GANNAWARRA ENERGY STORAGE SYSTEM

Project Summary Report

Edify Energy Pty Ltd

on behalf of GESS DevCo Pty Ltd
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Glossary of Terms

Acronym / abbreviation	Expanded name
AC	Alternating Current
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AEMC	Australian Energy Market Commission
AGC	Automatic Generation Control
ARENA	Australian Renewable Energy Agency
BOP	Balance Of Plant
BSSA	Battery Storage Services Agreement
C&AA	Connection and Access Agreement
DC	Direct Current
DELWP	The Victorian Government’s Department of Environment, Land, Water and Planning
DUID	Dispatch Unit Identifier
DUOS	Distribution Use Of System
Edify	Edify Energy Pty Ltd and its related entities
EPC	Engineering, Procurement and Construction
ESS	Energy Storage System
FCAS	Frequency Control Ancillary Services
FIA	Full Impact Assessment
FRMP	Financially Responsible Market Participant
GESS	Gannawarra Energy Storage System
GPS	Generator Performance Standard
GSF	Gannawarra Solar Farm
GUI	Graphical User Interface
HV	High Voltage
ICCP	Inter-Control Centre Communications Protocol
JV	Joint Venture
LGC	Large-scale Generation Certificate
MLF	Marginal Loss Factor
MV	Medium Voltage
NEM	National Electricity Market
NER	National Electricity Rules
NMI	National Metering Identifier
NSP	Network Service Provider
OEM	Original Equipment Manufacturer
Project	GESS
RCR	RCR Tomlinson Limited
SCADA	Supervisory Control and Data Acquisition
SPV	Special Purpose Vehicle
TUOS	Transmission Use Of System
WIRCON	Wircon Energie 9 GmbH and its related entities

EXECUTIVE SUMMARY

GESS is a pioneering project in Australia's National Electricity Market. It is the first attempt at retrofitting a battery behind the existing point of connection of a utility scale renewable energy power plant, GSF[1]. At the time of writing GESS and GEF is the largest integrated renewable energy and battery system in Australia and among the largest in the world.

The battery retrofit model is one that will be increasingly sought out by existing renewable projects as both the economics of battery systems improve and as these renewable projects seek out options to mitigate risks that are becoming increasingly prevalent, such as curtailment, causer pays FCAS and wholesale market power price volatility and depression. It is also a model that makes better use of existing network infrastructure, including substations that are dedicated to single assets, which in the case of solar are utilised only during daylight hours.

Over the course of its development, Edify worked closely with its project partners, AEMO, the AER, Powercor, DELWP, ARENA and WIRCON to pave a regulatory, commercial and technical pathway to enable GESS's deployment. In doing so, a number of lessons were learned, which are outlined in this report for the benefit of the broader sector.

Principal among these lessons is that GESS is a classic example of technological development outpacing that of the regulatory reforms required to enable it. Retrofitting batteries to renewable assets was, and remains, a complex task that will require a renegotiation of existing connection arrangements and Generator Performance Standards. Depending on the chosen implementation model, the risk profile of the existing asset could be affected by altering its classification to a scheduled generator. This complexity and risk can create impediments and barriers to the uptake of battery systems, which may result in lost opportunities and an ultimately less cost-efficient power system. Fortunately, and largely informed by learnings from GESS, reforms are underway at present to better enable regulatory frameworks for hybrid battery systems.

As large-scale solar and wind continue to cement their place as the cheapest source of electricity in Australia and globally, with speed to market advantages over conventional power plant, the use of batteries and other storage technologies will play an increasingly important role in their continued deployment at pace and scale. As a sector, we need to identify the most efficient regulatory, physical and commercial solutions to achieve this. Edify will continue to play a market-leading role in pursuit of this vision by continuing to bring into operation a portfolio of renewable and storage projects[2] generating more sustainable, reliable and affordable energy to Australian electricity consumers[3]. Edify aims to deliver many more projects similar to GESS and GSF.

ARENA and DELWP have produced informative videos on GESS[4].

1 See http://edifyenergy.com/projects/gannawarra/ and https://wirsol.com.au/portfolio/gannawarra-solar-farm/

2 See http://edifyenergy.com/

3 The projects Edify has brought, or is bringing, into operation in 2019 will produce enough electricity to power over 280,000 homes, representing nearly 3% of all homes in Australia

4 See https://youtu.be/tEUiqYu28OA (ARENA) and https://www.energy.vic.gov.au/media-releases/australias-largest-integrated-battery-and-solar-system (DELWP)

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.

1 INTRODUCTION

This Project Summary Report covers the pathway from project inception to completion of GESS, which was financed by Edify in a consortium with WIRCON as 50-50 joint venture co-investors, and DELWP and ARENA as providers of $25 million in grant funding.

This report represents one 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 the process to achieve completion of GESS, covering development, construction and commissioning learnings, including the following:

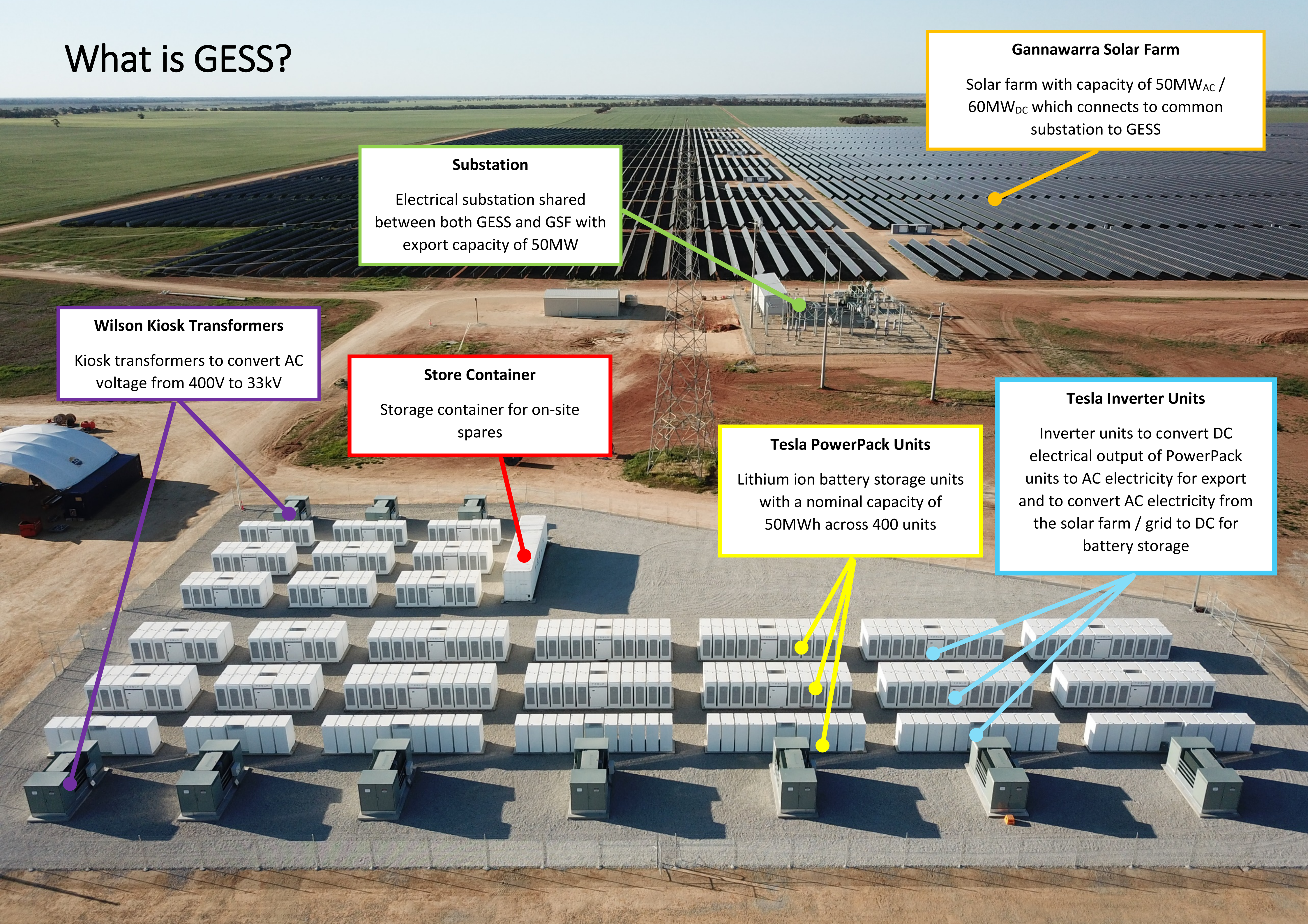
- Overview of the Project including revenue determination, associated business case and technical characteristics including function description;
- Regulatory treatment, challenges and recommendations;
- Project development activities, risk and learnings;
- Procurement challenges, risks and learnings; and
- Construction and commissioning activities, risk and learnings.

The report is public with an intended audience that includes:

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

Figure 1 Aerial view of GESS, GSF, GSF network and the point of connection to Powercor

What is GESS?



Gannawarra Solar Farm
Solar farm with capacity of 50MWAC / 60MWDC which connects to common substation to GESS
Substation
Electrical substation shared between both GESS and GSF with export capacity of 50MW
Wilson Kiosk Transformers
Kiosk transformers to convert AC voltage from 400V to 33kV
Store Container
Storage container for on-site spares
Tesla PowerPack Units
Lithium ion battery storage units with a nominal capacity of 50MWh across 400 units
Tesla Inverter Units
Inverter units to convert DC electrical output of PowerPack units to AC electricity for export and to convert AC electricity from the solar farm / grid to DC for battery storage

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[5] • AEMO Emerging Generation and Energy Storage (EGES) stakeholder paper response; December 2018[6] • Energy Magazine Article; February 2019[7] • ARENA Insights Spotlight: Gannawarra Energy Storage System (GESS) An interview with Edify Energy, April 2019[8] • DELWP's GESS media release and video, July 2019[9]
Site visits	• Construction visit; August 2018 • Completion visit; June 2019 (see Figure 2) [10]

Future knowledge sharing reports will be published every 6 months for a period of 24 months and will focus on operational learnings covering the relevant preceding period, including the following:

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

5 https://youtu.be/tEUiqYu28OA

6 https://www.aemo.com.au/-/media/Files/Electricity/NEM/Initiatives/Emerging-Generation/Submissions/Edify-Energy_20181204.pdf

7 https://www.energymagazine.com.au/exploring-the-retrofit-model-and-offtake-agreements-for-battery-integration/

8 https://arena.gov.au/assets/2019/04/gannawarra-energy-storage-system.pdf

9 https://www.energy.vic.gov.au/media-releases/australias-largest-integrated-battery-and-solar-system

10 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

Figure 2 Knowledge sharing at the GESS completion site visit (learning about PowerPacks)

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 (see Figure 3).

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 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.

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	• Under construction • Target commissioning Q4 2019	• 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

Figure 3 Edify Energy is strongly connected with local communities and sponsors the local rodeo in Collinsville

1.3 ADVISERS

The realisation of GESS would not have been possible without its advisers, which included, but was not limited to:

- Ashurst on legal, regulatory and project structuring advice representing GESS;
- DIgSILENT as grid consultant undertaking all network studies for both GESS and GSF;
- RINA as technical due diligence adviser on interfaces between GESS and GSF;
- EY as tax adviser;
- Willis Towers Watson as insurance due diligence adviser and AON as insurance placement broker; and
- Mazars as financial model auditors.

2 PROJECT OVERVIEW

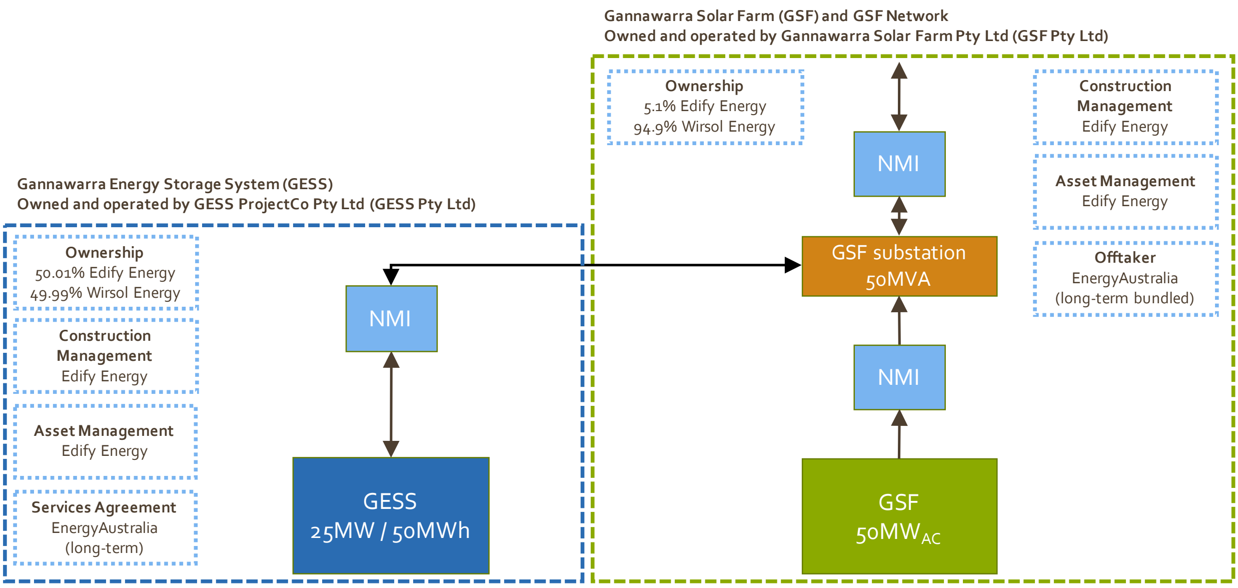
GESS[11] is a 25MW / 50MWh battery that is integrated with Victoria's first large-scale solar farm – GSF (being a 50MW_{AC} solar farm). GESS was developed and structured by Edify and financed by ARENA and DELWP as providers of $25 million in grant funding with Edify in a consortium with WIRCON as 50-50 joint venture co-investors. Tesla was the battery provider, RCR the EPC contractor and EnergyAustralia the long-term operator of GESS under a novel battery storage services agreement (**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 4 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[12], that complements its operational role for GESS under the BSSA.

Figure 4 Commercial arrangements for GESS and its interaction with GSF



11 See http://edifyenergy.com/projects/gannawarra-energy-storage-system/

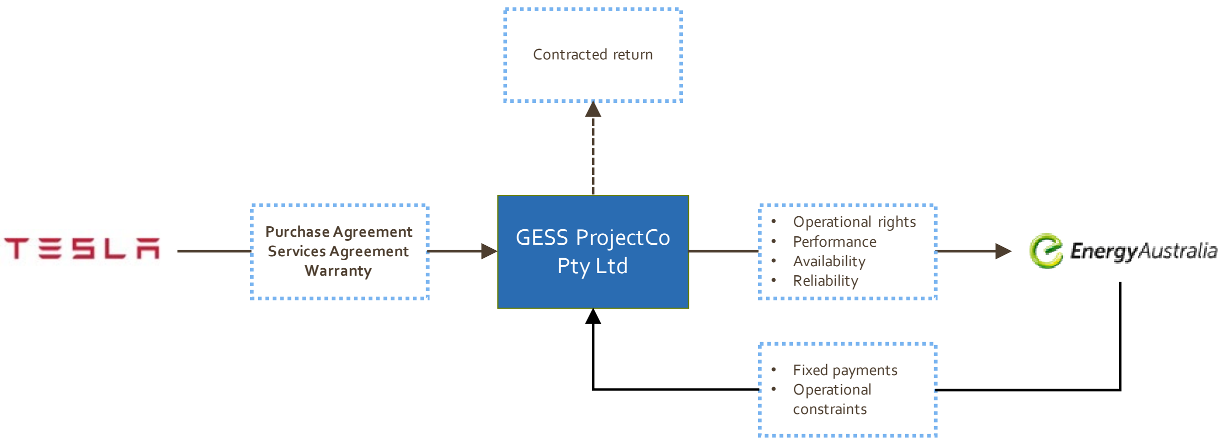
12 See https://www.energyaustralia.com.au/about-us/media/news/energyaustralia-underpin-victorias-first-commercial-solar-farm

2.1 Revenue determination and associated business case

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.

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 5 outlines these arrangements.

Figure 5 Structure of the novel long-term services agreement with EnergyAustralia



At the time of contract negotiation, a number of alternative revenue and operational rights structures were considered. The details of some of these (ranging from most to least operational flexibility for the battery operator) are outlined in Table 3.

Table 3 Alternative revenue and operational rights structures considered

Revenue concept	Details	Pros	Cons
A fixed capacity payment paid by EnergyAustralia to GESS	• Fixed payment in exchange for the right for EnergyAustralia to issue instructions to GESS for specific dispatch profiles	• Bankable fixed payment improves certainty in cashflows for GESS • Affords greatest flexibility to EnergyAustralia to tailor dispatch profiles	• Functionally difficult to achieve without EnergyAustralia assuming intermediary rights over GESS
Targeted dispatch profile	• Parties agree a fixed volume dispatch profile that shifts generation from GSF	• EnergyAustralia gets greater certainty on dispatch than current GSF output	• Mismatch in GSF and GESS capacities (50MW vs 25MW) would mean fixed profile would in

Revenue concept	Details	Pros	Cons
	into peak periods (say) • This profile may differ by season • Various payment options to GESS including fixed and variable (e.g. linked to realised uplift in value of GSF output)	• GESS could receive cashflow certainty improving bankability	practice be a fixed base volume with an additive variable component • Limits opportunities to target FCAS • How to define penalties for non-compliance
Defined time-of-day pricing	• Parties agree fixed black prices for different trading intervals	• Retains autonomy for GESS allowing a greater degree of optimisation with other markets • If priced correctly EnergyAustralia should receive power in higher value periods (at a discount) • No need to define a penalty for non-compliance	• Less certainty in dispatch profile for EnergyAustralia
GESS sells a cap to EnergyAustralia	• In exchange for a fixed payment GESS commits to pay EnergyAustralia the floating price above a strike ($300/MWh say)	• Retains autonomy for GESS • No need to define a penalty for non-compliance	• Less certainty in dispatch profile for EnergyAustralia • High degree of exposure for GESS may introduce costly prudential requirements

Ultimately the first of these structures was landed upon following two conclusions reached between parties:

1. Full operational rights of the battery should be in the hands of a single party, to ensure its flexibility attributes are correctly valued; and
2. Of the two parties, EnergyAustralia was best placed to take on market risks and prudential requirements and manage them in the context of a broader and diversified portfolio.

Further insights into the conceptual basis for this type of revenue contract for a battery are articulated in the opinion piece on GESS that Edify wrote for Energy Magazine in February 2019.[13]

[13] https://www.energymagazine.com.au/exploring-the-retrofit-model-and-offtake-agreements-for-battery-integration/

2.1.1 Revenue opportunities for EnergyAustralia

For EnergyAustralia, the revenue determination and business case for purchasing operational rights over the battery are subject to market risks. Optimising the operation of GESS across energy and FCAS markets will be a key focus for EnergyAustralia. However, this operation must be done so with reference to the operation of GSF. As both GESS and GSF export via the same substation, the physical constraint that this substation creates (being 50MW for a $50MW_{AC}$ solar farm and 25MW battery) means that operational decisions for the battery must first respect the dispatch of the solar farm.

A key commercial principle in developing GESS was the priority dispatch of GSF. As GSF is a separate corporate entity with ownership rights over the substation, the control and commercial framework governing the dispatch of GESS preferences the dispatch of GSF. However, any operational constraints that EnergyAustralia experiences on account of this framework are mitigated in a large part by the fact that EnergyAustralia is the offtaker and has entitlement to all energy and LGCs from GSF over an equivalent contractual period to the BSSA. With the combined entitlement to GSF output and operational control GESS, EnergyAustralia is also well placed to use GESS to firm the profile of GSF and monetise this through avoided purchasing of cap contracts, subject to the duration restriction of GESS.

Although the shared network infrastructure does introduce an operational constraint on GESS, it does so with two broad benefits that could not be achieved with a physically separate grid connection:

1. Reduced cost of the overall connection due to the use of a common transformer, switching, cabling and connection to Powercor's network via the GSF network; and
2. A physical ability for GESS to capture generation from GSF during periods of wider network curtailment, provided the correct dispatch framework to do so is in place[14].

2.1.2 Network tariffs

The application of network tariffs for the Market Customer segmentation of battery projects is an area of inconsistency between NSPs in the NEM. In the case of GESS, Powercor is currently applying its standard set of tariffs for all load that is drawn through its network.

The application of tariffs in this case places a commercial incentive on GESS to charge during the solar hours in which GSF is exporting and in doing so avoid drawing from Powercor's network and incurring these tariffs.

This is an area that needs due consideration and a standardised approach across the NEM as it can result in perverse market outcomes, such as the creation of load during daytime hours, when operational demand is typically higher than overnight.

2.2 TECHNICAL CHARACTERISTICS INCLUDING FUNCTIONAL DESCRIPTION

GESS is a 25MW / 50MWh (2 hour) lithium-ion battery facility based on the Tesla PowerPack units. The key technical components of the GESS facility are summarised in Table 4.

[14] See Table 9 below

Table 4 Technical characteristics of GESS

Technical characteristic	Overview
Nominal capacity	25MW / 50MWh (2 hours)
Battery units	250 x PowerPack 1.5 units 150 x PowerPack 2.0 units
Inverters	50 x inverters (10 x power stages in each inverter) Active harmonic filtering capability
Voltages	DC voltage: 440V High voltage: 33kV
Balance of plant	10 x 2.75MVA kiosk transformer units with integrated RMUs 1 x 33kV switchgear DC and HV cabling
Harmonic filter	1 x 7.5MVA 'wide bank' filter unit 1 x 7.5MVA 'C-type' filter unit

The 25MW / 50MWh sizing was converged on for a number of reasons:

1. With a combined export constraint of 50MW between the $50MW_{AC}$ GSF and the capacity of the battery solution, there becomes a limit on the maximum capacity of battery that can be economically deployed before the export constraint becomes commercial binding;
2. Given limitations on full power export opportunities around this constraint, there are more opportunities to use the battery for energy applications (e.g. time shifting) as opposed to power applications (e.g. price spike capture). This resulted in a 2-hour duration battery, which is typically longer than the other shorter duration batteries that had been deployed in the NEM to date; and
3. The chosen sizing was consistent with the guidelines set out by the DELWP in its competitive process and was achievable within the limits of the total grant funding on offer.

Most other technical characteristics of the system are largely a function of standardised designs within the Tesla product range or related to the need to integrate with existing infrastructure already in place for GSF (e.g. connection to the spare bay of the 33kV busbar of the GSF substation). The installation of the harmonic filter was done so to ensure that the combined operation of GESS and GSF would not breach power quality limits across a broad set of wider network conditions (that can evolve over time) that were previously defined as part of the GSF connection application and GPS negotiation process.

Figure 6 Harmonic filter

3 LESSONS LEARNED

3.1 REGULATORY TREATMENT

The key learning outcomes from the development and deployment of GESS are largely regulatory in nature. The challenges in retrofitting GESS behind the existing point of connection for GSF, particularly given the differences in classifications of the two assets (i.e. semi-scheduled for GSF and scheduled for GESS), revealed a number of areas for reform required to assist in facilitating these types of connections for other assets in the NEM.

These learnings and findings are set out in Table 5 to Table 9 and as part of Edify's broader engagement on driving reform, have also been articulated in Edify's submission to AEMO's Emerging Generation and Energy Storage consultation.[15]

Table 5 Location of connection point for dedicated asset substations

Issues	Potential solutions
• The current rules require that a connection point and associated relationships (e.g. NMI, FRMP, DUID, etc.) are located as close to the physical point of common coupling with the connecting NSP as possible. • In the case of new-build renewables, this requirement typically results in the placement of the connection point on the HV side of dedicated substations. • Locating the connection point on the HV side limits the potential for future assets to connect into these substations in a retrofit arrangement. • At present, connecting a new asset (ESS or otherwise) into these substations requires complex changes to the existing asset, including the movement of the point of GPS enforcement, movement of meters and market roles (e.g. Market Generator), and redetermination of MLFs and / or DLFs. • Among other things, this requires a renegotiation of the existing GPS, which includes giving regard to: - the new FIA process; - changes to the system that have occurred since negotiation of the initial GPS; and - a new commissioning and testing procedure and hold point process to prove compliance with the new GPS. • Particularly in the case of renegotiating the GPS, these changes create a material risk to the existing asset and therefore an impediment to investment for the new connecting asset. • This would be a sub-optimal market outcome as it limits the potential for new connecting assets to access	**Greenfields development** • In the case of new asset development, where it may be contemplated in advance that an additional asset could connect in the future, create a transparent set of arrangements that allow for a connection point to be situated on the MV side of substations such that the GPS and all associations to the connection point are correctly based from the onset. • These arrangements may include a clear set of guidelines for the creation of a network (registered, exempt, embedded or otherwise) that sits between the new and future assets, and the existing NSP and common point of coupling (see below for suggestions). **Brownfields development** • For existing arrangements, create a clear 'rubber stamping' process for moving the point of connection to the MV side that does not introduce risk on the part of the standing asset,

[15] http://aemo.com.au/-/media/Files/Electricity/NEM/Initiatives/Emerging-Generation/Submissions/Edify-Energy_20181204.pdf

Issues	Potential solutions
existing underutilised network infrastructure and to be deployed at lower overall system cost. • The materiality of this opportunity would be significant, with likely dozens of examples of dedicated substations, which in the case of solar are only used for ~8hrs of the solar day.	particularly with relation to any renegotiation of the existing GPS.
See Figure 7 and Figure 8 below, outlining the before and after regulatory arrangements for GSF and GESS that highlight the changes alluded to above.	

Figure 7 Regulatory arrangements for GSF before the introduction of GESS

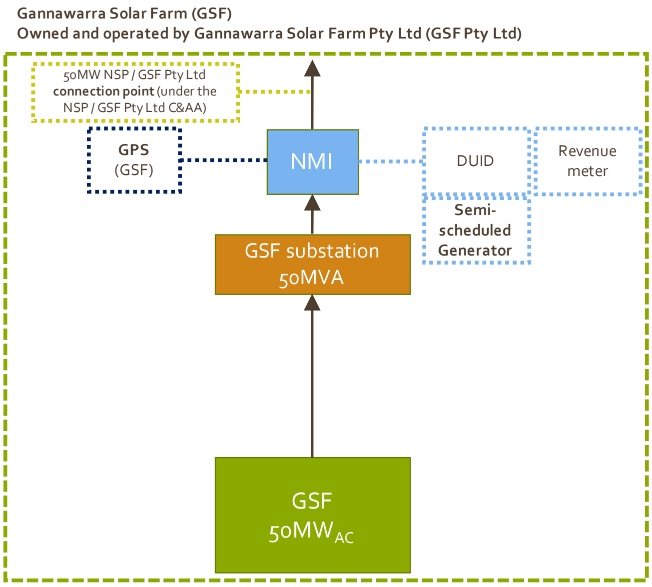


Figure 8 Regulatory arrangements for the combined GSF and GESS systems connecting into a common substation

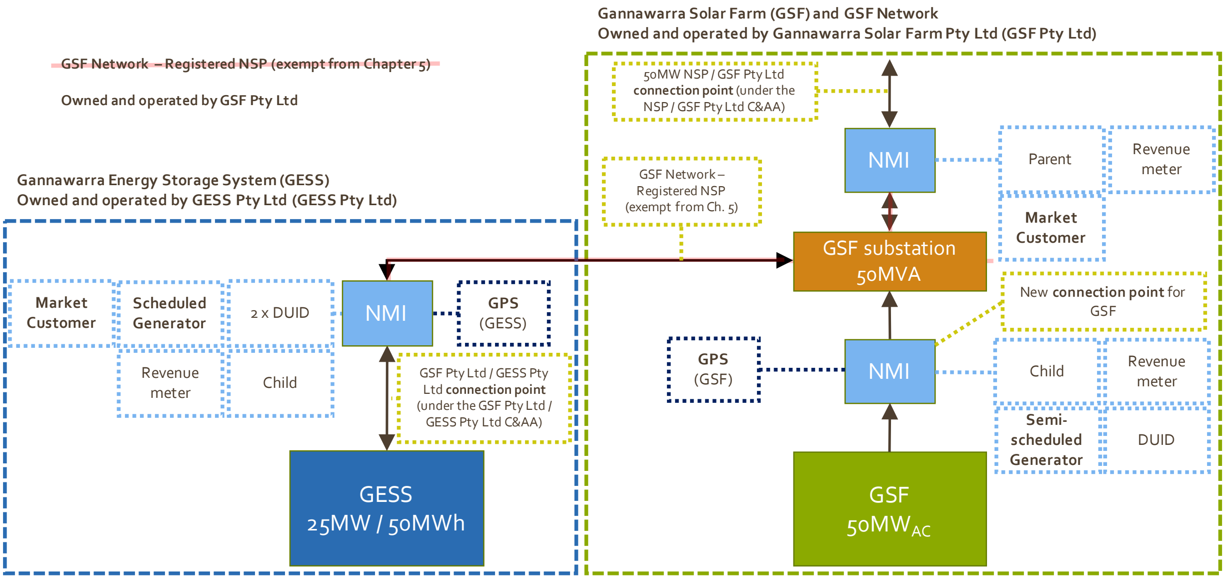


Table 6 Clarity in the creation of networks

Issue	Potential solutions

• As alluded to above, placing a point of connection between a substation and a NSP creates a network.
  - In the case of GSF and GESS, this was a registered network not an embedded network so that AEMO was able to ensure GPS enforceability rights (Edify Energy acknowledges that this is something that is looking to be addressed as part of this stakeholder consultation).
• The network that is created in this case (i.e. a substation and cabling) is conceptually removed from what is intended by a network (i.e. mass conveyance of power over large distances).
• Moreover, project SPVs do not make natural NSPs and have the capacity or capability to take on the obligations associated with being one.
• For this reason, exemptions from elements of Chapter 5 of the NER are required in a relatively complicated process that requires individual negotiations with the connecting NSP and the AER.
• Particularly in the case of negotiating NSP-NSP Connection Agreements / Standards, there is unlikely to be consistency across the NEM in undertaking this.
• It also gives rise to complicated commercial arrangements between the assets connected into the new network, particularly concerning the allocation of prudential requirements, responsibility for import tariffs from the upstream NSP, and the ambiguity and beneficiary of avoided TUOS payments that may be payable by the upstream NSP (in the case of this being a distribution network).
	• Create a clear 'rubber stamping' process for the creation of networks used for this purpose with:
	  - Known exemptions from Chapter 5;
	  - Template NSP-NSP connection agreements / standards;
	  - Seamless allocation of prudential requirements and pass-through of network charges to the party responsible (usually battery as large consumer);
	  - Recognition that the standing asset in a retrofit situation should retain its existing network charge classification and not be penalised with a new tariff on account of the new asset; and
	  - Clarity on the entitlement to avoided TUOS payments where the upstream NSP is a distribution network and the seamless transfer of these avoided TUOS benefits to the correct asset in the new network.

Table 7 Classification that recognises the real-time firming attributes of ESS

Issue	Potential solutions
• The classification of ESS as scheduled has the potential to limit its flexibility attributes in energy markets as could be applied at a sub 5-minute dispatch interval granularity. • This is particularly true with respect to ESS's potential to operate in tandem with a renewable asset and respond in real-time and in a converse way to its fluctuations to produce a combined output that is firm. • The application of the scheduled classification limits this 'firming mode' operation of the ESS	• Introduce a different classification (e.g. 'quasi-scheduled') that permits separate ESS and renewable asset generating systems to submit joint offers. • As a 'quasi-scheduled' unit, the ESS is permitted to depart from its scheduled dispatch at a sub 5-minute dispatch interval granularity for the purpose of firming. • Causer pays factors for the two assets are considered jointly.

Issue	Potential solutions
as departures from a scheduled dispatch at a sub 5-minute dispatch interval granularity would result in a non-compliance breach direction. • This is a sub-optimal outcome for both the market and for the renewable asset: - Market: the wider market will be required to procure these firming services in any event, but via more expensive FCAS markets. By affording the right to ESS to firm in the energy market, there will be greater wholesale adoption of firm renewables and lower system FCAS costs; and - Renewable asset: the renewable asset will not be able to access an opportunity to procure a firming service to manage a hedge position or to assist in the management of causer pays FCAS factors. • Addressing this will unlock business cases for ESS and improve its deployment and contribution to improved market outcomes.	• Recognising the system security prerogative of AEMO, the ESS is only permitted to maximally depart +/- [x]MW or [x]% from its scheduled dispatch. • For the purpose of determining causer pays FCAS factors, these two assets are combined. • When not submitting a joint offer, the ESS should revert to a scheduled classification as normal. • The application of this classification should be technology neutral (i.e. equally apply to coal, say) but it is anticipated that a benefit will be derived in its ability to respond at 4 second granularity to address causer pays factors. • The application of this mode should be equally possible for both co-located systems exporting through a single connection point (e.g. GSF and GESS) as well as 'virtual' (physically separate) arrangements within the same RRN.
See Figure 9 below, outlining the application of 'firming mode'.	

Figure 9 The application of a 'firming mode' concept at sub 5-minute dispatch interval granularity

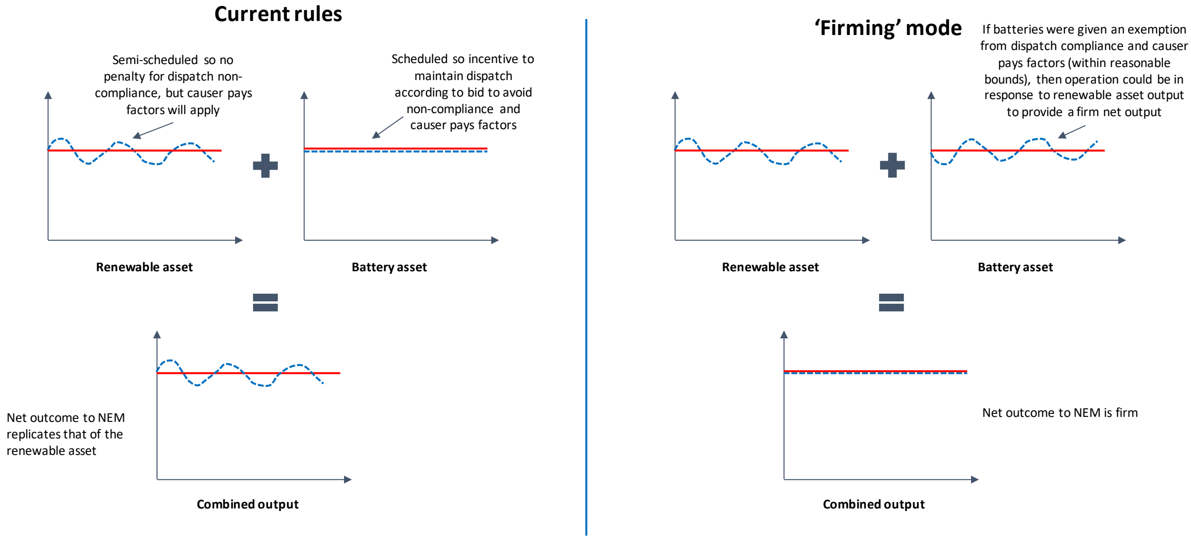


Table 8 Scheduled classification for hybrid single generating systems

Issue	Potential solutions
• Where ESS is coupled with a renewable asset behind a single point of connection, the application of scheduled status for the generating system may be inappropriate. • Depending on the relative proportion of ESScapacity (MW) and stored energy (MWh) to the capacity (MW) of the renewable asset, it may be challenging for the system to comply with its scheduled classification. • For instance: - Where the ESS is full, it will be unable to manage an increase in output from the renewable asset; - Where the ESS is empty, it will be unable to manage a decrease in output from the renewable asset; and - Where the ESS is offline, it will be unable to manage any fluctuations in output from the renewable asset. • This will impose a risk burden on the renewable asset that is challenging to manage and in doing so may create an impediment to investment of combined ESS and renewable generating systems.	• Dynamic classifications should be considered, where either a scheduled or semi-scheduled classification applies to a system, dependent on its operating characteristics for the relevant dispatch interval. • For instance, where the ESS is full, empty or offline, the combined system reverts to a semi-scheduled status, otherwise, scheduled status applies. • Tolerances (i.e. approaching full or empty) would need to apply for this to work in practice. • For example, a dynamic classification metric could be established where, for any given dispatch interval, if the ESS is able to provide [x]MW or [x]% coverage to the renewable asset (in both charge and discharge directions) for the full 5 minutes, then the system is classified as scheduled, otherwise it is classified as semi-scheduled.

Table 9 Use of ESS for the management of curtailment in a local network

Issue	Potential solutions
• Where a renewable asset is at risk of systemic curtailment (through the application of semi-dispatch caps), an opportunity should exist to use an ESS to capture any curtailed energy above the semi-dispatch cap for export at a later time. • At present, semi-dispatch caps are applied at an asset's connection point, which would prevent the use of a co-located ESS to capture curtailed energy in instances where the assets are registered as independent generating units. • Particularly where the business case for co-locating a battery is premised on capturing curtailed energy from an existing asset, it is highly likely that the system may be set up as independent generating units, similar to the retrofit GSF and GESS example. • Failure to address this, will prevent the adoption of a natural business case for ESS in the market (and risk mitigation measure for curtailed renewables) and limit	• Where a local network is created due to the presence of two independent generating units, there should be opportunity to apply a semi-dispatch cap at the common point of coupling with the surrounding network that is subject to the constraint event. • If for instance a 50MW solar farm has a 25MW semi-dispatch cap applied, this 25MW cap should apply at the network-to-network connection point, thereby permitting the renewable plant to dispatch its full 50MW output, with the balance of the 25MW used to charge the co-located ESS.

Issue	Potential solutions
opportunities to capture renewable energy that would otherwise have been usefully used.	

3.2 Project Development Activities

A benefit of retrofit development is the ability to leverage off many of the incumbent project's development attributes. This was the case with GESS, where it was able to benefit from the substantial amount of development activities which were previously undertaken as a part of the development of GSF.

A summary of some of the development activities and considerations for GESS is outlined in Table 10.

Table 10 Project development activities

Issue	Overview
Amendment of Development Approval	The GSF Development Approval already contemplated a battery facility at the site and that the project benefited from early engagement with Council to seek endorsement of the formalised plans. Nevertheless, in order to facilitate approval of the GESS facility an amendment to the existing site Development Approval was required. This required liaising with Council in order to seek approval and endorsement of the updated planning permit that included the battery facility. As a part of this process, general details including layout drawings, system size and technology type were required as well as an assessment against the planning conditions for other elements.
Management Plans	As a part of the execution of GESS, several of the project management plans were required to be updated to facilitate construction of the facility. Due to the nature of GESS being constructed concurrently with the later stages of GSF, the project benefited from updates to common plans by the same EPC contractor. Updated management plans included: • Traffic Management Plan; • Construction Environmental Management Plan; • Workplace Health and Safety Management Plan; and • Emergency Response Management Plan. The update of these plans was straightforward on account of the existing close relationship with Council and emergency

Issue	Overview
	services and the regular and open lines of communication. Future project proponents are advised to maintain strong dialogue with local authorities and make any intent to change existing site conditions or previously approved project parameters known early to avoid disruption and ensure the content of management plans are mutually acceptable.

Key learnings from the development activities associated with lithium-ion battery projects include:

- Retrofitting batteries to solar farms is assisted where the battery facility is contemplated in the original development consent associated with the solar farm, such that implementation of the battery only requires relatively minor amendments to the existing development consent;
- Battery projects are significantly more energy dense and will require considerably less land than solar farms, which means it can be generally expected that the planning requirements for battery projects are typically less onerous than that of solar farms; and
- Battery system fire mechanics and risks are not well understood in the market; discussions with both the battery OEM and local fire-fighting authorities will be necessary.

3.2.1 Renegotiation of Generator Performance Standards

As indicated in Table 5, retrofitting GESS to the existing GSF required a movement of the connection point for GSF from the 66kV to the 33kV side of the substation. Consequently, a renegotiation of GSF's GPS and connection agreement were required, together with the creation of a registered network, a network-to-network connection agreement and standard between the new GSF Registered Network and Powercor. This created significant risk for GESS and its likelihood of succeeding as well as adding considerable development time and expense through extensive further grid modelling requirements and negotiations of multiple new agreements.

A key concern and development risk associated with the requirement to open and renegotiate a GPS for existing assets (e.g. GSF) is the fact that the new GPS must consider new generators that were not previously contemplated at the time of the original GPS negotiation (and the design of the power plant to meet that GPS). Moreover, the relatively recent introduction of the System Strength Impact Assessment process (in this case introduced after GSF was awarded an offer to connect) makes new GPS negotiations considerably more costly, longer and at greater risk of failing than was likely the case when many incumbent generators initially connected. Although understandable and in accordance with the NER, it does introduce a significant risk and impediment to such retrofit systems being deployed, which may inadvertently result in less deployment of battery systems that have many positive attributes for network management and system support.

The complexities in moving the connection point and the requirement for extensive new modelling and negotiations in a more challenging environment was the primary reason for delays in achieving an offer to connect for GESS beyond the initial timeframes contemplated. New projects looking to connect under a similar arrangement should engage early with the relevant NSP, AEMO and modelling consultants and factor in conservative timeframes and costs for this development workstream.

Figure 10 GESS and 220kV AusNet transmission line

3.3 Procurement Challenges

3.3.1 Overall procurement model

The procurement model chosen for GESS was based on evaluation of a range of possibilities as summarised in Table 11.

Table 11 Different procurement models considered

Procurement model	Positives	Negatives	Considerations
Turnkey EPC contract **(single contract delivery)**	• Single point of responsibility for delays, cost and performance. • Reduced interfaces between project parties.	• Mark-up and cost premium for taking all project risks. • Risks not allocated to most suitable party to manage that risk. • Relative cost values of the Project heavily weighted to the battery OEM, making them the only party suitable to take full risk wrap for the overall project. • Use of non-solar farm EPC contractor introduces inter-	Significant cost premium for 'risk wrap' made the full turnkey EPC contract not viable. However, existing presence and construction stage of GSF, as well as significant proportion of shared infrastructure, meant that advantages existed in leveraging existing solar farm EPC contractor for the additional works. **<u>Contracting model not chosen</u>**

Procurement model	Positives	Negatives	Considerations
		project risk between solar farm and battery as well as reducing cost efficiencies of common contractor. • Reduced flexibility to nominate subcontractors.	
Multi-contract **(battery supply agreement and BOP installation contract)**	• Risk allocated to party most suitable to manage those risks (e.g. construction risk with construction contractor). • Elimination of mark-up on costs of major subcontracts (e.g. EPC marking up battery equipment). • Ability to leverage cost saving potential of existing solar farm EPC contractor through flexibility in constructor choice.	• Interfaces introduced which require management. • Splitting of value of contracts means that cost compensation of liquidated damages does not full reimburse project losses. • No inherently formal relationship between multiple contractors.	Value of cost reduction associated with removal of price premium associated with a full 'risk wrap' is not expected to outweigh the potential cost exposure associated with risk of a multi-contract delivery. Ability to leverage potential cost savings and risk reductions associated with use of same construction contractor as solar farm. Ability to implement a 'Coordination Deed' to facilitate coordination and cooperation between the major project contracts. **Contracting model chosen as most appropriate for project delivery**
Joint Venture (JV)	• Single point of responsibility for delays, cost and performance. • Reduced interfaces between project parties. • Risk allocated to party most suitable to manage those risks (e.g. construction risk	• JV relationships typically only used where two parties have significant working relationship with each other or where there are capability shortfalls with either party. • JVs generally require each party to be joint	Not progressed as contracting model as no JV parties were available for pursuit. Potential exists for JV relationships in future projects where established OEM and construction contractor

Procurement model	Positives	Negatives	Considerations
	with construction contractor). • Elimination of mark-up on costs of major subcontracts (e.g. EPC marking up battery equipment). • Ability to leverage cost saving potential of existing solar farm EPC contractor through flexibility in constructor choice (only if able to dictate JV arrangements).	and severally liable which introduces significant commercial discussions between the JV parties.	relationships can be formed. **Contracting model not chosen**

3.3.2 Contracting considerations for battery procurement

Table 12 outlines key considerations and learnings associated with contracting approaches for battery procurement.

Table 12 Contracting considerations for battery procurement

Consideration	Overview and learnings
Evaluation point of guarantees	Under a stand-alone battery supply agreement, it is important to consider the point at which guarantees are made and ideally align these with the functional points of the project. Or where there are differences (due to the procurement model for instance) ensure that the corresponding components of the balance of plant also consider these. An overview of specific considerations is included below. **Generator Performance Standard (GPS)** The GPS of the facility is evaluated at the point of connection. However, the battery supplier will typically seek to guarantee compliance at the inverter terminals. It is important that the effects of a balance of plant are included in assessing compliance at the relevant facility connection point and ensure that the battery supplier's guarantees contemplate the expected balance of plant being installed. **Maximum power** The maximum power measured at the battery inverter terminals is typically greater than that measured at the point of connection due to parasitic losses. Power guarantees should contemplate balance of plant losses where it is a single turnkey EPC contract or be measured at the inverter terminals and have an allowance for maximum balance of plant losses under the BOP installation contract. **Round-trip efficiency**

Consideration	Overview and learnings
	Round-trip efficiency guarantees are typically defined at the inverter terminals. Similar to maximum power guarantees, the effects of balance of system losses should be considered in these tests either through a guarantee of performance to the point of connection, or through determination at the inverter terminals and allowance for expected balance of plant losses under the BOP installation contract.
Determination of liquidated damages	It is important that the performance based liquidated damages, and also availability based liquidated damages, properly consider the interfaces between the battery provider scope of supply and the balance of plant equipment. Such interfaces should accommodate for the following: • Expected balance of plant losses to the point of connection; and • Expected availability of the battery system and the balance of plant system.

3.3.3 Balance of plant installation

Table 13 outlines key considerations and learnings associated with contracting approaches for balance of plant installation contractor procurement.

Table 13 Balance of plant installation considerations

Consideration	Learning and Overview
Guarantees	The balance of plant contract should include a provision for guarantee of the maximum plant auxiliary losses which should ideally be measured as a part of the battery performance testing. Whilst the balance of system losses are typically small, they are important to understand and to ensure that the system design accommodates for an expected upper limit of parasitic losses.
Coordination Deed	There is significant overlap and interfaces between the scope of the battery supply agreement and the balance of plant installation contractor. It is important that these interfaces are clearly defined and ideally agreed between the parties in the form of a Coordination Deed (or equivalent) so that any interfaces can be properly managed. Some considerations include: • Defining a responsibilities matrix that outlines the key interfaces and separation of responsibilities between the parties; • Timing expectations and processes between delivery receipts; • Handling and required care of battery components including all necessary conditions of warranty to be adhered to by the balance of plant contractor; • Joint programming and scheduling for coordination between the parties; • Battery installation instructions and acceptability criteria for battery supplier sign-off of installation; and • Responsibilities between the parties for testing and commissioning, including allocation of specific responsibilities.

3.3.4 Procurement challenges conclusion

The adopted multi-contract solution requires greater sponsor management than a typical turnkey EPC contract as there are multiple accountable parties. However, this separation also allows better monitoring of the performance of individual contractors than under a single wrap. The key to a successful implementation of this approach is having a clear responsibility matrix and a well-articulated and exhaustive Coordination Deed that is enforceable under the contracts.

For retrofit situations, where there is opportunity to leverage an existing site presence of any contractors, this presents savings benefits for both time and costs associated with mobilisation and site preparations.

3.4 Construction and Commissioning Activities

Key learnings during the construction stage of the project are as follows:

Table 14 Construction and commissioning considerations

Consideration	Issue	Solutions
SCADA	• Few SCADA system providers will have experience in developing Graphical User Interfaces (**GUI**) for battery systems. • This resulted in more time and resources than budgeted for to create an acceptable GUI.	• Upfront consideration should be given to using the battery supplier's GUI.
Communications link	• Powercor was unable to provide bi-lateral communication paths through its network for site Inter-Control Centre Communications Protocol (**ICCP**) to the AEMO datacentres. • Without an ICCP link, the Project would be unable to access the AGC dispatch from AEMO and provide high fidelity services such as regulation FCAS.	• In lieu of Powercor providing an ICCP link, AEMO committed to facilitate the establishment of such a link directly. • This represented a first for AEMO and proved to be a complicated communications link to establish in a stable way that does not adversely impact AEMO's communication and information obligations and requirements in operating the market. • During the extended period required to establish the ICCP link, the Project was set up to make use of the site's existing semi-dispatch market system, to enable the following of 5-minute dispatch targets.

Consideration	Issue	Solutions
Constraints on commissioning activities	• The application of onerous network tariff charges coupled with restrictions on energy exports during solar hours resulted in conditions that were difficult to complete some commissioning tests, particularly where tests required a short period between a charge and a discharge.	• Preparation, timing and close coordination between commissioning teams and trading teams were crucial to complete the required tests under these conditions.
Insolvency of EPC contractor	• The EPC contractor was subject to an insolvency event and abandoned site during the Project deployment phase, causing construction and commissioning activities to cease. • This insolvency impacts on the warranties, guarantees and liability periods otherwise available from the principal contractor.	• The developer was required to take on an expanded role and engage additional contractors (and site supervisors) to complete the remaining portions of construction and commissioning activities.

Whilst construction of a battery system is technically relatively simple, specific site conditions can hinder the required commissioning tests. Being able to commence commissioning under a notifiable exemption (i.e. less than 5MW) allowed for communications testing and firmware upgrades to proceed but did not allow the complete system to be activated. This exemption only allowed for one block at a time to be operated (where one block is 2.75MW), such that firmware upgrades were required to take place one at a time, on an individual block basis. Permitting the complete system to be operated but with a safeguard in place to limit exports to no more than 5MW, would have allowed for the all communications to be tested and firmware upgrades to take place in a single iteration, rather than as individual blocks. This activity was completed remotely from the US, so scheduling was made difficult with these constraints in place.

With a combined export constraint between GSF and GESS of 50MW and the application of DUOS charges for any loads drawn through the Powercor network (i.e. outside of solar hours), there were both physical and commercial limits placed on GESS for the purposes of conducting charge and discharge cycles at full capacity during commissioning. This meant that at times, it was not possible to charge the system at the required rate due to low solar output and at other times it was not possible to generate at the required rate due to high solar output. Moreover, charging for testing or otherwise was limited to during solar hours and at rates dependent on the solar export during those periods. Combined with considerations relating to maintaining the battery in appropriate states of charge for idle periods made the coordination of commissioning and performance tests challenging.

Utilising the existing market dispatch system used to manage semi-dispatch caps for GSF whilst the AGC was not yet operational was critical to completing the project within scheduled dates. The ICCP link proved to be very onerous to set up as this was the first time that it had been completed by AEMO for this purpose. Using AEMO's ICCP vendor should be considered if the NSP cannot provide bilateral communication paths.

Figure 11 Laying the GESS foundations

Figure 12 Placing PowerPacks in position

4 CONCLUSION

GESS is a pioneering project in Australia's National Electricity Market. It is the first project to retrofit a large battery behind the existing point of connection of a utility scale renewable energy asset and at the time of writing is among the largest integrated utility scale renewable energy and battery systems in the world.

The pioneering nature of GESS means it has made a valuable contribution to uncovering learnings on integrating batteries with renewable systems. These learnings are now being used to inform regulatory reform such that the benefits of such arrangements are more seamlessly realised by future projects. It has also set interesting commercial precedence in its novel long-term BSSA with EnergyAustralia, which may become a commonplace model as future storage projects look to efficiently allocate market and technical risks among parties. Finally, from a technical, construction and commissioning perspective, some of the opportunities and challenges that a project such as GESS presents, can be anticipated but only learnt in full in a practical deployment.

Edify will continue to play a market-leading role in pursuit of a high penetration renewable and smart power technology future, in-part enabled by batteries, by continuing to bring into operation renewable and storage projects generating sustainable, reliable and affordable energy to Australian electricity consumers. Edify aims to deliver many more projects similar to GESS and GSF.

Figure 13 Aerial view of GESS, GSF, GSF network and the point of connection to Powercor