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South Australian Council of Social Service

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Mr John Pierce
Chairman
Australian Energy Market Commission
PO Box A2449
SYDNEY SOUTH NSW 1235

19 October 2018

Dear Mr Pierce,

RE: Coordination of generation and transmission investment – options paper (EPR0052)

As the peak body for the health and community services sector in South Australia, the South Australian Council of Social Service (SACOSS) has an established history of interest, engagement and provision of proposed advice on the supply of essential services including electricity. SACOSS research shows that the cost and supply of basic necessities like electricity have significant and disproportionately greater impacts on vulnerable people. SACOSS' advocacy is informed by our members and direct consultations with consumers and other consumer organisations: organisations and individuals who witness and experience these impacts in our community.

Our primary comments refer to the direction to convert the ISP into an actionable strategic plan. We note a significant degree of concern about possible interpretations of "actionable strategic plan". Our primary objective is to ensure investment in line with the NEO that addresses the energy trilemma: **affordability**, reliability, emissions (our emphasis). We are extremely concerned that some of the options the AEMC is considering would result in unnecessarily high costs for consumers and greater and significant risk of stranded assets, particularly those options with greater stages of involvement of AEMO.

We draw the attention of the Commission to Recommendation 5.1 **and 5.2** of the Finkel Review Panel Final Report:

> 5.1 By mid-2018, the Australian Energy Market Operator, supported by transmission network service providers and relevant stakeholders, should develop an integrated grid plan to facilitate the efficient development and connection of renewable energy zones across the National Electricity Market.
>
> 5.2 By mid-2019, the Australian Energy Market Operator, in consultation with transmission network service providers and consistent with the integrated grid plan, should develop a list of potential priority projects in each region that governments could support **if the market is unable to deliver the investment required to enable the development of renewable energy zones**. **The Australian Energy Market Commission should develop a rigorous framework to evaluate the priority projects**, including guidance for governments on the combination of

circumstances that would warrant a government intervention to facilitate specific transmission investments **[our emphasis]**.

It is very clear to SACOSS that these two recommendations are intended to be read together. We believe they provide necessary guidance around how the integrated grid plan was intended to function. Our first point of emphasis ("if the market is unable to deliver the investment required to enable the development of renewable energy zones") clarifies that the integrated plan was not intended to override market outcomes. In balancing the trilemma, the Finkel Review provides adequate time for market responses to reliability and emissions goals.

Our second point of emphasis is around the need to evaluate the priority projects identified by AEMO ("The Australian Energy Market Commission should develop a rigorous framework to evaluate the priority projects"). There is a clear role provided for the AEMC to assist in this evaluation. Hence, the integrated plan developed by AEMO was not viewed as a fait accompli. It was intended that there be thorough evaluation of the plan and rigour applied in the course of this evaluation.

Taken together, the above two points of emphasis provide some guidance for how to interpret "actionable strategic plan". It is clear that the plan should facilitate market information and response and that the plan produced by AEMO was never intended to be a blueprint plan.

Further, SACOSS believes that when considering the meaning of actionable strategic plan it is essential to differentiate the terms "strategic" and "implementation". According to the Australian Institute of Company Directors, a strategic plan documents where the entity "is going. It can be defined as a roadmap to sustainable value creation based on the best possible information available at the time. It addresses the long-term direction of the organisation by describing what it's going to do and how."[1] A strategic plan is intended to be differentiated from an implementation plan: "An organisation must also have a detailed plan for implementing the strategy and a set of measures to indicate how well the implementation is going."[2] SACOSS notes that this distinction points to the conclusion that as a strategic plan the ISP is not intended to be prescriptive. Rather, it functions to provide guidance and direction to the market about where investment needs to occur, and what would be the most likely consequence if that market based investment did not occur. In relation to the term "actionable strategic plan", the action in this case is the action of the market in responding to the signals it is receiving form the market operator.

We have attached a report produced by Greenview Strategic Consulting which demonstrates the rapid scale of market development and the massive potential for market response.

SACOSS notes that in relation to the ISP, all of the Group 1 projects identified by AEMO in the ISP have been identified and are being progressed by individual TNSPs under current arrangements. SACOSS also notes that these Group 1 priority projects are investment projects that AEMO considers should be progressed as soon as possible because they provide immediate benefits. SACOSS notes

[1] Australian Institute of Company Directors (nd) Strategic Plan Development at https://aicd.companydirectors.com.au/~/media/cd2/resources/director-resources/director-tools/pdf/05446-5-14-mem-director-rob-strategic-plan-development_a4-web.ashx p.1

[2] AICS (nd) p.1

the costs of these investments are in the order of $450 to $650 million, a very substantial investment. SACOSS is concerned about the speed at which these projects are being facilitated, which is out of step with the Finkel Review recommendations. SACOSS is concerned that the market is being given insufficient opportunity to respond to market signals from AEMO.

In terms of the Group 2 and Group 3 projects, SACOSS believes the appropriate course of action at this stage is to apply a rigorous framework to evaluate the Group 2 and Group 3 priority projects.

Given all of the above comments, SACOSS does not support options 2—5 as outlined by the AEMC in making the ISP an actionable strategic plan. SACOSS believe these options put enhanced risks on consumers that they will bear the costs associated with investments that may no longer be required.

SACOSS believes option 1 is an efficient use of the information gathered by AEMO for the purpose of transmission planning and decision making.

SACOSS strongly supports the Commission's view that the role that the RIT-T fulfils in protecting consumers from inefficient investment should not be diminished. SACOSS recently engaged in the AER review of the RIT and generally supports the direction of the AER in further enhancing the RIT-T.

SACOSS agrees with the assessment by the Commission that access and congestion management issues are likely to need to be addressed in the near term. SACOSS supports optional firm access being introduced at the earliest stage possible as we believe current circumstances demonstrate the need for additional generation and transmission investment and it is in the long term interests of consumers to introduce more commercial drivers into transmission and generation development.

We would like to thank the AEMC for the work done to date on enhancing coordination of generation and transmission, and for consideration of our comments. If you have any questions relating to the above, please contact SACOSS Policy Lead, Jo De Silva on (08) 8305 4211 or via jo@sacoss.org.au.

Yours sincerely,

Ross Womersley
Chief Executive Officer

Utility Scale Storage in the Move to Zero Carbon: A review of the first 9 months of HPR Operation

October 2018
Final – Public Release

Prepared by:

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Surrey Hills VIC 3127

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Executive Summary

The South Australian Council of Social Services (SACOSS) engaged Greenview Strategic Consulting (GVSC) to develop a report on the first few months of operation of the Hornsdale Power Reserve (HPR) in South Australia, and then to assist its understanding about the next wave of batteries being constructed.

The South Australian market is characterised by a concentrated thermal generation sector with growing capacity in intermittent wind and solar generation. The majority of scheduled generation is owned by the Gentailer, AGL, with the rest held by a relatively small number of vertically integrated participants.

At the time of writing this report, HPR was the worlds largest utility-scale battery at 100MW discharge capability.

This report found HPR had performed at or above expectation, with accurate and timely response as required by AEMO and the owners. Given the number of batteries now coming online in the NEM in the second half of 2018 (Gannawarra and Ballarat – both in Victoria), plus additional batteries in SA (Lake Bonney and Lincoln Gap), it is expected that additional benefit will materialise for both the owners of these assets and the wider market.

1 Introduction

1.1 Context of Report

GVSC was engaged by SACOSS to assess in detail the initial performance of how the Hornsdale Battery has performed, with a particular focus on:

- Interaction with other generation in the market during typical days and for particular power system events;
- Assess its performance in terms of energy and system security, particularly in FCAS and FFR; and
- Evaluate desirability of similar investments especially by TNSPs.

GVSC is well placed to provide this assessment having conducted previous market assessments for SACOSS and having been involved in the implementation of the Hornsdale Power Reserve as a sub-contractor with Neoen (owner/operator).

1.2 Description of Battery Assets

The Hornsdale Power Reserve Battery Energy Storage System (HPR) is located near Jamestown, north of Adelaide in South Australia. The HPR battery is rated at 100 megawatts (MW) discharge and 80 MW charge, and has a storage capacity greater than 129 megawatt hours (MWh). This capacity represents approximately 75 minutes at full discharge. The HPR shares the same 275 kilovolt (kV) network connection point as the 300 MW Hornsdale Wind Farm but is not connected to the wind farms, hence the battery is not 'filled' by the battery in any way.

In terms of overall cost, in September 2018, Neoen released some additional information as part of an Initial Public Offer (IPO)[1]. In that report, it highlighted some of the revenue achieved by the partnership (see later sections), as well as the cost of the battery to the South Australian government, which equated to approx. $6m per year. In terms of overall cost to the partnership, the capital cost was approx. $90m.

[1] https://reneweconomy.com.au/revealed-true-cost-of-tesla-big-battery-and-its-government-contract-66888/

2 General Battery Overview

2.1 Battery Technology

The Hornsdale Power Reserve utilises the Tesla's Powerpack lithium-ion units (similar to that installed within residential homes), with approximately 40,000 individual units used, as well as associated equipment. While this is the largest single battery Tesla has constructed, the technology had been proven on a smaller scale at several other sites worldwide. Please see https://www.tesla.com/en_AU/powerpack for more detail on Tesla's Powerpack technology.

In general, Lithium Ion (Li ion) is the preferred storage device of choice at present, due to the lower cost of stored energy and high efficiency levels (~80%).

Other storage technologies are progressively being introduced, such as silicon energy storage (used by 1414 degrees) and flow batteries.

2.2 Market Coverage - HPR

Several reports have been written on the recent introduction of HPR and the topic discussed at various conferences and on-line forums, particularly about the HPR and how it has affected the market in South Australia.

A summary of two papers from AEMO and Advanced Microgrid Solutions (AMS) are outlined below:

- The AEMO report focuses more on the overall advantages of the Battery installed in the grid and some suggestions for what might need to change in market systems if more batteries are installed.
- The AMS report is a detailed data analysis report which shows how the battery has impacted the market in terms of price changes and market share.

For background, AMS is a software platform supplier to Virtual Power Plants in the US and is looking to expand operations in Australia. AMS presented at Energy Week in Sydney in early June and has recently been interviewed in GreenTech Media (GTM) in the US.

2.2.1 AEMO Report

The AEMO Report, titled, 'Initial Operation of the Hornsdale Power Reserve Battery Energy Storage System', was produced in April 2018 following summer operations of HPR.

The main points noted included:

- The description of services HPR provided including energy arbitrage, reserve energy capacity, Network Loading Ancillary Services (NLCAS), and frequency control ancillary services (FCAS)
- the quality of regulation services that were being provided, demonstrating far superior performance when compared to a conventional thermal generator. However, the report noted that the current assessment methods do not measure or reward the

performance of each generator in how they provide regulation services. Therefore, the HPR does not receive any extra benefit or payment for providing a superior service.

- Similarly, the full capability of HPR to provide contingency services is not being fully utilised as the calculation methodology for FCAS does not recognise response performance below 49.5Hz or above 50.5Hz – see further information in Section xx.
- Funding arrangements for the HPR were quite specific at the time to maximise capabilities of the battery to serve South Australia's needs, including reserve of 70MW at all times for system security. To date, this has not been required.
- AEMO noted that new markets may be required to cater for higher performing services provided by batteries.

2.2.2 Advanced Microgrid Solutions

The AMS Report, titled "Analysis of the Hornsdale Battery's Impact on the National Electricity Market" was a presentation conducted in early June 2018 in Sydney at Energy Networks 2018.

The main points of the presentation were:

- HPR has reduced regulation costs to SA by 80 to 90% in 5 months after commissioning
- However Contingency costs rose over the same time period, so overall FCAS costs only reduced 16%, For example, there has been a 162% increase in 5 min Raise
- AMS are of the view that there are still "compelling investment opportunities" for additional grid scale batteries, due to level of renewable projects proposed in the future, available revenue streams, and AEMO signals through statements from CEO etc.
- HPR has captured 10% share of "addressable" FCAS market

2.3 Market Coverage - General

The battery has also been the topic of many articles through organisations such as RenewEconomy. Below are some of the many links although several feed on each other with the main point often repeated ("that it is lowering FCAS costs in South Australia since commissioning").

Godart van Gendt of McKinsey & Company is often mentioned regarding a presentation to the Australian Energy Week Conference in May 2018 and research they have done on the battery.

- GTM article: "Did Tesla's Big Australian Battery Kill the Business Case for More?" mentions research by McKinsey & Company.
    - Notes that frequency response is low hanging fruit for utility scale batteries, inference that this is only for the first participant that installs such a battery.
    - Notes that it is more difficult for the ones that follow. While prices have declined with the installation of Hornsdale, the volume of payments has gone up.
    - Questions whether grid scale battery projects would work without FCAS revenues.
    - Investment by the South Australian government to have the Hornsdale battery installed, even though exact cost is not known, but based on $50m, could be

as short as a year pay back based on the savings in FCAS costs to the government due to the lower FCAS costs to the economy.

- An article in RenewEconomy by Sophie Vorrath and Giles Parkinson: "The stunning numbers behind success of Tesla big battery" mentions:
    - the presentation to the Australian Energy Week Conference in May by Godart van Gendt.
    - Claims Hornsdale battery has taken 55% of SA's FCAS market revenue and lowered prices by 90%.
    - Point is that it will now be much harder for other battery projects to be viable.
    - Combined with a renewable generator, with much lower O&M costs than a thermal power station, and the speed that the battery can charge and then switch to discharging energy, coupled with the control system, it is more versatile than a traditional thermal generator and is better placed to respond to changes in the market , bidding as often as every 5 minutes to capitalise on the market and optimise the charge capacity over the trading day.
    - Figure 1 is from another RenewEconomy article by Giles Parkinson, "Tesla big battery is changing the way people think about the grid", showing how responsive the battery is to correcting frequency. This article also mentions the System Integrity Protection Scheme (SIPS), a scheme being implanted in SA by ElectraNet (yet to be commissioned) to help maintain system security and that using batteries such as the HPR could be integral to the schemes success.

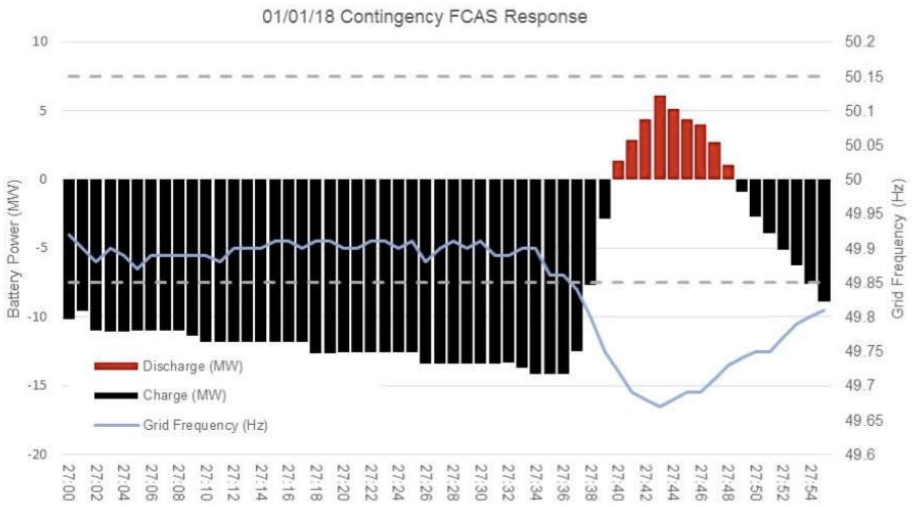


Figure 1: RenewEconomy Graphic

- An article in RenewEconomy by Giles Parkinson Tesla big battery is already bringing Australia's gas cartel to heel refers to the gas generators, namely the AGL owned Torrens Island, who have had a the lion's share of the FCAS market and bid capacity to take advantage of it. This article also compares the same two dates noted in this report, 14 September 2017 and 14 January 2018 and describes what effect HPR and the Hornsdale 2 windfarm had on pricing outcomes.

3 Recent Events in South Australia

3.1 Energy Market Operation

The National Electricity Market (NEM) is managed and operated by the Australian Energy Market Operator in all the Eastern States of Australia, Queensland, New South Wales, Victoria, Tasmania and South Australia. It incorporates physical assets such as generators and transmissions lines that are interconnected across the NEM.

The operation of the market, which is a wholesale spot market, is managed by AEMO in accordance with the National Electricity Rules (NER) to fulfil the National Electricity Objective. It operates 24 hours a day, 365 days a year.

Pricing and dispatch of generators occur in 5-minute dispatch intervals and settlements are based on half hour trading intervals (until mid 2021 when it changes to 5 minute settlement).

Prices are set based upon offers submitted to AEMO and the level of demand in each region. There are separate prices for each region in the NEM, where regions are identified as the individual states such as Victoria, New South Wales etc.

As well as an energy market, AEMO also operates and manages eight separate markets for Frequency Control Ancillary Services. These are:

• Raise 6 second • Raise 60 second • Raise 5 minute • Lower 6 second • Lower 60 second • Lower 5 minute	Contingency Services
• Raise Regulation • Lower Regulation	Regulation Services

These are divided into two categories, Contingency and Regulation Services.

Contingency Services are designed to arrest and restore large and sudden increases or decreases in the level of frequency, while Regulation services make small incremental changes to frequency to keep it within the frequency operating band.

FCAS are dispatched on a 5 minute basis and are also settled on a 5 minute basis.

To recoup the costs AEMO pays to participants in procuring ancillary services, it charges participants and customers.

In recent years there has been a rise in the cost of ancillary services including FCAS. The chart below illustrates the increase in 2017 to over $40 Million to South Australia compared to previous years (see Figure 2: Recent FCAS Costs (SA))

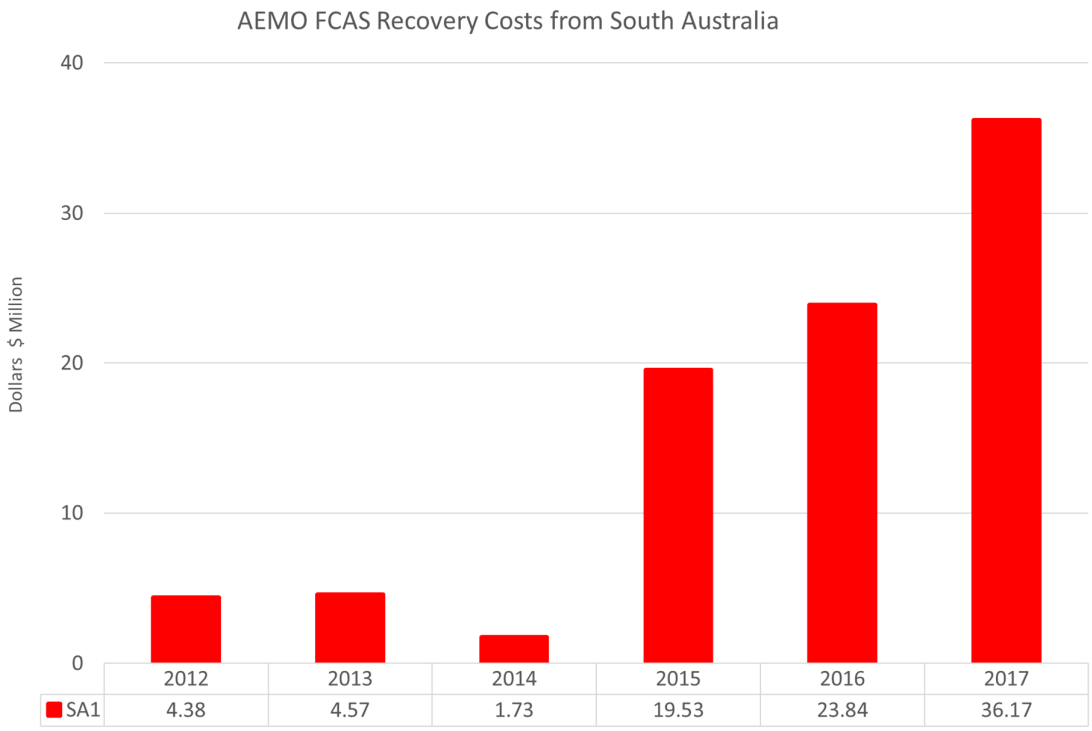


Figure 2: Recent FCAS Costs (SA)

3.2 Pool price history last 10 years

Figure 3 below shows 10 years of Quarterly spot prices across the NEM. While South Australia is often higher than other regions, this has not always been the case. But the Quarter ending April 2018 is $116/MWh, which was $72 higher than the same Qtr 10 years ago. It is also more than five times higher than the Qtr ending January 2011.

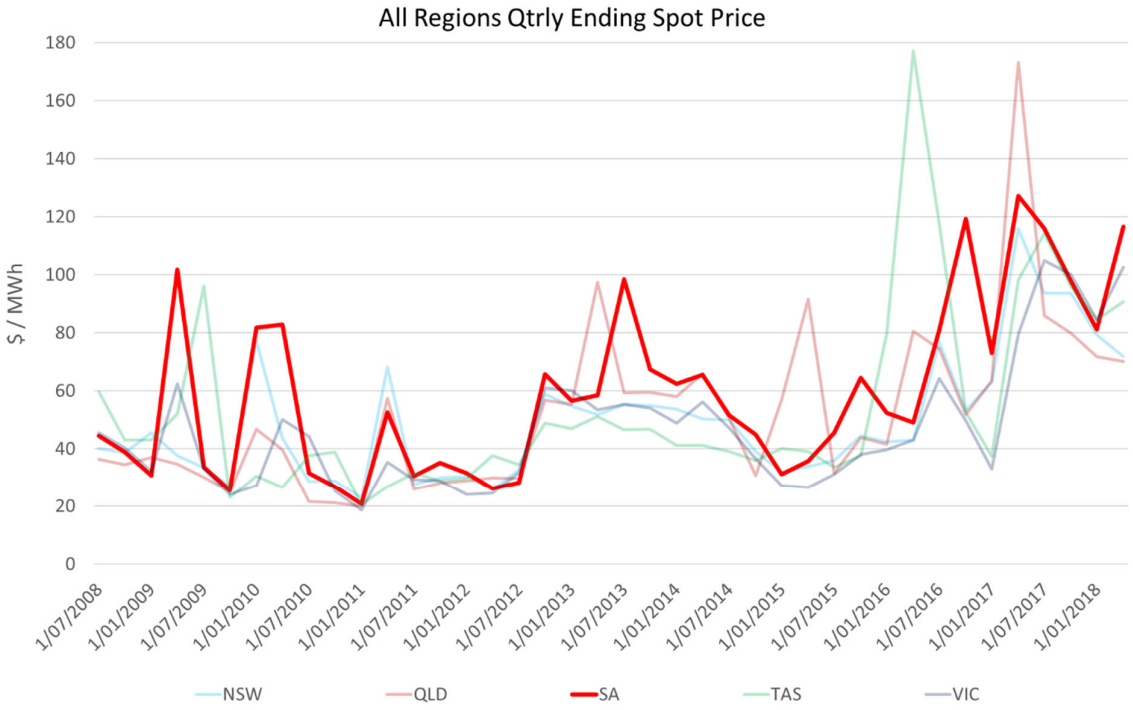


Figure 3: Last 10 years prices in SA

3.3 Region Availability Last 10 years

Figure 4 shows how SA Region Availability declined between 2013 and 2017 mainly due to Pelican Point being reduced in capacity and Northern Power Station being removed from service. Increasing wind penetration has continued over the last 10 years with utility-scale Solar just commencing with the commissioning of Bungala Solar Farm (not shown). Coal fired generation retired for good in 2016 with the closure of Northern Power Station. Gas fired generation availability continues to be variable depending on the overall gas and electricity trading strategies of owners. From all indications, there appears to be adequate gas if required, depending on the price the Station owners are prepared to pay for it. The yellow line in the far-right corner is the Hornsdale Battery coming into service the end of 2017. In future years this may increase in a similar fashion to wind as other participants install battery storage systems.

Figure 4 also shows how gas fired station availability has changed over the last 10 years. Also evident is how Torrens Island filled in the gap in 2015 and 2016 on the back of cheaper gas from Victoria (a scenario that does not exist at present).

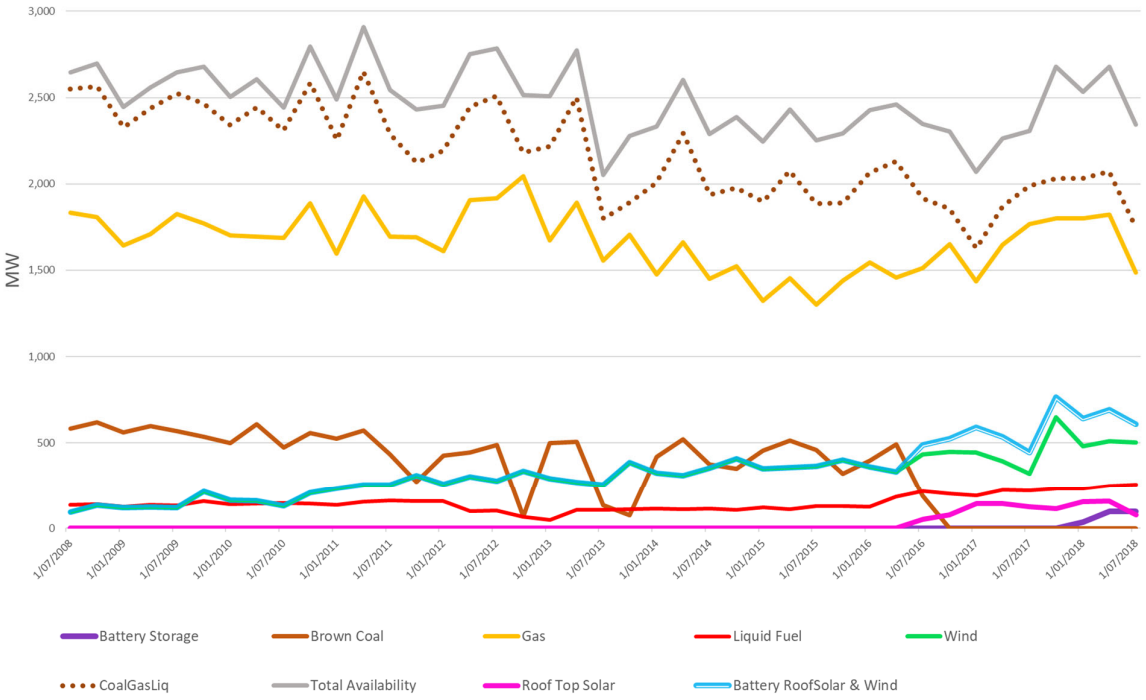


Figure 4: SA Plant Availability (10 years)

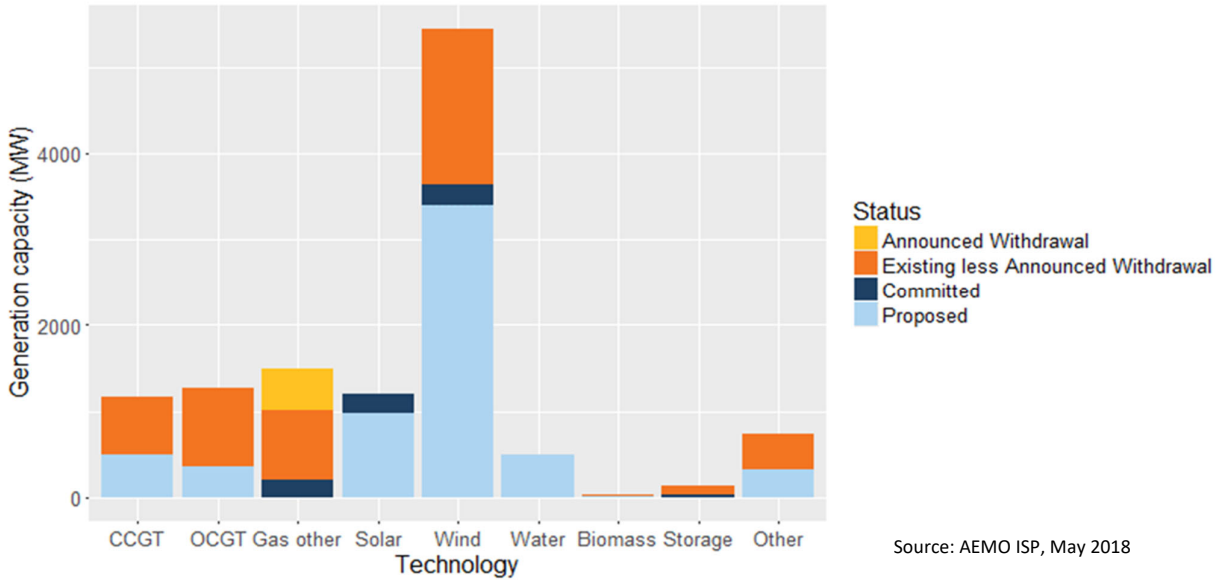
3.4 Current SA Developments

Information from AEMO has noted that are a number of new "Committed" Projects totalling 705 MW which will increase the capacity of South Australia generation reserves in the next 12 months. These are:

- Bungala Solar Power Project (220 MW)
- Lincoln Gap Wind Farm Stage 1 (126 MW)
- Barker Inlet Power Station (210 MW, Gas fired)
- Tailem Bend Solar Farm (200MW)
- Willogoleche Wind Farm (119 MW)

However, there are over 6000 MW again of proposed projects, mostly wind and solar on top of existing and committed projects. It is not expected that they will all get to the committed stage, although the new SA Government OTR (Office of Technical Regulator) requirements will require any new Solar or Wind generator to install battery-like capability before Development Approval will be given.

None of the committed projects are likely to contribute to increased inertia, except possibly Barker Inlet, with most relaying on the FFR-like capability of batteries.



Source: AEMO ISP, May 2018

Figure 5: SA Project Development

3.5 Batteries and Ancillary Services

Since the NEM started nearly 20 years ago, the main suppliers of energy and ancillary services were large fossil fuel generators such as coal fired units and smaller peaking type plant such as gas turbines and hydro units in Tasmania, the Snowy Mountains region of Victoria and NSW as well as large pumped storage hydro station in the Southeast QLD.

Until recently it was widely considered that electricity cannot be stored in large enough proportions to be incorporated into a power system at scale because of cost and technology. However, the decreasing cost of batteries made available through the organisation such as Tesla and policy decisions such as that of the SA government, this is beginning to change.

There are various types of ancillary services used in the NEM which include:

- Frequency Control Ancillary Services (FCAS)
- System Restart Ancillary Services (SRAS)
- Network Control Ancillary Services (NCAS)

Batteries such as the one at Hornsdale are adept at providing FCAS due the very fast response and control characteristics inherent in the units. The Hornsdale Battery participates in both the Energy and FCAS markets in South Australia.

Being a battery, it both supplies energy and consumes energy, consuming for the purpose of recharging. For economic participation in the market, charging of the battery occurs and is managed when market prices are low, and supplying energy to the market occurs when prices are higher. Therefore, a profit is earned in the energy market through an arbitrage management of energy prices, mostly controlled by automatic bidding algorithms. Nearly 44% of revenue earned by Hornsdale from participating in the market in the first Quarter of 2018 was from energy, although that has subsequently decreased to around 25% as the year has continued.

A benefit to the electricity markets and the economy of South Australia is how Hornsdale participates in the FCAS markets. FCAS is used by AEMO to manage and control frequency and is essential in providing a secure and stable system.

Hornsdale participates in all eight of the FCAS markets. In the first Quarter of 2018 it earned approximately 24% of its market revenue from providing Regulation FCAS services and approximately 32 % form providing Contingency FCAS services. In providing FCAS Hornsdale has entered the markets as a participant and a competitor to other participants such as AGL and saved the South Australian economy significant costs by lowering FCAS spot prices.

To illustrate this, two days in the South Australian Raise Regulation market were studied and the pricing outcomes compared with a what if scenario for the second day if the Hornsdale Battery and Wind farm did not participate. The two days studied are 14 January 2018 and 14 September 2017. On both days the local constraint F_S+RREG_0035 was invoked. The Hornsdale battery participated in the January 2018 scenario, but not in September 2017, as it had not yet been commissioned.

September 2017

On the 14 September 2017 the constraint F_S+RREG_0035 was invoked. This meant that for SA the Raise requirement was 35 MW, to be sourced from SA participants only. Below is the bid stack.

This was before the Neoen Hornsdale Battery was commissioned. The Hornsdale wind farm was not bid to provide these services.

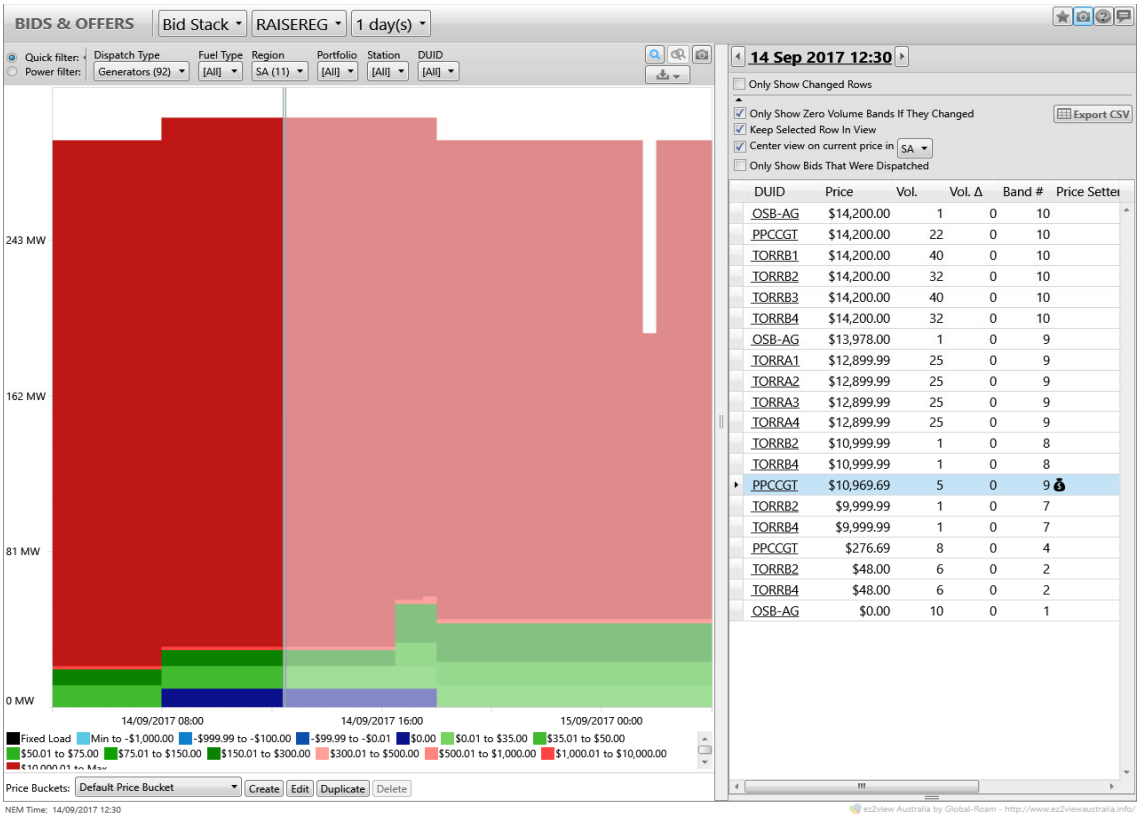
There was up to 307 MW of RReg capability available for a demand of only 35 MW.

Providers on the Day were:

- Torrens Island at 260 MW
- Pelican Point at 35 MW
- Osbourne at 12 MW

Figure 6 below shows the Raise Reg bid stack and the price being set at $10,969.69 / MWh for the Dispatch Interval 12:30 hrs on 14 September 2017.

It shows there were very few MWs between low FCAS prices in the regulation markets and the market price cap.



Interval	Duid	NormalisedPrice	EffectiveVolume	BandNumber	BidType	
14/09/2017 12:30	OSB-AG	14200	1	10	RAISEREG	
14/09/2017 12:30	PPCCGT	14200	22	10	RAISEREG	
14/09/2017 12:30	TORRB1	14200	40	10	RAISEREG	
14/09/2017 12:30	TORRB2	14200	32	10	RAISEREG	
14/09/2017 12:30	TORRB3	14200	40	10	RAISEREG	
14/09/2017 12:30	TORRB4	14200	32	10	RAISEREG	
14/09/2017 12:30	OSB-AG	13978	1	9	RAISEREG	
14/09/2017 12:30	TORRA1	12899.99	25	9	RAISEREG	
14/09/2017 12:30	TORRA2	12899.99	25	9	RAISEREG	
14/09/2017 12:30	TORRA3	12899.99	25	9	RAISEREG	
14/09/2017 12:30	TORRA4	12899.99	25	9	RAISEREG	
14/09/2017 12:30	TORRB2	10999.99	1	8	RAISEREG	
14/09/2017 12:30	TORRB4	10999.99	1	8	RAISEREG	
14/09/2017 12:30	PPCCGT	10969.69	5	9	RAISEREG	37
14/09/2017 12:30	TORRB2	9999.99	1	7	RAISEREG	32
14/09/2017 12:30	TORRB4	9999.99	1	7	RAISEREG	31
14/09/2017 12:30	PPCCGT	276.69	8	4	RAISEREG	30
14/09/2017 12:30	TORRB2	48	6	2	RAISEREG	22
14/09/2017 12:30	TORRB4	48	6	2	RAISEREG	16
14/09/2017 12:30	OSB-AG	0	10	1	RAISEREG	10

Figure 6: 5min Bid Stack - 14 September 2017

January 2018

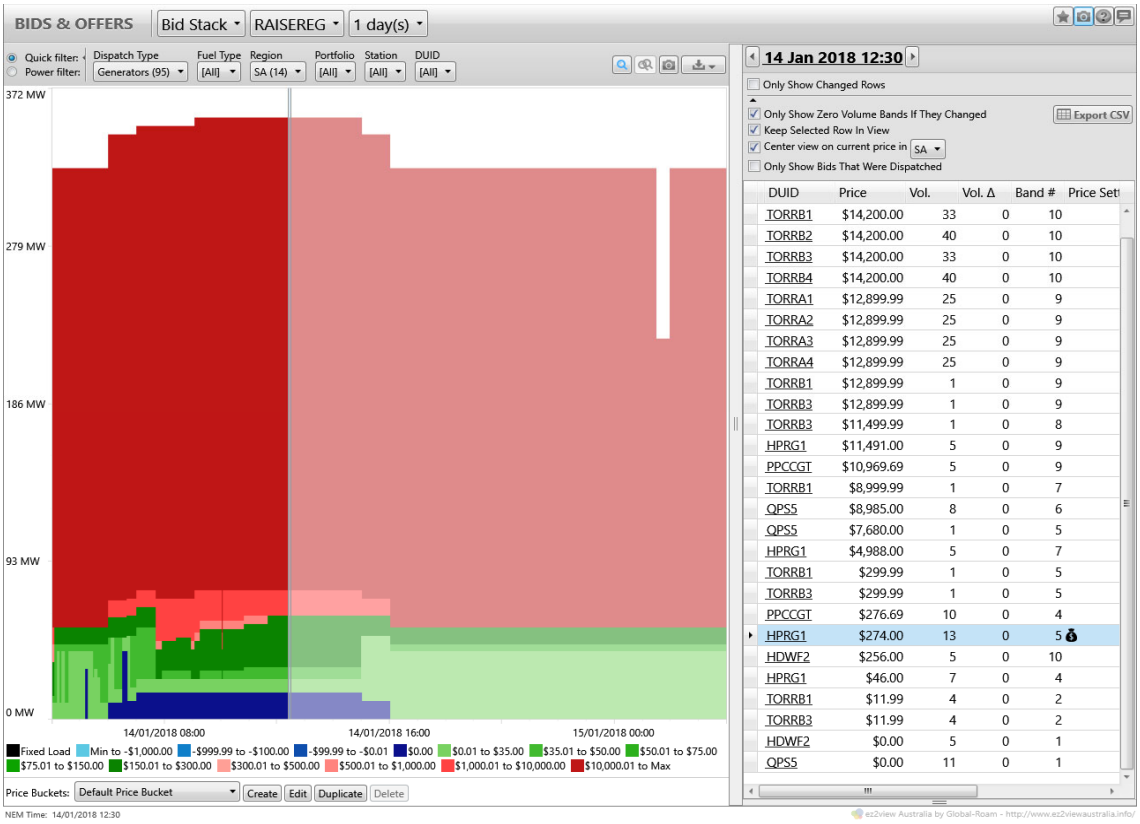
On the 14 January 2018 the constraint F_S+RREG_0035 was also invoked, however this time, HPR and Hornsdale 2 Wind Farm were able to supply additional capability.

There was up to 355 MW of RReg capability available for a demand of only 35 MW.

Providers on the Day were:

- Torrens Island at 260 MW
- Pelican Point at 35 MW
- Neoen Hornsdale Battery at 30 MW
- Quarantine at 20 MW
- Neoen Hornsdale 2 (windfarm) at 10 MW

The bid stack below for SA shows the price being set at $274 MWh by the Hornsdale battery and is shown in Figure 7. The 30 MW from Hornsdale 2 windfarm and the Hornsdale battery is priced at $274 and under has therefore reduced the price outcomes if these units were not available to provide Regulation services.



Interval	Duid	NormalisedPrice	EffectiveVolume	BandNumber	BidType	
14/01/2018 12:30	PPCCGT	14200	20	10	RAISEREG	
14/01/2018 12:30	TORRB1	14200	33	10	RAISEREG	
14/01/2018 12:30	TORRB2	14200	40	10	RAISEREG	
14/01/2018 12:30	TORRB3	14200	33	10	RAISEREG	
14/01/2018 12:30	TORRB4	14200	40	10	RAISEREG	
14/01/2018 12:30	TORRA1	12899.99	25	9	RAISEREG	
14/01/2018 12:30	TORRA2	12899.99	25	9	RAISEREG	
14/01/2018 12:30	TORRA3	12899.99	25	9	RAISEREG	
14/01/2018 12:30	TORRA4	12899.99	25	9	RAISEREG	
14/01/2018 12:30	TORRB1	12899.99	1	9	RAISEREG	
14/01/2018 12:30	TORRB3	12899.99	1	9	RAISEREG	
14/01/2018 12:30	TORRB3	11499.99	1	8	RAISEREG	
14/01/2018 12:30	HPRG1	11491	5	9	RAISEREG	
14/01/2018 12:30	PPCCGT	10969.69	5	9	RAISEREG	
14/01/2018 12:30	TORRB1	8999.99	1	7	RAISEREG	
14/01/2018 12:30	QPS5	8985	8	6	RAISEREG	
14/01/2018 12:30	QPS5	7680	1	5	RAISEREG	
14/01/2018 12:30	HPRG1	4988	5	7	RAISEREG	
14/01/2018 12:30	TORRB1	299.99	1	5	RAISEREG	
14/01/2018 12:30	TORRB3	299.99	1	5	RAISEREG	
14/01/2018 12:30	PPCCGT	276.69	10	4	RAISEREG	
14/01/2018 12:30	HPRG1	**274**	13	5	RAISEREG	49
14/01/2018 12:30	HDWF2	256	5	10	RAISEREG	36
14/01/2018 12:30	HPRG1	46	7	4	RAISEREG	31
14/01/2018 12:30	TORRB1	11.99	4	2	RAISEREG	24
14/01/2018 12:30	TORRB3	11.99	4	2	RAISEREG	20
14/01/2018 12:30	HDWF2	0	5	1	RAISEREG	16
14/01/2018 12:30	QPS5	0	11	1	RAISEREG	11

Figure 7: 5min Bid Stack - 14 January 2018

If Neoen units were taken out of the bid stack, as shown in Figure 8, the following price is likely to have occurred (shown in yellow).

Interval	Duid	NormalisedPrice	EffectiveVolume	BandNumber	BidType	
14/01/2018 12:30	PPCCGT	14200	20	10	RAISEREG	
14/01/2018 12:30	TORRB1	14200	33	10	RAISEREG	
14/01/2018 12:30	TORRB2	14200	40	10	RAISEREG	
14/01/2018 12:30	TORRB3	14200	33	10	RAISEREG	
14/01/2018 12:30	TORRB4	14200	40	10	RAISEREG	
14/01/2018 12:30	TORRA1	12899.99	25	9	RAISEREG	
14/01/2018 12:30	TORRA2	12899.99	25	9	RAISEREG	
14/01/2018 12:30	TORRA3	12899.99	25	9	RAISEREG	
14/01/2018 12:30	TORRA4	12899.99	25	9	RAISEREG	
14/01/2018 12:30	TORRB1	12899.99	1	9	RAISEREG	
14/01/2018 12:30	TORRB3	12899.99	1	9	RAISEREG	
14/01/2018 12:30	TORRB3	11499.99	1	8	RAISEREG	
14/01/2018 12:30	PPCCGT	10969.69	5	9	RAISEREG	
14/01/2018 12:30	TORRB1	8999.99	1	7	RAISEREG	
14/01/2018 12:30	QPS5	**8985**	8	6	RAISEREG	40
14/01/2018 12:30	QPS5	7680	1	5	RAISEREG	32
14/01/2018 12:30	TORRB1	299.99	1	5	RAISEREG	31
14/01/2018 12:30	TORRB3	299.99	1	5	RAISEREG	30
14/01/2018 12:30	PPCCGT	276.69	10	4	RAISEREG	29
14/01/2018 12:30	TORRB1	11.99	4	2	RAISEREG	19
14/01/2018 12:30	TORRB3	11.99	4	2	RAISEREG	15
14/01/2018 12:30	QPS5	0	11	1	RAISEREG	11

Figure 8: What if Scenario - 14 January 2018

The cost to the South Australian consumers due to the high Regulation FCAS prices on the 14 September 2017 was $6.2 Million. This was after 10.5 hours of the local constraint

F_S+RREG_0035 binding resulting in Regulation Spot prices averaging around $9,080 MWh.

The cost to the South Australian consumers on the 14 January 2018 when the same constraint was applied was only $100,717. Admittedly on this occasion the constraint was invoked for only 4.75 hours rather than 10.5, but even so the costs were greatly reduced because of the participation of the Hornsdale Power Reserve Unit and the Hornsdale Wind Farm. If they had not been part of the bid stack on the day, the cost to the SA consumer would have been $2.9 Million due to prices calculated at $8,985 MWh for Raise Regulation and $7,980 MWh for Lower Regulation. A summary is shown below in Figure 9.

	RREG	LREG	Total
ACTUAL Cost to SA due to Local Reg Constraints 14 Sep 2017 No Neoen Participation	3,100,559	3,098,460	**6,199,019**
ACTUAL Cost to SA due to Local Reg Constraints 14 Jan 2018	48,325	52,392	100,717
CALCULATED Cost to SA due to Local Reg Constraints 14 Jan 2018 WITHOUT Neoen Units providing Regulation	1,521,649	1,360,924	2,882,573
SAVING in Costs with Neoen Units participation	1,473,324	1,308,532	**2,781,856**

Figure 9: Comparative Costs (Sep 17 & Jan 18)

3.6 Assessment of FCAS Performance

HPR can be fully available for energy yet have a 0MW energy target (i.e. priced high in energy), and still providing all FCAS services. Table 1 below shows HPRG1 dispatch outcomes through a 90 minutes period in February 2018. With its Energy Availability = 100MW, AGC Upper Limit (RaiseRegEnablementMax) = 30MW and AGC status remaining on throughout the period, the dispatch outcomes below highlight actual movement of the battery for regulation control occurred (see green line in Figure 10) in over half the described intervals, with a regulation throughput of approx. 40%. There are also two highlighted periods where the generation in HPR was above the regulation levels when the frequency had fallen through 49.85 (twice within a 60 minute period). Note the periods where the Regulation level is below zero indicate when HPR was charging (i.e. HPRL1 shows InitialMW's).

DATETIME	INITIAL MW	TOTAL CLEARED	RAISE 5 MIN	RAISE 60 SEC	RAISE 6 SEC	RAISE REG	LOWER REG
16-Feb 13:30	0	0	41	19	63	7.96	0
16-Feb 13:35	0	0	41	19	63	7.95	0
16-Feb 13:40	7.3	0	41	19	63	15	0
16-Feb 13:45	0	0	41	19	63	7.96	0
16-Feb 13:55	0	0	41	19	63	8	0
16-Feb 14:00	0	0	41	19	63	7.96	0
16-Feb 14:05	4.1	0	41	19	63	15	0
16-Feb 14:10	10.4	0	41	19	63	7.98	0
16-Feb 14:35	0.2	0	41	19	63	30	0
16-Feb 14:40	28.5	0	41	19	63	30	0
16-Feb 14:45	27.4	0	41	19	63	23	0
16-Feb 14:50	8.1	0	41	19	63	20	0
16-Feb 14:55	2.5	0	41	19	63	20	0
16-Feb 15:00	15.7	0	41	19	63	23	0
16-Feb 15:05	0	0	41	19	63	23	0
16-Feb 15:10	0	0	41	19	63	16	0
16-Feb 15:15	15.9	0	41	19	63	20	0

Table 1: HPR (Gen) FCAS Provision (no energy target)

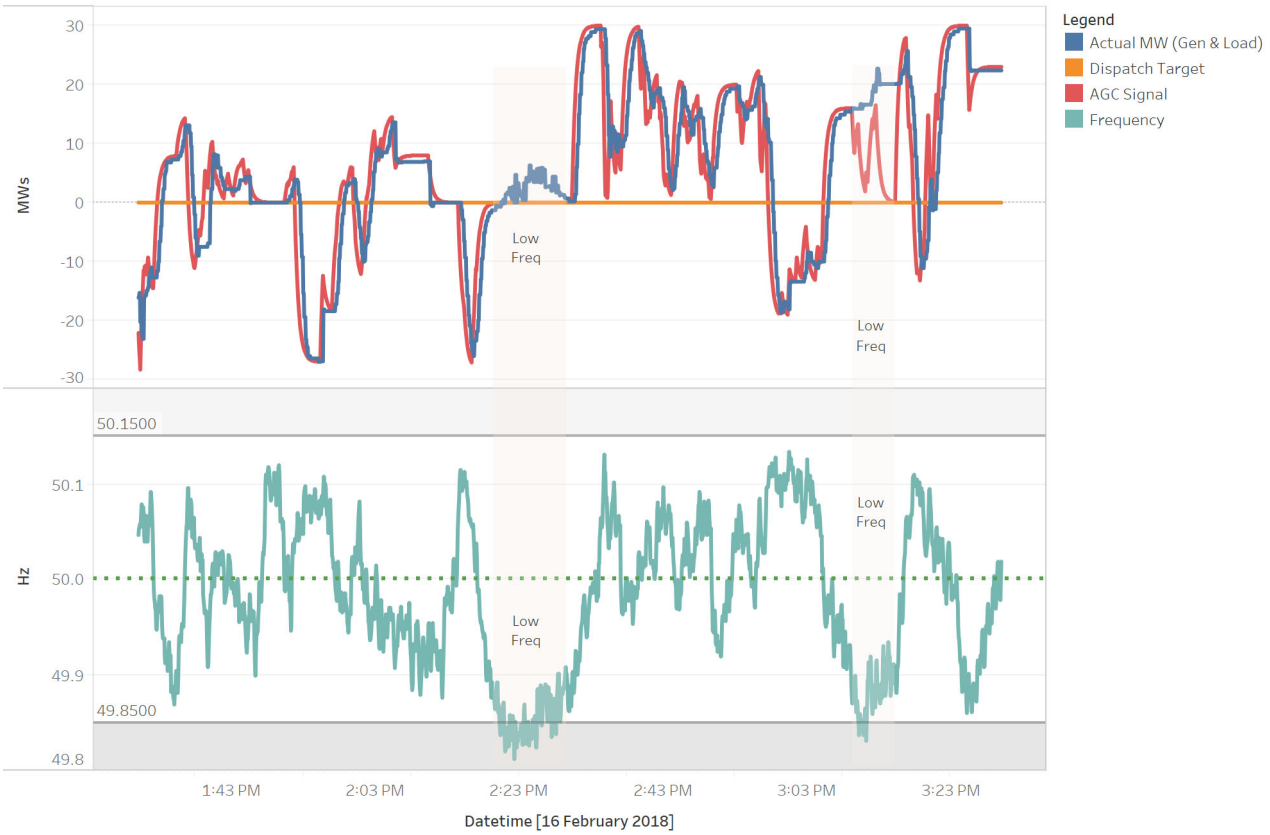


Figure 10: HPR Frequency Response (16 Feb 18)

4 Comparison with other Generators

4.1 HPR in Context

As of March 2018, the installed capacity of Scheduled and Semi Scheduled generators in South Australia which are currently in service totalled 4500 MW. There is also 277 MW of Diesel generation owned by the South Australian Power Networks, but as of March 2018 they were not classed as being in service.

In total there are some 665 Units across 28 power stations operating in South Australia.

The Hornsdale battery is in a category all by itself and is the smallest of its type. At 100 MW it has only 2% of the regions capacity: It is a little player with a big impact.

In terms of FCAS it has more of a market share with 21 % of the regions capacity. This is combining both the capability of the Battery as a generator and as a load.

There are only six power stations that are registered to provide FCAS in SA.

These are:

- Pelican Point Power Station owned by Pelican Point Power Ltd
- Torrens Island owned by owned by AGL SA Generation Pty Ltd
- Osborne Power Station owned by Origin Energy Electricity Ltd
- Lonsdale Power Station owned by Snowy Hydro Limited
- Hornsdale Wind farm owned by HWF Pty Ltd
- Hornsdale Power Reserve (Battery) owned by Hornsdale Power Reserve Pty Ltd

Total capacity of all services is illustrated below (Figure 11).

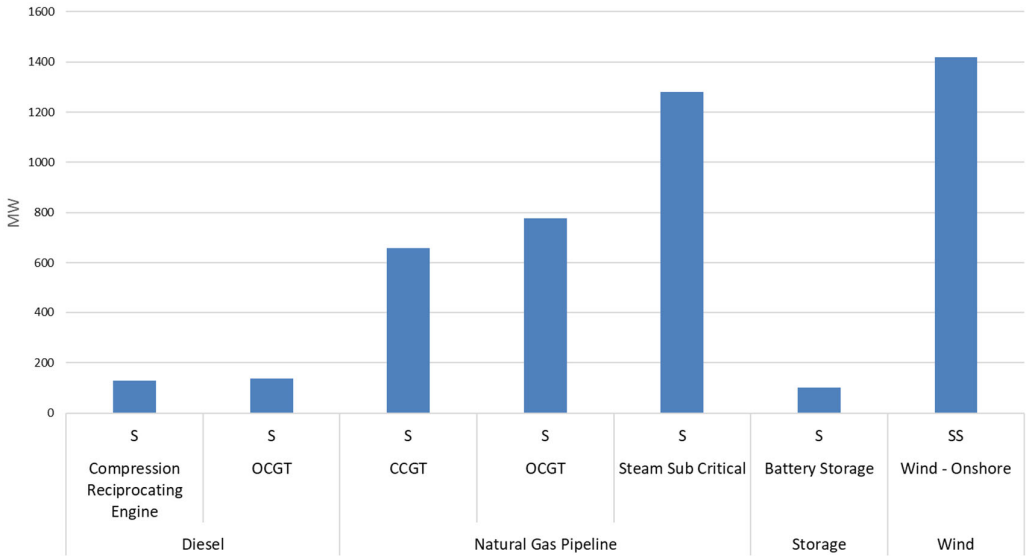


Figure 11: SA Generator Capacity

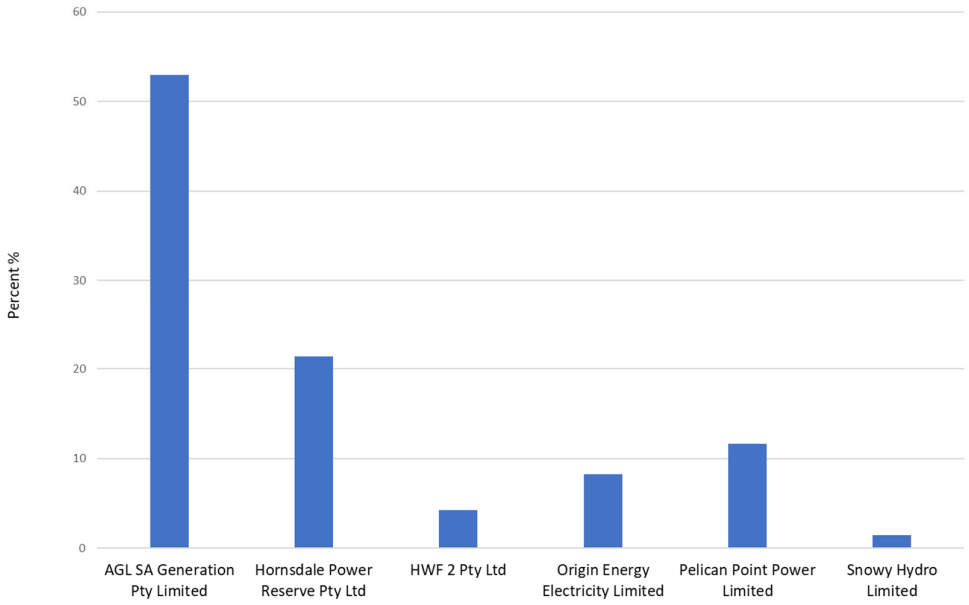


Figure 12: Percentage Share of FCAS Market

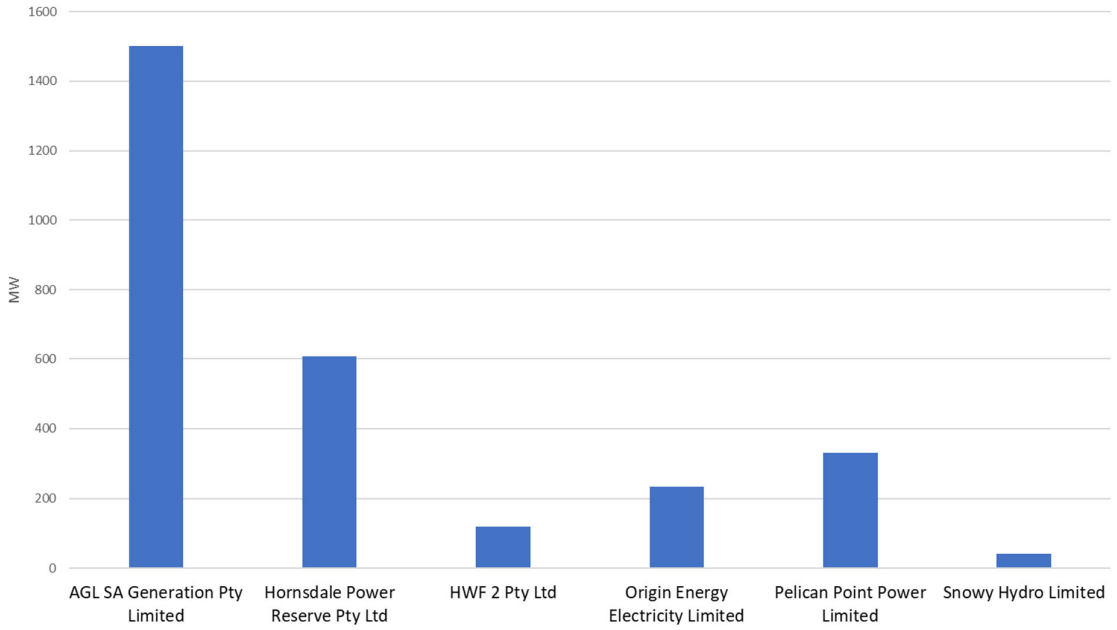


Figure 13: SA Total FCAS Capacity by Participant

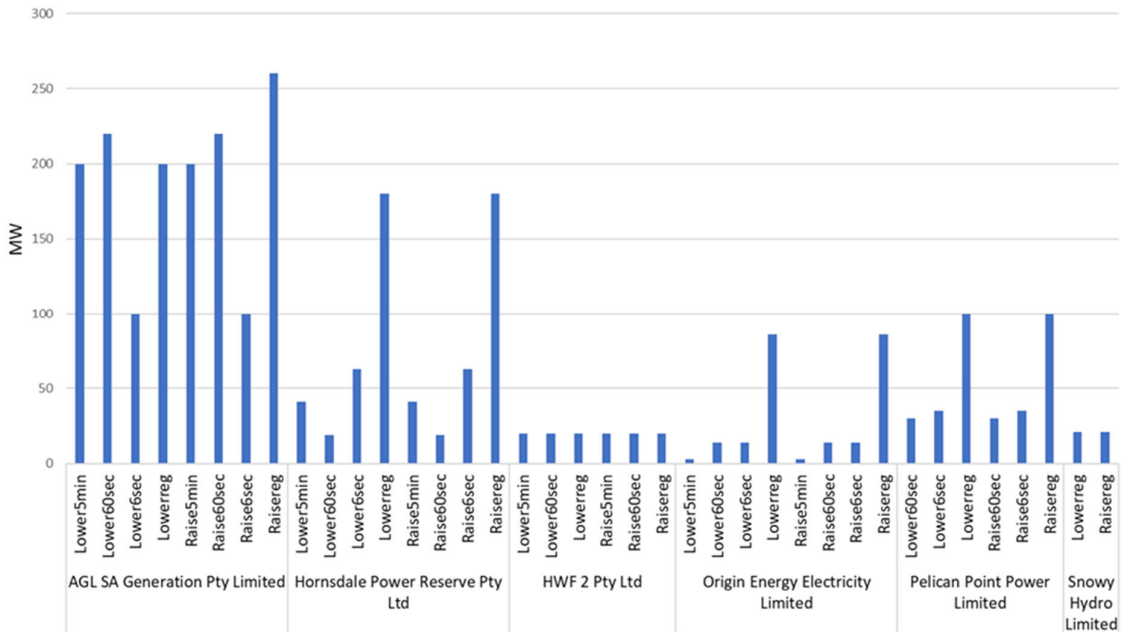


Figure 14: SA FCAS Capacity by Participant & Service

Therefore, although it is a small contributor to the energy and ancillary service markets, it is having a big impact in the market. HPR is the most active participate in the market based on the number of bids submitted each day. The programming of the market bidding systems is designed to maximise the benefit to its owners by continually optimising its position in the

market each dispatch interval. The average number of bids per day is 250, compared to other participants who only submitted a fraction of this at approx. 25-30.

4.2 Revenue Comparisons with other Storage Facilities

The following table lists the relative revenue of HPR, as well as similarly sized storages facilities in QLD and NSW. As can be seen, the relative mix of energy and FCAS services is similar despite different time periods

Figure 15: Financial Outcomes - Similar Storage Solution

	Shoalhaven	**Wivenhoe**	**Hornsdale Power Reserve**
Time Period:	*1 Jan 2017 to 30 Sep 2018 = 638 days*		*Jan to Sep 2018*
Generation			
Gen Energy Rev $	32,541,423	22,842,094	5,110,211
Gen Regulation Rev $		0	1,662,519
Gen Contingency Rev $		8,813,921	9,569,550
Gen Energy MWh	198,180	85,835	29,588
Gen Regulation MWh		0	51,646
Gen Contingency MWh		1,054,367	796,350
Load			
Load Energy (Cost) $	16,719,742	9,049,301	2,448,574
Load Regulation Rev $		0	1,394,529
Load Contingency Rev $		21,198	276,655
Load Energy MWh	250,910	142,733	36,218
Load Regulation MWh		0	87,532
Load Contingency MWh		5,715	532,775
Generation to Pump Load Ratio	0.8	0.6	0.8
LWA $			
Generation Energy	164.20	266.12	172.71
Gen Regulation			32.19
Gen Contingency		8.36	12.02
Load Energy	66.64	63.40	67.61
Load Regulation			15.93
Load Contingency		3.71	0.52
Total Revenue			
Energy	15,821,681	13,792,793	2,661,637
Regulation FCAS	0	0	3,057,048
Contingency FCAS	0	8,835,119	9,846,206
Total	15,821,681	22,627,912	15,564,890
Percentage of Total Revenue %			
Energy	100	61	17
Regulation FCAS	0	0	20
Contingency FCAS	0	39	63

	Shoalhaven	Wivenhoe	Hornsdale Power Reserve
Period - Days	638	638	273
Revenue per day			
Energy	24,799	21,619	9,750
Regulation FCAS	0	0	11,198
Contingency FCAS	0	13,848	36,067
Total	24,799	35,467	57,014
Revenue per day per MW Capacity			
Station Capacity	240	500	**100**
Energy	103	43	97
Regulation FCAS	0	0	112
Contingency FCAS	0	28	361
Total	103	71	570
Station Capacity Factor			
Station Capacity MWh	3,674,880	7,656,000	655,200
Actual Generation MWh	198,180	85,835	29,588
Capacity Factor	5.4	1.1	4.5

At this stage, there is no verifiable determination of the cost similarities for various VPP's that have been proposed and the above storage solutions, especially the battery. Similarly, although the Dalrymple Battery has been commissioned, there is currently inadequate operation for meaningful comparisons at this stage.

5 Further Considerations

As identified above, there have been a number of benefits associated with the installation of HPR that have contributed to SA and the wider NEM, particularly around FCAS. Despite the battery not impacting the amount of inertia on the overall system, it's response rate and performance through the past 9 months have been positive and at or above expectation.

Although the exact amount of benefit to the SA economy from the battery alone is difficult to estimate, it would appear the initial benefits have outweighed the initial SA Government outlay. This would require further detailed analysis.

There have been numerous periods in the assessment period when the battery has charged during high renewable generation periods, which on some occasions has been associated with low priced energy RRP within SA. Despite initial reports, there is no electrical connection between the Hornsdale wind farms and the battery, so the concept of the battery 'being filled by curtailed wind' does not (and will not) exist – it will take a hybrid dispatchable solution for this concept to be realised.

As noted in section 3.4, the current development approval process for SA includes the need for additional inertia or fast frequency response capability at the time of development approval[2]. This requires developers to ensure that adequate equipment is installed to meet the stated requirements. Although more significant than other NEM regions, this measure

[2] https://www.sa.gov.au/__data/assets/pdf_file/0003/311448/Generator-development-approval-procedure-V1.1.pdf

does continue the process of increasing installation of equipment other than simply MW / MVaR equipment and recognises the system-wide impacts of all generation types.

This was further recognised in AEMO's Integrated System Plan (ISP) released in July 2018[3], which notes that additional system security constraints are currently (and will continue) to be required in SA (and possibly other regions) going forward. Even under scenarios involving increased interconnection with other regions (such as NSW via Riverlink), existing system security considerations will be necessary and will remain in place as short-circuit current rations (sometimes used as a measure of system strength) is not altered through enhanced through interconnectors. Although this should be welcome by SACOSS as ensuring system security remains a key priority of AEMO, there is a minor increase in cost of generation in SA due to the addition of these requirements, which would eventually be passed onto SA consumers. Similarly, the enhancement of the SA Transmission network with the addition of the System Integrated Protection Scheme (SIPS) by AEMO/Electranet is a welcome addition once commissioned. It is GVSC's understanding that most (or all) new batteries in SA will be required to participate in the protection scheme, especially where SA government money has been used to enhance any new project.

For SACOSS, as has occurred in recent years[4], public support for utility-scale batteries is recommended and to be supported for the short-to-medium term (from now until at least the next 18 months). After 18 months, another minor review should be conducted to ensure any public money spent in SA on utility scale batteries is worthy of continued support.

[3] https://www.aemo.com.au/Media-Centre/2018-Integrated-System-Plan

[4] https://www.sacoss.org.au/sacoss-welcomes-sa-governments-plan-energy-security