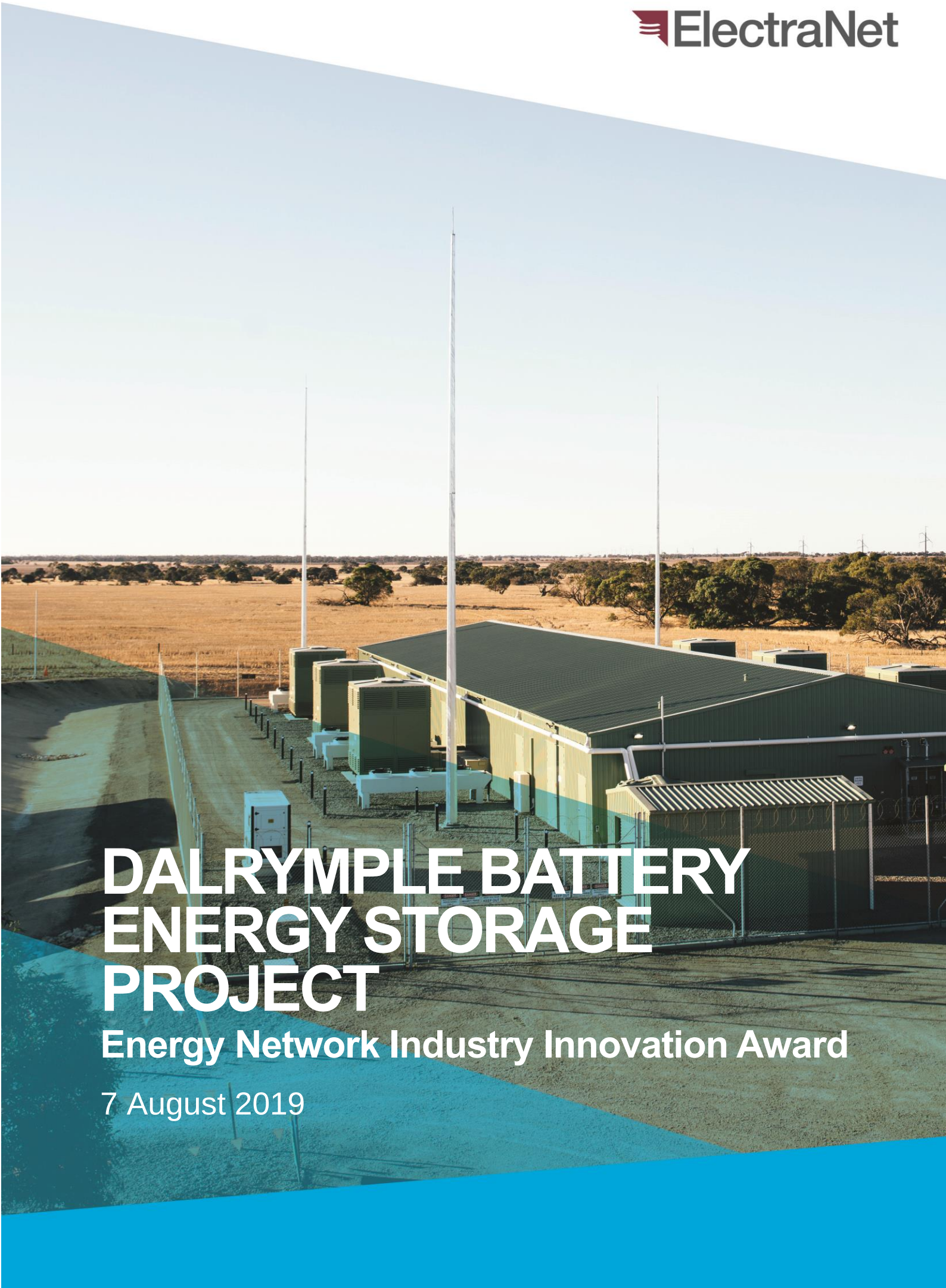
ElectraNet



DALRYMPLE BATTERY ENERGY STORAGE PROJECT

Energy Network Industry Innovation Award

7 August 2019

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1. Project partners

ElectraNet is the principal electricity Transmission Network Service Provider (TNSP) in South Australia. Our role in the electricity supply chain is shown in Figure 1.

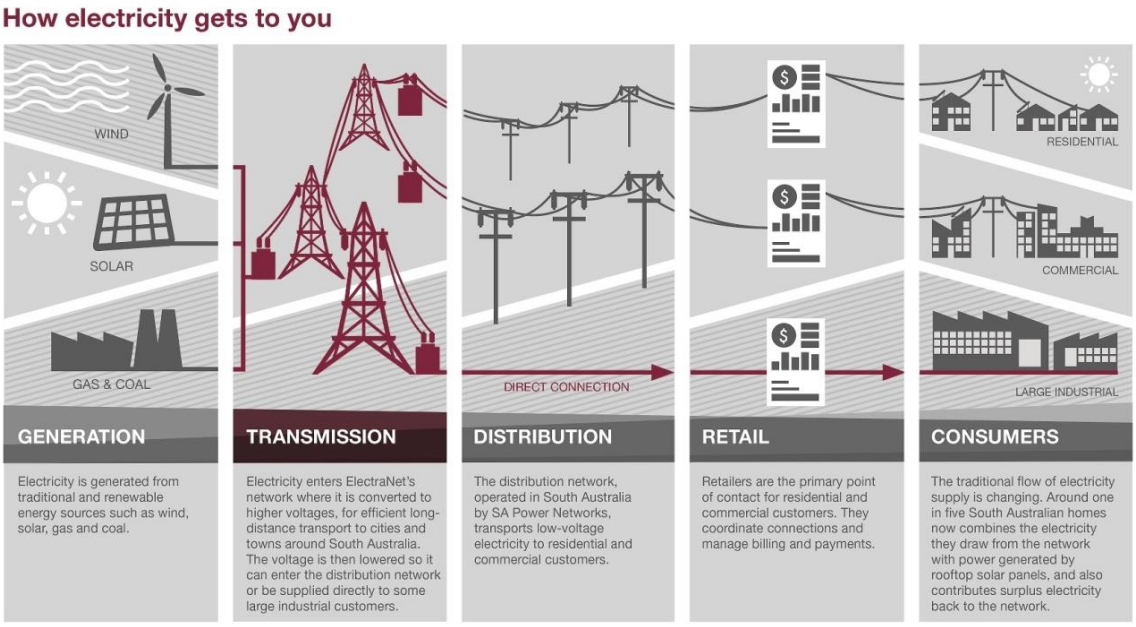

Figure 1: Role of ElectraNet in the electricity supply chain

ElectraNet's transmission network is one of the most extensive regional transmission systems in Australia, extending across some 200,000 square kilometres of the state with more than 90 substation sites and 5,500 circuit km of transmission lines operating at 275,000 and 132,000 volts.

ElectraNet worked with its project partners AGL and Advisian to develop the Dalrymple Battery Energy Storage System (BESS) project.

ElectraNet owns and maintains the 30 MW 8 MWh BESS, which provides both regulated network and competitive market services. AGL leases and operates the BESS in the competitive electricity market.

Advisian provided technical and project management input in the early stages of the project and subsequently was engaged as project knowledge sharing partner.

2. Project timeline

The Dalrymple BESS project was delivered according to the following timeline:

- Financial close – 13 November 2017
- Grid-connected commissioning completed – 7 September 2018
- Start of commercial operation – 14 December 2018
- Islanding with the Wattle Point Wind Farm commissioning completed – 5 April 2019

3. Location

The Dalrymple BESS is located adjacent to ElectraNet's Dalrymple substation on the Yorke Peninsula in South Australia, as shown in Figure 2.

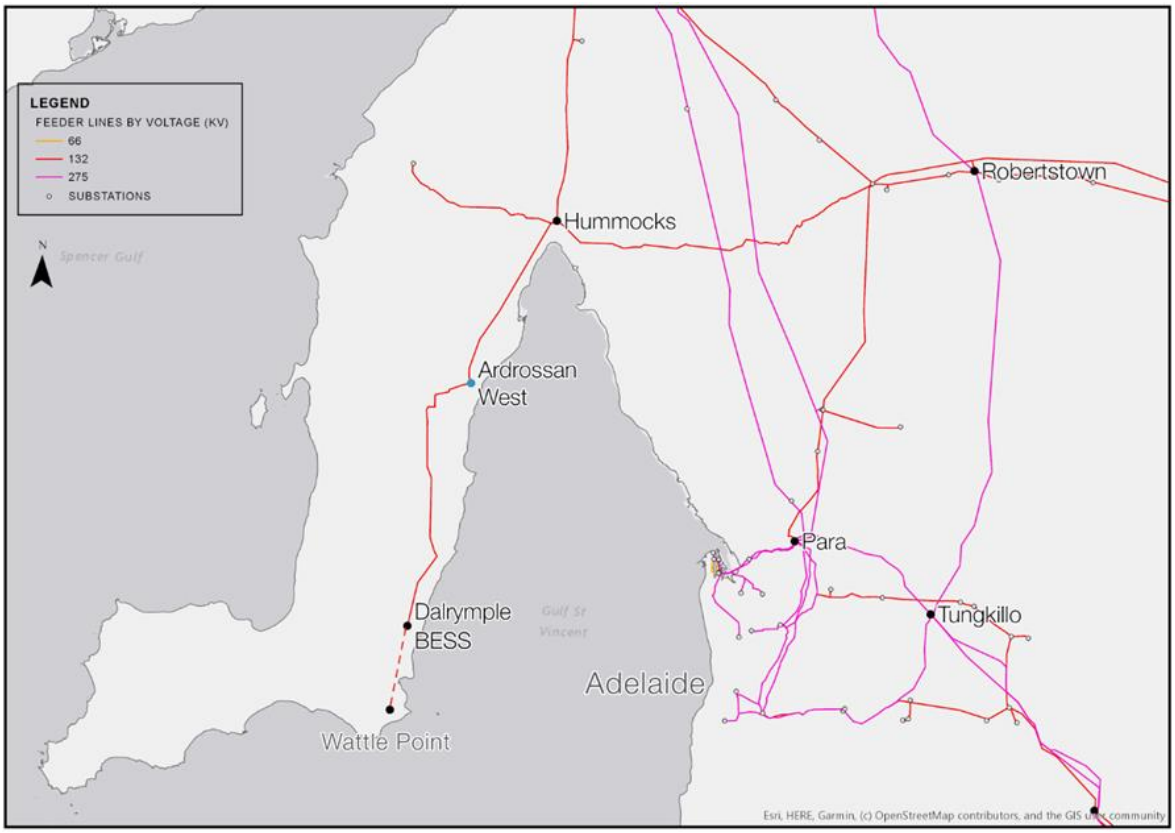

Figure 2: Dalrymple connection point relative to transmission network and Wattle Point Wind Farm

4. Funding

The project received grant funding support of $12 million from the Australian Renewable Energy Agency (ARENA) through its Advancing Renewables Programme.

5. Themes

The Dalrymple BESS project provides a wide range of services and knowledge-sharing activities that support three themes of the Energy Network Transformation Roadmap:

- Customer Oriented Electricity
- Power System Security
- Intelligent Networks and Markets

6. Description

The Dalrymple 30 MW, 8 MWh BESS is the first transmission grid-connected battery in the National Electricity Market (NEM) providing both regulated and competitive market services.

The success of the project, which is now in full commercial operation, required significant innovation leadership including:

- development of a first-of-its-kind commercial model to support the provision of regulated reliability and security services alongside competitive market services;
- navigating the NEM registration, licencing and connection processes for the first time paving the way for others to follow; and
- largest autonomous regional micro-grid development to date co-optimised for both grid-connected and islanded operation with 100% renewables.

7. Rationale

The primary objectives of the project were to demonstrate that utility scale battery storage can effectively provide:

- network reliability and security services alongside competitive market services in a network with a high penetration of renewable non-synchronous generation; and
- "seamless" islanded operation with 100% renewable generation following transmission outages.

Secondary objectives of the project were to:

- demonstrate a commercial model for the provision of regulated services and competitive energy market services; and
- build delivery capability for such assets.

8. Approach

The project had ambitious objectives targeting a wide range of battery services, including the unprecedented islanding of an 8 MW distribution area with the 90 MW Wattle Point Wind Farm.

A collaborative approach was required to achieve these objectives, including regulatory approvals, registration and technical delivery.

Regulatory arrangements were not well developed to support the connection of the BESS to the NEM with its unique commercial arrangements – this required working collaboratively with market and regulatory authorities including the Australian Energy Market Operator (AEMO) and the Australian Energy Regulator (AER) to develop regulatory solutions to support the project.

ElectraNet conducted a competitive tender process to select Consolidated Power Projects (CPP) as its Engineer Procure and Construct (EPC) contractor who engaged ABB as power system integration partner.

With several novel applications, close collaboration was required between ElectraNet, AGL, AEMO, CPP and ABB to implement BESS functionality.

A key challenge was to optimise the BESS control parameters to be suitable for both grid-connected as well as islanded operation. This proved more difficult than expected and required dedication and patience by everybody involved to achieve.

Eventual success is a testament to the positive collaboration between all relevant parties.

9. Benefits, results and outcomes

ElectraNet designed, built and owns the BESS and leases commercial operation to AGL. The Dalrymple BESS is the first in the NEM to provide both regulated network reliability and security services alongside competitive market services.

In addition, the project also had the ambitious goal to integrate the 90 MW Wattle Point Wind Farm as part of an islanding scheme with the local 8 MW distribution area.

The BESS is successfully achieving all its objectives in operation.

The Dalrymple BESS provides a wider range of services compared to other BESS applications in the NEM making it well suited to increase industry knowledge on the application of battery systems in the NEM.

This is being achieved via an extensive knowledge sharing program, including via the real-time web portal at https://www.escri-sa.com.au/.

The Dalrymple BESS is the largest ‘edge-of-grid’ application that can seamlessly island the local distribution area (8 MW peak demand). This is providing learnings on how the reliability of ‘edge-of-grid’ communities can be improved in a cost-effective manner.

In its first six months of operation the Dalrymple BESS has experienced several planned and unplanned transmission network outages requiring the BESS to supply the local 33 kV distribution system to successfully maintain customer supply for up to seven hours.

In addition, the BESS has successfully ridden through network fault events with its measured voltage, active power and reactive power response in line with design and technical performance expectations.

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

Customers are benefiting from the BESS operation through improved reliability and security and the provision of competitive market services.

10. Innovation indicators

10.1 Innovation leadership

Energy storage has a significant role to play in the future energy system with the continued growth of intermittent renewable energy sources.

The Dalrymple BESS showcases the widest range of services provided by a grid connected BESS in the NEM covering both energy and system security services.

Innovations that contribute to the advancement of the application of battery storage technologies include:

- a first-of-its-kind commercial model to support the provision of regulated reliability and security services by a Network Service Provider (ElectraNet) alongside competitive market services (AGL), challenging perceived limitations to network ownership of battery energy storage technologies;
- navigating the market registration, licencing and connection processes for the first time paving the way for others to follow;
- largest autonomous regional micro-grid development to date co-optimised for both grid-connected and islanded operation with 100% renewables allowing seamless transition between the two operating modes (for both planned and unplanned islanding);

The Dalrymple BESS project has also demonstrated further innovation leadership with an additional function added to provide pre-emptive emergency response as part of the South Australian System Integrity Protection Scheme (SIPS), providing fast power injection into the network following a significant loss of generation to help prevent a major loss of supply to customers.

A more complete list of project innovations is included in Section 11.

10.2 Innovation Impact

ElectraNet has developed significant learning and capability from this innovation project.

The complexity of the project and short project timeframes required us to challenge the way projects are developed and undertaken and take a more flexible approach.

The innovative impact of the project is demonstrated by examples summarised below.

The work to incorporate the BESS fast frequency response into the SIPS has led to the inclusion of this functionality as a standard requirement for new BESS grid connections.

With the BESS being one of the first to be registered in the NEM, this has assisted AEMO in developing registration procedures for utility scale battery technology[1] [2].

The project knowledge sharing portal provides a significant amount of information to assist industry in observing first-hand how the BESS is performing.

The project is also being closely observed by AEMO to gain insights into how a BESS can effectively provide system security services. The experience gained from this will assist to determine when a BESS can be relied upon to provide such services, potentially leading to less reliance on synchronous generation to provide system security services in the NEM.

10.3 Knowledge sharing

ElectraNet has developed an extensive knowledge sharing program to share information about BESS performance, as part of its funding agreement with ARENA. This includes the delivery of four six-monthly operational reports.

To date the project has:

- held four Knowledge Sharing Reference Group meetings with government stakeholders and industry representatives;
- established a dedicated website that displays BESS real-time operational data and project information and resources;
- presented the project at several key industry conferences; and
- engaged directly with other network service providers to share learnings from the Dalrymple BESS project.

The extent of knowledge sharing represents unprecedented transparency for a grid-scale BESS in the NEM, with all knowledge-sharing material being available on the online web portal at https://www.escri-sa.com.au/.

10.4 Efficiency and productivity

The AEMO Integrated System Plan published in July 2018 highlighted the rapid transformation of the energy system towards higher penetration of intermittent renewable energy and the associated need for adding significant amounts of energy storage to the system together with stronger transmission links between regions.

The Dalrymple BESS demonstrates utility scale energy storage as a key enabler of large scale intermittent renewable energy on an interconnected power system.

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1 See http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Participant-information/New-participants/Interim-arrangements-Utility-Scale-Battery-Technology

2 See https://www.aemo.com.au/-/media/Files/Electricity/NEM/Participant_Information/New-Participants/Fact-Sheet--NEM--Hybrid-Generator-Registration.pdf

The BESS demonstrates the application of energy storage to providing essential system security services such as fast frequency response (FFR) that enable a higher penetration of renewable energy by allowing more conventional synchronous generation to be displaced by renewable generation.

Also, the BESS enables evaluation of the operation of a local islanded system where demand is supplied by a local wind farm and small-scale solar generation, with no conventional generation, and regulation services are provided by the BESS.

This will lead to learnings that are applicable at a broader level to a South Australian system with 100% intermittent renewable generation, such as the amount of storage that is needed to manage varying levels of demand and intermittent generation.

More specifically, customers on the lower Yorke Peninsula are already benefiting from improved reliability with the Dalrymple BESS keeping the lights on during planned and unplanned 132 kV transmission line outages.

11. Optional background information

11.1 Project description and approach

The information in this section adds to that provided in Section 8.

Key features of the commercial model for the project are illustrated in Figure 3.

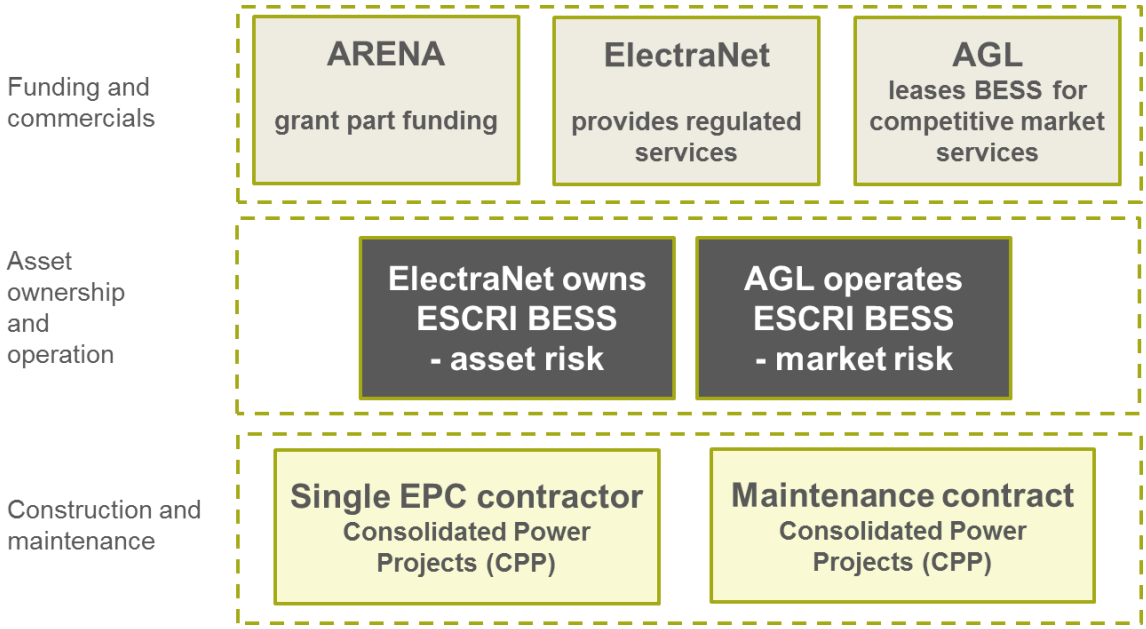

Figure 3: Dalrymple BESS commercial model

BESS services are summarised in the following table:

Regulated Services (ElectraNet)	Competitive Market Services (AGL)
Fast frequency response Heywood Interconnector benefit	Frequency control ancillary services
Reduced unserved energy (improved reliability)	Market cap trading

11.2 Project innovation

The BESS includes several innovative features relative to other generation and energy storage installations.

The following innovations add to those described in Section 10.1:

- inverters with grid-forming capability and the ability to operate at very low Short Circuit Ratios (<<1.5), significantly beyond what existing grid-forming electronic converter-based generation can perform;
- Fast frequency response (synthetic inertia) with unprecedented response speed (less than 100ms) and bandwidth (frequency droop down to 0.2%);
- non-synchronous fault level/system strength support capability via short-term fault current overload (>1.0pu rating);
- islanded grid master control including wind farm generation MW dispatch/ curtailment facilitating supply to the local island indefinitely under reasonable wind conditions;
- black-start capability for the local island with a peak demand of 8 MW; and
- largest-known indoor and climate-controlled BESS installation (30 MW), with the advantages of quicker installation and lower cost compared to containerised battery solutions.
- an additional function was added to the BESS to provide pre-emptive emergency response as part of the South Australian System Integrity Protection Scheme (SIPS), providing fast power injection into the network following a significant loss of generation. The BESS can be operating at full capacity and providing meaningful network support within 350ms of a network event being detected about 400 km away in the South East of South Australia;
- topology-based Islanding Detection Scheme; and
- BESS control system that allows for an external set point, voltage and reactive power regulation or power factor regulation based on control mode priorities as listed in the table below.

Priority based Services		Inherent Services	
		ID	Description of Service
1	Islanded Operation	A	Voltage Control Frequency Control Fault Current Support
	Grid Connected modes below	B	(Voltage Control or Power Factor Control) Fast Frequency Response Fault Current Support
2	Network Support - SIPS		
3	Contingency FCAS services		
4	External set point mode (P & Q) (Energy Trading Modes) Market Trading		

Figure 4: Dalrymple BESS control mode priorities

11.3 Knowledge sharing portal

For more information on the Dalrymple BESS, please go to the Dalrymple ESCRI-SA Project Portal at: www.escri-sa.com.au.

Visitors to the portal can put questions to the project team.

Information available via the portal includes:

- live and historical BESS operational data;
- images of the Project's construction and operation;
- all publicly published knowledge-sharing material, including key reports, operational updates and presentations; and
- information from the ESCRI-SA Knowledge Sharing Reference Group, which has been formed to share information about the Project, discuss issues relevant to large scale batteries in the NEM and to inform key stakeholders.

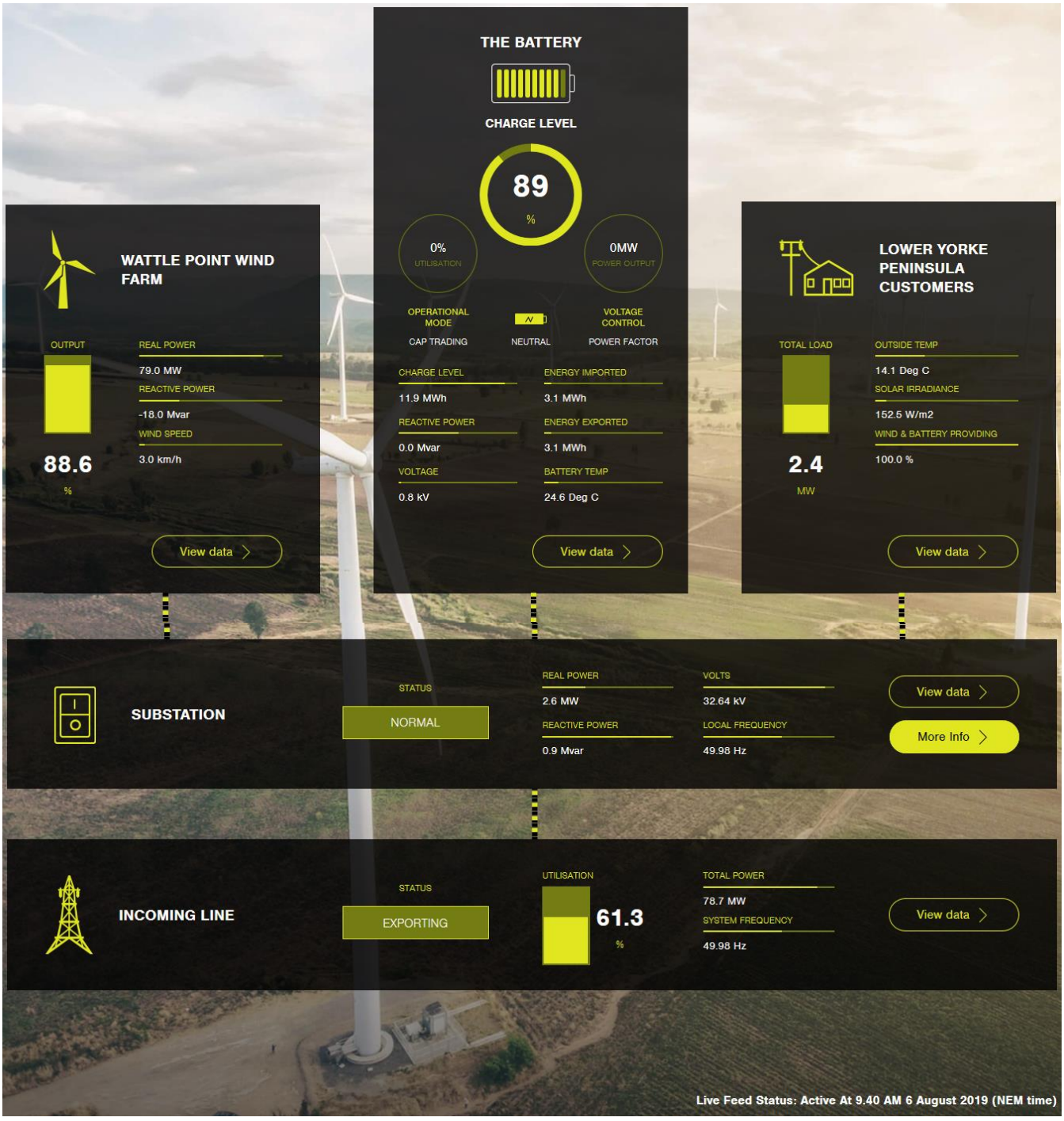

Figure 5: Dalrymple BESS dashboard snapshot from the Project Portal

11.4 Photos and video

Photo 1: View of the completed Dalrymple Battery Energy Storage System located on South Australia's Yorke Peninsula (photo by Floodlight Media)

Photo 2: View of the completed Dalrymple Battery Energy Storage System and ElectraNet Dalrymple substation (photo by Floodlight Media)

Photo 3: The external transformers outside of the Battery Energy Storage System (photo by Floodlight Media)

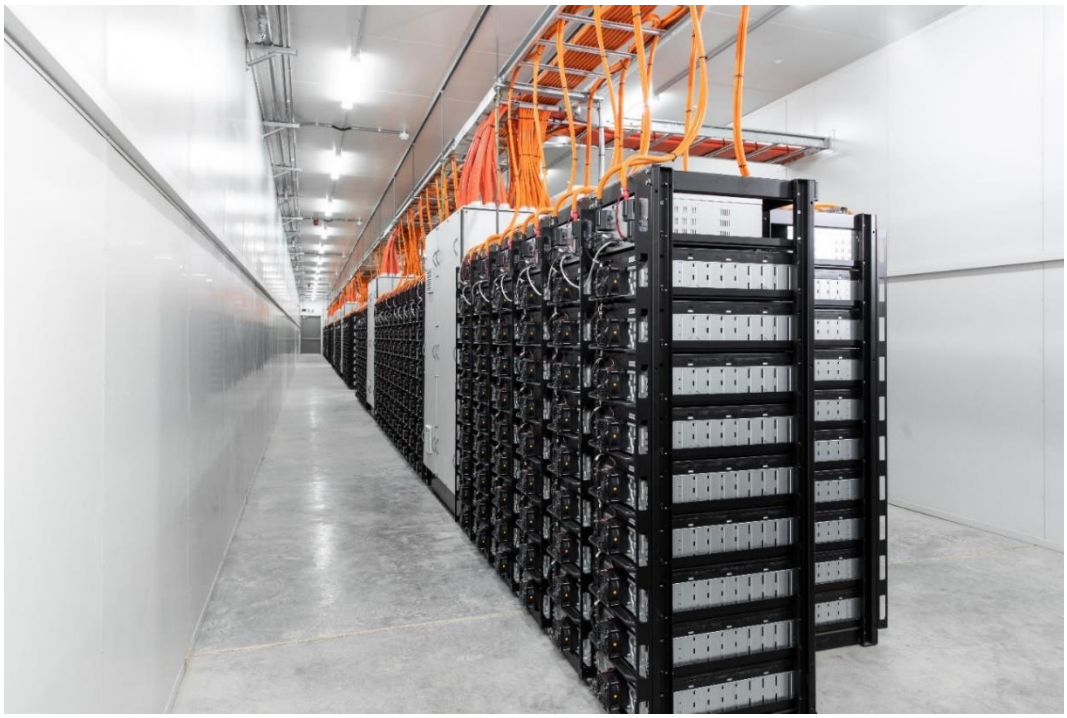

Photo 4: Battery banks located inside the Battery Energy Storage System (photo by Floodlight Media)

Photo 5: Inverters inside the Battery Energy Storage System (photo by Floodlight Media)

A video of construction of the Dalrymple BESS can be made available upon request.

ElectraNet