Gannawarra Energy Storage System

Operational Report #3 and #4

Edify Energy and EnergyAustralia
hello@edifyenergy.com

Table of Contents

List of Figures

List of Tables

Disclaimer

Glossary of Terms

Acronym	Meaning
AC	Alternating Current
AEMO	Australian Energy Market Operator
API	Application Programming Interface
ARENA	Australian Renewable Energy Agency
BSSA	Battery Storage Services Agreement
DELWP	The Victorian Government's Department of Environment, Land, Water and Planning
DLF	Distribution Loss Factor
DUOS	Distribution Use of System
Edify	Edify Energy Pty Ltd and its related entities
EPC	Engineering, Procurement and Construction
FCAS	Frequency Control Ancillary Services
GESS	Gannawarra Energy Storage System
GSF	Gannawarra Solar Farm
LLV	Large Low Voltage
MLF	Marginal Loss Factor
NEM	National Electricity Market
NMI	National Metering Identifier
Project	GESS
RCR	RCR Tomlinson Limited
RRN	Regional Reference Node
SCADA	Supervisory Control and Data Acquisition
SOC	State-of-Charge
ST	Subtransmission
TUoS	Transmission Use of System
WIRCON	Wircon Energie 9 GmbH and its related entities

Executive Summary

This operational report covers the second of two 6-month operational periods for the Gannawarra Energy Storage System – March to August 2020 and September 2020 to February 2021. Between the Project Summary Report and the first Operational Report, the GESS project has already provided the sector with a number of development, regulatory, delivery and operational learnings, particularly in relation to coordinated battery and renewable plant arrangements. This report should therefore be read in conjunction with these previous reports to provide the reader with the project's full breadth of findings.

The key insights articulated in Executive Summary of the first operational report remain current for the second 12-month operational period. Otherwise, a summary of the key lessons learned from an operational and financial perspective discussed in this report, is as follows:

- At current prices, FCAS revenues are a significant component of battery revenues and therefore the value stack, but the volatility and depth of these value streams make it difficult to rely on for capital investments.
- Batteries connecting to the distribution network face significant demand-based charges which can result in sub-optimal trading decisions and therefore underutilisation of storage assets. This is mitigated in part by 1) the option to charge during solar hours in the case of the co-located arrangement of GESS and GSF; and 2) access to avoided TUOS payments, which in turn are subject to the accessibility of this revenue stream when managing connection constraints of co-located facilities.
- As alluded to above, while co-locating batteries with renewable assets has capital and operating cost benefits, there can be downsides from sharing a connection when the connection size requires constraints on the battery, particularly where the co-located renewable asset is pre-existing and a separate financial entity. Accurate forecasting of the renewable resource feeding into real-time decision-making tools is important to retain the option to maximise any available headroom in connection assets.
- Automation of bidding is a useful tool to optimise trading decisions and manage dynamic constraints, but it has its limitations.
- The intrinsic characteristics of battery assets such as GESS make them high performers from a safety and environmental perspective.

Project partners

GESS would not have been possible without the support of DELWP as part of its Energy Storage Initiative, ARENA as part of its Advancing Renewables Program or WIRCON as 50-50 joint venture co-investors. GESS's other project partners Tesla and EnergyAustralia also worked tirelessly to turn the project from concept to reality.

INTRODUCTION

Edify™

1 Introduction

This Operational Report #3 and #4 covers the time from completion to the end of the second 2 x six-month periods (March to August 2020 and September 2020 to February 2021) of operation of GESS. This report represents two of the Knowledge Sharing deliverables under the Funding Agreement with DELWP and ARENA, and also forms a key part of ARENA's Advancing Renewables Programme objectives.

The report focuses on operational learnings, including the following:

- Operational regimes (e.g. arbitrage and firming);
- Ancillary Services provided;
- Technical performance;
- Financial performance; and
- Safety and environmental performance.

The report is public with an intended audience that includes:

- Developers;
- Renewable energy industry;
- General public;
- Vendors;
- General electricity sector; and
- Governments.

1.1 Knowledge sharing activities to date

To date, a number of knowledge sharing activities for GESS have taken place as listed in Table 1.

Table 1 Knowledge sharing activities to date

Activity	Details
Industry presentations	• RenewEconomy / Informa Conference; June 2018 • All Energy Conference; October 2018 • Baker McKenzie panel seminar; October 2018 • AEMO Advanced Systems Integration Group (ASIG) meeting; October 2018 • ARENA Insights Forum; November 2018 • Australian Solar + Energy Congress and Expo; December 2018 • Clean Energy Summit; July 2019
Reports and other published materials	• ARENA's GESS video, November 2018[1] • AEMO Emerging Generation and Energy Storage (EGES) stakeholder paper response; December 2018[2] • Energy Magazine Article; February 2019[3]

[1] https://youtu.be/tEUiqYu28OA
[2] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Initiatives/Emerging-Generation/Submissions/Edify-Energy_20181204.pdf
[3] https://www.energymagazine.com.au/exploring-the-retrofit-model-and-offtake-agreements-for-battery-integration/

	• ARENA Insights Spotlight: Gannawarra Energy Storage System (GESS) An interview with Edify Energy, April 2019[4] • DELWP's GESS media release and video, July 2019[5] • Project Summary Report, September 2019 • Operational Project Report #1 and #2, August 2020 • Energy Magazine Article; November 2020[6] (also published in the May 2021 issue of Utility Magazine)
Site visits	• Construction visit; August 2018 • Completion visit; June 2019[7]

1.2 About Edify Energy

Edify is a leading 100% Australian owned renewable energy company, with significant experience in developing, project financing and delivering renewable and storage projects across Australia. Edify has under construction, or brought into operation, six large-scale solar farms (640MW_{AC} / 770MW_{DC}) and a 25MW / 50MWh lithium-ion battery.

The Edify business model supports the full lifecycle of energy project development and operation, including greenfield development, project structuring and financing, construction management and a full asset management offering, including trading, reporting and managing operations and maintenance personnel. Edify's philosophy is to ensure that its interests are as closely aligned with investors and project stakeholders as possible. For this reason, in addition to providing long-term asset management services, Edify seeks to maintain an equity interest in its projects, resulting in best-in-class assets.

The Edify management team has in excess of 130 years' experience in the power and renewables sector internationally, raised and deployed around $3 billion in capital, brought over 40 solar and wind projects into commercial operation and overseen the construction and operation of a collective operational portfolio of more than 1.7GW. Edify operates as a team across Australia in capital cities and in towns close to the project sites, maintaining a strong connection with the communities in which the solar power and storage plants operate.

Table 2 outlines the projects that Edify has developed, structured, financed and managed the construction of to date. With the exception of the under-construction Darlington Point Solar Farm, all projects are operational and under Edify's asset management function.

As is noted in Section 1.4 below, GSF and GESS required the creation and registration of a network in order to enable the connection arrangement for these two assets. Edify is one of very few energy companies that has overcome many of the challenges presented in the energy sector's transition in that, in addition to the GESS / GSF network, Edify has developed, structured, financed and has under construction or operation renewable assets, a battery, harmonic filters and a synchronous condenser.

[4] https://arena.gov.au/assets/2019/04/gannawarra-energy-storage-system.pdf
[5] https://www.energy.vic.gov.au/media-releases/australias-largest-integrated-battery-and-solar-system
[6] https://www.energymagazine.com.au/co-locating-renewables-and-batteries-assessing-the-operational-implications/
[7] https://reneweconomy.com.au/edify-energy-celebrates-completion-of-gannawarra-big-battery-73122/, https://www.abc.net.au/news/2019-06-14/australias-largest-solar-and-battery-farm-opens-in-kerang/11209666

Table 2 Edify Energy's Australian development and transaction experience

Project	Capacity	Location	Status	Comment
Whitsunday Solar Farm	$58MW_{AC}$ $69MW_{DC}$	Collinsville, QLD	• Operational • Commissioned 2018	• Received ARENA funding • Secured largest Solar 150 Support with QLD Government • Debt funding with CBA, CEFC and NORD LB
Hamilton Solar Farm	$58MW_{AC}$ $69MW_{DC}$	Collinsville, QLD	• Operational • Commissioned 2018	• Short-term PPA with ERM Power for full output • Debt funding with CBA, CEFC and NORD LB
Daydream Solar Farm	$150MW_{AC}$ $180MW_{DC}$	Collinsville, QLD	• Operational • Commissioned 2018	• PPA with Origin Energy for full output • Equity funding with BlackRock • Debt funding with CBA, CEFC and Natixis
Hayman Solar Farm	$50MW_{AC}$ $60MW_{DC}$	Collinsville, QLD	• Operational • Commissioned 2018	• Merchant project • Equity funding with BlackRock • Debt funding with CBA, CEFC and Natixis
Darlington Point Solar Farm	$275MW_{AC}$ $330MW_{DC}$	Darlington Point, NSW	• Operational • Commissioned 2020	• PPA with Delta Electricity for portion of output • Equity funding with Octopus Investments • Debt funding with CBA and Westpac
Gannawarra Solar Farm	$50MW_{AC}$ $60MW_{DC}$	Kerang, NSW	• Operational • Commissioned 2018	• PPA with EnergyAustralia for full output • First large-scale solar farm in Victoria • Debt funding with CBA, CEFC and NORD LB
Gannawarra Energy Storage System	25MW / 50MWh lithium-ion battery	Kerang, NSW	• Operational • Commissioned 2018	• Grant funding provided by ARENA and VIC Government • Long-term services agreement with EnergyAustralia • One of the largest co-located solar farm and battery facilities in the world

1.3 About EnergyAustralia

EnergyAustralia provides gas and electricity to more than 2.5 million residential and business customer accounts in Victoria, New South Wales, the Australian Capital Territory, South Australia and Queensland. EnergyAustralia is dedicated to building an energy system that lowers emissions and delivers secure, reliable and affordable energy to all households and businesses. To support this, EnergyAustralia owns, contracts and operates an energy generation portfolio that includes coal, gas, battery storage, demand

response, solar and wind assets. Combined, these assets comprise 4,500MW of generation capacity. EnergyAustralia, which has its headquarters in Melbourne, is a wholly-owned subsidiary of CLP Group, one of the largest publicly-owned integrated power businesses in the Asia Pacific. Read more about us here: www.energyaustralia.com.au

1.4 Project overview

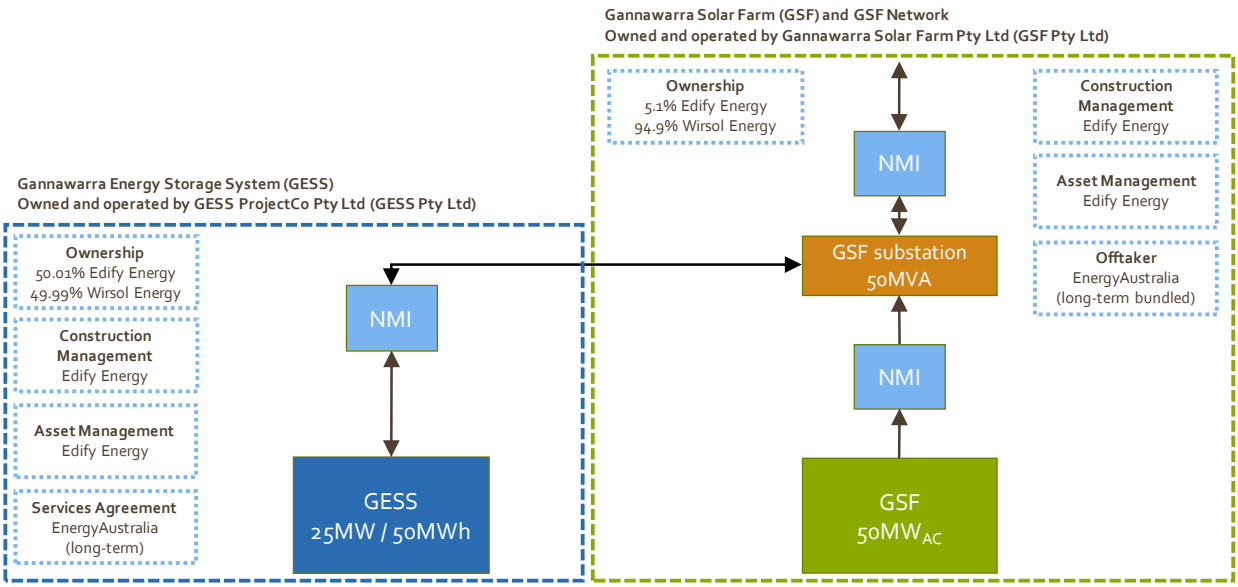
GESS is a 25MW / 50MWh battery that is integrated with Victoria's first large-scale solar farm – GSF (being a $50MW_{AC}$ solar farm). GESS was developed and structured by Edify and financed by ARENA and DELWP as providers of $25 million in grant funding with Edify in a consortium with WIRCON as 50-50 joint venture co-investors. Tesla was the battery provider, RCR the EPC contractor and EnergyAustralia is the long-term operator of GESS under a novel BSSA.

Now complete and commissioned, GESS is:

- The first integrated utility scale renewable energy and battery system in Victoria and among the first in Australia;
- The first retrofit of a battery to an existing or under-construction solar farm in Australia;
- Among the largest integrated renewable energy and battery systems in the world; and
- A pioneering project for all consortium members and the broader electricity sector given its importance in identifying necessary reforms to bring batteries and other storage technologies to market.

Figure 1 indicates the commercial relationships for GESS and how they interact with GSF. In addition to developing and being a majority owner of GESS, Edify also acts as asset manager and oversaw the construction of GESS, in a similar way to its role in GSF. Importantly, EnergyAustralia holds a long-term offtake position with GSF, that complements its operational role for GESS under the BSSA.

Figure 1 Commercial arrangements for GESS and its interaction with GSF



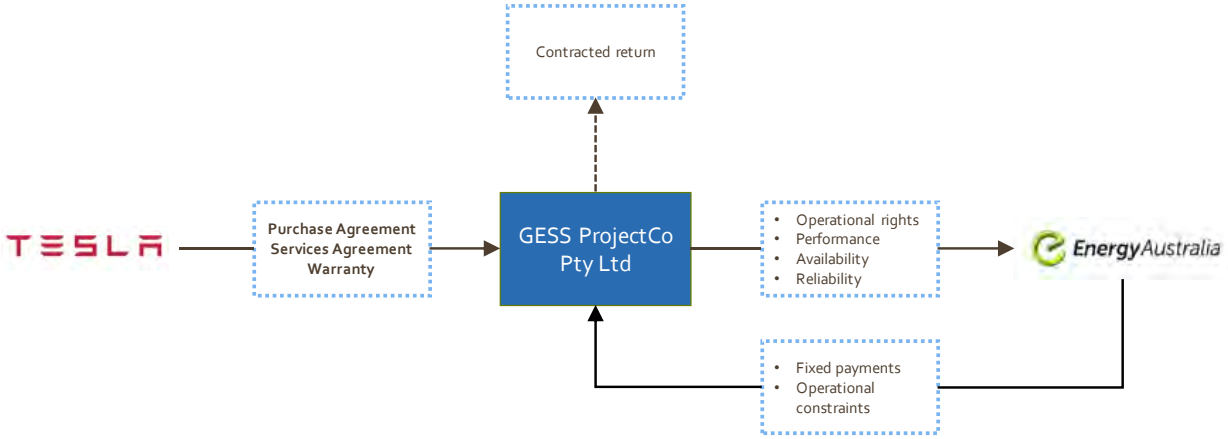
1.4.1 EnergyAustralia as operators

The revenues of GESS are wholly captured in the novel long-term BSSA between GESS and EnergyAustralia. The BSSA entitles EnergyAustralia to full operational rights over GESS, as they relate to charge and discharge decisions in both energy and FCAS markets. Accordingly, EnergyAustralia is the

beneficiary of all market-linked revenues from GESS, which it receives in exchange for making fixed payments to GESS.

The BSSA also provides EnergyAustralia with battery performance, availability and reliability commitments, subject to operational constraints, mainly relating to cycling frequency and depths and dispatch capacity limits relating to sharing a connection with the co-located solar farm. The battery purchase agreement provides GESS with performance, availability and reliability commitments from Tesla. Figure 2 outlines these arrangements.

Figure 2 Structure of the novel long-term services agreement with EnergyAustralia



OPERATIONAL REGIMES

Edify™

2 Operational regimes

2.1 Services provided

As outlined in Section 1.4.1, EnergyAustralia is the registered market intermediary for GESS and is therefore responsible for the bidding of the battery system with AEMO. GESS has been registered as both a Scheduled Market Generator and a Scheduled Market Load in the NEM, and since July 2019 has been registered in the regulation FCAS markets. In its second twelve months of operations, EnergyAustralia trading teams have continued with a similar strategy to operational year one, that is, GESS's primary use case being energy arbitrage and providing regulation FCAS services.

The year began with a restriction on GSF of 25MW to manage post contingent voltage oscillation. Consequently GESS was unrestricted in its operations with the ability to discharge its full capacity into the grid (given the firm 25MW headroom available in the shared 50MW connection during this restriction period). This constraint ceased on the 21/04/20 with transformer constraints again limiting discharge rates on GESS based on GSF output and the shared 50MW connection.

As noted in the year one report, contingency FCAS is likely to create additional revenue opportunities for GESS and give EnergyAustralia an additional tool to maximise value of the battery while keeping within contractual limitations on cycles and SOC. At the time of writing, EnergyAustralia was working with Edify to seek to register GESS in the contingency FCAS markets.

From an operations perspective, EnergyAustralia has continued to optimise GESS using human insight (similar to the first 12 months) but is in the process of developing an automated trading tool to inform trading desk decisions. As reported previously, this decision was driven by two primary considerations on EnergyAustralia's part:

1. A desire to use the battery as a learning tool to understand how flexibly it performs and responds and to apply those learnings within a portfolio of other assets and to tune any future automation; and

2. Where market / price forecasts are highly accurate then auto bidding can be an optimal approach, but many factors can change moving closer to dispatch intervals and specific market outcomes. For instance:

   – Demand / supply forecasts can deviate greatly, particularly with renewables playing a large part in the variability of supply;
   – Forced outages / de-ratings and lack of participant bidding until close to dispatch can cause auto bidding to produce sub-optimal results especially around managing SOC where the expected high price period of the day may evolve as the day progresses; and
   – FCAS price forecasts can be inaccurate, so relying on a high level of FCAS related cycling without an accurate forecast would be difficult.

On this basis, EnergyAustralia expects to continue to trade the battery with human bidding but will increasingly inform those decisions with automated trading tools where it sees value in doing so. For example, EnergyAustralia is looking to develop autobidding functionality that can trigger availability bids (of 0) when the battery's SOC reaches upper or lower limits. This functionality could also be utilised to update GESS availability to reflect the shared 50MW connection between GESS and GSF every 5 minutes.

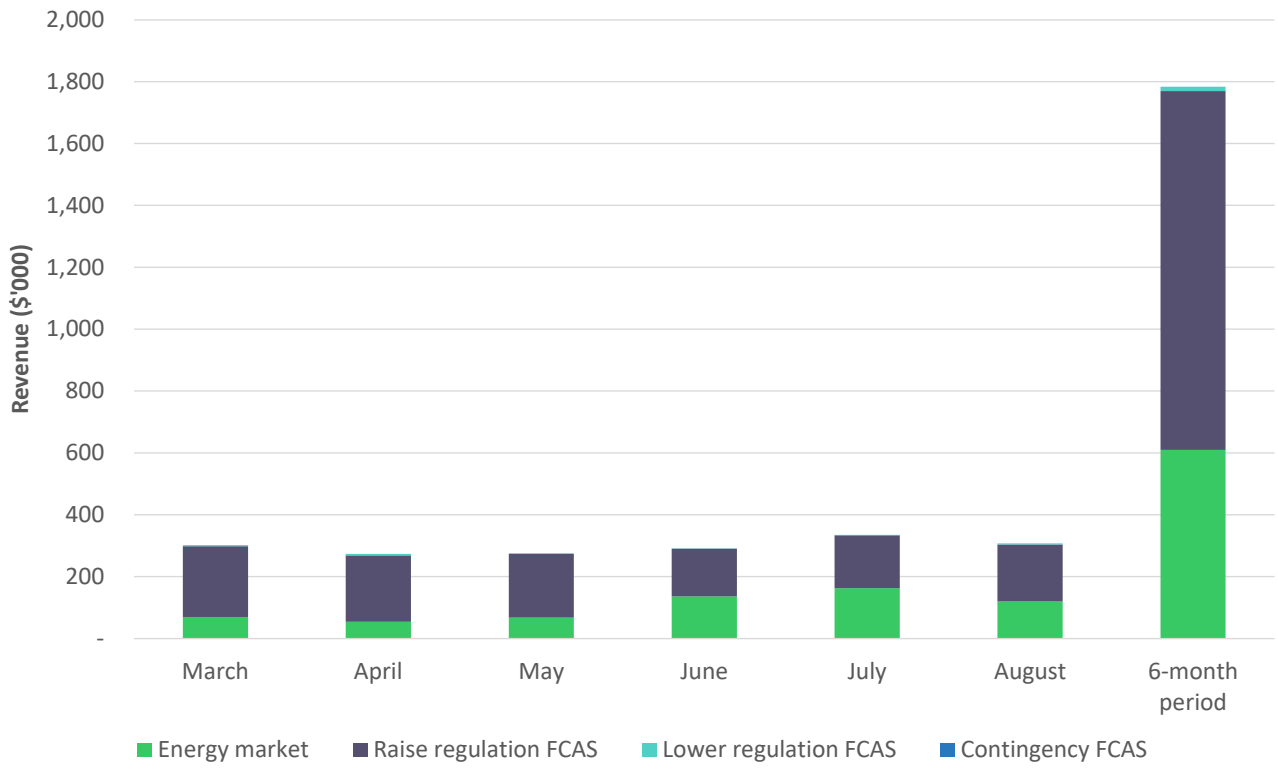
At present GESS does not provide additional non-market services, however in accordance with the agreed performance standards and the capability of the plant, we continue to scan for opportunities that a fast-responding asset of this type can provide. As previously reported, we note that at present the GESS is designed to:

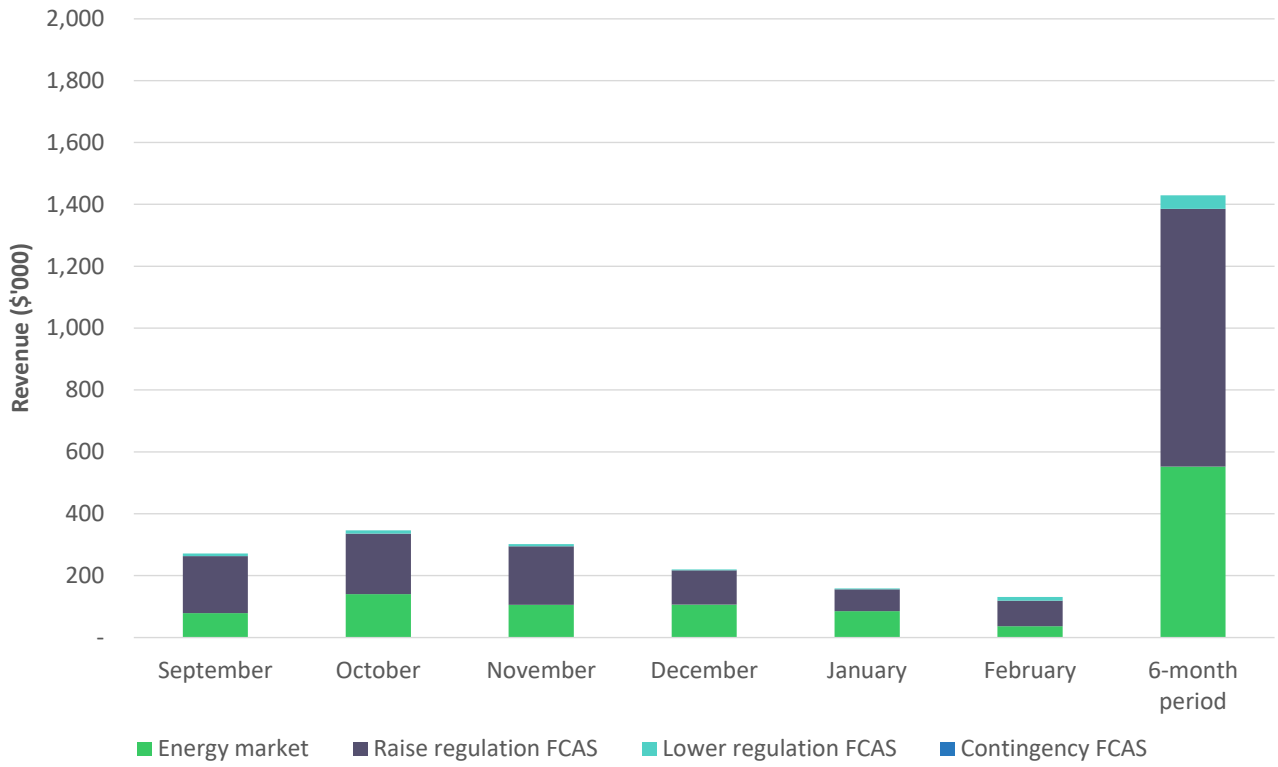
- Maintain its connection point power factor at unity whilst both charging and discharging, and regulate power factor in co-ordination with GSF and in a manner that helps to support network voltages during faults;
- Provide continuous uninterrupted operation within the frequency range 49.5-50.5Hz and in doing so provide support during the period of containment after a generation or load contingency event has occurred and contingency markets have recovered and stabilised the system frequency; and
- Utilise control system settings that are capable of providing for automatic increases or reductions in active power for frequency excursions outside the normal operating frequency band, as well as ensuring power system oscillations are adequately damped.

2.2 Financial performance

Although revenues are lower than operational year one, GESS has continued to perform well from a revenue perspective in operational year two (see Figure 3 and Figure 4) primarily driven by FCAS revenues exceeding the value expected in the initial business case. The average generation price for GESS between March and August 2020 was $68/MWh, with an average charging price of $36/MWh. The average generation price for GESS between September 2020 and February 2021 was $47/MWh, with an average charging price of $20/MWh. With less volatile pricing in regulation markets, the GESS has generated relatively more revenues from the energy market than in operational year one, but lower revenues in total compared to year one.

Figure 3 Financial performance of GESS





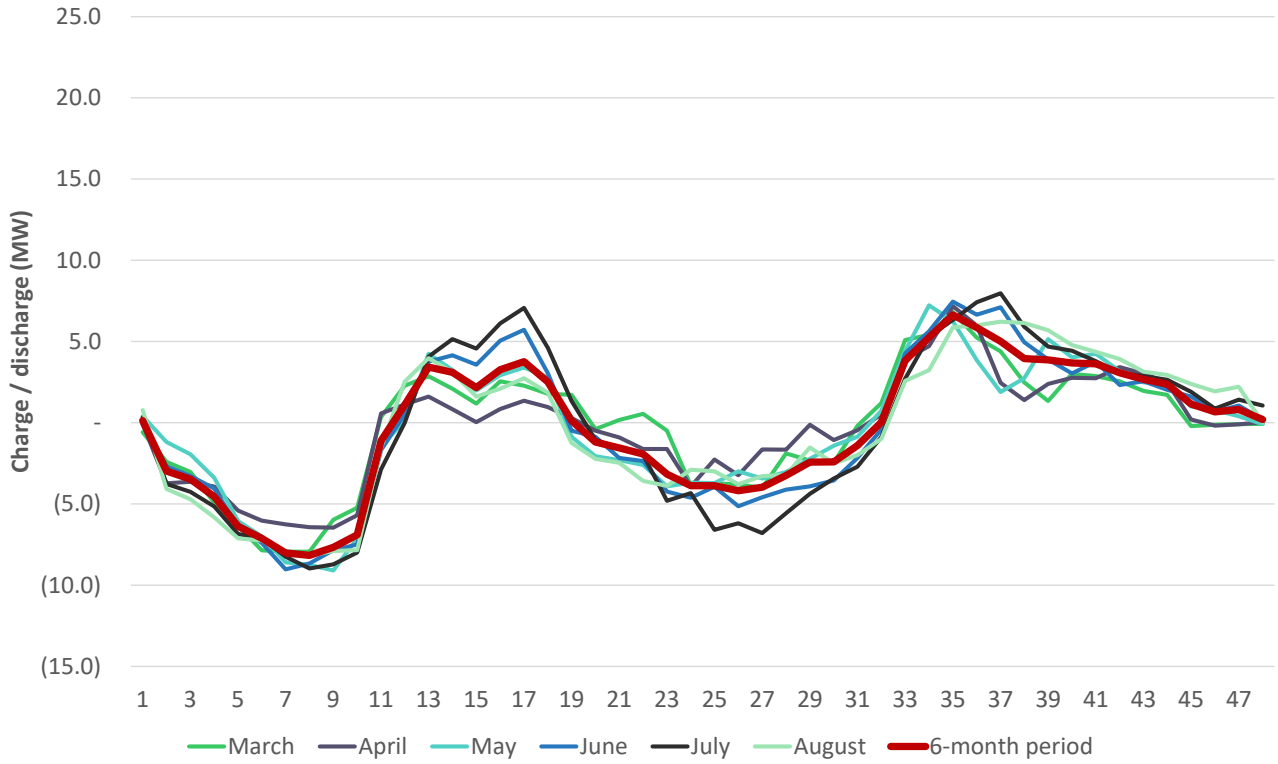
From an energy market perspective, Figure 4 and Figure 5 outline the average operational profile in year 2 of GESS and trading interval prices in VIC respectively. The operation of GESS has been largely unchanged from year one, that is, following energy market prices with morning and evening peak prices corresponding to two discharge patterns in the day. As discussed further in Section 2.2.2, GESS is predominantly charged in an early morning period, despite incurring network charges in doing so.

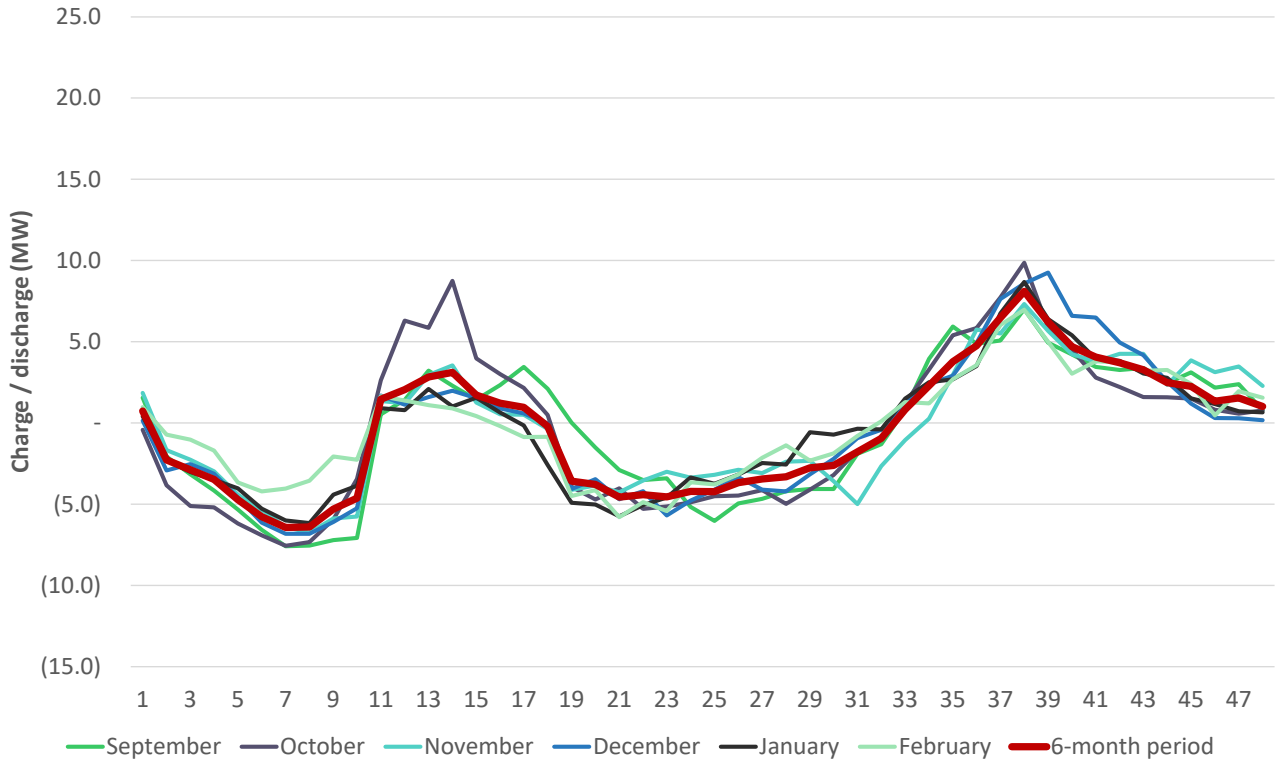
The VIC NEM price almost halved from 2019 to 2020 averaging $95/MWh and $52/MWh respectively. This reduction has continued into 2021, with a year-to-date price of $22/MWh in the wholesale market. This decline has reduced arbitrage revenues in the early months of 2021 as seen Figure 3. These reduced averages are driven by range of factors, which include:

- Continued growth in new wind and solar generation capacity;
- Improved brown coal availability; and
- Reduced export capability to NSW.

These factors combined have meant greater instances of VIC / SA oversupply, particularly on weekends, with the effect of reduced average spot prices.

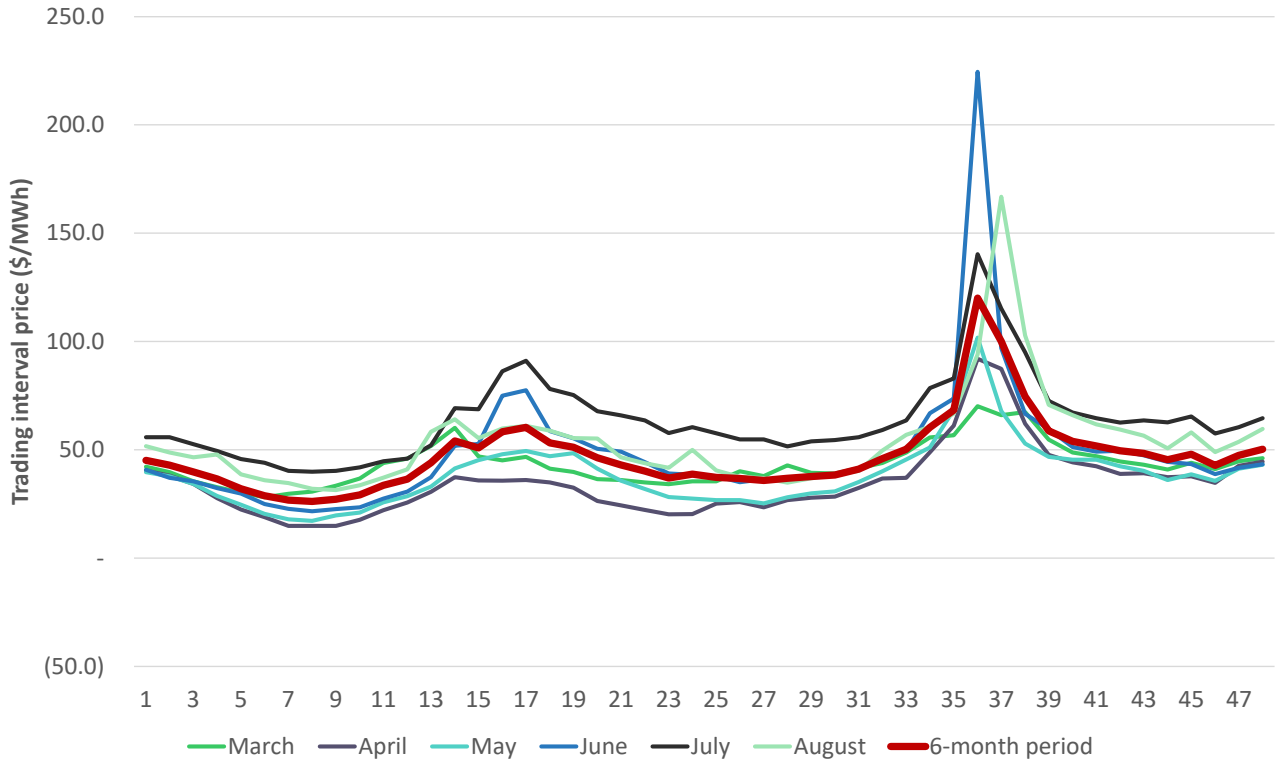
Figure 4 Average GESS operational profile by month[8]

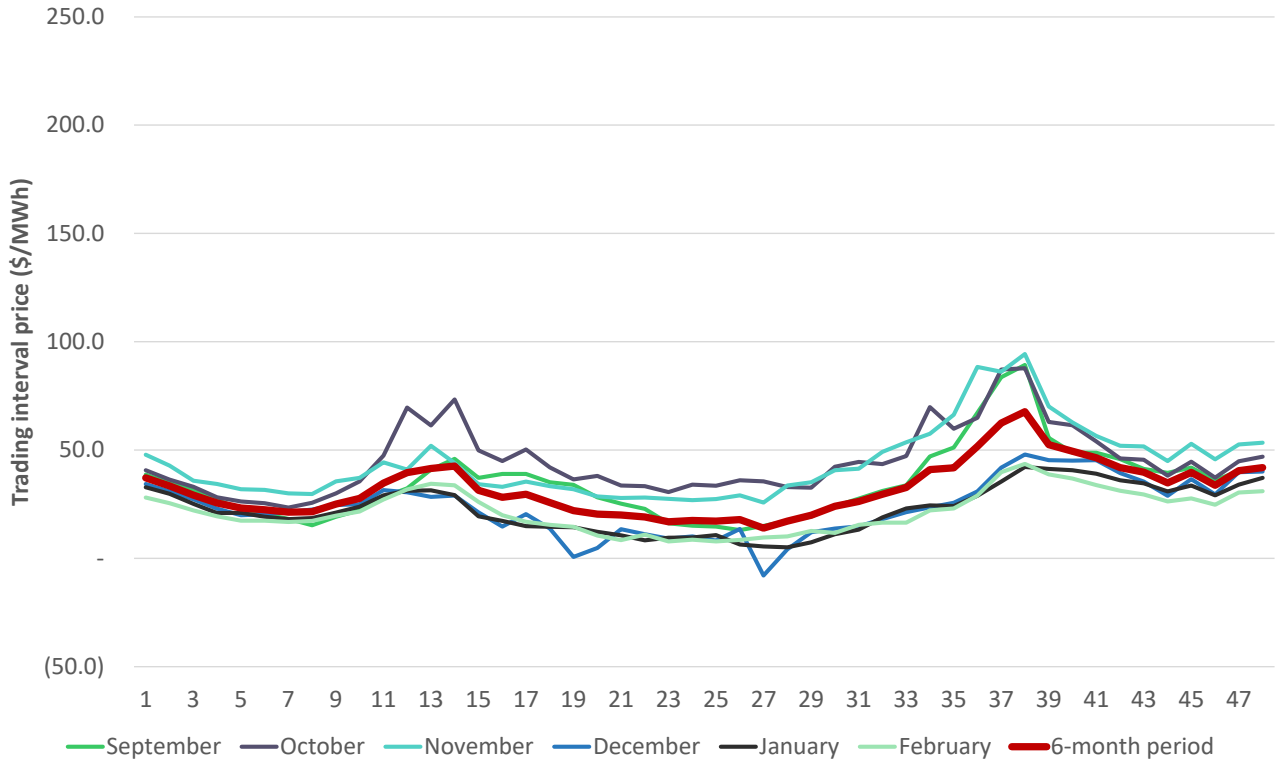




[8] 30-minute periods 1 to 48, where period 1 commences 12:00am

Figure 5 Average VIC trading interval prices by month[9]





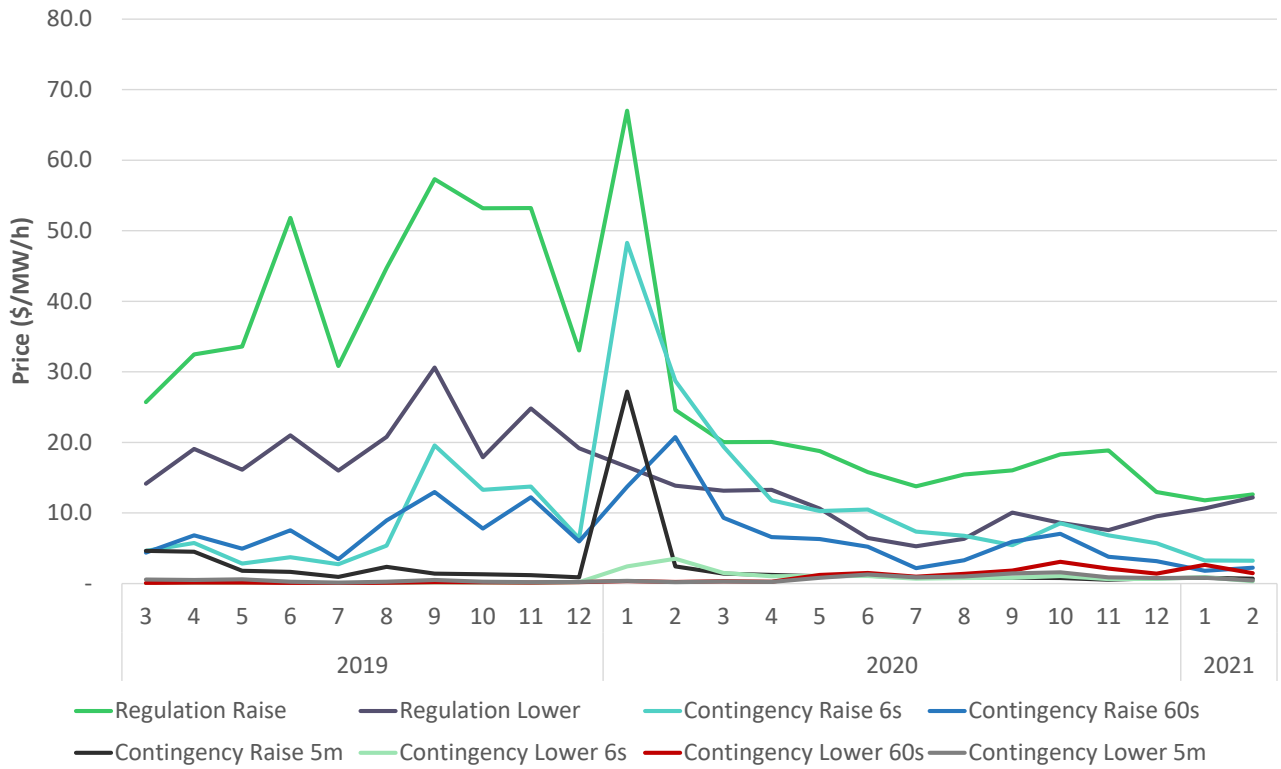
[9] 30-minute periods 1 to 48, where period 1 commences 12:00am

In its second year of operation, regulation revenues fell compared to the first year of operation, with FCAS revenues averaging ~$150,000 per month between July 2020 to February 2021 which compares to ~$500,000 per month between July 2019 and February 2020.

Lower FCAS prices in VIC have been driven by similar factors to those discussed for energy prices. However, some additional factors include:

- An increase in the available generation capacity providing FCAS;
- A commensurate reduction in the FCAS prices offered by participants; and
- A reduction in the demand for regulation services as a result of the introduction of mandatory primary frequency response.

Figure 6 Average interval FCAS prices by month and service: March 2019 to February 2021



As previously reported, coordinated and stacked participation in both energy and FCAS markets is a key feature of battery business cases. The FCAS market is an enablement market which means the battery can be paid on enablement without dispatch. The actual FCAS dispatch is generally 5-10 times less than energy dispatch. This means the same amount of energy stored can provide a longer duration enablement of FCAS than in the energy market. FCAS participation therefore preserves battery cycling and energy degradation limitations, while still ensuring revenue creation. GESS looks to optimise revenue between energy and FCAS markets. During the peak hours, most of its generation is still directed toward the energy market, which drives the regulation price up. Otherwise, when the system frequency behaviour cannot meet the operational standard, AEMO increases the demand of regulation FCAS (i.e. volumes procured) to bring the frequency back to the operational standard, which makes this market more profitable.

The facility has been designed to provide contingency FCAS and it can be enabled and switched on remotely. The high-speed recording equipment is already there to validate its delivered performance. As previously mentioned, EnergyAustralia is in the process of preparing a registration change application with

AEMO to formalise delivery of the contingency FCAS service and hopes to have this operational over the next 12 months.

2.2.1 Marginal and distribution loss factors

The application of losses to reference settlement for GESS back to the RRN is subject to one MLF and two DLFs – one for the Gannawarra Solar Farm Network and one for Powercor's Distribution Network[10] – for its generation and load. Given the short electrical distance between the interface of Powercor's network and GESS's metering point, the AER has determined that a DLF of 1.0 is appropriate for the Gannawarra Solar Farm Network. The MLFs and DLFs for the financial years ending June 2020 and June 2021 are indicated in Table 3.

Table 3 MLF and DLFs for the reporting period

Loss factor	Generation	Load
FY 2019-20		
MLF	0.9643	1.0191
Powercor DLF (DLF_1)	0.9951	0.9951
Gannawarra Solar Farm Network DLF (DLF_2)	1.0000	1.0000
MLF x DLF_1 x DLF_2	0.9596	1.0141
FY 2020-21		
MLF	0.9793	0.9823
Powercor DLF (DLF_1)	0.9901	0.9901
Gannawarra Solar Farm Network DLF (DLF_2)	1.0000	1.0000
MLF x DLF_1 x DLF_2	0.9696	0.9726

2.2.2 Network charges and charging implications

As previously reported, the registered network that provides the interface for GSF and GESS with Powercor is subject to DUOS charges imposed by Powercor. As GESS is the primary source of load, most of these DUOS charges flow through to GESS. The network tariff allocated to the combined system is the Subtransmission class, which is usually reserved for subtransmission customers (not generators). Prior to the connection of GESS, GSF was subject to the Large Low Voltage tariff class, where maximum overnight loads for auxiliary power consumption were low (in the order of 150kW) so this was not a material cost impost. In contrast, the fixed and demand charges now imposed on GESS are considerable Table 4 outlines the tariffs for each of the ST and LLV Powercor tariff classes applicable in 2020 and the first half of 2021.

[10] Reference NMI: 6203935735 with DLF code KGS

Table 4 Powercor ST and LLV tariffs for 2020[11] and HY 2021[12]

Charge	Subtransmission	Large Low Voltage
2020		
Fixed ($ p.a.)	262,600	8,800
Demand ($/kVA p.a.)	26.26	119.99
Peak usage (c/kWh)	2.80	4.67
Off-peak usage (c/kWh)	0.85	2.47
HY 2021 (January to June 2021)		
Fixed ($ p.a.)	250,000	8,000
Demand ($/kVA p.a.)	18.36	112.43
Peak usage (c/kWh)	1.75	3.85
Off-peak usage (c/kWh)	0.62	2.11

The EnergyAustralia imposed charging limit of 10MW has continued throughout year two of operations with this value limiting the yearly demand charge incurred when charging from the grid, but still allowing the battery to be used at times of no solar output (due to constraints, cloud cover, or maintenance). Largely a default charging profile remains between ~00:00-06:00 AEST with the addition of the afternoon period between ~09:00-17:00 AEST.

Further to the energy offers, raise regulation is also offered at a relatively low price as to incorporate another value stream and potentially slow the charge rate when raise regulation is utilised. These default offers are capped at 10MW availability and priced depending on the price / solar forecast for the upcoming day. Consequently, they are adjusted late evening (for next day) and intra-day to where the best value can be attained. Also, the availability of the load services can be increased depending on the solar farm output / forecast for the day. Even with this inefficient restriction, the monthly DUOS cost imposed on GESS has remained around $50k. In EnergyAustralia's opinion, there is still an opportunity to improve the economics of distribution connected battery storage projects. Energy storage facilities are not subject to network charges if connected to the transmission network in Victoria because they tend to use the network at times that are more helpful than a hindrance, which represents a more cost reflective and usage-based approach.

Table 5 summarises the evolution of revenues and costs and the financial performance of GESS for months 13 to 18 and Table 6 summarising months 19 to 24.

[11] https://media.powercor.com.au/wp-content/uploads/2019/11/13093923/Powercor-Pricing-Proposal-2020.pdf
[12] https://media.powercor.com.au/wp-content/uploads/2020/11/26113637/Powercor-HY-2021-Pricing-Proposal-min.pdf

Table 5 Summary of GESS financials from March to August 2020

Source of revenue / charge	March	April	May	June	July	August	6-month period
Pool revenue	69,249	54,378	67,646	135,889	162,739	119,418	609,318
Charging costs	(57,116)	(33,651)	(46,387)	(63,907)	(102,567)	(72,580)	(376,210)
Ancillary service revenue	232,885	218,975	207,637	155,090	172,043	188,021	1,174,652
DUOS charges	(49,530)	(52,178)	(49,067)	(53,273)	(51,558)	(55,148)	(310,754)
Market fees	(1,171)	(1,241)	(1,275)	(1,364)	(1,527)	(1,470)	(8,048)
Net	**194,318**	**186,282**	**178,554**	**172,436**	**179,129**	**178,240**	**1,088,959**

Table 6 Summary of GESS financials from September 2020 to February 2021

Source of revenue / charge	September	October	November	December	January	February	6-month period
Pool revenue	79,026	139,988	105,727	106,024	85,417	36,435	552,616
Charging costs	(36,845)	(63,116)	(48,944)	(17,630)	(19,057)	(11,041)	(196,633)
Ancillary service revenue	192,282	206,373	196,283	113,599	73,331	94,672	876,540
DUOS charges	(60,593)	(43,767)	(53,770)	(44,867)	(51,617)	(28,363)	(282,978)
Market fees	(1,347)	(1,578)	(1,303)	(1,923)	(1,894)	(872)	(8,917)
Net	**172,523**	**237,899**	**197,992**	**155,203**	**86,179**	**90,830**	**940,627**

2.2.3 Avoided TUoS

Avoided TUoS is a payment to an embedded generator "for the amount of the local transmission charge that would have been payable had the embedded generator not been connected to the distribution network"[13]. As an embedded generator in Powercor's distribution network, GESS, along with the co-located solar farm, are eligible for avoided TUoS payments. The avoided TUoS payment amount in Powercor's network is calculated based on the average megawatts generated during the ten maximum demand days in Victoria and the TUoS location price at the Kerang Terminal Substation.

In financial year 2019/20, this was approximately 4.7MW for GESS (which shares a connection with GSF), multiplied by the TUoS locational price of approximately $39,000/MW. This translated to an avoided TUOS payment of approximately $180,000 (excl. GST). It is worth noting that GSF also receives avoided TUoS payments based on its generation during the ten maximum demand days. Given GSF has priority dispatch

[13] https://media.powercor.com.au/wp-content/uploads/2018/11/23170056/fact-sheet-avoided-transmission-payments-to-embedded-generators.pdf

through the shared connection, the avoided TUoS amount for GESS is lower than a stand-alone distribution connect battery might have otherwise received at this location given the connection constraint.

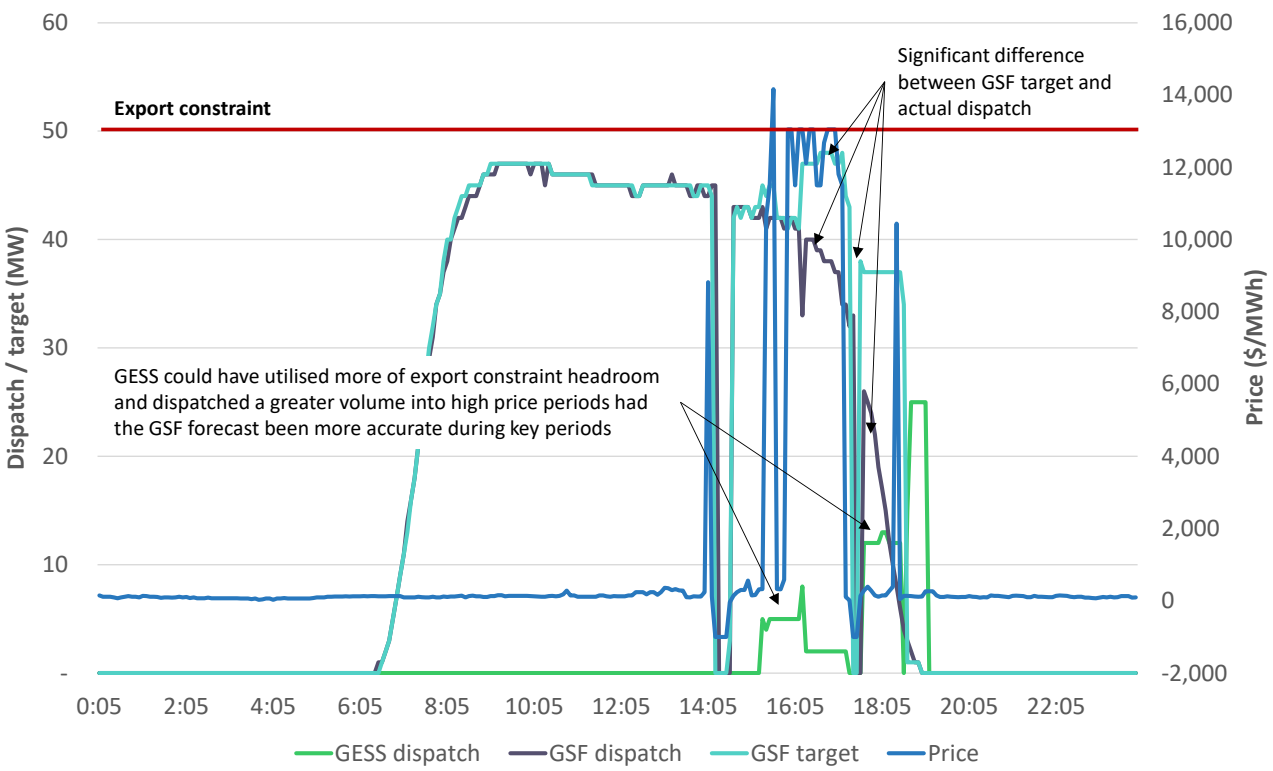
2.3 Constraints on operation

A 25MW constraint placed on GSF's output from 13/09/2019 continued through parts of this reporting period (invoked constraint equation V_GANWRSF_FLT_25 implemented by AEMO to manage post contingent voltage oscillations), which meant that the battery had unrestricted access to the network during these times. This constraint was lifted on 21/04/2020 and as this occurred prior to diminishing solar output (moving into winter) it allowed the default generator offer of 10MW to safely dispatch into the grid (dependant on price) with the solar farm output not exceeding 40MW until August. The remainder of the reporting period required the trading team to be more active in managing the transformer / solar farm constraint but more often than not, with high solar / renewables output, prices remained suboptimal for generator dispatch during these periods.

EnergyOffer (EA's bidding system) will be upgraded mid-year, which will allow a direct feed of the solar farm forecast to limit the battery generation prior to each dispatch interval, meaning there is improved potential to fully utilise the transformer headroom while still allowing EnergyAustralia to remain compliant within its bidding rules. Utilising the solar farm forecast to adjust the generator offer will also assist in optimising the periods where sharp increases / decreases are witnessed when the sun rises / sets. Further to assisting with generator offers, load offers can also be optimised by only charging when the solar farm is producing to avoid increased network demand charges.

The issue that was highlighted on 1 March 2019 (Figure 7 below) where the inaccuracy of the solar forecast reduced the efficiency of GESS's dispatch and consequently lost revenue, did not re-occur during the reporting period. With volatility kept to a minimum during the reporting period, only three trading intervals were observed with prices above $1,000/MWh, all of which occurred during 0MW output from the solar farm.

Figure 7 Impact of forecast error on GESS dispatch



TECHNICAL PERFORMANCE

Edify™

3 Technical performance

3.1 Technical performance

3.1.1 Cycle performance

GESS has operated with an average of one cycle per day since the beginning of March, for a total charge energy of 10,510 MWh and discharge energy of 8,920 MWh for the 6-month period to August 2020, and 9,989 MWh and 8,267 MWh for the 6-month period to February 2021. Similar to the previous year, it is the shoulder season leading into Summer that observed the greatest cycling behaviour. Table 7 summarises the charge and discharge cycle outcomes for the 6-month period to August 2020 with Table 8 summarising the 6-month period to February 2021.

Table 7 Charge and discharge cycle summary: March to August 2020

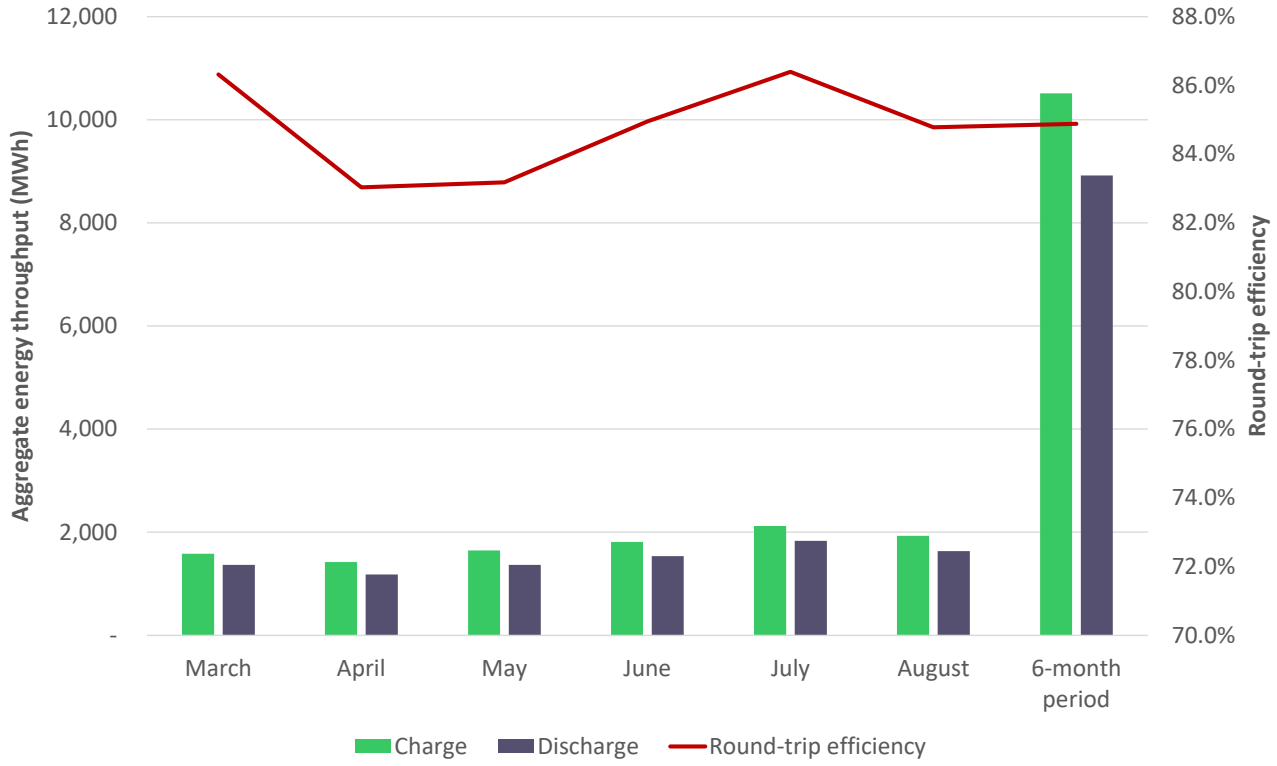
Parameter	March	April	May	June	July	August	6-month period
Charge energy (MWh)	1,584	1,423	1,644	1,809	2,122	1,928	10,510
Discharge energy (MWh)	1,367	1,181	1,368	1,537	1,833	1,634	8,920
Cycle count	27	24	27	31	37	33	178
Cycles per day	0.9	0.8	0.9	1.0	1.2	1.1	1.0

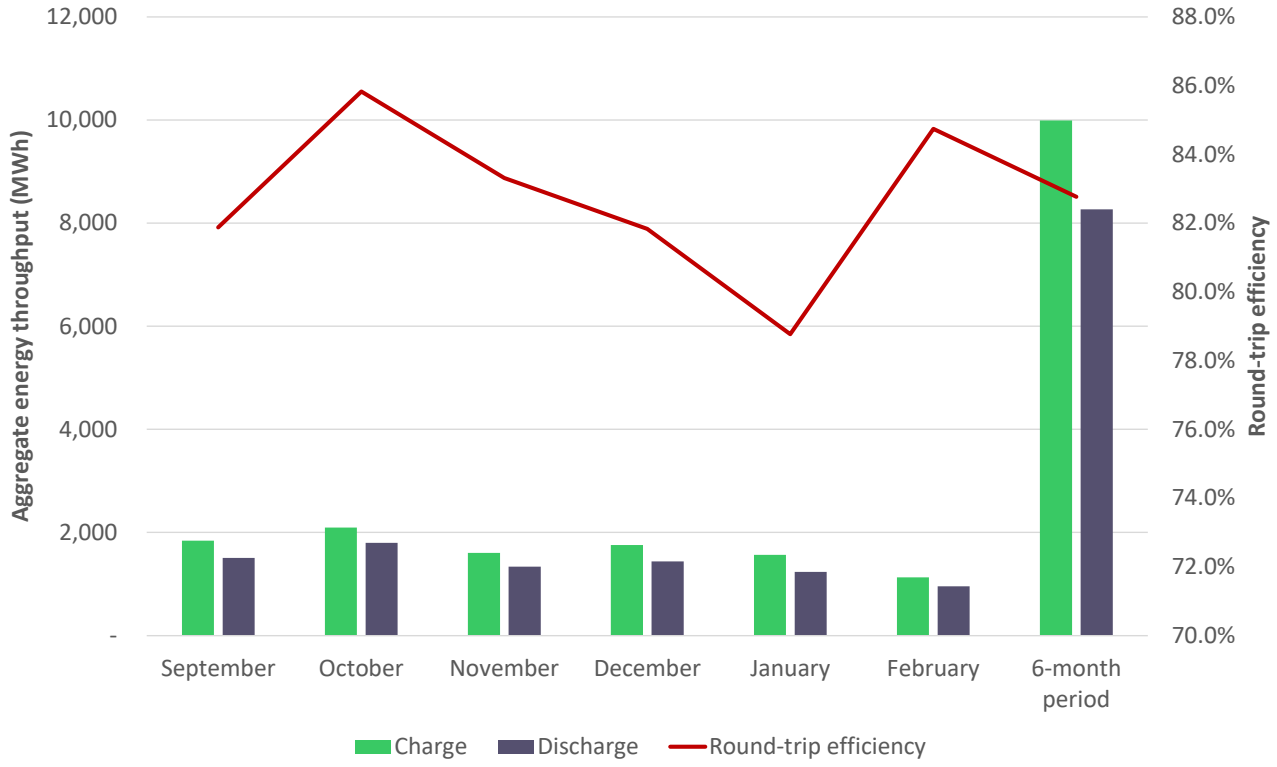
Table 8 Charge and discharge cycle summary: September 2020 to February 2021

Parameter	September	October	November	December	January	February	6-month period
Charge energy (MWh)	1,840	2,096	1,603	1,756	1,567	1,127	9,989
Discharge energy (MWh)	1,506	1,799	1,336	1,437	1,234	955	8,267
Cycle count	30	36	27	29	25	19	165
Cycles per day	1.0	1.2	0.9	0.9	0.8	0.7	0.9

As Figure 8 indicates, the round-trip efficiency for GESS averaged 84.9% for the 6-month period to August 2020 and 82.8% for the 6-month period to February 2021, fluctuating in a band between ~79-86%. Note this round-trip efficiency calculation is made at the facility revenue meter based on observed aggregate energy bought and sold into the market (i.e. aggregate discharge / aggregate charge). It is therefore inclusive of balance of system losses and has not been adjusted for MLF. This is a different and more approximate calculation than what would be undertaken for formal performance testing, which would stipulate standard test conditions, including the power rating of the charge and discharge, and a defined period of time between conducting the charge and discharge.

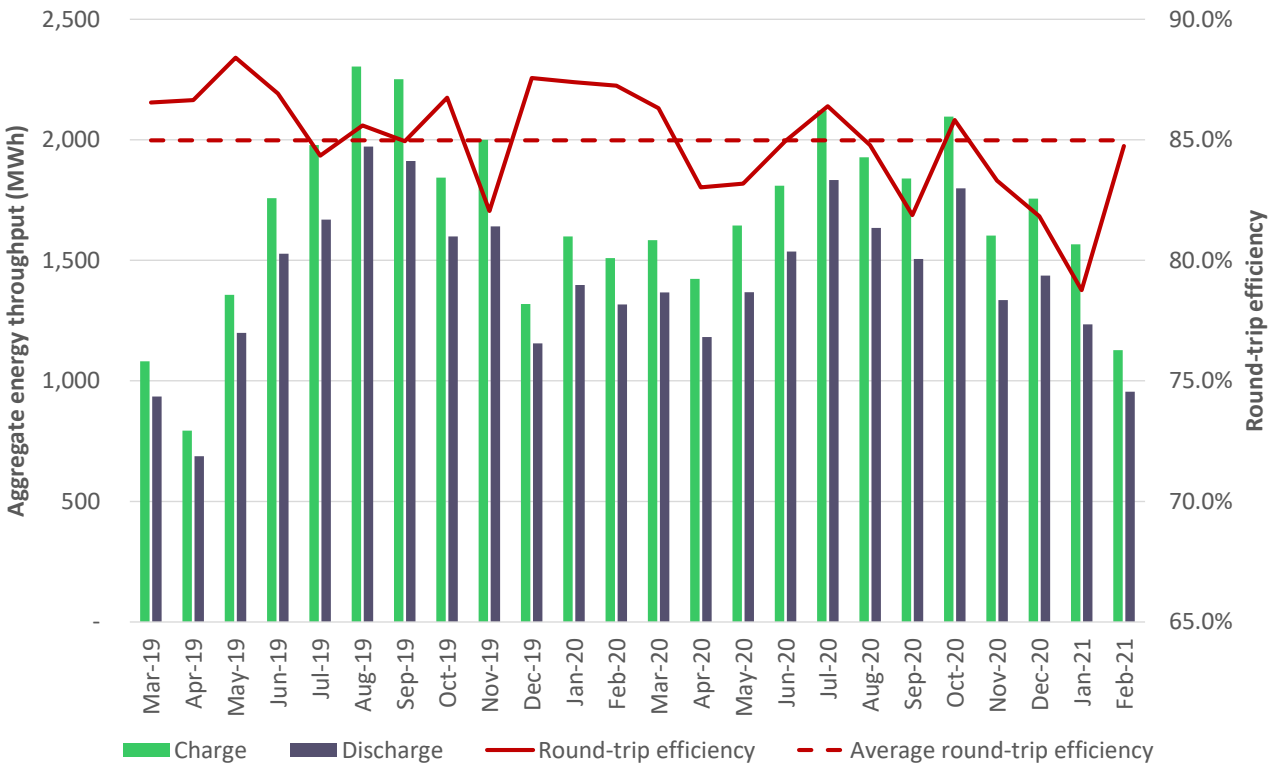
Figure 8 Round-trip efficiency





If we consider the charge and discharge cycle patterns of the system over the first two years of operations, we can observe an average round-trip efficiency of approximately 85.0% (see Figure 9), noting the non-standard test conditions nature of this analysis.

Figure 9 Round-trip efficiency and usage over two-year operational period



3.1.2 Availability

The availability for GESS has also been high throughout the reporting period, with an average of >99% and no lower than 97.4% inverter block availability recorded in all months (see Table 9 and Table 10).

Table 9 Inverter block availability: March to August 2020

Parameter	March	April	May	June	July	August	6-month period
Availability	99.8%	100.0%	99.0%	99.8%	100.0%	98.5%	99.5%

Table 10 Inverter block availability: September 2020 to February 2021

Parameter	September	October	November	December	January	February	6-month period
Availability	98.7%	100.0%	97.4%	100.0%	100.0%	99.7%	99.3%

3.2 Safety and environmental performance

GESS recorded no safety or environmental incidents in the 6-month period to August 2020 nor the 6-month period to February 2021. This is not unexpected due to the nature of the facility as well as the workplace health and safety policies adopted on site. As a company Edify is always targeting zero incidents for our sites.

During the design of the battery system, elimination of risk has been adopted wherever possible, which is the first principal of risk control. This has been done by eliminating the need for intervention by staff in the operation of the facility as far as possible. The site is designed for fully unmanned operations meaning that staff only attend site to respond to faults or to conduct preventative maintenance inspections. This avoids the majority of safety and environmental risk with the facility.

Where staff are required to go to site, the operations and maintenance contractor responsible for oversite of safety on the site has safety procedures in line with best industry practice. This includes ensuring that correct isolations are in place for works to be undertaken and using lock-out procedures to prevent unintended re-energisation. The O&M contractor reviews the work plans of any Tesla staff coming to site to maintain the batteries which are maintained under a services agreement.

The safety record of the facility is also in large part to the inherent safety architecture aspects of the battery system that includes:

- Individual cell testing prior to module assembly to ensure flawed cells are not introduced into the battery system;
- Pods (collection of cells) are fully sealed to prevent thermal spread and have dedicated management systems that monitor individual cells to ensure they are operated within safe parameters;
- Packs (racks of 16 pods) are contained in weather-proof steel enclosures with monitoring and operation optimised to reduce the risk of cascading failure of pods;
- Compliance with national and international safety standards; and
- Exceedance of standards related to fire safety and propagation resistance to thermal runaway within individual cells.

Tesla technicians perform all preventative maintenance and inspections of the battery system which ensures that any issues are identified before they become a safety or environmental concern.

With two consecutive 12-month periods of no recorded safety or environmental incidents at GESS, its performance in this regard has been high.