Infigen

Lake Bonney BESS

Operational Report #1

September 2020

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Executive Summary

This report summarises the operations of the Lake Bonney BESS in its first seven months of operation, from December 2019 to June 2020. The Lake Bonney BESS is a 25MW / 52MWh energy storage system that utilises Tesla's Powerpack battery technology and was installed alongside Infigen's operational Lake Bonney wind farms that have a combined capacity of 278.5MW.

NEM Overview

Records for energy demand in South Australia were set for both minimum and maximum operating levels during the reporting period. However, average energy prices during summer were not adversely impacted by high operational demand. Contingency FCAS requirements in the NEM were increased over the reporting period as AEMO updated its load relief assumptions.

Two major separation events occurred in the South Australian region of the NEM in the reporting period. The larger of these, the 31st January separation event, saw South Australia operate as an island for over two weeks. During this time, all FCAS prices greatly increased as AEMO could only source these services from participants within the SA region.

Charging and Discharging Behaviour

The Lake Bonney BESS (as a generator) had an equivalent capacity factor, in energy only, of 1.64% during the reporting period and this contributed to 27% of the total discharge energy, highlighting that the BESS' operation is not limited to the energy market.

Energy arbitrage opportunities were variable between months, but the majority of potential energy revenue was concentrated on isolated high-priced events. While the participation of the BESS during high-price events was hindered in some instances due to constraints imposed in islanded conditions, the decisions made by a human operator with experience of the SA market dynamics allowed for the BESS to discharge throughout a high-price event.

Ancillary Services Provided

The Lake Bonney BESS has shown it is an effective participant in the regulation and contingency FCAS markets throughout the reporting period, providing an accurate, adequate and timely response to AEMO's AGC command and local frequency deviations respectively.

Enablement in the FCAS markets has contributed to 73% of the total discharge energy throughput of the BESS in the reporting period, with the vast majority of this due to regulation FCAS responses.

The ability of the BESS to be enabled in the FCAS markets during high-price events was also distorted due to the constraints imposed during islanded conditions. This led to the average contingency FCAS enablement for each market during high-price intervals being between 85% to 100% of the enabled capacity, while regulation FCAS enablement was around 10% to 15% of the registered capacity.

Technical Performance

System availability throughout the reporting period was maintained at 100% due to the modular structure of the system and despite individual equipment downtime. A major planned outage at the Mayurra substation for LBWF, which required the BESS to be taken offline, was utilised to undertake some balance of plant maintenance on the system. While no unplanned outages were recorded, initial AGC availability issues hindered enablement in the regulation FCAS markets.

Despite a number of AEMO constraints including the Lake Bonney BESS, its typical operation has not been significantly impacted, aside from the unique constraints applied during islanded conditions. The management of the transformer capacity between the wind farm and the BESS has also not impacted operations in this reporting period.

There were no safety or environmental incidents of note during this reporting period.

Financial Performance

Most of the revenue earned by the BESS was due to FCAS market conditions during islanded events beginning on 31st January 2020 and 2nd March 2020. The contingency FCAS markets, which the Lake Bonney BESS was not constrained from participating in during these separation events, accounted for almost 70% of total revenue earned in the reporting period.

There are a number of future revenue streams that Lake Bonney BESS may have access to, including by altering its configuration to reduce the causer pays factor of the Lake Bonney market participant (that impacts the reimbursement costs for regulation FCAS), and a number of market proposals initiated through rule change requests.

Key Events

A single key event occurred within the reporting period; the 31st January separation event caused when a section of 500kV transmission towers collapsed, and system frequency in South Australia increased to ~51.11Hz immediately following the event.

The utilisation of the Lake Bonney BESS, along with the other utility-scale batteries in the SA region, highlighted how AEMO is likely to deploy these assets in future islanded conditions – restricting operation in the energy and regulation FCAS markets to maintain power capacity headroom and energy storage capacity to provide a sustained contingency FCAS response.

The islanded conditions also highlighted how future events could impact upon Infigen's generation portfolio in South Australia. While islanded, the Lake Bonney wind farms were constrained to 0MW generation, leaving Infigen exposed to energy prices against its C&I contracts. The additional revenue earned by the BESS during the separation event across the nine spot markets broadly offset the economic impact of the curtailed production at LBWF due to AEMO constraints, highlighting the importance of a diversified portfolio.

Lessons Learnt and Recommendations

A number of lessons learnt and recommendations were identified during the operation of the Lake Bonney BESS and discussed in this report. These are:

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Glossary

Acronym	Description
AC	Alternative Current
AEMO	Australian Energy Market Operator
AGC	Automatic Generation Control
ARENA	Australian Renewable Energy Agency
BESS	Battery Energy Storage System
BoP	Balance of Plant
BRC	Building Rules Consent
C&I	Commercial and Industrial
COD	Commercial Operation Date
CPF	Causer Pay Factor
CPP	Consolidated Power Projects Australia Pty Ltd
DI	Dispatch Interval
DC	Direct Current
EPC	Engineering, Procurement and Construction Contract
ESCOSA	Essential Service Commission of South Australia
EWA	Early Works Agreement
FCAS	Frequency Control Ancillary Services
FID	Final Investment Decision
FSSIA / FIA	Full System Strength Impact Assessment / Full Impact Assessment (interchangeable)
GPS	Generator Performance Standards
HPR	Hornsdale Power Reserve
HSE	Health Safety Environment
IFC	Issued for Construction
LBWF	Lake Bonney Wind Farm

LGC	Large-Scale Generation Certificate
LPs	Linear Programs
MPWA	Master Preliminary Works Agreement
MV	Medium Voltage
MW	Mega Watt
MWh	Megawatt Hour
NEM	National Electricity Market
NOFB	Normal Operating Frequency Band
NSP	Network Service Provider (TNSP = Transmission NSP)
O&M	Operation and Maintenance
OCGT	Open Cycle Gas Turbine
OEM	Original Equipment Manufacturer
OTR	Office of the Technical Regulator (of South Australia)
PoE	Probability of Exceedance
PSCAD	Power Systems Computer Aided Design
PSSE	Power Systems Simulator for Engineering
pu	per unit
RTF	Renewable Technology Fund (South Australia grant program)
SCAP	State Commission Assessment Panel (of South Australia)
SCR	Short Circuit Ratio
SoC	State of Charge
SoE	State of Energy (same as SoC)
TCA	Transmission Connection Agreement

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1. Purpose and Distribution

1.1 Purpose of Document

This document covers the operational learnings over the first 7 months of operation of the Lake Bonney BESS project, a 25MW / 52MWh Battery Energy Storage System (**BESS**).

This project received $5 million in funding from ARENA as part of ARENA's Advancing Renewables Program and $5 million in funding from the South Australian Government's Renewable Technology Fund.

This document is to focus on the following areas relating to the operation of the BESS, including:

— Charging and discharging behaviour in the energy market;
— Ancillary services provision and performance;
— Technical, safety and environmental performance;
— Financial performance and any future revenue opportunities; and
— Any key events that occurred during the report period.

1.2 Distribution of Report

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

The intended audience of this document includes:

— Project developers
— Renewable energy industry participants
— General public
— Equipment vendors
— General electricity sector members
— Government bodies
— ARENA

2. Knowledge Sharing Plan

This document represents the second reporting deliverable under the Knowledge Sharing Plan that forms part of the funding agreement between Infigen Energy and ARENA. All documentation associated with the Knowledge Sharing Program for the Project will be available from Infigen's dedicated Lake Bonney BESS knowledge sharing portal.

The full schedule of knowledge sharing deliverables associated with the project are given in Table 1 below.

Table 1 Knowledge Sharing Commitments

Deliverable	Timeline
Project Summary Report	Publicly available
Industry Presentation on Project Summary Report	Delayed due to COVID-19
Project Web Portal	Publicly available
Operational Report #1	This document
Industry Presentation on Operational Report #1	Delayed due to COVID-19
Operational Report #2	Q1 CY2021
Industry Presentation on Operational Report #2	Q1 CY2021
Operational Report #3	Q3 CY2021
Operational Report #4	Q1 CY2022

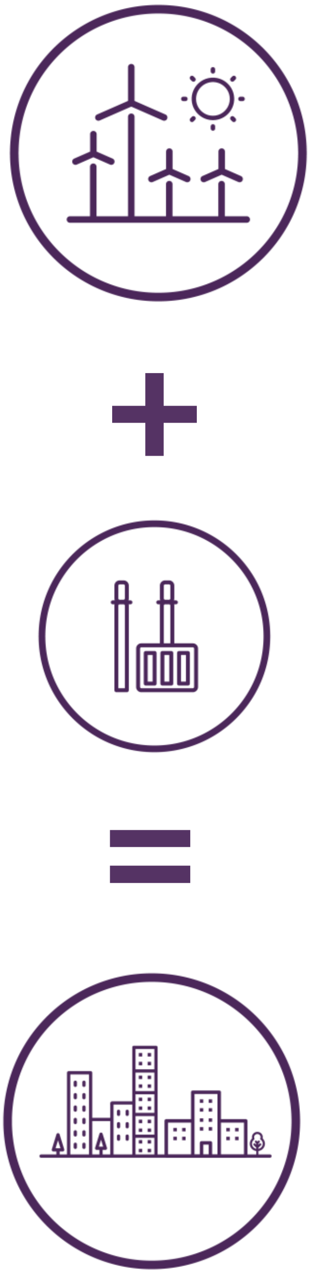
3. Project Introduction

3.1 Infigen Energy

We generate and source renewable energy

We generate renewable energy from our fleet of owned wind farms. With a total of 670MW of nameplate capacity, it is one of the largest renewable energy fleets in Australia.

We also source renewable energy from third parties where we contract to purchase their output under long term Power Purchase Agreements. This diversifies our supply and enables us to serve a growing customer base.



We add value by firming

Because renewable energy is inherently intermittent, and because customers need electricity on demand, flexible, fast-start assets are needed to manage intermittency risks.

Our firming portfolio comprises Smithfield Open Cycle Gas Turbine, a 123MW gas peaker in NSW, the Lake Bonney Battery Energy Storage System, a 25MW/52MWh battery in SA, and the South Australia Gas Turbines, 120MW of dual-fuel peaking capacity in SA.

Firming assets operate with very low levels of utilisation (sometimes as low as 2%) and because they are used to manage intermittency risk, Infigen's economic outcomes are not directly correlated with their output.

We provide customers with reliable and competitively priced clean energy

By combining a diversified fleet of renewable generators with a portfolio of flexible, fast-start assets, we can provide customers with firm supplies of clean energy in a way that minimises their bills.

Because more than 95% of our generation is renewable and because we can still serve customers on demand, our model has been called 'the utility of the future'

3.2 Lake Bonney BESS

The Lake Bonney BESS is a 25MW / 52MWh energy storage system that utilises Tesla's Powerpack battery technology. The Lake Bonney BESS was installed on Infigen's operational Lake Bonney wind farms (**LBWF**) as a brownfield development.

3.2.1 Key Project Objectives

The key project objectives of the Lake Bonney BESS were to allow Infigen to:

— firm up Infigen's generation capacity from LBWF to increase Infigen's contracting capacity with commercial and industrial (**C&I**) customers by between 50% and 75% of the battery's power output capacity, to increase retail competition for C&I customers in South Australia;

— deliver system security services in the South Australian region of the NEM by participating in the regulation and contingency Frequency Control Ancillary Services (**FCAS**) markets, as well as providing a fast frequency response (**FFR**) when a market arises; and

— seek to use the Lake Bonney BESS to reduce LBWF's Causer Pays Factor (**CPF**) and curtailed generation losses.

3.2.2 Technical Overview

The key technical characteristics of the operational Lake Bonney BESS are outlined in Table 2 below.

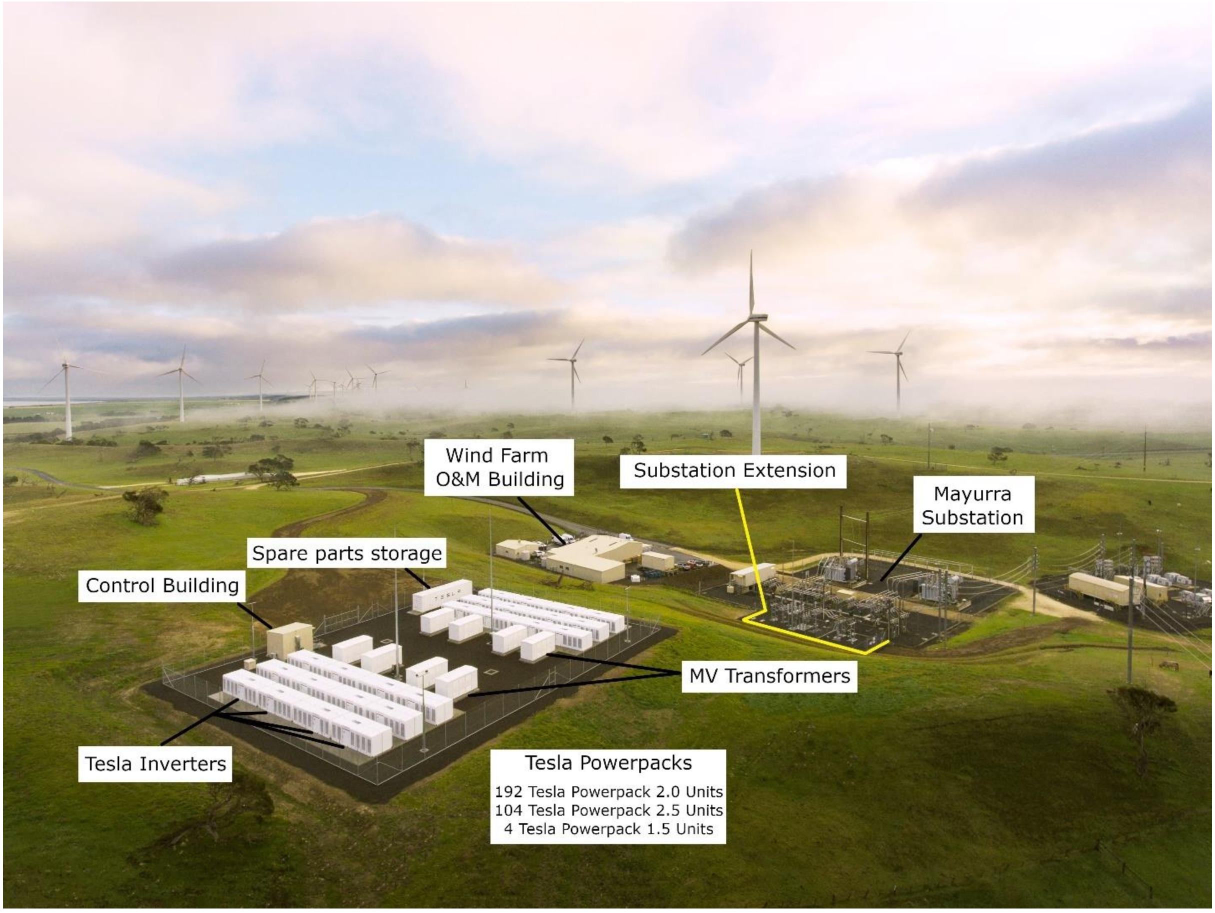
Table 2 Summary of key technical parameters of the Lake Bonney BESS

Technical Parameter	Summary
Nominal Power Capacity	+/-25MW (charge and discharge power)
Nominal Energy Storage Capacity	52MWh
Power Capacity Degradation	None
Energy Storage Capacity Degradation	~2-3% per annum
Battery Units	192 Tesla Powerpack 2.0 Units 104 Tesla Powerpack 2.5 Units 4 Tesla Powerpack 1.5 Units
Inverter Units	48 Tesla inverters
System Voltages	Inverter AC voltage: 440V Kiosk Transformer: 33kV

Balance of Plant	8 ABB 3.5MVA 440V/33kV transformers 33kV AIS switchgear Control building DC, MV and control cabling
Point of Connection	33kV extension bay at 33kV/132kV Mayurra substation

An overview of the completed Lake Bonney BESS is shown in Figure 1 below.

Figure 1 Lake Bonney BESS site overview



4. Lake Bonney BESS Operation

The reporting period for Operational Report #1 is December 2019 to June 2020 inclusive.

4.1 NEM Overview

4.1.1 NEM Operations Summary

Operational Demand

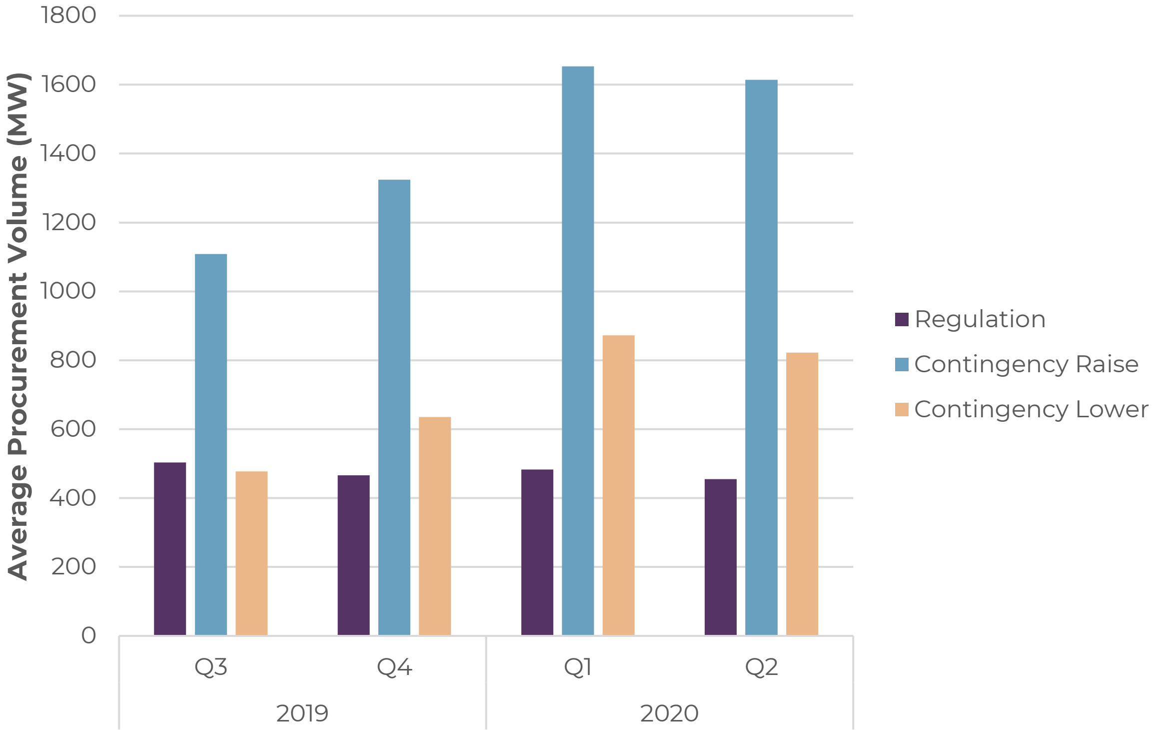
In the SA region of the NEM, minimum operating demand records were set for the three quarters relevant to the reporting period. Minimum operating demand records fell between 150MW to 250MW across the three reporting quarters, as the SA region continues to see its rooftop PV capacity increase without a substantial change to its underlying demand.

A maximum demand record for Q4 was also reported, during Adelaide's hottest December day on record, which resulted in the energy price reaching the market price cap for one hour. However, reduced cooling needs across summer meant that average demand for the first quarter of the year was down compared to 2019.

COVID-19's impact on demand in the SA region has been minimal, due to the lower proportion of commercial loads and a higher proportion of electrical residential heating systems than the other regions in the NEM, alongside colder than average temperatures which increased heating loads.

The operational requirements for FCAS in the NEM in the previous four quarters are shown in Figure 2 below. The average procurement volumes of raise and lower contingency FCAS across the NEM have increased in Q4 2019 and Q1 2020 and stabilised in Q2 2020. This is in part due to AEMO updating the load relief characteristics of the grid, increasing the volume of contingency services required to stabilise the system if an event was to occur. Regulation FCAS procurement volumes were relatively stable across the reporting period.

Figure 2 Average procurement volume of FCAS in the NEM over the past four quarters[1]



Power System Events

A major power systems event occurred on the 31st January 2020 when several transmission towers on the Moorabool – Mortlake and Moorabool – Haunted Gully 500 kV lines collapsed. While the impacts of this event are discussed in more detail in Section 5.1 below, the separation of the SA region from the remainder of the NEM required AEMO to procure the required FCAS volumes locally to maintain the system security of the islanded network for the duration of the separation event. The SA region was reconnected with the NEM on the 17th February 2020.

Another separation event occurred on 2nd March 2020, but the SA region was resynchronised with the remainder of the NEM later that day. This separation event was caused when a circuit breaker at Heywood Terminal Station tripped.

Major Market Participants Movement

There were no major movements in available capacity across the energy and FCAS markets in the reporting period. Utility-scale battery capacity was also stable in the reporting period, with the Lake Bonney BESS being the most recent utility-scale BESS to connect to the NEM.

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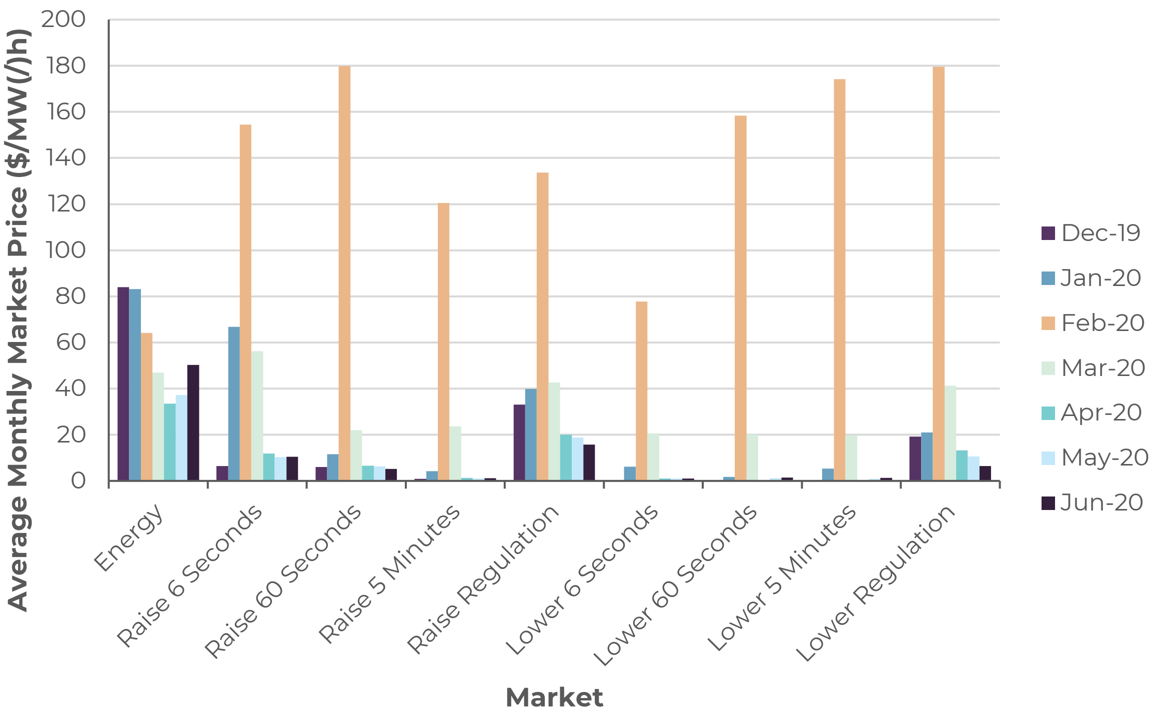
[1] Data sourced from AEMO's QED Q2 2020 Report, available here: https://aemo.com.au/-/media/files/major-publications/qed/2020/qed-q2-2020.pdf?la=en

4.1.2 NEM Market Prices Summary

As noted in the Section 4.1.1 above, a key event during this reporting period was the separation event on the 31st January 2020. This period of islanded operation for the SA region of the NEM led to greatly increased prices across all eight FCAS markets, as seen in Figure 3 below.

Figure 3 Average monthly price by market in the SA region of the NEM

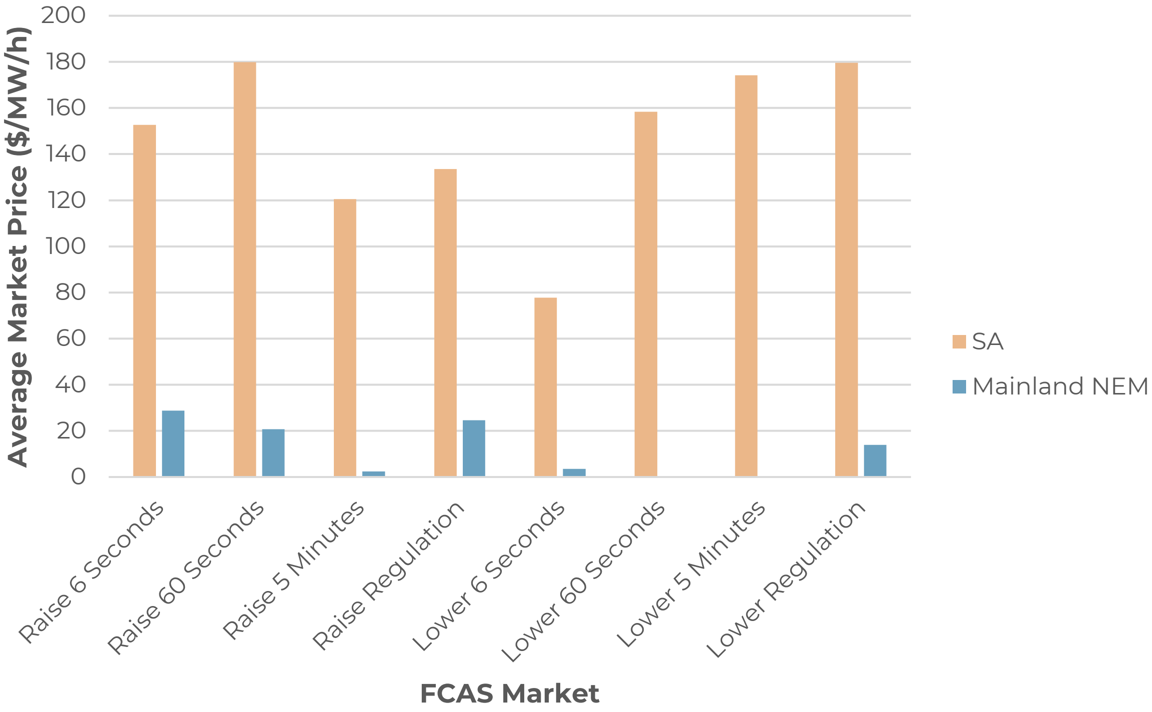


As noted above, the separation event that occurred on the 31st January 2020 required AEMO to procure the required FCAS volumes to maintain system security of the islanded network from within the SA region only. This led to the notably increased prices across all eight FCAS markets in February within the SA region of the NEM.

At 07:25 on 1st February 2020, the cumulative price threshold was breached in the Raise 6 Seconds market, leading to an administered price period being instated by AEMO for the eight FCAS markets. This limited the maximum settlement price of all FCAS markets to $300/MW/h and was in place until 04:00 on 10th February 2020.

The average price for each FCAS market in the SA region and the average price across three other mainland NEM regions for February 2020 is shown in Figure 4 below, highlighting the potential for increased FCAS costs within the SA region when operating in an islanded state.

Figure 4 Average FCAS prices in SA & other mainland regions of the NEM in February 2020



The price impact of the 2nd March 2020 separation event can also be seen in the average FCAS market prices in March, particularly on the three lower contingency services that are significantly increased above their average prices in April to June primarily due to this single separation event. Outside of these two months, FCAS prices were comparatively low, especially in the last three months of the reporting period where energy prices were also seen to decrease below the average market prices seen during the summer months.

The volatility in the average market prices seen in Figure 3 is reflected in Table 3 below, which outlines the number of extreme high-priced dispatch intervals (**DIs**) in the SA region of the NEM across the previous four quarters.

Table 3 Number of DIs above $5000/MWh in the SA region of the NEM

NEM Service	Q3 CY2019	Q4 CY2019	Q1 CY2020	Q2 CY2020
Energy	2	18	28	2
Raise 6 Seconds	0	23	109	1
Raise 60 Seconds	0	0	79	0
Raise 5 Minutes	0	0	47	0
Raise Regulation	0	0	56	0
Lower 6 Seconds	4	39	31	0
Lower 60 Seconds	4	19	59	0
Lower 5 Minutes	0	0	70	0
Lower Regulation	0	0	75	0

The volatility in prices seen in the first quarter of 2020 (primarily due to the two separation events) was not repeated in the second quarter, leading to much lower average FCAS market prices.

4.2 Charging and Discharging Behaviour in the Energy Market

4.2.1 Energy Market Operation

Capacity Factor

The energy-only capacity factor[2] of the Lake Bonney BESS throughout the reporting period is shown in Table 4 below, alongside the percentage of intervals in which the BESS is active in a discharge (energy, raise regulation and raise contingency) or charge (energy, lower regulation and lower contingency) market.

Table 4 Lake Bonney BESS energy-only capacity factor and active intervals

	Energy-Only Capacity Factor (%)	Active Intervals (%)
Discharge	1.64	97.43
Charge	2.74	96.29

These results highlight that the participation of the Lake Bonney BESS in the energy market is limited. However, this is due to the BESS operating across all nine markets, not just the energy market. In comparison to the capacity factors presented, the Lake Bonney BESS is an active participant in at least one of the services that may require a discharge/charge response for the vast majority of the reporting period.

It should also be noted that given the constraints of operating a system with an energy storage capacity, the maximum discharge capacity factor that the Lake Bonney BESS could achieve while adhering to a one cycle per day operating regime is 8.33% (with a corresponding maximum charge capacity of 9.80%). This would leave no additional capacity to participate in the FCAS markets, which would not be an optimal use of the asset.

In this reporting period, participation in the energy markets contributed approximately 27% of the total energy discharged by the Lake Bonney BESS, and approximately 39% of the total energy charged.

[2] Capacity factor represents the average generation (or consumption) of a power plant across a year as a percentage of its nameplate capacity.

For example, a 100MW generator with a 50% capacity factor might have run at 100MW capacity for half a year, and 0MW for the remainder of the year; or at 50MW for the entire year.

Arbitrage Opportunities

The opportunity for revenue for the Lake Bonney BESS in the energy market is based upon the principle of energy arbitrage – being able to buy energy when prices are low or negative (by charging) and/or selling this energy when prices are high (by discharging). The key market factors that dictate the opportunities of the Lake Bonney BESS in the energy market are shown in Table 5 below. These are the average, and the 50% and 25% probability of exceedance (**PoE**)[3] difference between the highest and lowest value trading interval (**TI**) each day.

Table 5 Market factors for consideration for an energy arbitrage strategy

	Average Daily TI Max/Min Difference	50% PoE Daily TI Max/Min Difference	25% PoE Daily TI Max/Min Difference
Dec-19	712.95	84.21	207.14
Jan-20	819.30	81.62	212.20
Feb-20	542.18	269.71	593.07
Mar-20	331.49	68.46	132.21
Apr-20	137.44	116.67	207.61
May-20	124.38	106.78	194.00
Jun-20	238.05	120.66	170.92

Excluding the results for February due to the market separation event, it is seen that the 50% PoE difference between the maximum and minimum TI price in the SA region is fairly low and does not represent a high value opportunity to the Lake Bonney BESS. For example, in January for half of the days in the month, the difference between the daily maximum and minimum energy TI prices was less than $81.62/MWh.

[3] Probability of Exceedance (PoE) is a statistical metric that describes the probability of a particular value being exceeded.

This is an important metric for energy prices as the average value can be distorted by a minimal number of extreme pricing events, so the 50% PoE is a much better indication of what normal market conditions will be than the average value.

The revenue earned by a BESS based on this price difference would be further eroded by round-trip efficiency losses and the MLF [4] difference between the generator and load portions of the BESS.

The importance of considering opportunities using PoE instead of the average is also shown in the figures above, where the average value being far higher than the 25% PoE value indicates that the average opportunity price is distorted by a limited number of high value arbitrage opportunities (such as Dec-19, Jan-20 and Mar-20). This indicates that a large amount of the revenue opportunities presented by arbitrage can be captured with only a few cycles of the BESS.

It should also be noted that these results only consider the highest and lowest value TI prices, while as a 2 hours of storage battery, the Lake Bonney BESS could consider the value of up to 4 of the highest/lowest value TIs each day under a cycle per day regime. This consideration would further erode the difference between the average cost paid to charge and discharge and weaken the case for a purely energy arbitrage strategy.

A cycle per day regime is considered good practice for Lake Bonney BESS as its warranty guarantees the end of year energy storage capacity based on an annual throughput of the system equivalent to roughly one cycle per day.

4.2.2 Extreme Energy Market Prices Capture Rates

The average energy response of the Lake Bonney BESS during extreme energy price events within the reporting period is shown in Table 6 below.

Table 6 Lake Bonney BESS response during extreme energy price events

	# of TI periods	**Average energy response (MW)**
TI above $5000/MWh	7	13.33
TI below $-500/MWh	8	3.29

While these results may indicate that the Lake Bonney BESS is not operating as expected to capture energy market revenue opportunities, it is important that the context of when these extreme price events occurred is considered to properly understand the results. During this reporting period, a high percentage of the extreme energy price trading intervals (including all negative price trading intervals) occurred during the February 2020

[4] Lake Bonney BESS' MLFs in FY2020 were 0.9922 as a generator and 1.0059 as a load and will be 0.9741 as a generator and 0.9925 as a load in FY2021.

The difference in MLFs between the generator and load portions of the BESS created an 'artificial' ~1.4% decrease in the round-trip efficiency in FY2020, increasing to ~1.8% in FY2021.

islanding event, when the BESS was constrained from providing its full power capacity (discussed in further detail in Section 5.1).

In addition to this, the co-optimisation of the BESS' capacity across the energy and FCAS markets means that it may not be optimal to participate in the energy market during extreme price events if the FCAS markets present an even greater revenue opportunity.

The response of Lake Bonney BESS, along with the response of Hornsdale Power Reserve (**HPR**) and the Dalrymple Battery (a.k.a. **ESCRI**) during a high energy price event on 19th December 2019 is shown in Figure 5 below. During this event, FCAS prices were below $50/MW/h for all services, so being dispatched into the energy market was the optimal solution. The extreme price event occurred over 4 consecutive trading intervals, that settled at $3,595/MWh, $14700/MWh, $14700/MWh and $2,590/MWh respectively.

Figure 5 SA battery responses to extreme high price event – 19th December 2019

The response of each SA battery differs during the high price event. Firstly, the ESCRI battery has only 8MWh of storage capacity, so is unable to provide a prolonged response at its full power capacity of 30MW. The ESCRI battery discharges the majority of its energy within the most valuable trading interval but is seen to begin responding at the initial price increase at 17:30.

HPR is also seen to begin discharging long before the two-hour high price event. With a usable storage of ~4 hours based on a 30MW discharge rating, HPR was able to provide an extended response from 16:00 to 19:15, where it appears that the battery's state of charge was reduced to zero as it stopped discharging. Therefore, HPR missed out on the final 45 minutes of the high price event, including 15 minutes were the price was at $14,700/MWh.

With 2 hours of energy storage capacity, Lake Bonney BESS was capable of discharging at full capacity throughout the whole event. While the battery did not start dispatching until 15 minutes into the high price event, missing out on an energy price of $3,595/MWh, it was able to discharge throughout the most valuable hour of prices at $14,700/MWh and the full trading interval worth $2,590/MWh.

The initial dispatch of the BESS during this event was controlled manually by an Infigen operator, who determined that the pre-dispatch prices provided by AEMO (which indicate the likely cost of market services over the remainder of the trading day) were not reflective of when a high-price event was most likely to occur. The manual intervention overrode AutoBidder's decision to begin dispatching the BESS before 18:00, and instead conserved the BESS' state of charge on the assumption that an unforecasted high-price event would occur.

Box 1 Lesson learnt: Value of a human operator

Although an optimal bidding strategy for Lake Bonney BESS is generated through Tesla's AutoBidder software, Infigen does not rely solely on AutoBidder to determine how the BESS is bid and dispatched/enabled in the NEM.

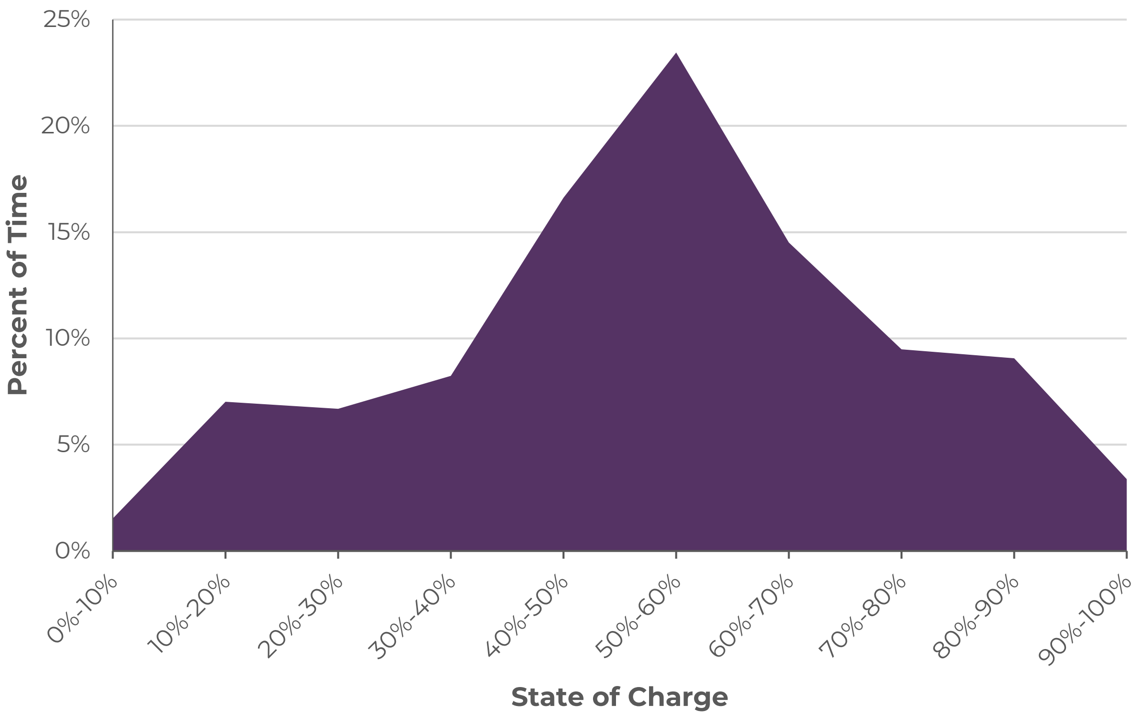
A key reason for this is the value of a human operator being able to interpret the price signals seen in AEMO's pre-dispatch prices (which the AutoBidder relies upon to optimise its bidding strategy) and assess the probabilistic outcome of those prices being realised.

A human operator is also well placed to make 'least regret' decisions, such as the event described above. The potential downside in conserving the BESS' state of charge and potentially missing out on a $379/MWh energy price is minimal compared to the potential upside of capturing an energy price at $14,700/MWh.

4.2.3 Lake Bonney BESS State of Charge

The distribution of the state of charge for the Lake Bonney BESS throughout the reporting period is shown in Figure 6 below. This highlights that the BESS is preferentially maintained around a 50% state of charge, allowing for the BESS to capture any unforeseen short-term market opportunities that require either a charge or discharge response.

Figure 6 Lake Bonney BESS operational state of charge distribution



There is a slight bias in the distribution of the BESS' state of charge, with a preference to have a slightly higher state of charge during the summer months. This is due to the higher likelihood that an unforeseen high-price energy event occurs during these periods of higher temperatures and operational demand.

Infigen is also required to reserve 2.1MWh of energy storage capacity under its operating protocol agreed under its agreement with the SA Government through the Renewable Technology Fund. This is equivalent to a 4% state of charge.

4.3 Ancillary Services provided

4.3.1 Ancillary Services Overview

A general overview of the operation of ancillary services in the NEM is provided by AEMO in the Guide to Ancillary Services in the National Electricity Market report available here:

https://aemo.com.au/-/media/files/pdf/guide-to-ancillary-services-in-the-national-electricity-market.pdf

and summarised for the Lake Bonney BESS below.

Regulation FCAS

Regulation FCAS is procured by AEMO to manage the instantaneous supply and demand balance in the NEM to maintain the power system frequency at 50Hz and operates within the normal operating frequency band (**NOFB**) of 50Hz +/- 0.15Hz.

The response of a generating unit when enabled to provide regulation FCAS is managed through AEMO's Automatic Generation Control (**AGC**) system. The AGC system calculates a MW setpoint every 4 seconds based on system frequency for each regulation enabled generating unit, that can range from 0MW to the regulation enabled volume of the generating unit for that dispatch interval.

When a generating unit provides a regulation response, the energy that is either discharged (for a raise response) or charged (for a lower response) is also considered when calculating the metered energy response of the generating unit. It is very common for a generating unit to be required to provide regulation FCAS when enabled, due to the non-linear nature of generator ramps (e.g. lag/difference between AGC command and a generator's actual response), the resource available at intermittent generators, and errors in AEMO's demand forecasting (e.g. the difference between what AEMO forecasts non-scheduled or semi-scheduled generators like wind and solar will do compared to their actual output).

Lake Bonney BESS is registered to provide 25MW of raise and lower regulation FCAS as both a generator and load, subject to its enablement in other markets for each dispatch interval. For example, if the BESS is enabled at 10MW as a load in the energy market (charging), it can provide 15MW of lower regulation as a load, 10MW of raise regulation as a load, 25MW of raise regulation as a generator, and 0MW of lower regulation as a generator.

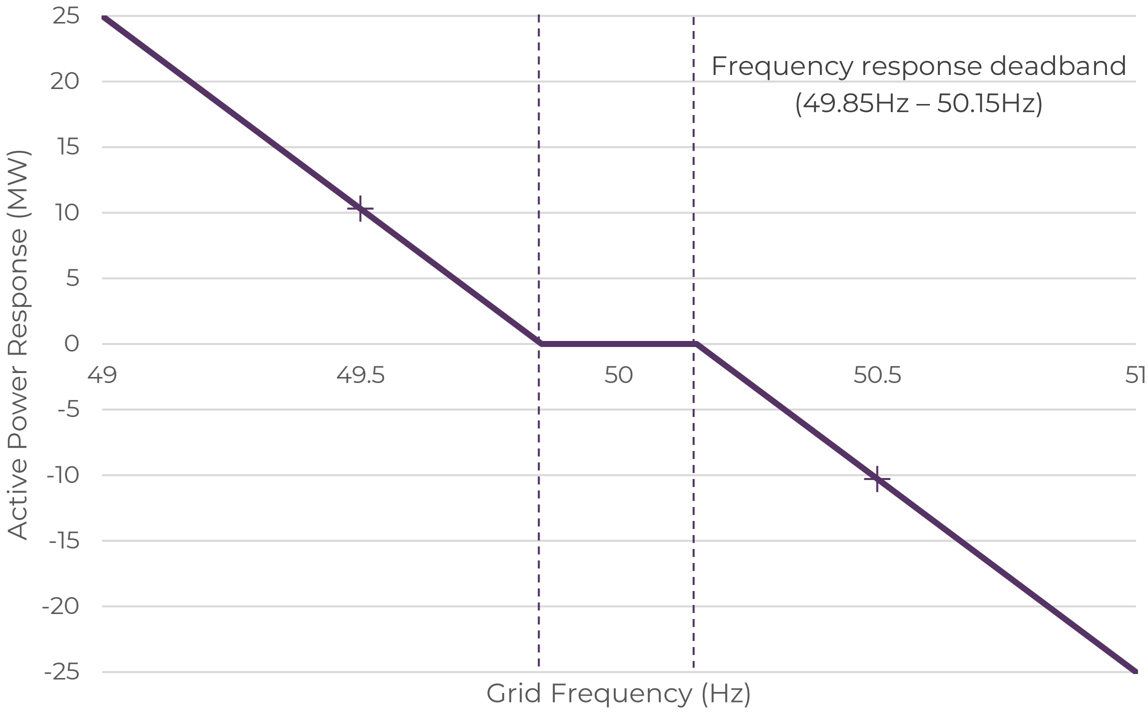
Contingency FCAS

Contingency FCAS is procured by AEMO to manage large imbalances in the supply and demand balance in the NEM and return the power system frequency to within the NOFB, typically after the occurrence of a major power system event, such as a generator tripping offline or a failure of the transmission network.

The response of a generating unit when enabled to provide contingency FCAS is managed locally through the generating unit's frequency droop settings (frequency deadband and droop coefficient). Those settings dictate how much a generating unit responds to a frequency deviation, with the frequency deadband typically set at +/-0.15Hz (corresponding to the NOFB (50Hz +/- 0.15Hz)) and the droop coefficient imposed by AEMO. The Lake Bonney BESS has a droop coefficient of 1.7%. Its expected response to frequency deviation is shown in Figure 7 below.

AEMO procures contingency services based on the response that each generator is configured to provide at 50Hz +/- 0.5Hz. For the Lake Bonney BESS, this is 10MW for either a raise or lower contingency FCAS response.

Figure 7 Active power response of Lake Bonney BESS based on its droop setting



While both raise and lower contingency FCAS are comprised of three separate services (6 second, 60 second and 5 minute), these three services are complementary to each other and the enablement of one of these services does not limit the Lake Bonney BESS from being enabled in the other two services. Instead, the ability to offer contingency FCAS is determined by the power capacity that the BESS will have available after enablement in the energy and regulation FCAS markets for each dispatch interval.

As noted above, the Lake Bonney BESS is required to provide a 10MW response to provide its full registered contingency FCAS capacity. Therefore, the BESS is able to be enabled for its full registered capacity across the three raise contingency markets so long as the combined energy and raise regulation enablement for the generator portion of the BESS is less than or equal to 15MW. Similarly, for the three lower contingency services, their full registered capacity can be provided so long as the combined energy and lower regulation enablement for the load portion of the BESS is less than or equal to 15MW.

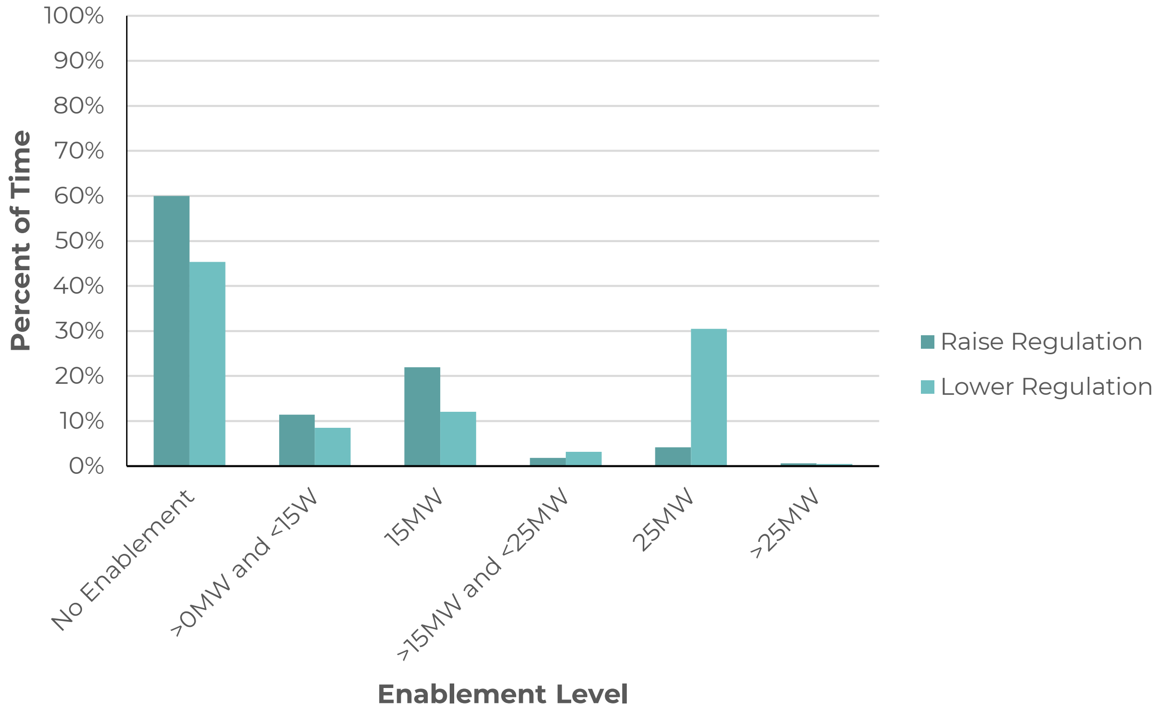
If the available response that can be provided for contingency FCAS in any dispatch interval is less than 10MW, the amount of contingency FCAS that can be enabled is also reduced proportionally.

4.3.2 Provision of Regulation FCAS

Enablement

The levels of regulation FCAS enablement for the Lake Bonney BESS for the reporting period are displayed in Figure 8 below.

Figure 8 Regulation FCAS market enablement



* Enablement >25MW is possible when the BESS is dispatched in the energy market in the same DI

The distinct levels of enablement were chosen to highlight how the enablement of regulation FCAS are considered alongside contingency FCAS enablement. As discussed above, Lake Bonney BESS is required to maintain up to 10MW of capacity when made available to provide contingency FCAS, which limits the amount of regulation FCAS that can be enabled to 15MW (dependent on the dispatch of the BESS in the energy market).

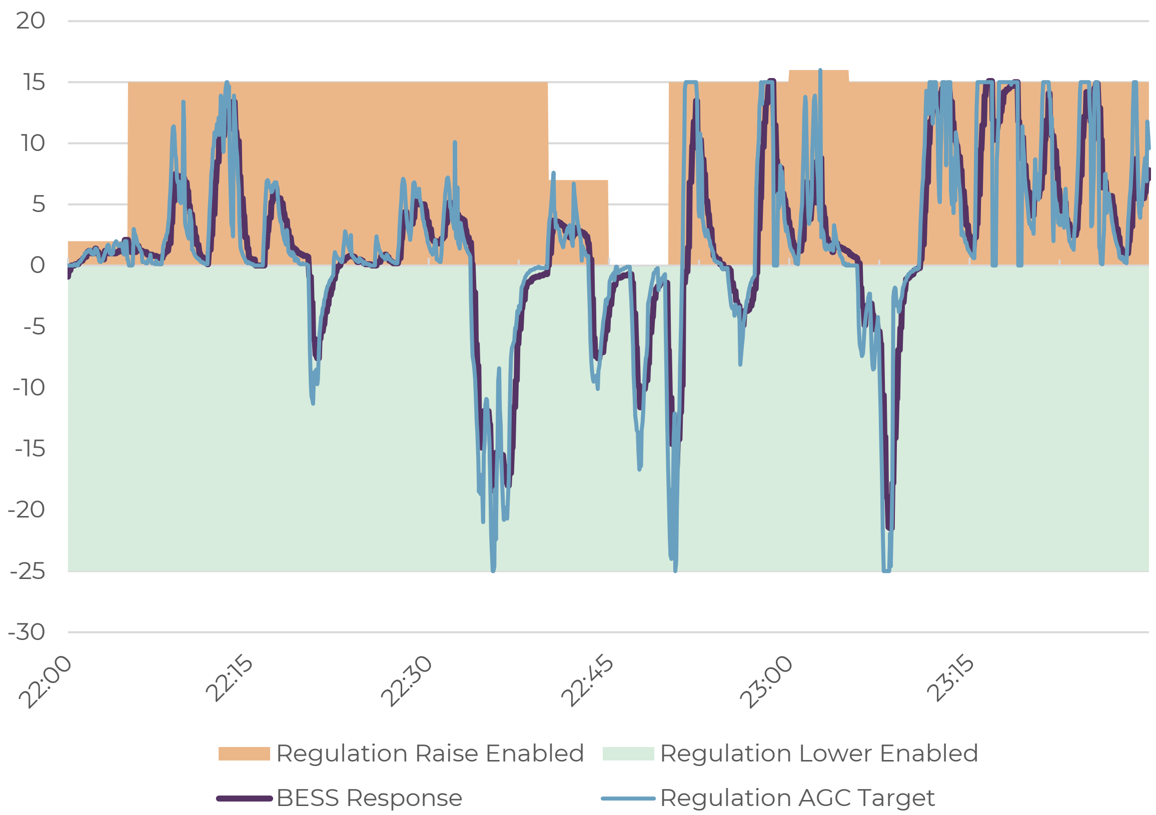
In the reporting period, the Lake Bonney BESS was enabled to provide 25MW of lower regulation for over 30% of the reporting period, while it was only enabled to provide 25MW of raise regulation for 4% of the reporting period. This is in part due to the corresponding value of providing raise or lower contingency FCAS, with raise contingency services having a higher market value than the lower contingency services.

The enablement results were in line with Infigen's expectations, except for the percentage of intervals where raise regulation was not enabled at all. This behaviour was experienced during the first few months of operation of the BESS, and an alteration to the settings in the Tesla AutoBidder software that manages the bidding of the Lake Bonney BESS was made. Following this modification, enablement in the raise regulation market increased from 3.7MW in January 2020 and 2.3MW in March 2020 to 8.9MW in May 2020 and 7.2MW in June 2020.

Performance

The performance of the Lake Bonney BESS in providing regulation FCAS over 90 minutes is shown in Figure 9 below.

Figure 9 Regulation FCAS response of Lake Bonney BESS



While Figure 9 shows the AGC target as recorded by AEMO (for clarity, the time delay between when the regulation AGC target is calculated by AEMO through to when the BESS receives that target via AGC signal is removed in the above figure), Figure 10 below shows the response of Lake Bonney BESS against the AGC signal command at site, and Figure 11 provides a zoomed-in view of the response profile.

Figure 10 Regulation FCAS response of Lake Bonney BESS (as received)

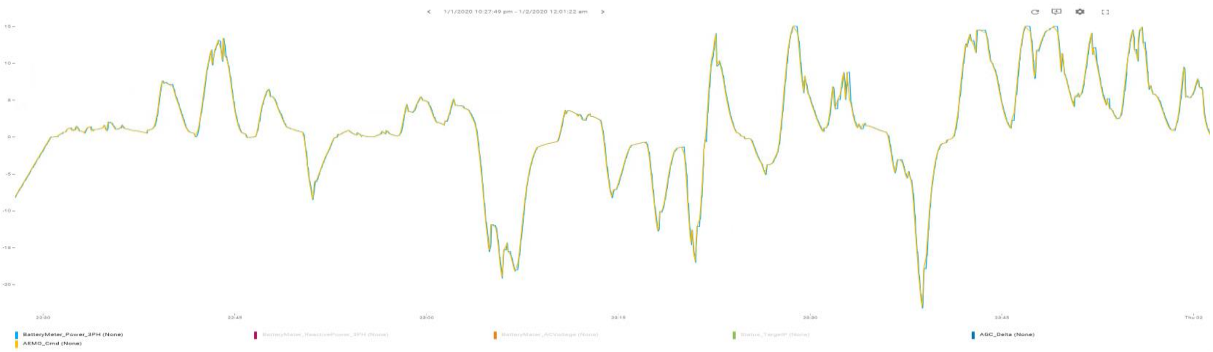
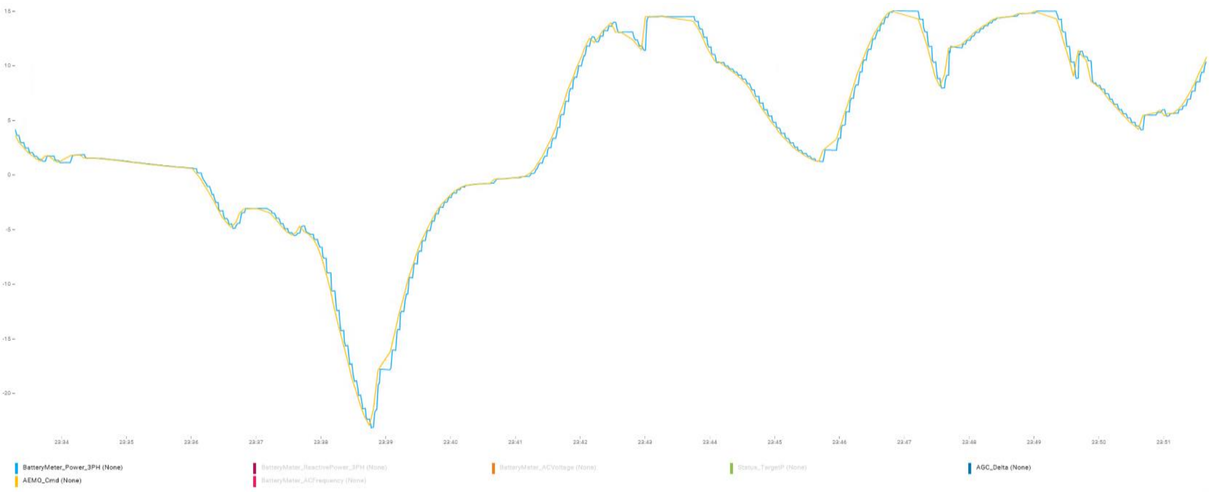


Figure 11 Regulation FCAS response of Lake Bonney BESS (zoomed in)



As seen above, Lake Bonney BESS provides a highly accurate response to the regulation AGC target that is calculated every 4 seconds. The BESS was not required to respond in the energy or contingency FCAS markets in the period shown above.

The variable BESS response required when operating in the regulation FCAS markets is also clearly shown, with the BESS commanded to dispatch as a generator or a load across its full range, from 0MW to the full enabled response for a given dispatch interval.

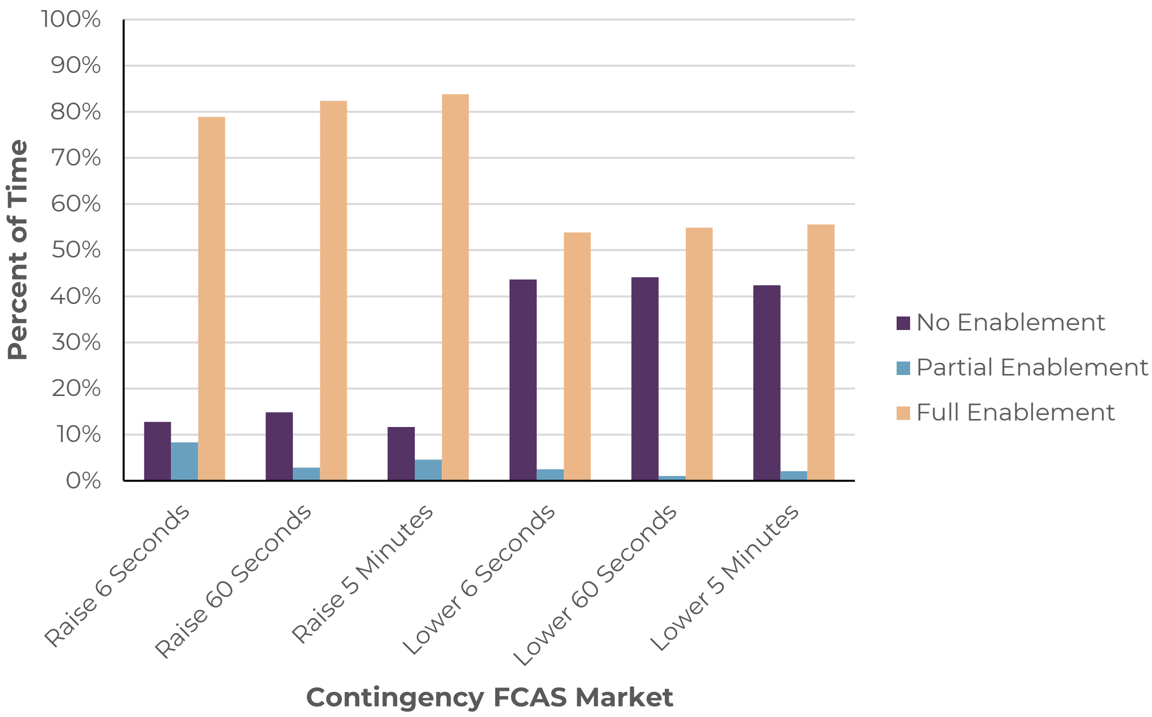
The response of Lake Bonney BESS while providing regulation FCAS has contributed to 72% of the energy discharged and 60% of the energy charged from the system during the reporting period. Any energy throughput due to a regulation FCAS response is also bought or sold at the corresponding energy price for that trading interval.

4.3.3 Provision of Contingency FCAS

Enablement

The levels of contingency FCAS enablement for the Lake Bonney BESS for the reporting period are displayed in Figure 12 below.

Figure 12 Contingency FCAS market enablement



As discussed in Section 4.3.2 above, the enablement in the regulation and contingency FCAS must be considered together due to their co-optimised nature. These results explain the disjoint between the full enablement percentage of the raise and lower contingency service, when considering the percent of time that the Lake Bonney BESS was enabled to provide 25MW of raise and lower regulation. The slight deviation in the enablement percentages of each raise and lower contingency FCAS market is due to the bidding process and misalignment between the bid offers placed by the BESS and final market price cleared by AEMO.

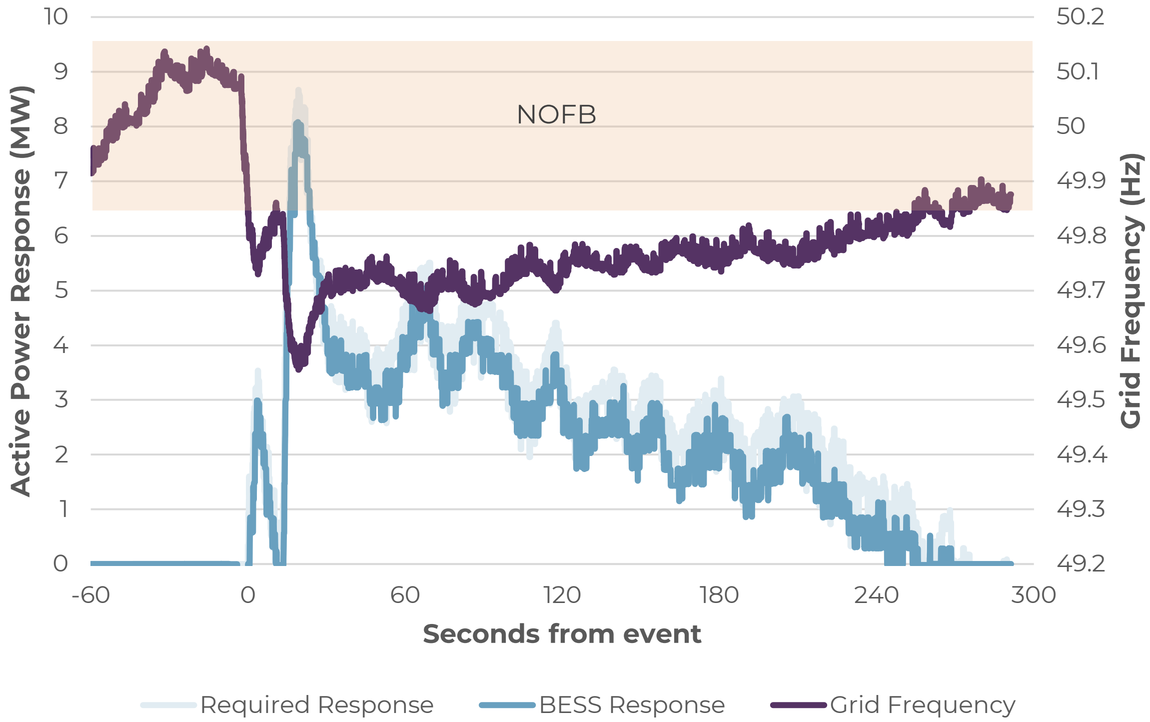
The additional 26% of time that the BESS is enabled to provide 25MW of lower regulation compared to raise regulation is reflected in these results, increasing the amount of time that lower contingency services can't be enabled due to a lack of spare capacity.

The dynamics of enablement in the contingency FCAS markets are also different to the regulation FCAS markets, with the BESS rarely being enabled to partially provide a contingency FCAS response. This is due to the limited impact that enablement has on the state of charge of a BESS, with a physical response only initiated when frequency deviates outside the NOFB. Therefore, the optimisation of contingency FCAS enablement is simplified, as the level of enablement is assumed to have no impact on the dynamic state of charge of the battery, unlike in the energy and regulation FCAS markets.

Performance

The performance of Lake Bonney BESS during a contingency event on the 7th June 2020 is shown in Figure 13 below.

Figure 13 Lake Bonney BESS response during 7th June 2020 contingency event



This event demonstrated the ability of the Lake Bonney BESS to provide a fast and accurate response to a contingency event. In the 300 seconds after the contingency event, the energy discharged due to the contingency response was only 0.22MWh, highlighting the minimal energy throughput required to provide a contingency response.

However, large contingency events like this are rare, and although frequency is measured outside of the NOFB around 1% of the time[5], these excursions are usually very small and last only a few seconds. Energy throughput due to contingency FCAS responses is estimated to

[5] AEMO reporting on system frequency can be found here: https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/frequency-and-time-deviation-monitoring

have contributed to less than 1% of the energy charged and discharged by the Lake Bonney BESS during this reporting period.

4.3.4 Extreme FCAS Market Prices Capture Rates

The average market enablement of the Lake Bonney BESS during extreme FCAS price events within the reporting period is shown in Table 7 below.

Table 7 Lake Bonney BESS enablement during extreme FCAS price events

	DIs above $5000/MW/h	Average Enablement (% of registered capacity)
Raise 6 Seconds	110	86.47
Raise 60 Seconds	79	98.75
Raise 5 Minutes	47	100.00
Raise Regulation	56	14.56
Lower 6 Seconds	31	99.93
Lower 60 Seconds	59	98.25
Lower 5 Minutes	70	96.80
Lower Regulation	75	11.72

* Registered capacity of regulation services is 25MW for the purpose of these calculations

As with the response results for energy prices presented in 4.2.2Table 64.2.2Table 6, the impact of constraints throughout the islanding event in February limited the amount of enablement that the Lake Bonney BESS could achieve in the regulation FCAS markets, which coincided with the majority of these high-priced intervals.

However, as contingency FCAS enablement was not limited by constraints during this period, the BESS was able to achieve almost full enablement across all six contingency markets for the reporting period.

4.4 Technical performance

4.4.1 System Availability and Outages

System Availability

Throughout the reporting period, the Lake Bonney BESS was able to maintain full availability at the plant level. Availability of the plant is calculated as the maximum of the available charge or discharge power for each dispatch interval at the point of connection and recorded as a percentage of the nameplate capacity (in MVA). This means that the system availability accounts for all balance of plant equipment alongside the Tesla Powerpacks and inverters.

There was some equipment downtime (individual battery pods or inverters) that was promptly addressed by Tesla and did not result in reduced plant availability given the modular nature of such failures.

Planned Outages

One major planned outage during the period was coordinated with a LBWF outage, which has the effect of putting Lake Bonney BESS out of service by virtue of sharing the same transmission infrastructure. During this time, BoP maintenance was undertaken on the BESS equipment.

Other planned outages were minor in nature to address some minor defects on the balance of plant equipment as part of closing the EPC contract.

Unplanned Outages

There were no unplanned outages for the Lake Bonney BESS within the reporting period.

However, the operation of the BESS is highly dependent on communications systems also remaining available, including AEMO's AGC signal which control's the dispatch of the BESS in the energy and regulation FCAS markets, and the site telemetry data that is used by Tesla's AutoBidder software to generate optimal market bids. The availability of the AGC signal at site for each month of the reporting period is shown in Table 8 below.

Table 8 Monthly AGC availability

	AGC Availability (%)
Dec-19	98.981
Jan-20	95.116
Feb-20	99.976
Mar-20	99.989
Apr-20	99.618
May-20	99.978
Jun-20	100.000

A number of disruptions to the AGC signal were recorded in January 2020, which lead to the Lake Bonney BESS being unable to participate in the regulation FCAS markets for almost 5% of the time. Depending on where the communication loss occurs, the system may signal an alarm to Infigen's operator and keep following the last signal it received, or ramp to 0MW after two minutes without an AGC signal.

4.4.2 Dispatch Constraints

AEMO Constraints

Constraints that have been described by AEMO that include the Lake Bonney BESS in the reporting period are shown in Table 9 below.

Table 9 AEMO constraints that include Lake Bonney BESS

Constraint Type	Number of Constraints	Constraints That Have Bound	Number of DIs That Constraints Bound
FCAS	14	6	4589
OTHER	15	2	391
STABILITY	288	4	116
THERMAL	105	8	650
VOLTAGE	265	5	644

All binding FCAS and "other" constraints were directly related to the separation event that occurred on the 31st January 2020. On the 3rd February, AEMO introduced constraints that limited Lake Bonney BESS regulation FCAS capacity to 0MW in order to ensure that AEMO could access as much contingency FCAS response as possible. On the 5th February, additional constraints were added which limited energy availability to 2MW. On the 13th February, the constraints relating to regulation FCAS were relaxed to allow 5MW of raise or lower regulation to be supplied. This separation event is further discussed in Section 5.1.

The Lake Bonney BESS is included in 658 Thermal, Voltage Stability, and Transient Stability constraints. In this reporting period, these types of constraints have bound the Lake Bonney wind farms and BESS for 1410 DIs (~2% of the time). These constraints rarely impact the dispatch of the BESS, as it spends most intervals operating in the FCAS markets rather than the energy market.

Site Constraints

Temporary FIA constraint

Following energisation of the BESS, and until confirmation was received in May 2020 that the second FIA conducted on the combined Lake Bonney BESS and LBWF showed no issues, AEMO and ElectraNet imposed a 253MW limit on the combined output of Lake Bonney. Infigen chose to apply a combined 228MW constraint on LBWF for the duration of this limit, in order to allow the BESS to operate unimpeded. The financial impact on LBWF was low due to the wind generation seen throughout the period.

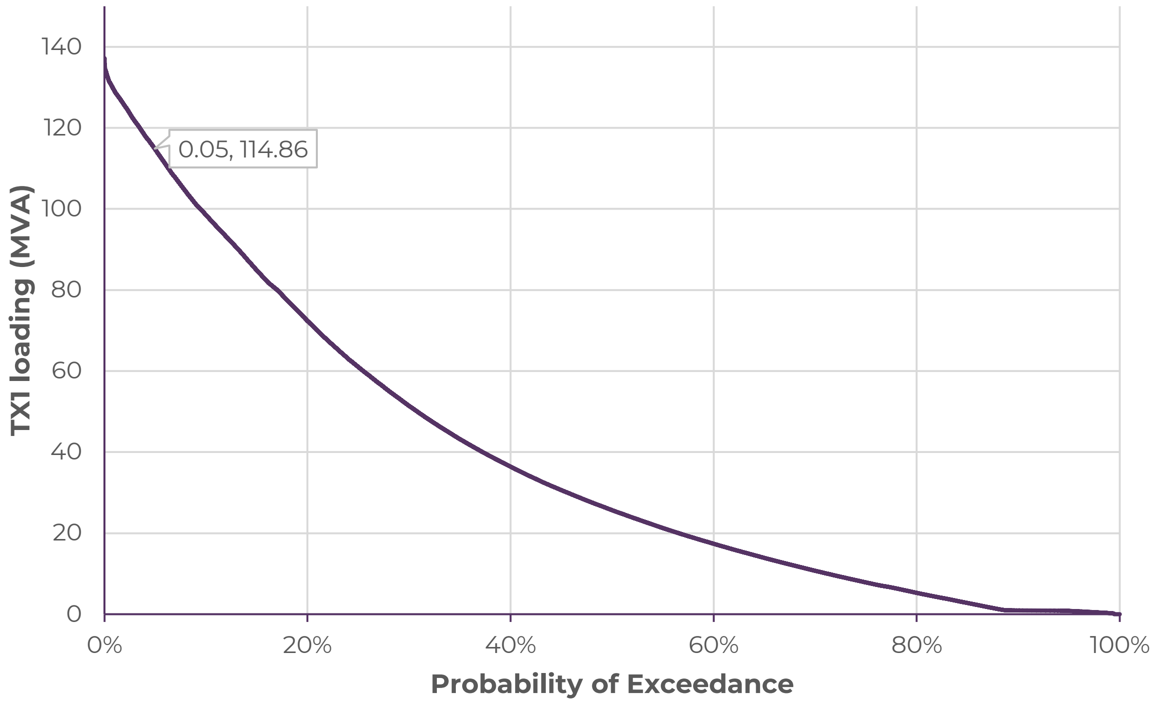
ElectraNet transformer load management

The transformer (**TX1**) at the Mayurra substation that the Lake Bonney BESS connects into is shared with LBWF stages 2B and 3.

TX1 has a continuous limit of 145MVA. However, this limit can be exceeded for up to 10 minutes to a maximum of 156.1MVA, but only for the purpose of providing raise contingency FCAS through the Lake Bonney BESS.

Historical analysis of the windfarm loading on TX1 from 2011 to 2019 is shown in Figure 14 below. This highlights that the loading on TX1 has historically been above 115 MVA for less than 5% of the time.

Figure 14 Historical loading of TX1 from 2011 to 2019



If an excess of 115MVA loading due to LBWF occurs with the additional generation of the Lake Bonney BESS now connected, Infigen operators can opt to constraint LBWF's output to let Lake Bonney BESS operate unconstrained. Otherwise, Lake Bonney BESS has the necessary control logic implemented to ensure that it doesn't exceed the transformer limits.

During the reporting period, there was no occurrence of the generation of LBWF connected to TX1 exceeding 115MVA. This is due to the constraints that the combined output of Lake Bonney was put under until the FIA was completed (as discussed above), and the occurrence of other constraints that limit LBWF's output during periods of high wind generation in the state.

DVAR related constraint

When all DVARs from LBWF are out of service, ElectraNet requests Infigen to limit the output of the Lake Bonney BESS to +/- 22MW. This situation only eventuated once during the reporting period, from 20:05 on the 17th February (after the end of SA separation event), until 15:25 on the 18th February.

It is expected that this constraint will be removed following completion of the R2 process.

4.4.3 Safety and Environmental Performance

There were no major safety or environmental incidents of note during this reporting period.

All high voltage switching activities involving the BESS are managed under the existing LBWF procedures by LBWF maintenance personnel. The familiarity of the personnel with the site facilities helps to minimise the risk of undertaking such works.

Site rehabilitation following the construction period is progressing well, with the disturbed ground vegetation re-seeded and replenished.

4.5 Financial performance

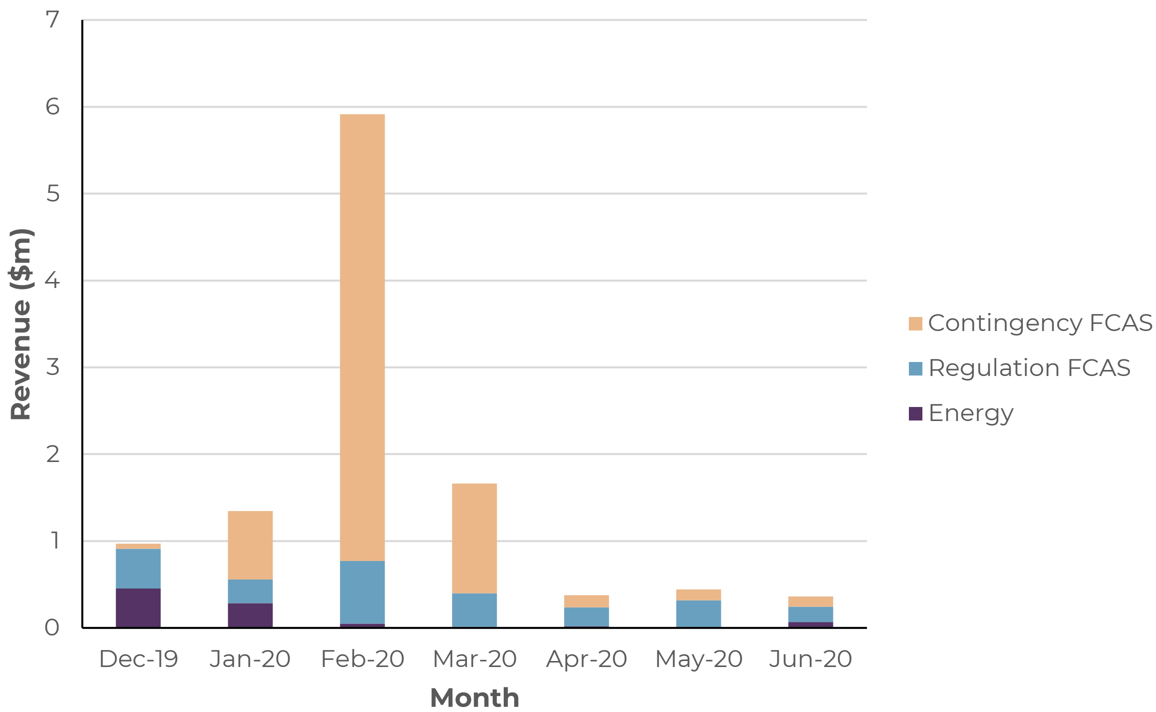
4.5.1 Lake Bonney BESS market revenue

The revenue figures shown below are compiled using operating data for the battery from AEMO's MMS database (which has not been verified for accuracy) and AEMO's settlement procedures for the applicable revenue sources. The presented revenue results for the battery may not reflect actual outcomes due to errors in underlying data or due to contract positions held by Infigen. Accordingly, this information should not be used as an indication of the net revenues earned by Infigen from the battery's operations.

Market revenue by month

The revenue earned by the Lake Bonney BESS each month is shown in Figure 15 below.

Figure 15 Lake Bonney BESS revenue by month



The impact of high FCAS market prices in February 2020 are displayed above, with the Lake Bonney BESS earning more than $5 million from contingency FCAS in this month. This islanding event, as well as the islanding event in March and the initial impact of the February islanding on the 31st January 2020 is seen to generate a large premium on contingency FCAS revenues over the other months.

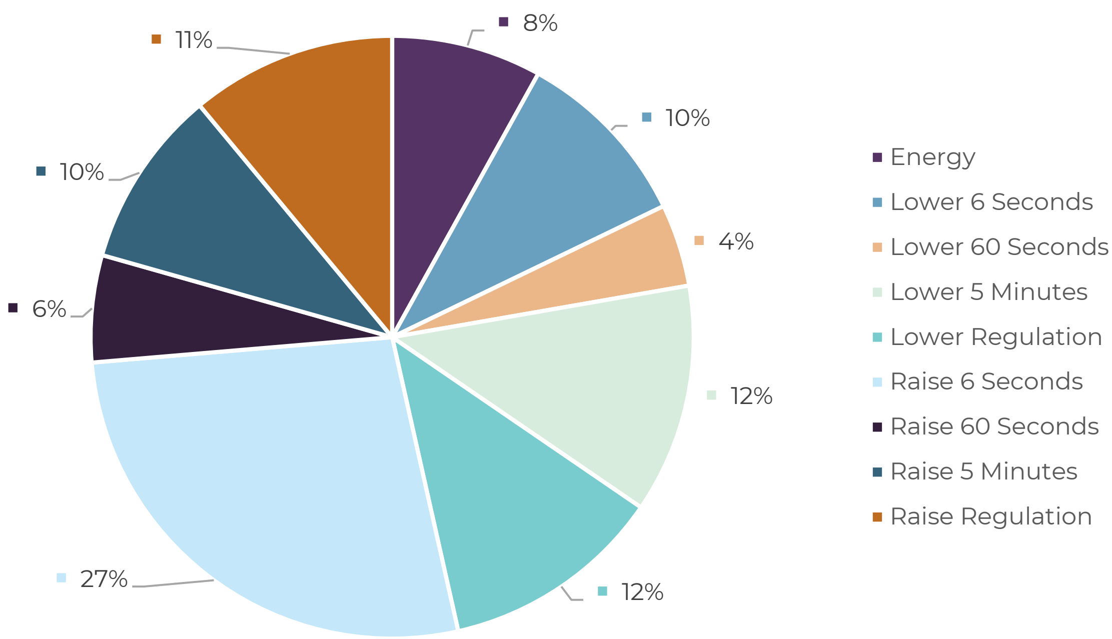
Energy revenues are also highly reliant on a limited number of arbitrage opportunities. Almost half of the energy revenue earned by the Lake Bonney BESS in the reporting period was made during the extreme price event previously outlined in Figure 5. In months with less energy market volatility, there is almost no revenue earned from energy arbitrage.

Regulation FCAS revenue is relatively stable throughout the reporting period. Reduced enablement in the initial months of the reporting period limited the revenue earned, such that the total monthly revenue in the later months are similar despite the lower average market prices for regulation FCAS.

Market revenue by service

The revenue earned by the Lake Bonney BESS per service is shown in Figure 16 below.

Figure 16 Lake Bonney BESS revenue by service



Together, contingency FCAS revenue makes up almost 70% of the total revenue earned by the Lake Bonney BESS during the reporting period. Again, this is primarily a function of the February 2020 islanding event, and these conditions are highly unlikely to occur again.

4.5.2 Future revenue opportunities

Implementation of CPF management

A potential service that Lake Bonney BESS can provide to the benefit of Infigen's portfolio is to manage the causer-pays factors (**CPF**s) of the LBWF stages. The aggregate CPF for the Lake Bonney market participant determines how much reimbursement for regulation FCAS market costs must be paid. While this reimbursement cost can be hedged through active participation in the regulation FCAS markets, circumstances such as the 31st January islanding event (discussed further in Section 5.1 below) meant that this strategy can't be solely relied upon. Infigen explored two options that would reduce the CPF of LBWF through the use of the BESS.

The first option was to utilise the BESS to provide a "balancing service" to ensure that the LBWF appeared to follow a linear trajectory as assumed by AEMO. This would require Lake Bonney BESS to calculate the difference between LBWF's actual output and its linear trajectory for a dispatch interval and account for this difference as either a generator or load.

This option was not preferred as this "balancing service" would have meant that Lake Bonney BESS would have deviated from its own target (AGC dispatch signal plus frequency droop response), raising concerns around the potential non-compliant operation of the BESS, as well as the risk of Lake Bonney BESS accruing a negative CPF due to the "balancing service" it would provide.

The second option explored by Infigen was to increase the responsiveness of the Lake Bonney BESS to frequency deviations, by tightening the frequency deadband from 50Hz +/- 0.15Hz. In this option, the Lake Bonney BESS would respond independently of the LBWF, preventing the issues identified above.

Utilising the frequency response option would ensure that the response was proportional to the size of the frequency deviation and could be implemented and adjusted using existing frequency response parameters. This option was therefore preferred by Infigen.

Infigen is currently undertaking a trial on the impact of the Lake Bonney BESS in reducing the CPF for the LBWF market participant. The results of this trial will be presented in the second operational report.

Rule change requests for new markets

A number of rule change requests for the introduction of new system security markets have been made to the Australian Energy Market Commission (**AEMC**), including:

- a "fast frequency response" ancillary service market for raise and lower responses measured within a timeframe of 0.5-2 seconds from the frequency excursion event;
- an "operating reserve" market for generators that can provide a dispatchable response within 30 minutes (with a 15-minute call time);
- a "ramping service" ancillary service market for raise and lower responses that operate over a 30-minute period.

There should be no barriers for Lake Bonney BESS to participate in these markets in the future if/once they are established, with the BESS able to provide the required responses within either short-term or medium-term timeframes (subject to operational state of charge limitations).

Major considerations for Infigen utilising the Lake Bonney BESS to participate in future markets such as these are the enablement constraints with other market services and the potential energy throughput due to enablement.

5. Key Events in Reporting Period

5.1 January 31st Separation Event

Overview of separation event

On January 31st 2020, at around 13:24 the SA region was separated from the rest of the NEM after a number of transmission towers collapsed in the vicinity shown in Figure 17 below.

Figure 17 Location of transmission towers that collapsed during the separation event[6]

Immediately prior to this fault, the power flow on the Heywood interconnector was ~500MW from SA to VIC. Immediately following the fault, the power flows reversed and ~500MW was flowing from VIC to SA. This led to an increase in system frequency in the SA region, with a maximum frequency of ~51.11Hz recorded following the fault.

The SA region of the NEM remained in an islanded state until 17th February 2020 (aside from the Murraylink DC connection which has a maximum transfer capacity of 220MW but can't provide any FCAS). During this time, AEMO had to source all of the required FCAS to

[6] Further details on the separation event can be seen in AEMO's preliminary incident report, available here: https://aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2020/preliminary-report-31-jan-2020.pdf?la=en

maintain system security from SA generators and loads, leading to the high market prices discussed previously in this report.

Operation of Lake Bonney during the fault

Immediately prior to the separation event, the Lake Bonney BESS was charging at ~10MW, and the LBWF was generating at ~140MW. Immediately following the event, frequency was seen to increase to a maximum of 51.3Hz, with a maximum rate of change of frequency (**ROCOF**) observed of 0.75Hz/s.

Lake Bonney BESS performed as expected during the event and provided a contingency FCAS response as per its droop characteristic. As the maximum ROCOF observed during that event was 0.75Hz/s, and with the 1.7% droop setting of the BESS (providing 25MW following a 0.85Hz deviation), the maximum rate of change of the BESS' active power response was ~22MW/s. This is well within the response time capability of the plant.

Upon review of the event, it was noted that Lake Bonney BESS continued to track its AGC signal while outside of the NOFB. AEMO's preference for the provision of contingency FCAS is that the most recent AGC setpoint received by the generating unit is frozen when the frequency moves outside the NOFB. A contingency response based on the BESS' droop setting will then be provided supplementary to this setpoint, with the AGC setpoint refreshed once frequency comes back within the NOFB. This logic has since been implemented and tested at Lake Bonney BESS.

Box 2 Lesson learnt: Configuration of BESS during frequency excursion events

Prior to the separation event, Infigen was unaware of the requirement to freeze the AGC setpoint when frequency goes outside the NOFB. It was only after discussing the performance of the system during that event that Infigen became aware of different logic being implemented on other assets.

This issue was then raised with AEMO to ensure that the BESS was adequately configured. After careful consideration, AEMO advised that the preferred configuration for the Lake Bonney BESS was to freeze its AGC signal's setpoint whenever frequency is outside the NOFB.

As a highly configurable and flexible system, further collaboration and knowledge sharing is welcomed, to improve how the BESS can improve its performance during power system events.

LBWF also performed as expected during the event. LBWF stage 1 was generating approximately 30MW and in accordance with its over-frequency generation shedding (**OFGS**) scheme, it disconnected when the frequency reached the threshold. LBWF stages 2 and 3 rode through the event as the frequencies at which their respective OFGS scheme is activated are higher than the maximum frequency recorded during the event.

Operation of Lake Bonney during islanded conditions

Within 30 minutes of the separation event, LBWF stages 2 and 3 were constrained to 0MW of generation (with LBWF stage 1 having already disconnected due to its OFGS settings). LBWF was constrained off by AEMO for the duration of the February separation event and did not begin generating again until 18th February.

Throughout the event, the battery was utilised under the instruction of AEMO (either through directions or constraints) that limited the BESS to participate mainly in the contingency FCAS markets. This approach was consistent with AEMO's treatment of the three utility-scale batteries in the region.

On the 3rd February, AEMO introduced constraints that limited Lake Bonney BESS regulation FCAS capacity to 0MW in order to ensure that AEMO could access as much contingency FCAS response as possible. On the 5th February, additional constraints were added which limited energy availability to 2MW and required the BESS to maintain a state of charge of 50% +/- 20%. On the 13th February, the constraints relating to regulation FCAS were relaxed to allow 5MW of raise or lower regulation to be supplied.

Box 3 Lesson learnt: Utilisation of a BESS during a SA islanding event

The 31st January separation event indicated how AEMO will likely look to utilise utility-scale battery systems in islanded regions of the NEM in the future, by constraining the operation of each BESS in the energy and regulation FCAS markets such that they are focussed on reserving both power and energy storage capacity for the provision of contingency FCAS.

The impact of these constraints on Infigen's SA generation and customer portfolios are discussed below.

Box 4 Recommendation: Utilisation of a BESS during a SA islanding event

While the focus on reserving contingency FCAS capabilities during the unusual islanding event was reasonable and helped AEMO maintain system security, Lake Bonney BESS, and battery energy storage systems in general, are capable of providing high-quality regulation FCAS to stabilise system frequency to the benefit of the islanded region.

Infigen would welcome further collaboration with AEMO on the most effective utilisation of utility-scale storage assets when a region is islanded, including the potential for increased BESS participation in the regulation FCAS markets and optimising the energy storage reserves in the event that a contingency FCAS response is required.

Infigen believes that optimal limits on energy storage reserves should be adequately selected for each BESS depending on what event AEMO is protecting against (e.g. a 1-hour excursion from NOFB) as opposed to being arbitrarily imposed as a SOC range (e.g. 30%-70%) for all BESS, each with different ratings and storage capacities.

Impact of separation event on Infigen SA portfolio

During the islanding of the SA region in February 2020, the additional revenue earned by Lake Bonney BESS was above expectation due to high FCAS prices, which broadly offset the economic impact of the curtailed production at LBWF due to AEMO constraints. This included the cost of covering Infigen's contract exposure with C&I customers in the spot market, and the increased reimbursement costs paid due to the Lake Bonney market participant CPF.

Box 5 Lesson learnt: Value of a diversified portfolio

The 31st January separation event demonstrated the value of a diversified portfolio in the SA region of the NEM. Access to revenue opportunities across the nine spot markets helped to mitigate the risk of curtailment, either for the LBWF stages in the energy market or the constraints on Lake Bonney BESS limiting participation in the regulation FCAS markets.

However, the co-location of these plants still poses the risk that all of the Lake Bonney assets could be constrained off during a particular event. Infigen's investment in the SA Gas Turbines, which will be located in a different part of the network, will reduce the impact of this risk on the SA customer portfolio.

While the cost impacts on Infigen throughout the separation event broadly offset as noted above, they did highlight that there are certain circumstances where Lake Bonney BESS may not be available to provide a physical hedge for Infigen's portfolio. During the 31st January separation event, this was true for both the energy and regulation FCAS markets. While the energy market risk posed by separation can't be reduced, the exposure of the LBWF market participant to regulation FCAS reimbursement costs through its CPF can be managed.

To date, CPF exposure has been managed by simply operating the BESS in the regulation markets and earning sufficient revenue in that market to offset the reimbursement costs. However, during the separation event Lake Bonney BESS was constrained from operating in the regulation FCAS markets, limiting its ability to earn sufficient revenue to cover the reimbursement costs (which were also inflated due to the higher FCAS prices under islanded conditions).

As CPF are calculated ahead of time and applied over the next four weeks once determined, the Lake Bonney market participant was exposed to reimbursing the costs based on its CPF determined for its operation from 8th December 2019 to 5th January 2020, even though the LBWF was curtailed at 0MW for the entirety of the 31st January separation event.

Box 6 Lesson learnt: Inability to physically hedge CPF exposure through market participation

The 31st January separation event highlighted that the Lake Bonney BESS would not always be available to hedge the exposure of the Lake Bonney market participant's CPF through active participation in the regulation FCAS markets.

Instead, the CPF exposure could be managed as it is calculated, by configuring the BESS as discussed in Section 4.5.2 above. This would ensure that the CPF is minimised prior to the time that it has market exposure, where it may or may not be able to be hedged by the BESS.