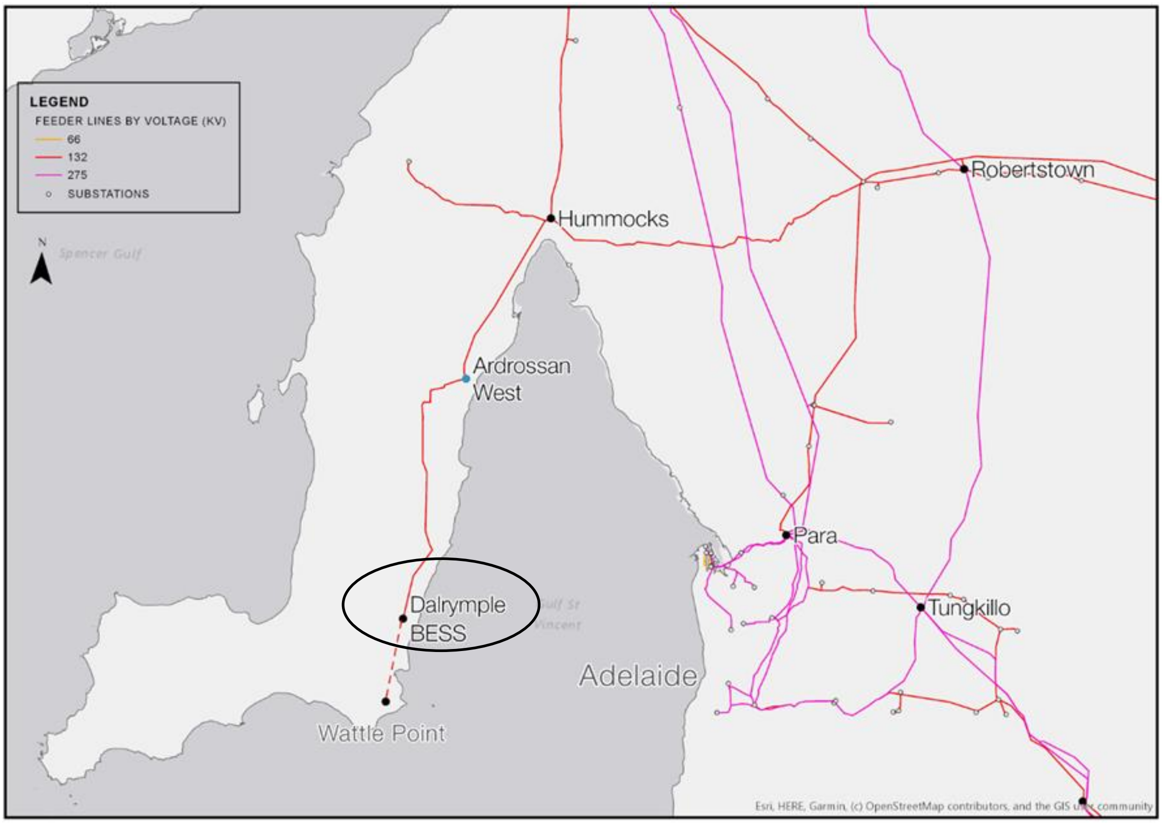

Figure 2-2: Dalrymple connection point relative to existing transmission assets

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 are 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 2006 to 2014 indicated 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.

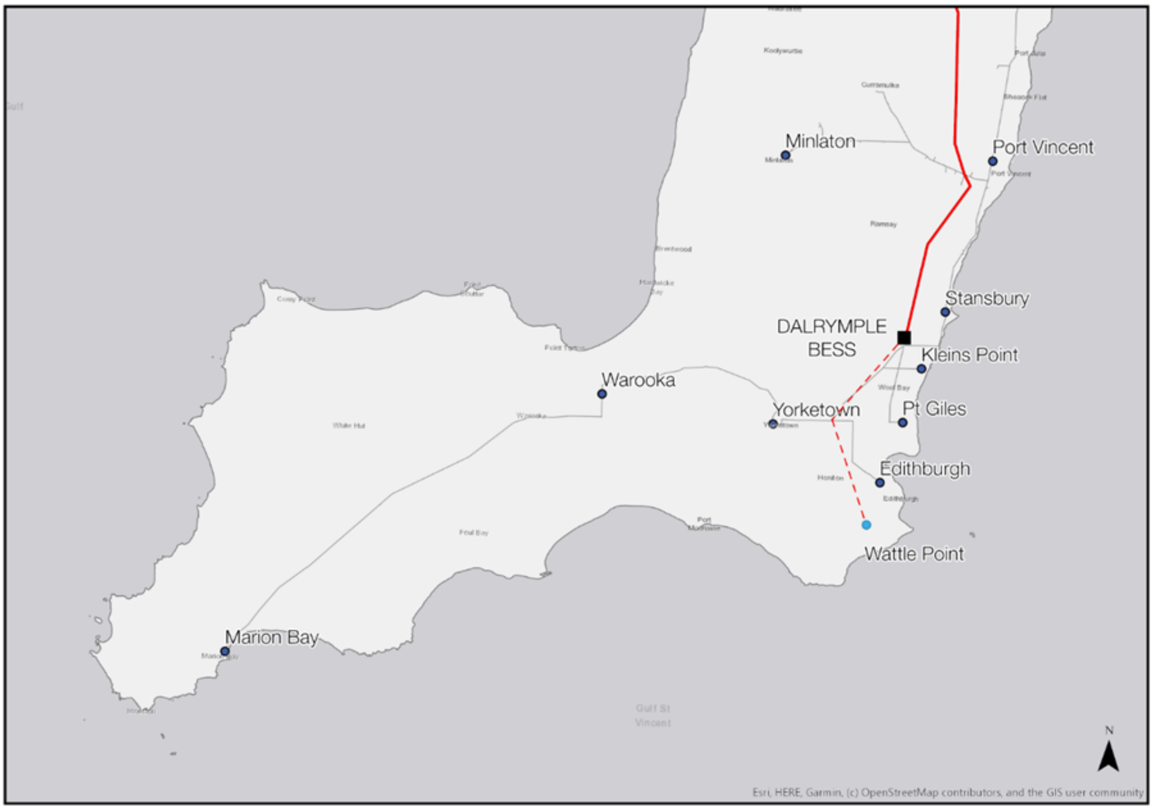

Figure 2-3: Region supported by the Dalrymple battery during an islanding event

During an islanding event, the Dalrymple battery supplies townships on the lower Yorke Peninsula region including Yorketown, Edithburgh and Stansbury. It also supplies communities, businesses 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 services in the following priority order:

1. Islanded operation to enhance local reliability of supply
2. Fast Frequency Response (FFR)
3. Network support
4. Frequency Control Ancillary Services (FCAS), and
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.

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, and
- 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 that causes substantial loss of generation in South Australia.

3. Summary of ESCRI-SA Operation

3.1 Current Operational Status

The BESS has been in commercial operational since 14 December 2018 and continues to meet performance expectations within its design specification.

The BESS is designed to be operated as a power battery, providing various network support, FFR and FCAS services as well as energy trading.

Following up from the third Operational Report:

- R2 model validation work is continuing. ElectraNet is working with ABB to refine specific aspects of the model which involves ABB's factory and Research & Development teams.

3.2 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 24 months of operation from 14 December 2018 to 14 December 2020 respectively, are shown in Table 3-1.

Table 3-1: Key Performance Metrics for First 24 Months of Operation

Key Performance Metric	Value for reporting period (14-12-2018 to 14-06-2019)	Value for reporting period (14-06-2019 to 14-12-2019)	Value for reporting period (14-12-2019 to 14-06-2020)	Value for reporting period (14-06-2020 to 14-12-2020)
Average BESS Availability	98.01%	97.35%	98.93%	98.80%
Total Energy Consumed	1,370 MWh	2,006 MWh	1,499 MWh	1,316 MWh
Total Energy Exported	160 MWh	768 MWh	198 MWh	99 MWh
Average auxiliary load and losses (% of 30 MW rated capacity)	2.19%	2.25%	2.35%	2.19%
Number of Charge and Discharge Cycles (per BOA definition)	2	4	1	1
BESS Charging Cost	$120,000	$101,000	$76,000	$32,750
BESS Discharge Revenue	$116,000	$97,000	$102,000	$4,820
FCAS Revenue	$1.33m	$3.73m	$15.6m	$1.94m

The average BESS availability for the period was 98.80%, which is greater than the 96% Guaranteed Annual Availability required under the Battery Operating Agreement.

The energy consumed by the BESS is significantly higher than the energy exported to the grid. The comparatively 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 at any point in time. This results in higher auxiliary load losses from transformers, inverters and the battery management system.

The number of charge and discharge cycles are contractually defined as the BESS state of charge (SOC) falling below 2.4 MWh. Limited cycles have been recorded during this reporting period which reflects how the BESS is being operated and how many significant unserved energy events have been avoided. Overall, for a power battery, the number of cycles is expected to be low.

The main source of revenue for this reporting period was FCAS, providing $1.94 million compared to just $4,820 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 5.

3.3 Overview of Key Events for Reporting Period

Since 14 December 2018 the BESS has been through 29 operational system events. Most of these events were single-line trips with the remaining being either frequency events or led to the BESS supplying load to prevent or reduce the duration of an unserved energy event. High-speed data recordings from Power System Performance Monitor (PSPM) confirmed the BESS successfully rode through the fault or responded as required.

This section of the Report focuses on eight system events during the fourth six-month period of commercial operation.

3.3.1 Planned Outages

No planned outages relevant to the Dalrymple BESS occurred during the fourth reporting period.

3.3.2 Unplanned Outages

Over the past six months, from 14 June 2020 – 14 December 2020, the Dalrymple BESS responded to several unplanned outages due to various reasons. These unplanned outages are listed below:

- On 4 November 2020 at 2:57 the Ardrossan West – Dalrymple 132 kV line successfully reclosed following a single phase to ground fault resulting in the Dalrymple BESS supplying the local load for a short period of time
- On 10 November 2020 at 20:03, the Ardrossan West – Dalrymple 132 kV line successfully reclosed following a single phase to ground fault resulting in the Dalrymple BESS supplying the local load for a short period of time, and
- On 24 November 2020, inadvertent trips at Dalrymple due to testing of the fire detection system at Dalrymple North resulted in the Dalrymple BESS supplying the local load for periods of time

3.3.2.1 Ardrossan West – Dalrymple 132 kV line, single phase to ground fault (4/11/2020)

On 4 November 2020 at 2:57, the Ardrossan West - Dalrymple 132kV line tripped and successfully reclosed following a single phase to ground fault caused by lightning. The Dalrymple local supply remained connected and supplied by the Dalrymple BESS until re-synchronisation at 2:58. The Wattle Point Wind Farm was generating 67 MW when the fault occurred and disconnected. The BESS output for the unplanned outage event is illustrated in the graph below. Note negative numbers denotes generating power.

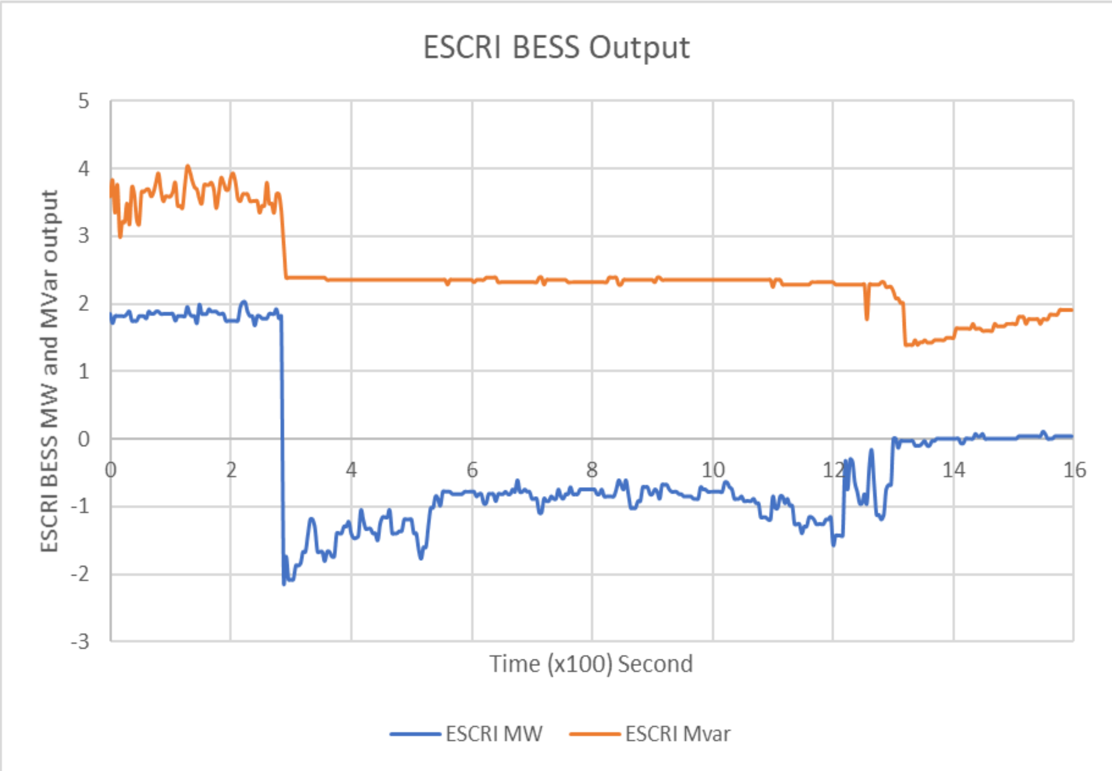

Figure 3-1: Dalrymple BESS active and reactive power output during the event

3.3.2.2 Ardrossan West – Dalrymple 132 kV line, single phase to ground fault (10/11/2020)

On 10 November 2020 at 20:03, the Ardrossan West - Dalrymple 132kV line tripped and successfully reclosed due to lightning. The Dalrymple local supply and Wattle Point Wind Farm remained connected and supported by the Dalrymple BESS until it re-synchronised at 20:03. Wattle Point wind farm was generating 59 MW at the time of the event and remained connected. The WPWF and BESS output for the unplanned outage event is illustrated in the graph below. Note negative BESS numbers denotes generating power. Note that the BESS initially charges to absorb power from the WPWF.

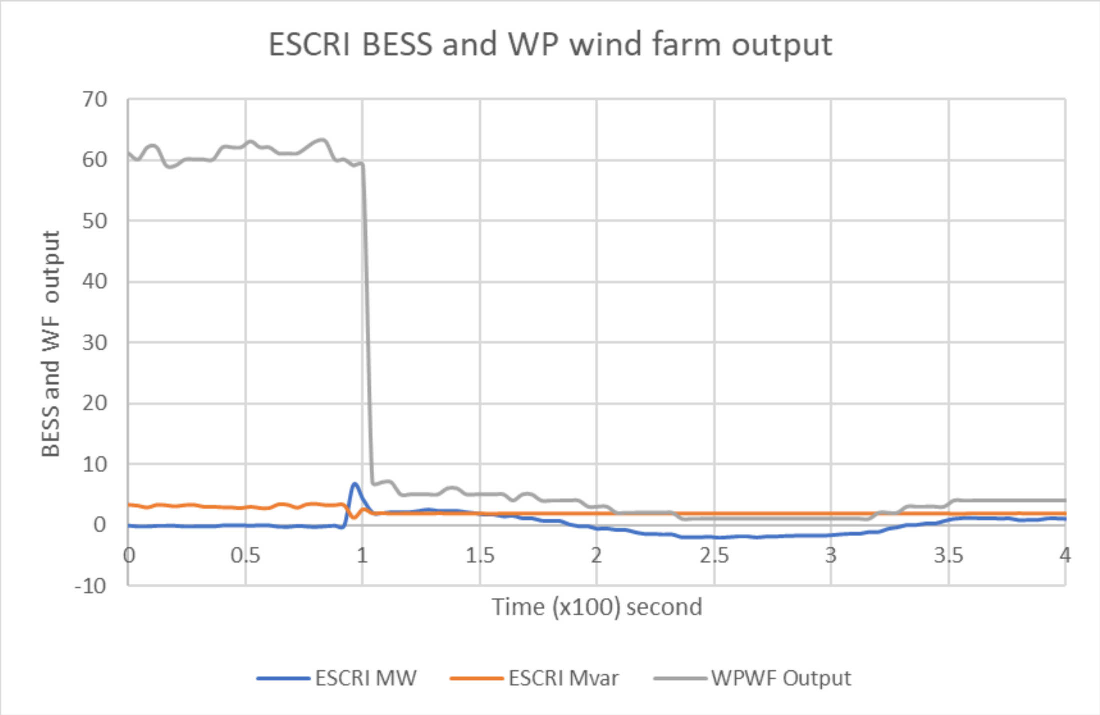

Figure 3-2: WPWF active power & Dalrymple BESS active and reactive power output during the event

3.3.2.3 Inadvertent trips at Dalrymple due to tests at the Wattle Point Wind Farm

On 24 November 2020 at 10:27, Dalrymple North 33/0.375kV TF1, TF2 and TF3 inadvertently tripped due to tests at the Dalrymple North fire system. The ESCRI BESS synchronised with the system at 11:20. No customer load was lost.

3.3.3 Transmission Network Faults

Over the past six months, from 14 June 2020 – 14 December 2020, seven transmission network fault events were relevant to the Dalrymple BESS, as summarised below:

- On 20 September 2020 at 17:04, the Hummocks – Kadina East 132 kV line successfully reclosed following a single phase to ground fault
- On 23 October 2020 at 15:12, Davenport – Bungama 275 kV line tripped and locked out due to CBF operation
- On 23 October 2020 at 14:30, the Bungama – Snowtown – Hummocks 132kV line was tripped and successfully reclosed following a lightning strike on the line
- On 4 November 2020 at 2:57, the Ardrossan West – Dalrymple 132 kV line successfully reclosed following a single phase to ground fault (also refer Section 3.3.2.1)
- On 10 November 2020 at 20:03, the Ardrossan West – Dalrymple 132 kV line successfully reclosed following a single phase to ground fault (also refer Section 3.3.2.2)
- On 11 November 2020 at 5:50, the Bungama – Blyth West 275 kV line successfully reclosed following a single phase to ground fault
- On 11 November 2020 at 5:57, the Waterloo - Hummocks 132kV line tripped and locked out following a 2 phase to ground fault

High speed data recorded at the Dalrymple substation has been downloaded and plotted for the transmission network fault events. These are shown in Figure 3-3 to Figure 3-18.

The downloaded 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.

3.3.3.1 Hummocks – Kadina East 132 kV line, single phase to ground fault

On 20 September 2020 at 17:04, the Hummocks – Kadina East 132 kV line tripped and successfully reclosed following a single phase to ground fault. Dalrymple BESS response due to this fault are shown below.

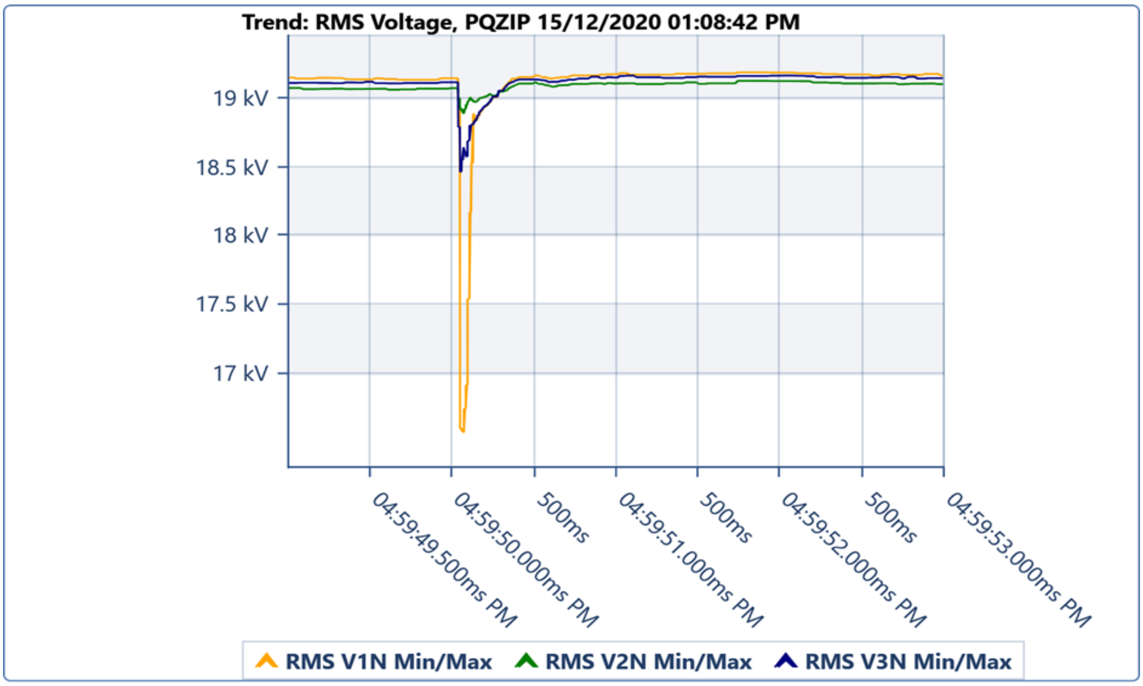

Figure 3-3: BESS voltage measured at the Dalrymple 33 kV substation

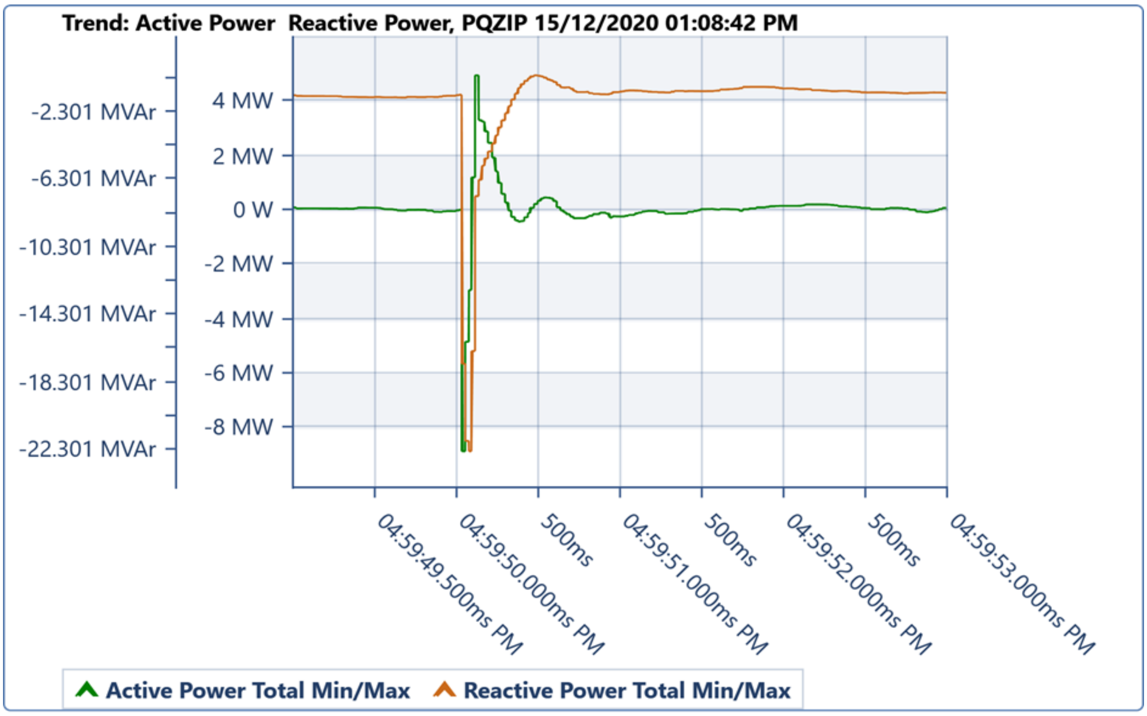

Figure 3-4: BESS active and reactive power output measured at the Dalrymple 33 kV substation

3.3.3.2 Davenport – Bungama 275 kV line, CBF operation

On 23 October 2020 at 15:12, the Davenport – Bungama line tripped and locked out due to CBF operation. High speed data recorded at the Dalrymple 33kV bus indicated the Dalrymple BESS successfully rode through the fault as shown below.

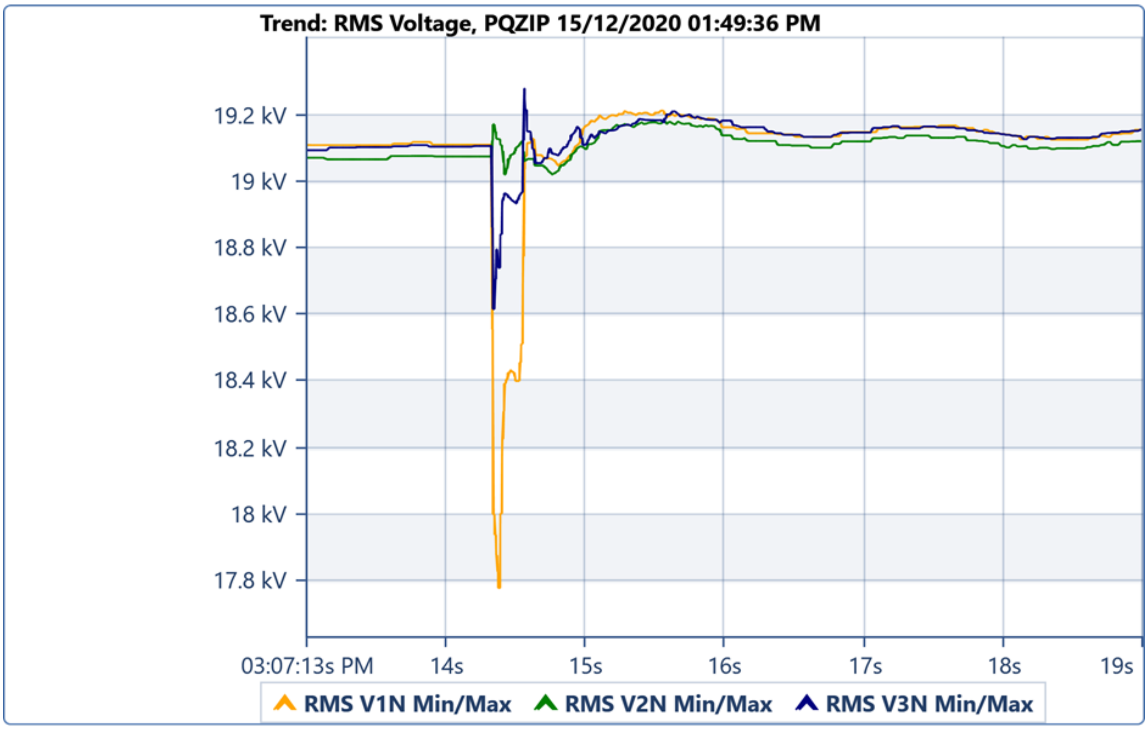

Figure 3-5: ESCRI BESS voltage measured at Dalrymple 33 kV substation.

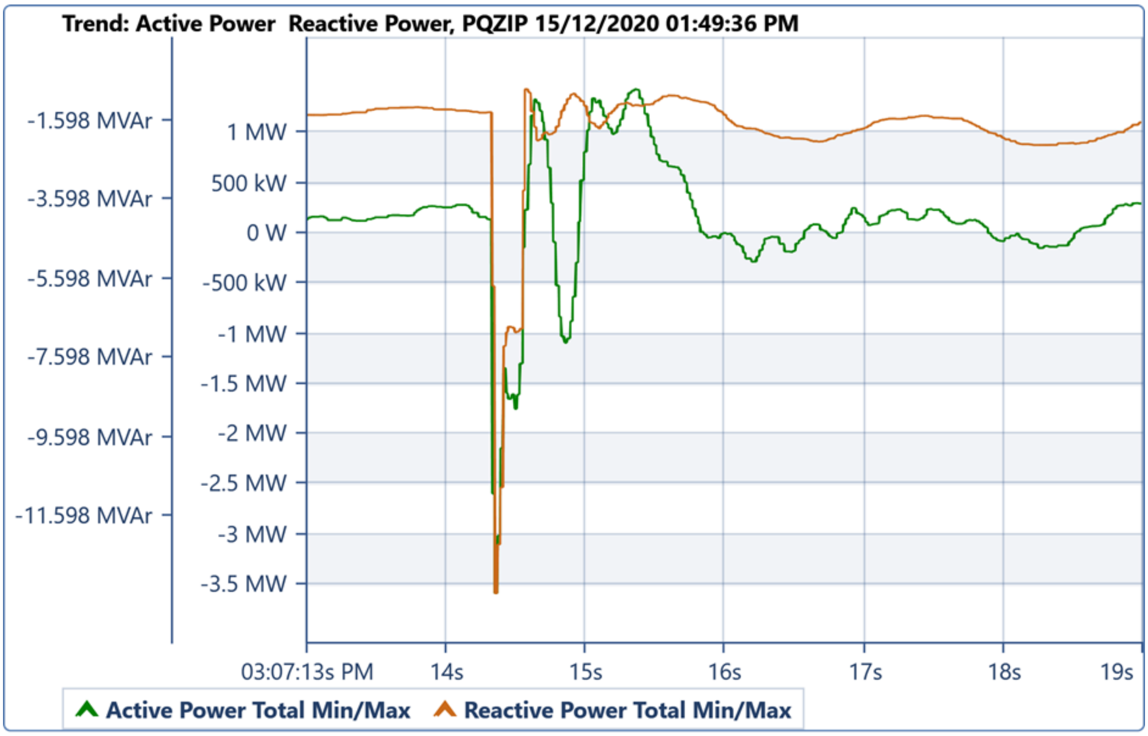

Figure 3-6: BESS active and reactive power response measured at the Dalrymple 33 kV substation

3.3.3.3 Bungama – Snowtown – Hummocks 132 kV line, single phase to ground fault

On 23 October 2020 at 14:30, the Bungama – Snowtown – Hummocks 132 kV line was tripped and successfully reclosed following a lightning strike on the line. High speed data recorded at the Dalrymple 33 kV bus indicated the Dalrymple BESS successfully rode through the fault as shown below.

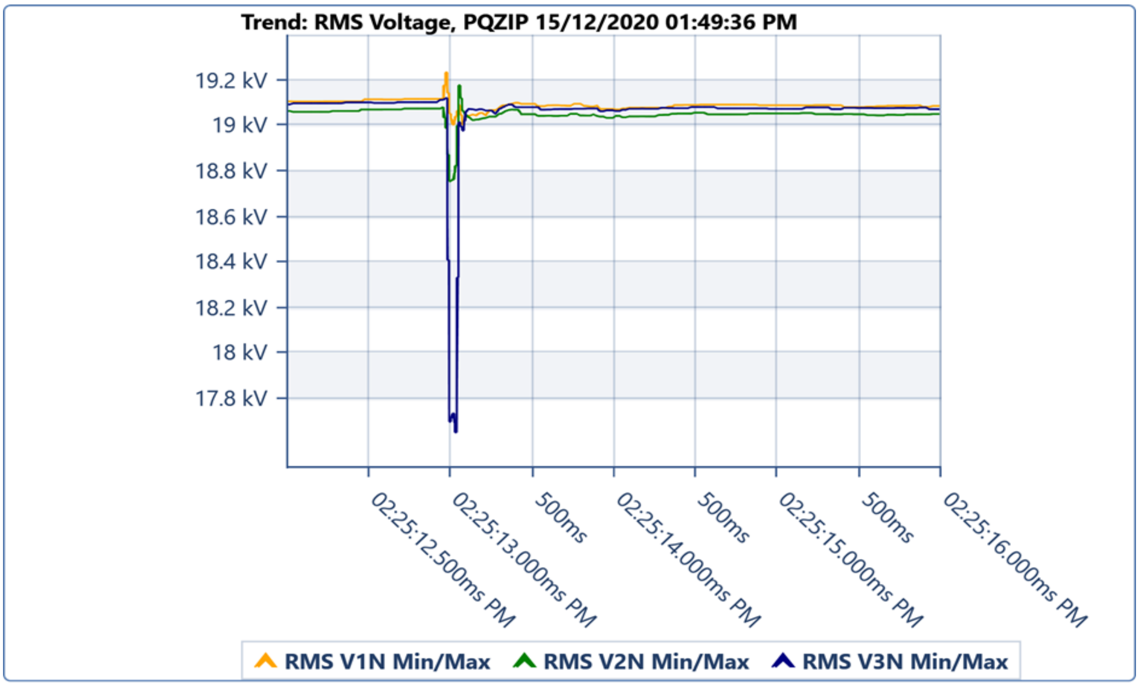

Figure 3-7: BESS voltage measured at the Dalrymple 33 kV substation

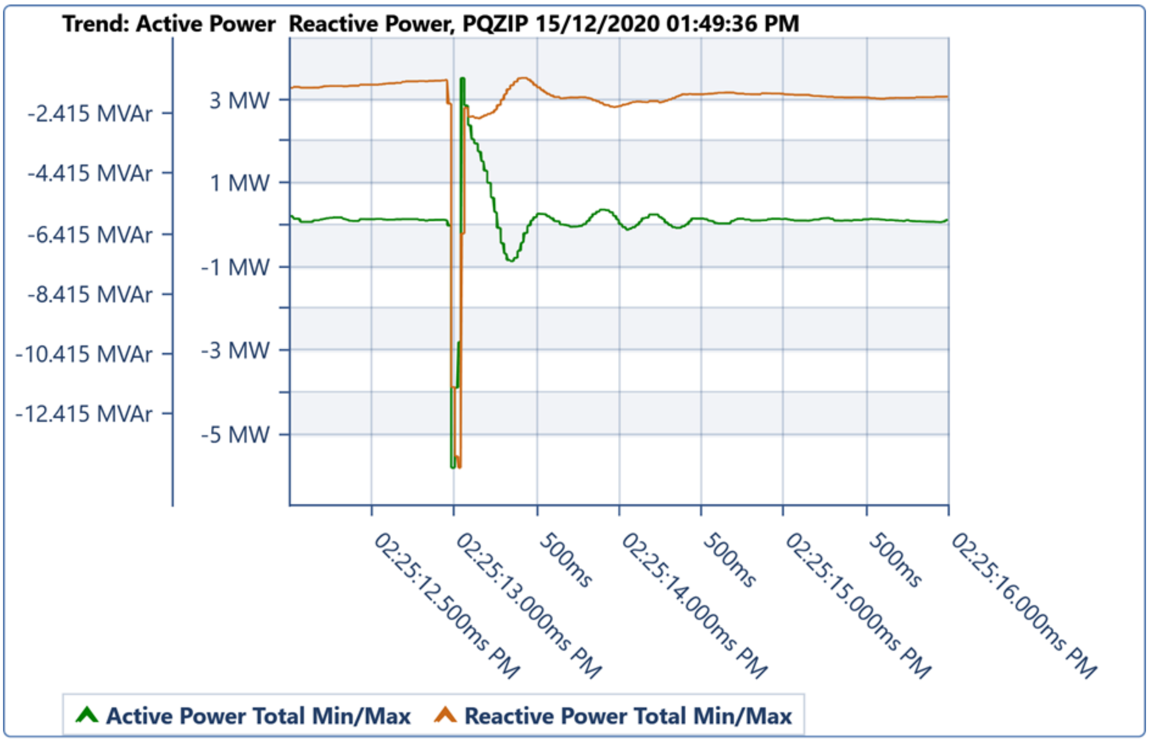

Figure 3-8: BESS active and reactive power output measured at the Dalrymple 33 kV substation

3.3.3.4 Ardrossan West – Dalrymple 132 kV line, single phase to ground fault (4/11/2020)

On 4 November 2020 at 2:57, the Ardrossan West – Dalrymple 132 kV line successfully reclosed following a single phase to ground fault. The Dalrymple BESS successfully rode through the fault as shown in the graphs below.

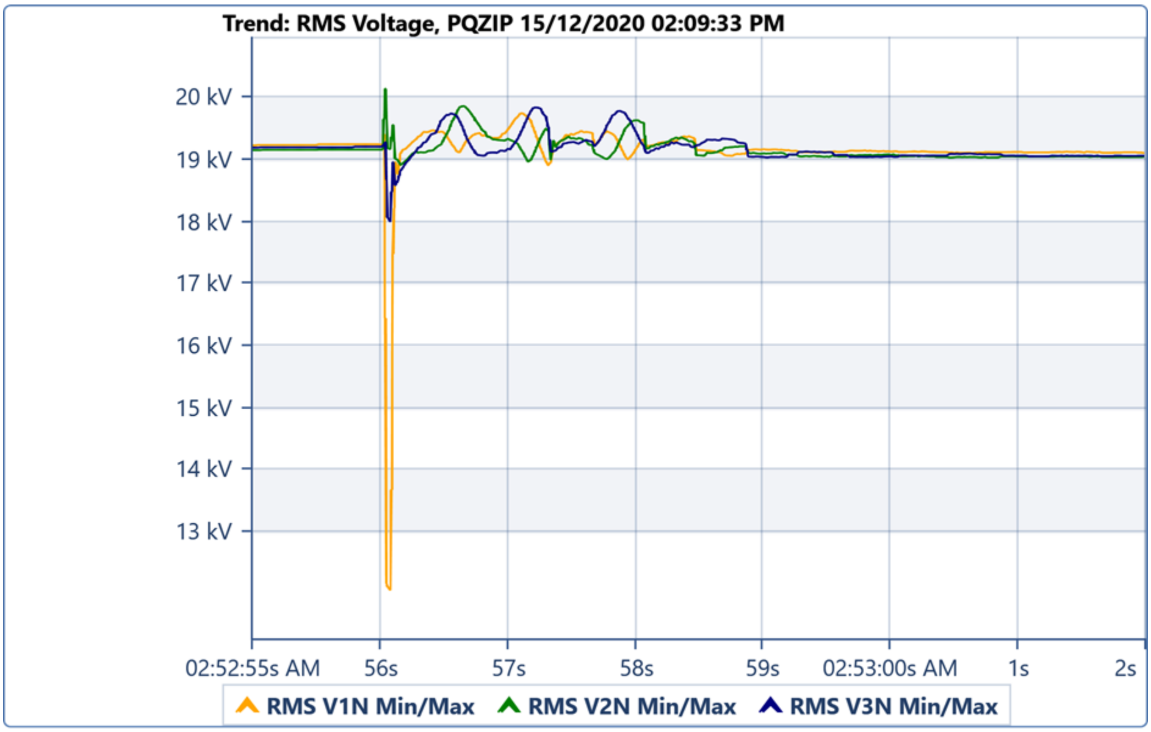

Figure 3-9: 33 kV Voltage measured at the Dalrymple 33 kV substation

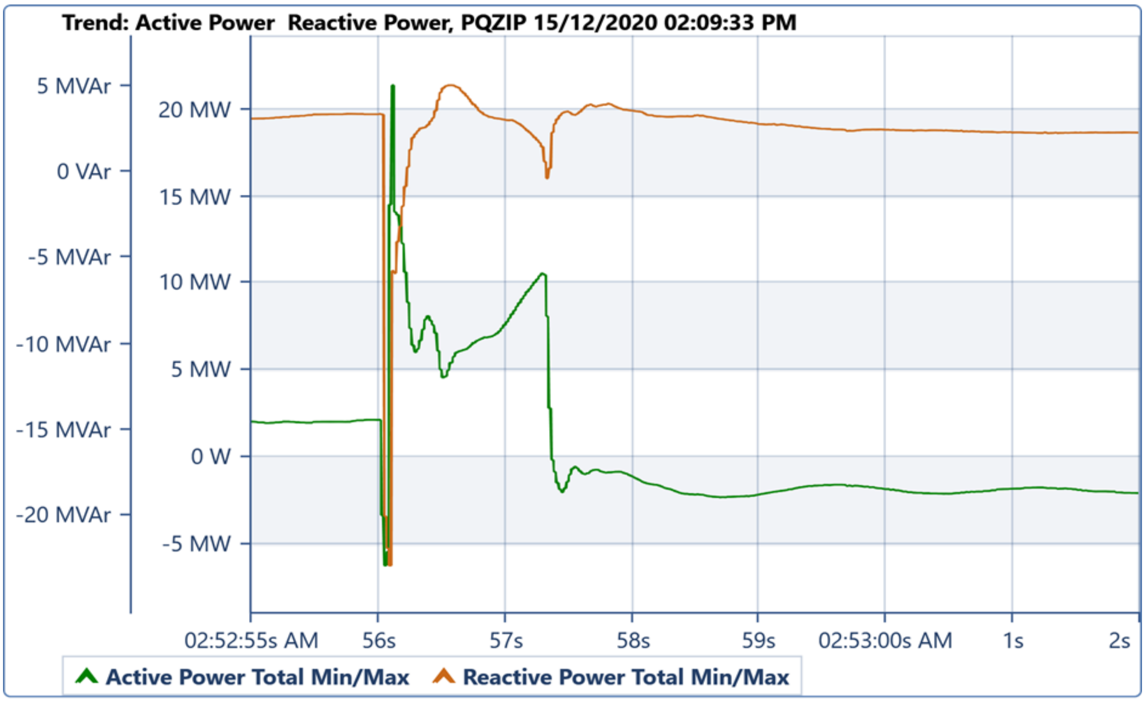

Figure 3-10: BESS active and reactive power measured at the Dalrymple 33 kV substation

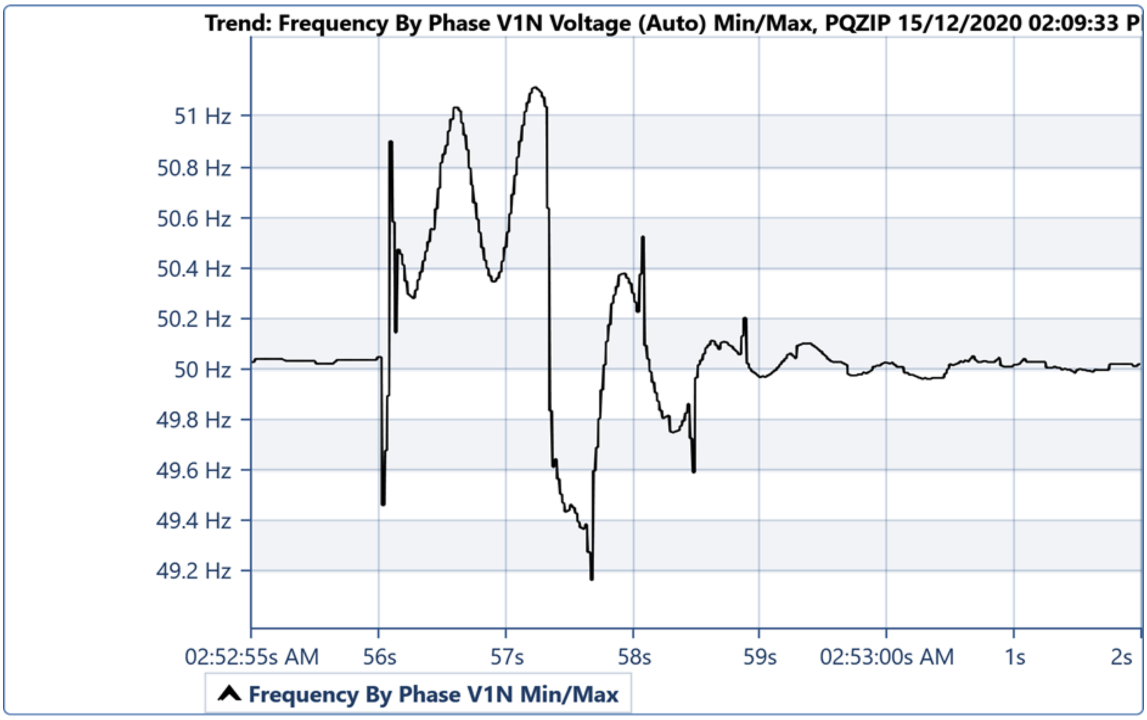

Figure 3-11: System frequency measured at the Dalrymple 33 kV substation

As measured at Dalrymple, system frequency reached 51.2Hz. This triggered over-frequency protection, with the result that Wattle Point WF was tripped when its output was at 67 MW.

3.3.3.5 Ardrossan West – Dalrymple 132 kV line, single phase to ground fault (10/11/2020)

On 10 November 2020 at 20:03, the Ardrossan West – Dalrymple 132 kV line successfully reclosed following a single phase to ground fault. The Dalrymple BESS successfully rode through the fault as shown in the graphs below.

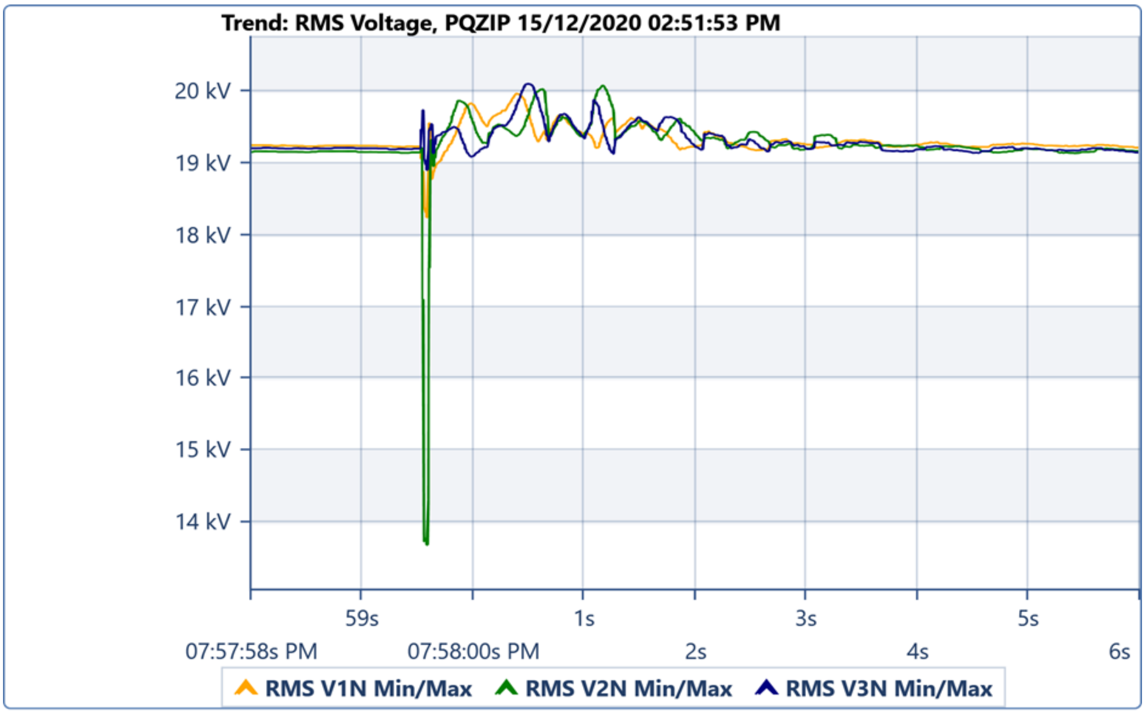

Figure 3-12: 33 kV Voltage measured at the Dalrymple 33 kV substation

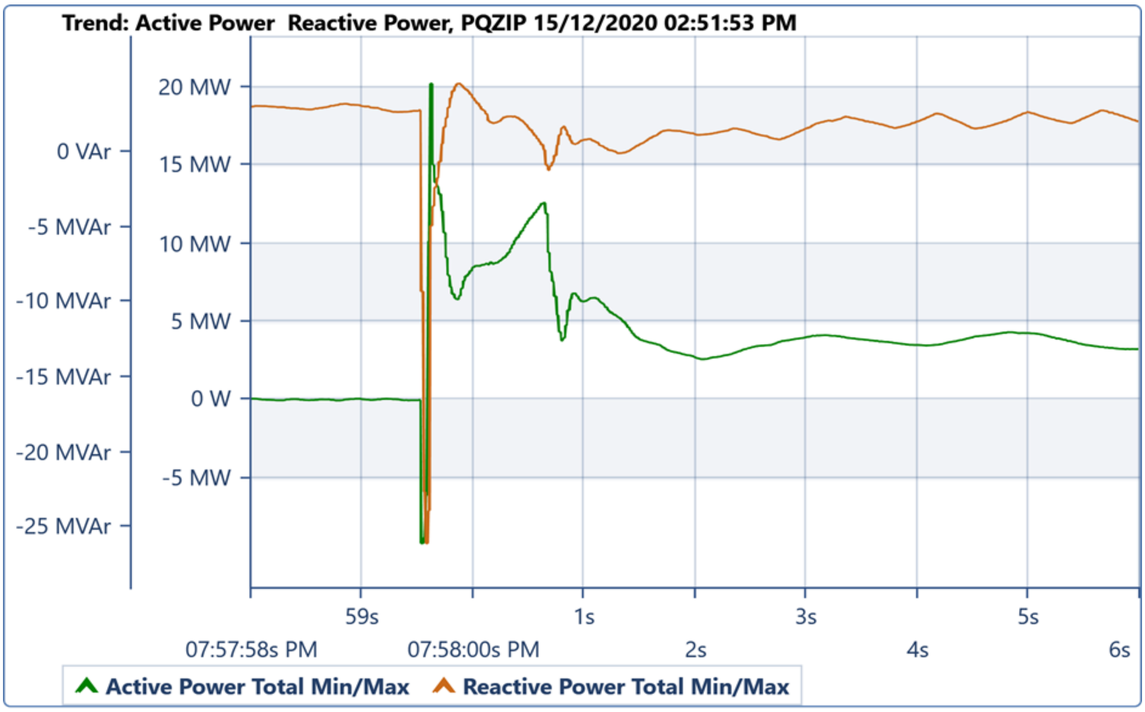

Figure 3-13: BESS active and reactive power measured at the Dalrymple 33 kV substation

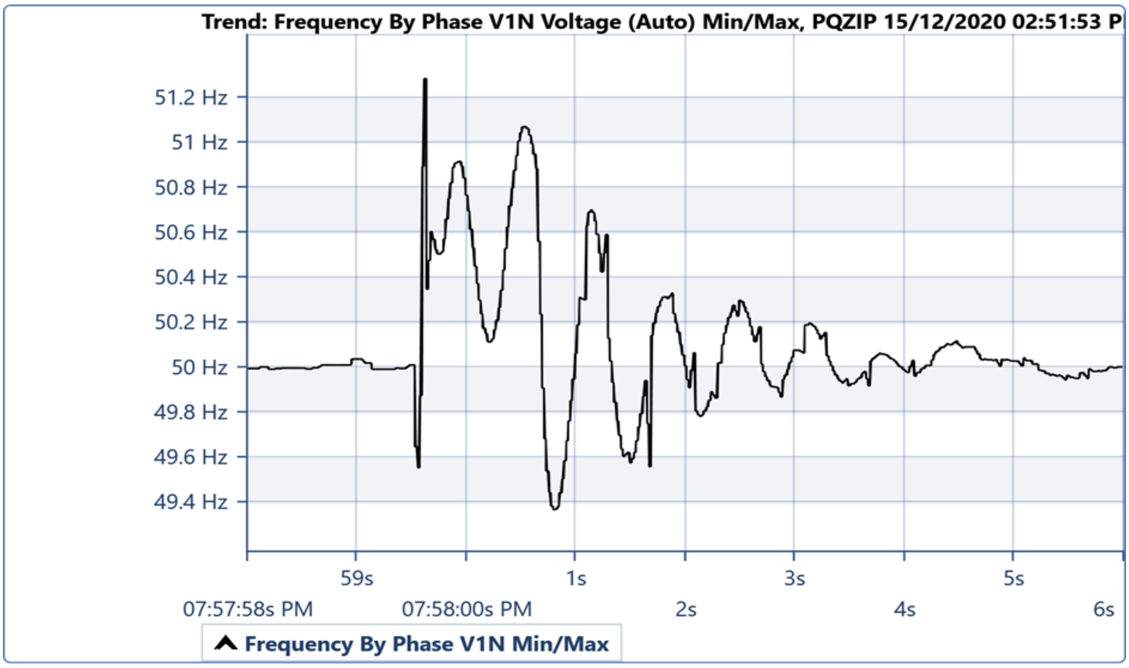

Figure 3-14: System frequency measured at the Dalrymple 33 kV substation

As measured at Dalrymple, system frequency briefly reached 51.02 Hz, which did not trigger over-frequency protection for the Wattle Point WF. As a result, the Wattle Point remained connected with its output at 59 MW at the time.

3.3.3.6 Bungama – Blyth West 275 kV line, single phase to ground fault

On 11 November 2020 at 5:50, the Bungama – Blyth West 275 kV line successfully reclosed following a single phase to ground fault.

The Dalrymple BESS successfully rode through the fault as shown in the graphs below.

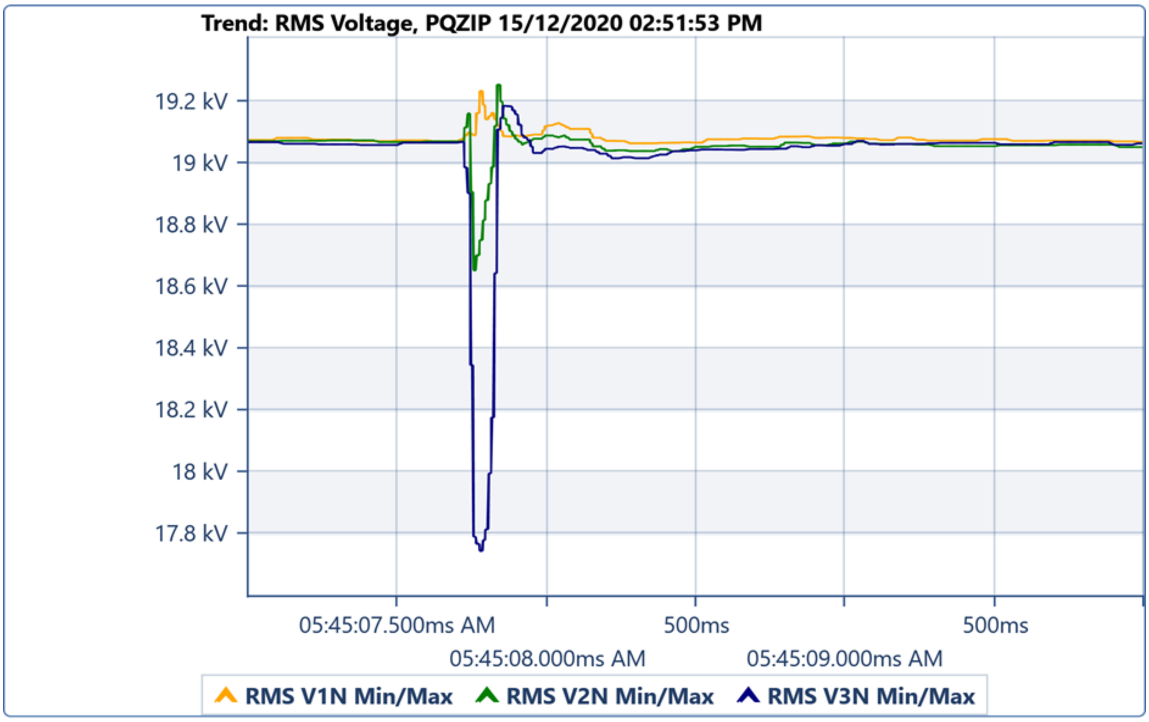

Figure 3-15: 33 kV Voltage measured at the Dalrymple 33 kV substation

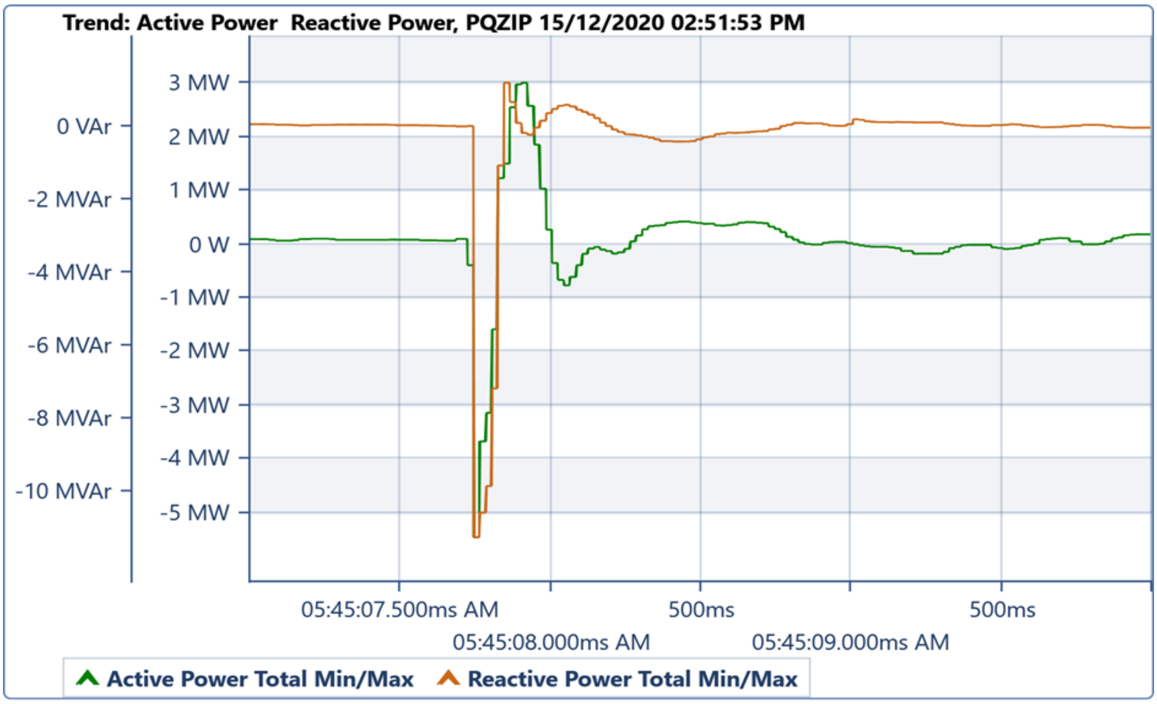

Figure 3-16: BESS active and reactive power measured at the Dalrymple 33 kV substation

3.3.3.7 Hummocks – Waterloo 132 kV line, two phase to ground fault

On 11 November 2020 at 5:57, the Waterloo - Hummocks 132kV line tripped and locked out following a 2 phase to ground fault.

The Dalrymple BESS successfully rode through the fault as shown in the graphs below.

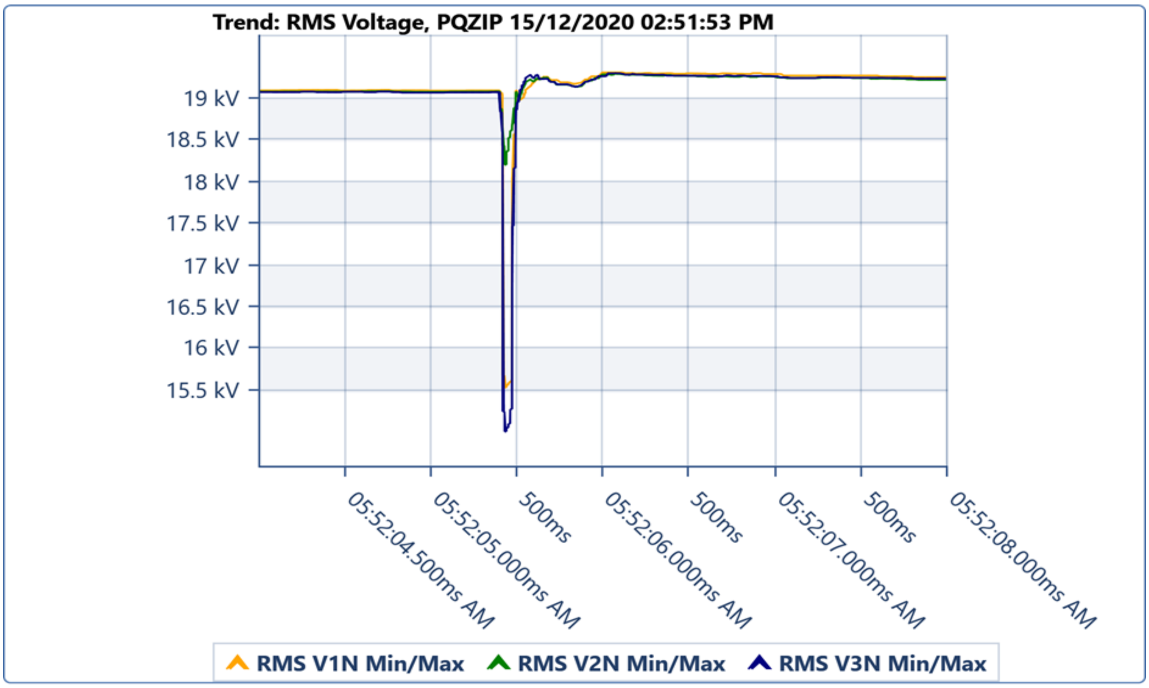

Figure 3-17: 33 kV Voltage measured at the Dalrymple 33 kV substation

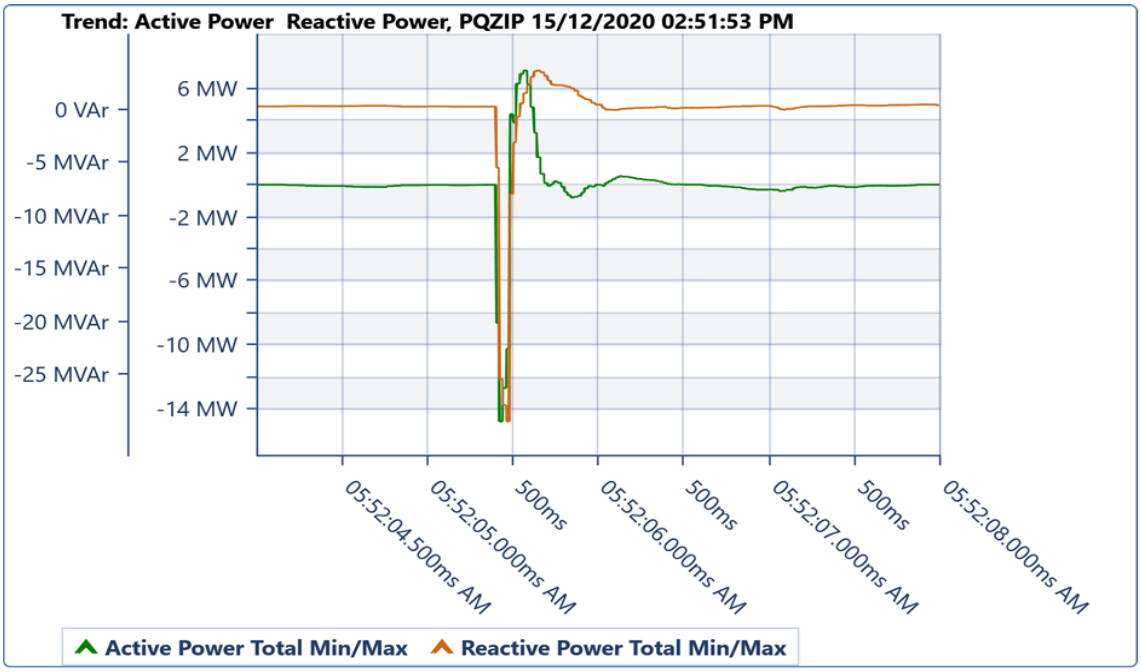

Figure 3-18: BESS active and reactive power measured at the Dalrymple 33 kV substation

3.4 Portal Operation and Usage

The ESCRI-SA web portal was one of the primary knowledge sharing tools for the Project and provided 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 3-19: ESCRI-SA Portal Dashboard

The portal also contains copies of ElectraNet's industry presentations and public reports on the Project. Access to the web portal is available at http://escri-sa.com.au/.

Between 14 December 2018 and 14 December 2020, Google Analytics shows that the site has been visited 3350 times from interested parties from 40 countries, with the number of views peaking in January 2019, May 2019, October 2019, May 2020, July 2020 and October 2020. Most 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 3-20 to Figure 3-22 and Table 3-2.

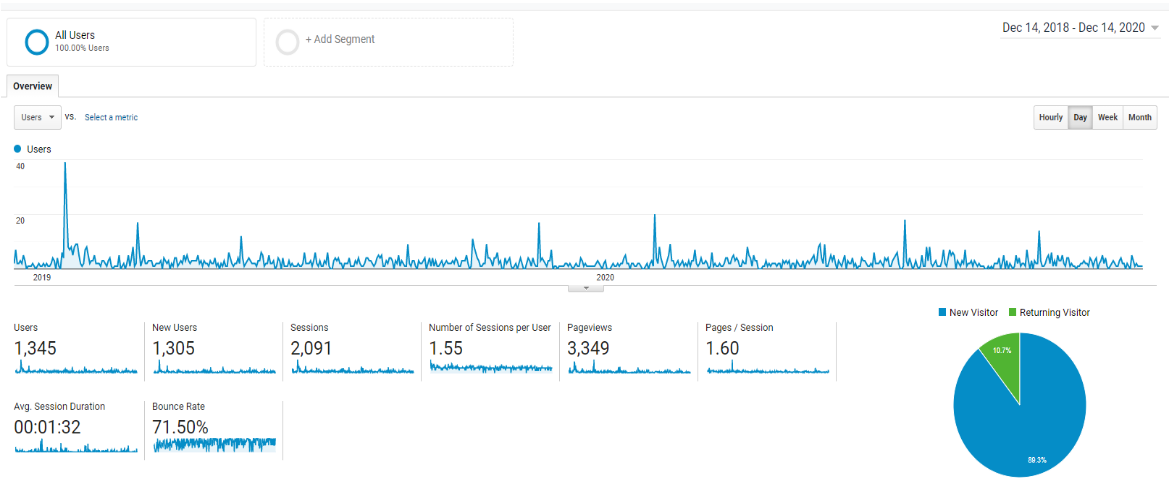

Figure 3-20: ESCRI-SA portal page views (24 months)

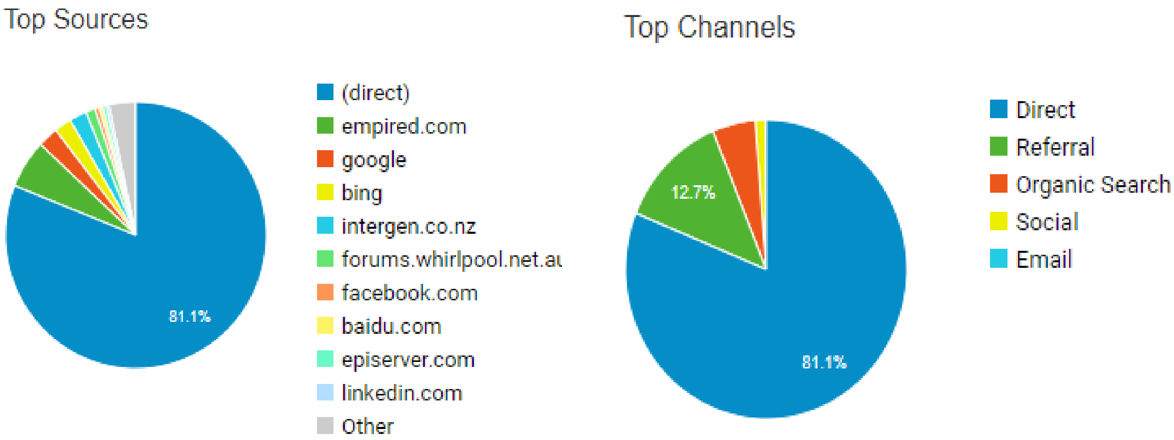

Figure 3-21: Top sources and channels used to locate ESCRI-SA portal (24 months)

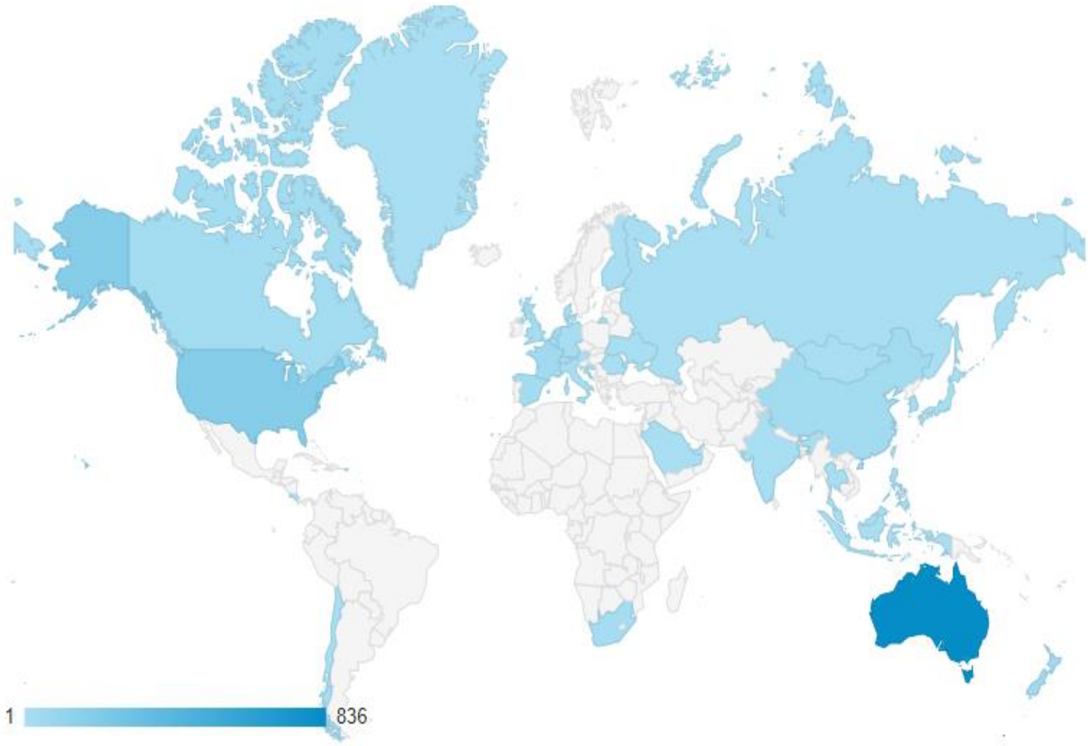

Figure 3-22: Geolocation of ESCRI-SA portal users (24 months)

	14/12/2018 to 14/06/2019	14/06/2019 to 14/12/2019	14/12/2019 to 14/06/2020	14/06/2020 to 14/12/2020	Total
Page views	1241	799	683	627	3350
Unique page views	984	666	592	574	2816
Average time on page	1:54	2:14	3:04	3:28	2:40
Number of report/presentation downloads	76	47	46	44	213
Number of data downloads	230	103	57	42	432

Table 3-2: Six-monthly metrics of Portal operation

4. Demonstration of Key BESS Regulated Services

4.1 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.

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 can 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.

From 14 June 2020 to 14 December 2020, there have been no planned outages requiring the Dalrymple BESS to supply the local load as an islanded network. However, there were two unplanned outages as discussed in Section 3.3.2. The Dalrymple BESS has prevented or reduced the duration of the unserved energy events. In combination, these events reduced the loss of supply from approximately 2 minutes to 0 (the only unplanned outages that would have led to unserved energy were successful 132 kV line recloses).

4.2 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. This is 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.

4.2.1 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 two system frequency events due the loss of the South East – Heywood Interconnector. These were on 16 November 2019 and on 31 January 2020. These confirmed the actual operation of the FFR function of the BESS.

During the fourth six months of operation the RoCoF constraint has bound for 4 hours for the SA import direction and it has not bound for the SA export direction with ESCRI BESS in service. Without the BESS in service, it is estimated that the RoCoF constraint would have bound for 6 hours and 5 minutes in the SA import direction and not binding for the SA export direction.

4.3 System Integrity 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 is 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 SIPS and is able to provide rapid response on receipt of a SIPS command. The SIPS function of the BESS has been tested and operated correctly.

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.

5. Demonstration of Key BESS Market Services

5.1 General Financial Performance

The BESS has continued to perform well over the past 6 months, 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. To date, this has primarily been the provision of contingency FCAS.

For the six-month reporting period up until 14 December 2020:

1. The charging cost for the BESS was approximately $32,750
2. Discharge revenue earned by the BESS was approximately $4,820
3. The BESS required an average daily charge of approximately 7.2 MWh
4. Average charge cost was approximately $178 per day
5. FCAS revenue was approximately $1.94 million - down from the $15.6 million for the 6 months prior (14/12/2019 – 14/06/2020). Average daily FCAS revenue was approximately $10,550
6. FCAS recovery paid was approximately $11,559. Average daily FCAS recovery paid was approximately $62

5.2 BESS Value Streams

The two market revenue streams for the BESS utilised in the last six months of operations were energy arbitrage and provision of FCAS services to the market. In this period, the majority of revenue earned from the BESS was through the provision of FCAS services, as it was for the first three six-month periods of operation.

The total revenue earned from energy arbitrage and FCAS services combined was again much greater than expected when compared to this period in the business case, entirely driven by significantly higher FCAS revenue than expected.

Charging costs for the battery were around $32,750 overall for the six-month period – this is required both for energy arbitrage opportunities (being able to charge during low priced periods and discharge during high priced periods), and for providing FCAS services (see further 5.2.2 below).

5.2.1 Energy Arbitrage

Energy arbitrage has continued to provide less value than estimated in the business case. Revenue from energy arbitrage has continued to remain low in favour of maintaining optimal availability for provision of the more valuable contingency FCAS services.

There were no significant days of net value from Energy. Overall, the discharge revenue earned over the 6 month operational period covered by this report was approximately $4,820. The maximum value on any one day for energy only was $536 on 27/11/2020.

5.2.2 FCAS Services

The majority of the BESS's current financial value continues to be derived from trading in the FCAS markets. During this 6-month operational period, FCAS trading revenue was approximately $1.94 million. This was composed of ~$1.57 million of contingency raise services and ~$368k of contingency lower services. In order to provide these contingency services, the BESS needs to be kept in a state where it can either charge (for lower services) or discharge (for raised services) in order to help return the frequency to the normal operating band following a frequency excursion.

October 6 and 7 2020 were the biggest FCAS revenue days with $42k and $58k respectively. This was caused by high FCAS raise contingency prices (~$200-$250). These were in turn caused by a mixture of strong demand in the NEM compared to generation available, and a transmission restriction on energy flows from Queensland into New South Wales. This caused high energy prices and strong FCAS prices over the peak periods.

5.2.3 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). AGL is currently developing an optimisation module to extract additional value from energy arbitrage. It is anticipated that this module will be commissioned and in-service prior to the commencement of five-minute settlement. Due to restrictions on planning and work completed during coronavirus work restrictions, the start of five-minute settlement has been delayed by the market from July 2021 to October 2021.

6. General Operational Issues

6.1 ElectraNet, ARENA and AGL Agreements

The Funding Agreement between ARENA and ElectraNet includes a provision for ARENA to recoup part of any potential upside return from the commercial operation of the BESS. Since AGL operates the BESS, a tri-partite agreement was also entered into to include AGL into this arrangement.

It was identified that the wording of the agreement should be clarified. At the same time the agreements were updated to reflect the commercial operation date of 14 December 2018 and align the delivery dates of future milestones with this commercial operation date.

6.2 ElectraNet - AGL Battery Operating Agreement

The Battery Operating Agreement (BOA) is structured as an energy storage services agreement which requires the parties to enter 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. ElectraNet and AGL have come to agreement on the method of calculation of the Availability Guarantee and ElectraNet provides monthly updates to AGL which give an indication of how the battery is tracking against the Availability Guarantee.

6.3 EPC Contract and Defect Resolution

The EPC contract reached practical completion and commercial handover on 14 December 2018.

At commercial handover of the BESS on 14 December 2018 there were 11 listed defects with the system. Of these, three remain outstanding as of December 2020. Significant items on this list are covered below.

6.3.1 Additional Cooling Requirements

Excess heat generated during maximum charge and discharge, combined with high ambient temperature, has been an ongoing issue that is still being worked on to be resolved.

A small leak was found on the condenser pipeline, which has been replaced.

Further work is being undertaken to optimise the cooling effect of the installed air conditioners, to direct most of the airflow directly towards the inverters, with the intention of improving the cooling effect during discharge / charge cycle. This will be by installing ducting to distribute cold air directly onto the inverters of each power store. Trial ducting, which was installed in one inverter during the last operation period has been successful and has now been installed on all power stores. Final testing to ascertain optimisation of the air conditioners is outstanding.

6.3.2 BESS Capability to Maintain Maximum Discharge at 30 MW

The capability of the BESS to maintain maximum discharge at 30 MW is restricted due to a temperature de-rating factor. The installation of the additional air-conditioning units and associated circulation fans and duct work changes, as detailed in Section 6.3.1, will further reduce the risk of temperature de-rating under maximum discharge. Testing is planned for when all the duct work has been completed. At the time of writing and under full discharge conditions, maximum output is within 1 MW of design.

6.3.3 R2 model validation

R2 model validation work is continuing. ElectraNet is working with ABB to refine specific aspects of the model which involves ABB's factory and Research & Development teams.

6.4 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 monthly visits to the site to inspect and test the on-site diesel generator and check and test the BESS fire suppression system, routine and corrective maintenance on the air conditioning units have all been completed as per schedules.

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

In the period from 14 June 2020 to 14 December 2020, the BESS system has been performing as per design.

6.4.1 Communications

Some communication issues have been experienced when downloading data from the high-speed recorder remotely (ELSPEC). This is being followed up with the meter vendor and CPP.

6.4.2 Air-Conditioning Operation

Aside from the minor repairs mentioned in Section 6.4.1, the air conditioning units have performed well and no derating due to heat was experienced over the six-month reporting period. No new air conditioning units were installed during this reporting period.

6.4.3 Air-Conditioning Alarms

The air conditioning units have performed well and no issue with alarms was observed over the six-month reporting period.

6.4.4 90-day re-set

After 90 days an issue occurred with the BESS, which required ABB to log in and reboot the system. A resolution on this issue is currently outstanding from ABB.

6.4.5 Component Failure and Changeover

Two inverter modules had failed and were replaced. Additionally, a condenser pipeline was replaced.

6.4.6 Spare Parts Inventory

SCADA spares have been ordered and are expected to be received soon.

6.5 Safety Incidents

There were no safety or environmental incidents reported during the fourth six months of commercial operation.

6.6 Stakeholder Management

There were no stakeholder management complaints reported during the fourth six months of commercial operation.

6.7 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.

7. Observations

This section contains observations about activities and engagements related to the BESS and summarises new lessons learnt during the past six months of commercial operation.

7.1 Knowledge Sharing

The ESCRI-SA Project continues to be sought out by industry and others for insights and learnings. Knowledge sharing activities include presentations at industry events, engagements with stakeholders and technical papers. A sample of knowledge sharing activities is provided below:

- A presentation by ElectraNet and Hitachi ABB Power Grids at a webinar in July 2020 on Grid Forming Energy Storage: Provides Virtual Inertia, Interconnects Renewables and Unlocks Revenue
- A technical paper presented to Cigre Session 48 on Grid Forming Energy Storage System addresses challenges of grids with high penetration of renewables (A case study)
- ElectraNet shared its ESCRI-SA experience with a number of utilities that reached out: Marinuslink (Tasmania), Altalink (Alberta, Canada), Power and Water (Northern Territory)

7.2 New lessons learnt

The lessons learnt that were documented in the first three Operational Reports are still relevant and will not be repeated here.

The past six months presented another key learning:

- AEMO has declared an inertia shortfall for South Australia, recommending that this shortfall is addressed by Fast Frequency Response (FFR) services. Grid-scale BESS, including ESCRI-SA, are well placed to provide these FFR services.

8. 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), ElectraNet is a critical part of the electricity supply chain. It builds, owns, operates and maintains 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 ESCRI-SA 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. AGL's 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 Worley Group	Advisian is the advisory and specialist consulting arm of Worley and has 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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