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KNOWLEDGE SHARING REPORT

# Ballarat Battery Energy Storage System

## Network revenue opportunities for Ballarat Battery Energy Storage

**The Consortium**

Downer SPOTLESS EnergyAustralia AusNet services

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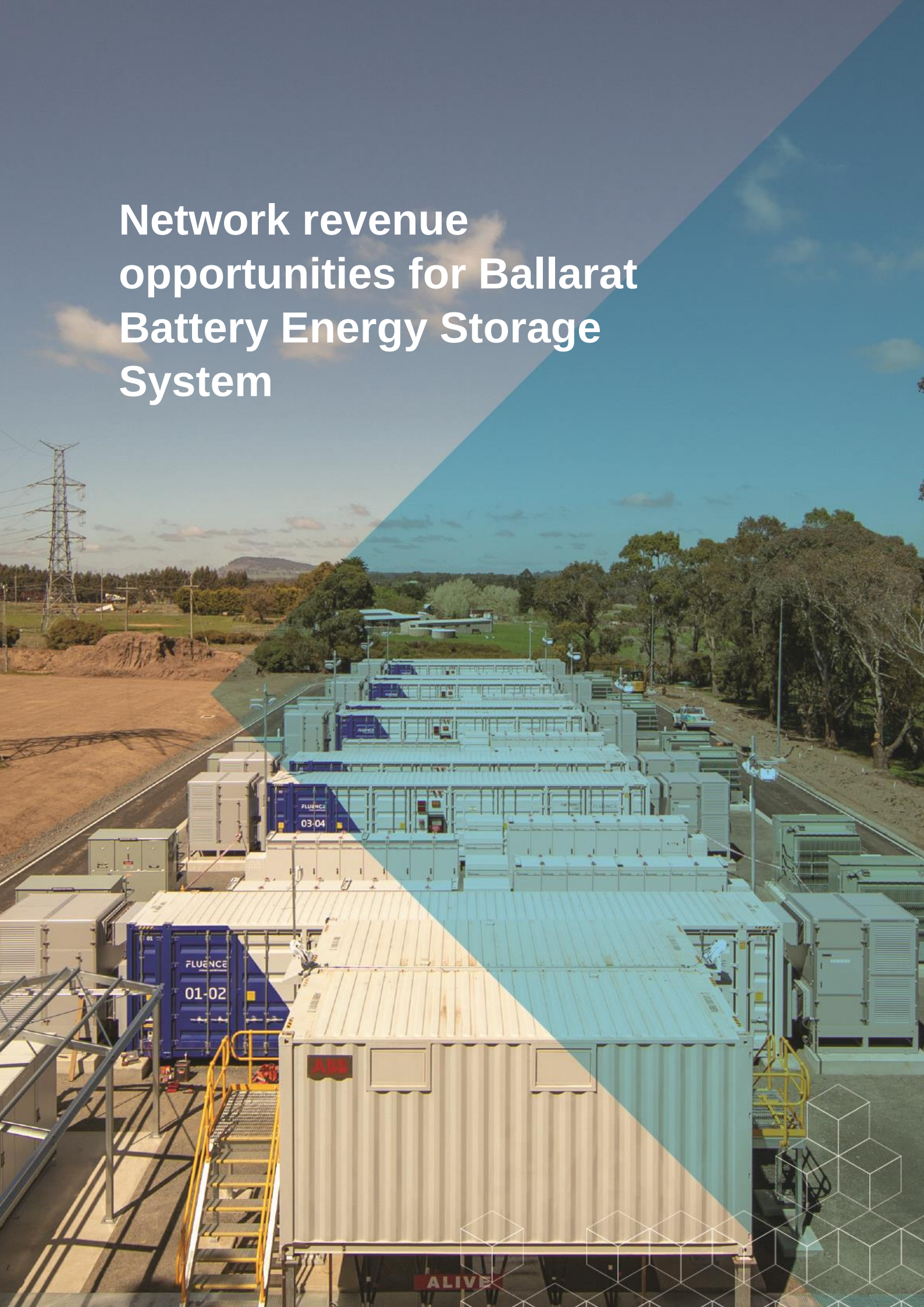

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# PART I
# Introduction

The Consortium is pleased to provide this knowledge sharing report that outlines potential revenue opportunities for the Ballarat Battery Energy Storage System (Ballarat System).

The Ballarat System is a consortium project undertaken by the Spotless / Downer Group, Fluence, AusNet Services, and EnergyAustralia. The project was selected during the Victorian Government Energy Storage Initiative tender process and is one of two projects under that program to be constructed and now in operation. The Victorian Government and the Australian Renewable Energy Agency (ARENA) through the Advancing Renewables Program contributed $25 million in grant funding for this project.

The project is the first of its kind in Australia -- a standalone battery-based energy storage system being installed in front of the meter and directly connected to the transmission network -- and the first grid-scale battery-based storage commissioned in the state of Victoria.

The Ballarat System is a 30megawatt (MW) / 30 megawatt-hour (MWh) system utilising Lithium-ion battery technology and Fluence's proprietary hardware and software controls. The system is installed at Ballarat Terminal Station (BATS) and is connected to the transmission network via the BATS No.2 transformer tertiary winding (rated at 22kV 40MVA). The Ballarat System was designed to operate at 250 full cycle charge and discharges per annum and is registered to operate as a 30MW generator, a 30MW load, and to provide regulation Frequency Control Ancillary Services (FCAS) raise and lower as well as all six contingency FCAS markets. The Ballarat Terminal Station is the central hub for the electricity transmission network in western Victoria and the location was chosen to add new capabilities at AusNet Services' existing facility to support further renewable electricity generation, in addition to over 620MW of local renewable energy generation at present.

After 12 months of operation (December 2018 to December 2019) the financial performance of the system has exceeded expectations in the FCAS markets and met expectations in the Energy Market.

This report will identify potential additional network services that the Ballarat System can offer as well as possible augmentations to the existing system to increase revenue.

**Key revenue streams for the Ballarat System in the first 12 months of operation**

# Overall Revenue

**Outperformed in FCAS markets and performed in-line with Energy Market expectations**

In the first 12 months of operation the Ballarat System generated 7312 MWh of energy and achieved $6.07M of revenue.

# Energy Market

**The Ballarat System delivered significant revenue in Q1 driven by summer volatility**

The Ballarat System achieved $849,000 of net revenue from the energy market. The Ballarat System's 1-hour duration means that it has limited firmness from a capacity perspective, which was highlighted by the sustained high price events on 24th-25th January 2019. The Ballarat System is able to effectively assist with peak shaving.

# Regulation FCAS

**The Ballarat System performed well in regulation FCAS, especially the Raise Regulation market**

The Ballarat System achieved $2.67M of revenue in the regulation FCAS market, with 95% of this revenue coming from the Regulation Raise market.

# Contingency FCAS

**The Ballarat System exceeded expectations in the contingency FCAS market**

The Ballarat System achieved $2.55M of revenue from the contingency FCAS markets.

# PART II
# Network Revenue Opportunities

Revenue stacking is critical to making battery storage systems economic without Government support. EnergyAustralia and AusNet Services continue to explore opportunities in relation to network service and revenue models and further opportunities to replicate the Ballarat System.

In December 2019, AusNet Services and EnergyAustralia explored further opportunities with respect to battery energy storage system opportunities post the 12-month operation at Ballarat. Both organisations concluded:

- Gentailers, specifically EnergyAustralia has an interest in more storage projects utilising a similar commercial model to the Ballarat System, if network value can be attributed to the asset alongside existing energy market value streams to support the capital investment.
- AusNet Services as a network operator saw value from a network operability and ownership model perspective in developing similar storage projects with a key focus on unlocking additional renewable integration opportunities in key constrained parts of its network.
- Key opportunities should be investigated further:
  - Review potential sites that minimise connection costs such as similar tertiary winding connections as the Ballarat System for smaller scale storage solutions that unlock additional renewable potential;
  - Look to establish ongoing relationships between owner, supplier and constructor to further develop the technical specifications and refine models as technology and markets evolve; and
  - Look for locational benefits where a battery can provide non-market services or support other parties wanting to manage MLF or congestion risk. Locations need to be wary of high Distribution Use of System (DUOS) charges for a distribution connection.

## 2.1 Available Revenue Streams

Currently in the NEM there are two possible revenue streams for a Generator or Market Load which include:

1. Market Services
   a. Energy Market
   b. Frequency Control Ancillary Services (FCAS) which includes:
      i. Regulation FCAS – raise and lower
      ii. Contingency FCAS – Fast Raise/Lower (6 secs), Slow Raise/Lower (60 seconds), Delayed Raise/Lower (5 mins)
2. Non-Market Services:
   a. Network Support Control Ancillary Services (NSCAS) which can include:
      i. Voltage Control Ancillary Services (VCAS)
      ii. Network Loading Control Ancillary Services (NLCAS)
      iii. Transient and Oscillatory Stability Ancillary Services (TOSAS)
   b. System Restart Ancillary Services (SRAS)

Further details of the above can be found in AEMO documentation as indicated below:

- AEMO - Guide to Ancillary Services in the National Electricity Market – April 2015
- AEMO – Non-market Ancillary Services – SO_OP3708 – July 2012

The Ballarat System currently provides all market services and has performed well in these markets during the first 12 months. However, without the government funding the revenue from these markets would have been insufficient to provide a viable business case for the Ballarat System. That said, since the Ballarat System was originally procured and commissioned, Battery Energy Storage System component, system and service costs have fallen and continue to decline. Future commercial viability hinges on further reductions in capital cost for the system along with additional revenue streams through Non-Market Services or currently non-established revenue streams.

The following sections discuss the ability of the Ballarat System to provide non-market services with a general discussion on future BESS's to provide these services.

## 2.2 Non-Market Services

The following sections outline the ability of the Ballarat System to provide non-market services, however it should be noted that in the 2018/2019 annual report on non-market services, the only non-market services procured by AEMO were VCAS services in NSW and is not forecast to procure these services in 2019/2020. It is understood that AEMO also procures VCAS services in Victoria with this contact to expire in 2021.

There are a number of RIT-T processes underway in various regions that include an option of installing or procuring services from a BESS compared to other network options and the results of these processes indicate that a BESS does not provide a better customer benefit. The most recent example is the RIT-T for Expanding NSW-QLD transmission transfer capacity – PACR released in December 2019. These processes indicated that the challenges of a BESS to provide non-market services were due to difficulty recognising in these frameworks the full value a BESS can provide, such as faster deployment and greater modularity than traditional assets. Other barriers include high upfront capital costs and perceived reliability of a 'new technology,' as no BESS had been installed at that point to deliver non-market services to Australia's networks.

Despite these challenges the Consortium believes that there is value in addressing the barriers that currently exist in being able to value stack traditional market services with network services. The flexible nature of a BESS in respect to sizing and its speed to market means it is well placed support AEMO and the TNSP's, but it is difficult for market participants and developers to access both these value streams to underwrite projects. The consortium encourages ARENA and other market participants through joint funding to demonstrate this robustness and reliability of a BESS to provide network services.

### 2.2.1. Voltage Control Ancillary Service

*AEMO is required to control the voltage on the electrical network to within specified tolerances. One method of controlling voltages is through the dispatch of Voltage Control Ancillary Services (VCAS) where a generator will absorb or generate reactive power from or onto the electricity grid. Typically, this service is provided by Synchronous Condenser or static reactive plants.*

A BESS is operated via inverter technology which has the ability to provide reactive power (absorb or generate) without any active power and would therefore be able to provide Voltage Control Ancillary Services. The Ballarat System is currently required as per the GPS to provide 0.395 X rated active power which is 11.85 MVAr of reactive power from 0MW to ±30MW of active power. However, the capability of the inverters is such that it could provide additional reactive power at all times as indicated in the figure below.

This is an excellent example of the capability of a BESS being able to value stack by providing market services in conjunction with being able to provide VCAS services to AEMO. The revenue of market services has the ability to offset the cost of the service to AEMO to provide a cost-effective solution for the service.

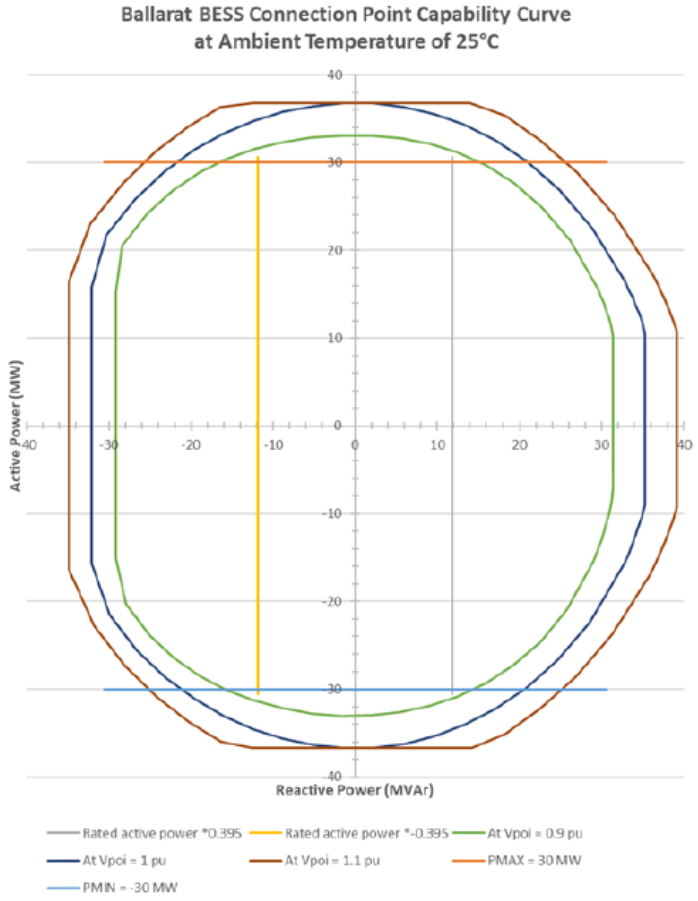


*Figure 1 - System Capability (yellow and grey vertical lines show GPS automatic standard for reactive power output, outer circles show system capability at various system voltages)*

Although the Ballarat System is able to provide VCAS, the point of connection at Ballarat Terminal Station does not currently require VCAS services to support the voltage as this is a relatively strong part of the network with regard to voltage control.

## 2.2.2. Network Loading Control Ancillary Service

*Network loading ancillary services are used, by AEMO, to control the flow on inter-connectors to within short-term limits. This is achieved by reducing the flow through the interconnector by increasing or decreasing generation in the required regions.*

As the Ballarat System is a scheduled generator it is able to be controlled via the AGC signal to provide this service. However, to provide this service it would require the system to have a minimum state of charge available at the required times to be dispatched either as a load or a generator. Given the system has a technical limitation of maintaining the average SoC below 41%[1] over a 12-month period providing this type of service would not be feasible for the Ballarat System.

In addition, further work would be required by the operator to determine the impact on revenue by reducing the ability to provide FCAS services and limit the amount of energy to trade.

Nonetheless, the advancement of the lithium-ion technology since the Ballarat System has seen the SoC constraint removed or revised for future BESS systems with the concept of reserved energy available for this service value stacked with market services a feasible offering for AEMO. Understanding of the typical periods of the year when this service is required would allow operators to develop a business case suitable for a commercially viable system.

## 2.2.3. Transient and Oscillatory Stability Ancillary Services

*When faults such as short circuits or malfunctioning equipment occur, a sharp transient "spike" in power flows can result. This can cause damage to equipment throughout the network.*

*Transient and Oscillatory Stability Ancillary Services (TOSAS) control and fast-regulate the network voltage, increase the inertia of rotating mass connected to the power system or rapidly increase/reduce load connected to the power system.*

*Some examples of TOSAS services are: Power System Stabilisers (PSS), Fast regulating voltage services (synchronous condensers, SVCs, generators), Inertia support services etc.*

Inverter technology has limited capacity to provide fault ride through services with the typically limit of the inverter between 1.1 to 1.2 X the rated output for fault current support. However, a BESS has an excellent ability to respond rapidly to events and inject or remove active power within 250 to 500ms of an event. This response from a BESS has been referred to as 'Synthetic Inertia' to provide TOSAS services to AEMO.

For the Ballarat System, as described in the section above, to provide these services it would need to maintain a minimum SoC to be able to provide the service at all times. Alternatively, the system could provide a seasonal service to assist in network support at key times of the year. Further discussion in the ability to provide synthetic inertia are in section 2.3.2.

[1] Refer to operation report #1 for details on the SoC limitation - https://www.ausnetservices.com.au/-/media/Files/AusNet/Projects/Ballarat-Battery-Energy-2.ashx?la=en

### 2.2.4. System Restart Ancillary Services

*System restart ancillary services are required to enable the power system to be restarted following a complete or partial black-out. This can be provided by two separate technologies:*

- *General Restart Source: a generator that can start and supply energy to the transmission grid without any external source of supply.*
- *Trip to House Load: a generator that can, on sensing a system failure, fold back onto its own internal load and continue to generate until AEMO is able to use it to restart the system.*

The Ballarat System does not have the required hardware to provide this service under the previous guidelines for SRAS as it does not have black-start capability.

The latest rule change by the AEMC in April 2020 has expanded the definition of SRAS to include support services which may include services from "grid-forming" inverter technology. The inverters at Ballarat are not able to provide grid-forming services but may be able to provide a small amount of reactive power support for SRAS.

## 2.3 Non-established Services

The Ballarat System has the ability to provide Services to the NEM which are not a service (market or non-market) identified by AEMO. These services include:

- Contingency Fast Frequency Response; and
- Synthetic Inertia

### 2.3.1. Contingency Fast Frequency Response

While the FCAS Contingency markets are currently set up to procure FCAS with response times within 6 seconds, the Ballarat system is capable of managing frequency droop with considerably faster response times.

A similar Fluence system deployed in Kilathmoy, Ireland for Statkraft Ireland, was engineered to deliver Contingency Fast Frequency Response (FFR) for the island of Ireland's Single Electricity Market, a service procured through its grid stability product program known as Delivering a Secure Sustainable Electricity System, or DS3. The fastest of the DS3 services, FFR requires a response in less than two seconds but provides a significant pay-for-performance incentive – a payment as much as 3 times higher – for responding in 150 milliseconds. That fastest response represents a 40x faster procured service than AEMO's currently fastest procured service.

Were a similar market and an FFR signalling system established by AEMO for the NEM, Ballarat could be similarly enabled to provide similar response speed with software upgrades to the existing system.

### 2.3.2. Synthetic Inertia

In addition to managing frequency droop, the Ballarat system is capable, with minor hardware and software modification, of providing synthetic inertia in response to a rapid rate of change of frequency (RoCoF). In order to respond quickly enough to meet standards proposed by Ireland's Eirgrid, instead of responding to a signal from AEMO, providing this service would require both software upgrades and the installation of additional monitoring and detection equipment onsite to minimise delay, measuring and identifying the threshold RoCoF level and dispatching the system when observed.

## 2.4 Ballarat System Upgrades

### 2.4.1. Additional Energy

During the first 12 months of operation an investigation was completed to expand the energy capacity of the Ballarat System from 1 hour to 2 hours (30MWhr to 60MWhr). Technically, the expansion was feasible with some challenges around the DC coupling and switching arrangement. However, the cost for the expansion did not offset the increased revenue obtained from the additional hour of storage.

### 2.4.2. Additional Power

The Point of Connection for the Ballarat System is the tertiary winding of an existing network transformer which has a limited capacity of 40MVA. As a result, the ability to increase the power output from the BESS is limited. In addition, increasing the power output of the BESS would require the Generator Performance Standards (GPS) to be renegotiated for the connection which given the changes to technical standards and the potential cost of meeting these new standards may well exceed the benefit for such a nominal increase in capacity.

## 2.5 Future Services from a BESS

Though speaking broadly to energy storage's capabilities (i.e., other suppliers' technology) is beyond the scope of this report, Fluence notes that in addition to capabilities that could be added to the existing site, battery-based energy storage technology supplied by the company is capable of providing more functionality than is currently contracted or envisioned for BATS:

- Energy storage can provide smoothing and ramping support for both existing variable renewable energy (VRE) and traditional generation, as well as provide voltage to start up generators.
- Deployed as single systems or multiple systems working in tandem, energy storage can serve as "virtual transmission," mimicking line flows in order to relieve transmission line congestion, minimize curtailment or redispatching of generation, or add capacity to existing lines holding back capacity for N-1 contingency events. "Virtual transmission lines" can provide either an interim step or a flexibility resource to support the development and growth of Renewable Energy Zones, like those currently in development in northwest Victoria, central-west New South Wales and in Queensland.
- Energy storage assets can inject power with very fast speed of response, making them particularly well-suited to providing System Integrity Protection Scheme (SIPS) services.
- Lastly, the right storage partner can provide overarching asset management and optimization, providing a single point of connection to aid Generator Performance Standard assessment and compliance.

# PART III
# Summary

**Summary of non-market revenue (network service) opportunities for the Ballarat System:**

This report provided details on potential non-market revenue streams for the Ballarat System and the challenges, regulatory and commercial, that system faces to provide these services. Key opportunities and their current challenges for the Ballarat System are highlighted below.

## Increasing Capacity

**Increase the energy or power of the Ballarat System**

The consortium investigated the expansion of the Ballarat System for additional market services however the investment case did not provide a suitable return on investment. The capital cost of the expansion was high.

## VCAS

**The Ballarat System and other BESS systems have excellent capability to provide reactive power to the network**

The location of Ballarat system is such that this service is not required by the network, however an appropriately positioned BESS in the network would be capable to provide VCAS.

## Synthetic Inertia

**The ability of a BESS to inject large amounts of active power quickly into the network can support the provision of inertia in response to a rapid rate of change of frequency**

With minor software and hardware updates the Ballarat System can provide inertia services to help manage low inertia in the Murray region of Victoria. Currently there is no requirement to provide this service or revenue stream.

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