Electricity spot prices above $5000/MWh

South Australia, 2 March 2020

29 April 2020

AUSTRALIAN ENERGY REGULATOR

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Amendment Record

Version	Date	Pages
Final report	29 April 2020	21

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1 Obligation

The Australian Energy Regulator (AER) regulates energy markets and networks under national legislation and rules in eastern and southern Australia, as well as networks in the Northern Territory. Its functions include:

- monitoring wholesale electricity and gas markets to ensure energy businesses comply with the legislation and rules, and taking enforcement action where necessary;
- setting the amount of revenue that network businesses can recover from customers for using networks (electricity poles and wires and gas pipelines) that transport energy;
- regulating retail energy markets in Queensland, New South Wales, South Australia, Tasmania (electricity only), and the ACT;
- operating the Energy Made Easy website, which provides a retail price comparator and other information for energy consumers;
- publishing information on the performance of energy markets, including the annual State of the energy market report and biennial effective competition report, to assist stakeholders and the wider community.

The AER is required to publish a report whenever the electricity spot price exceeds $5000 per megawatt hour ($/MWh) in accordance with clause 3.13.7 (d) of the National Electricity Rules.

The report:

- describes the significant factors contributing to the spot price exceeding $5000/MWh, including withdrawal of generation capacity and network availability;
- assesses whether rebidding contributed to the spot price exceeding $5000/MWh;
- identifies the marginal scheduled generating units; and
- identifies all units with offers for the trading interval equal to or greater than $5000/MWh and compares these dispatch offers to relevant dispatch offers in previous trading intervals.

These reports are designed to examine market events and circumstances that contributed to wholesale market price outcomes and are not an indicator of potential compliance issues or enforcement action.

2 Summary

On 2 March 2020 the spot price in South Australia for electricity reached $5063/MWh and $7027/MWh for the 2 pm and 2.30 pm trading intervals respectively.

At midday, the Heywood interconnector, which connects South Australia to Victoria, tripped due to equipment failure at the Heywood substation in south west Victoria. This trip meant the South Australian region was electrically separated or islanded from the rest of the power system. When a region is islanded all demand and power system security requirements must be met locally.

To manage the unplanned outage, AEMO (the market operator) invoked constraints and issued directions to generators to maintain power system security in South Australia. In effect, these constraints limited the output of multiple generators that had low priced capacity offered to the market.

Just before the high prices eventuated, participants rebid over 550 MW of wind generation from prices between the floor and $300/MWh to the market price cap. These rebids further reduced the available supply of low priced electricity and contributed to the dispatch price reaching $14 700/MWh for five dispatch intervals.

3 Analysis

The following sections provide analysis of the factors that led to the spot price exceeding $5000/MWh in South Australia.

3.1 Overview of actual and expected conditions

The spot price exceeded $5000/MWh for the 2 pm and 2.30 pm trading intervals. Table 1 shows the actual and forecast spot prices along with demand and local availability for the 2 pm to 3 pm trading intervals in South Australia.

Table 1: Actual and forecast spot prices, demand and available capacity for South Australia

Trading interval	Price ($/MWh)			Demand (MW)			Availability (MW)		
	Actual	4 hr forecast	12 hr forecast	Actual	4 hr forecast	12 hr forecast	Actual	4 hr forecast	12 hr forecast
2 pm	**5063**	**-3**	**-1000**	**693**	**618**	**629**	**2318**	**2277**	**2260**
2.30 pm	**7027**	**32**	**-1000**	**586**	**619**	**631**	**2376**	**2158**	**2291**
3 pm	-300	35	-1000	637	657	643	2684	2321	2483

Table 1 shows:

- For the 2 pm and 2.30 pm intervals, the actual price exceeded $5000/MWh. Earlier forecasts had anticipated prices to be below $33/MWh. The amount of generation offered into the market was higher than forecast. Due to the following factors, five dispatch intervals were priced at the cap:
    - First, there was a trip of the Heywood interconnector, leaving South Australia electrically isolated from the rest of the NEM.
    - Second, much of the low priced generation was held back for system security reasons and unable to make it to market, reducing the amount of low priced generation available.
    - Finally, participants rebid over 550 MW of low priced wind capacity to the price cap.
- The 3 pm spot price of -$300/MWh was lower than forecast because two 5 minute dispatch intervals were priced at the price floor as participants rebid capacity to the floor, in response to the high prices.

3.2 Supply

This section explores the supply side factors that had an effect on the high price outcomes. Following the unplanned outage of the Heywood interconnector, three factors reduced the availability of low priced generation by around 1400 MW. First, AEMO invoked constraints limiting certain generators for power system security reasons. Second, AEMO directed off some low priced generation, again, to protect the power system. Finally, participants rebid a significant amount of low priced wind generation to the market cap.

3.2.1 Outage of the Heywood Interconnector

Around midday, a high voltage switching device known as a circuit breaker at the Heywood substation failed, leading to a trip of the Heywood interconnector. This trip meant South Australia was electrically islanded from the rest of the NEM. As a result, from the 12.15 pm dispatch interval, constraints were invoked to manage system security of the power system in South Australia and to ensure local generators could provide Frequency Control Ancillary Services (FCAS).

Interconnectors and constraints in the NEM

The regions of the National Electricity Market are connected via high voltage interconnectors, through which electricity is transferred. For example, South Australia is connected to Victoria via two interconnectors, Heywood and Murraylink. The Heywood interconnector is an alternating current (AC) high voltage transmission link which can transfer frequency control ancillary services (FCAS) from the rest of the NEM, while Murraylink is a direct current (DC) transmission link that cannot transfer FCAS.

Import and export limits control the maximum amount of electricity that can flow between regions across interconnectors. The market operator, AEMO, manages the flow and source of electricity across the network using constraints to ensure that system security is maintained. Constraints are mathematical equations that manage or "limit" generation output or flows on specific transmission lines (including interconnectors) for each five minute dispatch interval.

Along with constraints, AEMO also issued directions to generators in South Australia to manage power system security. Three non-scheduled wind farms were directed off and two gas generators were directed on.

Table 2 below shows the stations that were directed on and off along with the registered capacity that was under direction. Details of these directions and other relevant notices can be found in *Appendix D: Market Notices.*

Table 2: System security directions issued by AEMO

Action taken by AEMO	Participant	Station	Capacity (MW)
Directed on	Engie	Mintaro	90
	Engie	Pelican Point	160
Directed off	Engie	Canunda WF	46
	AGL	Wattle Point WF	91
	Ratch	Starfish Hill WF	35

3.2.2 Constrained capacity following the islanding event

Once South Australia was separated from the rest of the NEM, AEMO invoked constraints to manage the local network and keep the power system in a secure operating state. During the

dispatch intervals of 1.55 pm to 2.15 pm inclusively, (when the price was at the cap) these constraints prevented up to 815 MW of generation capacity priced less than $5000/MWh from being dispatched. Despite participants offering this capacity, the operating conditions and security concerns effectively prevented them from participating and as a result more expensive capacity was dispatched to meet demand.

In effect, these constraints limited the output of some generators based on their technical capabilities, to enable other generators with different capabilities that could provide a number of services, other than just energy, such as inertia and FCAS, to be dispatched.

During the five dispatch intervals when the price was at the cap these constraints reduced imports across Murraylink to 0 MW and curtailed local generation. The following table shows the number of megawatts priced below $5000/MWh that were unable to make it to market during these times.

Table 3: Constrained capacity priced less than $5000/MWh

		Constrained capacity <$5000/MWh (MW)				
Participant	**Station**	**1.55 pm**	**2 pm**	**2.05 pm**	**2.10 pm**	**2.15 pm**
AGL	Barkers Inlet	175	183	199	199	210
AGL	Torrens Island	77	77	76	77	
EnergyAustralia	Hallett	60	20	20	18	20
Engie	Dry Creek				40	40
Engie	Snuggery	21	21	21	21	21
Infingen	Lake Bonney BESS	3				
Infingen	Lake Bonney 2 WF	33	29	34	35	31
Infingen	Lake Bonney 3 WF	5	7	8	8	7
Lincoln Gap	Lincoln Gap WF				6	6
Neoen	Hornsdale Power Reserve	25	28	28	28	28
Origin	Bungala SF	21	100	115	129	124
Origin	Ladbroke Grove			82	72	82
Origin	Quarantine			27	25	27
Snowy Hydro	Angaston		43	46	49	
Snowy Hydro	Lonsdale		9	9	10	10
Snowy Hydro	Pt Stanvac		55	59	63	63
Vena Energy	Tailem Bend SF			89	13	15
Total		**420**	**571**	**815**	**793**	**685**

3.2.3 Generation availability

This section discusses the amount and price of available generation on the day.

During the period that spot prices were above $5000/MWh, around 2300 MW of generation capacity was offered into the market out of the 4900 MW installed in South Australia. Of the

1800 MW of semi-scheduled wind installed, low wind conditions meant less than 200 MW was available. In line with AGL's announcement to displace Torrens Island A generation with Barker Inlet, 1000 MW of capacity was not offered at Torrens power station.[1] Also, Origin Energy's Osborne power station, a 180 MW gas powered generator, has been unavailable since the end of February 2020.

Figure 1 shows the cumulative generator offers for South Australia. Also known as closing bids, the figure shows the actual capacity offered by generators, to match changes to their own commercial and/or physical circumstances. Capacity offered below $5000/MWh is shown in light green and capacity offered above $5000/MWh is in dark green. The red, black and blue lines show the local dispatch (MW), local demand (MW) and spot price ($/MWh) for electricity in South Australia respectively.

Figure 1: Generator availability South Australia

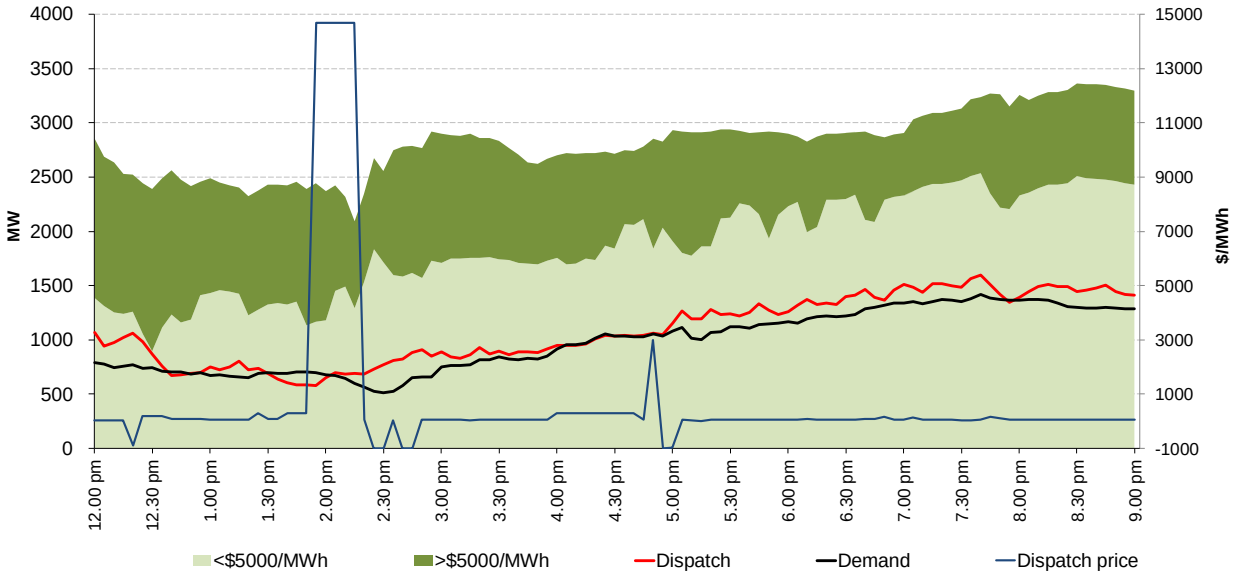


Figure 1 shows the local dispatch line for electricity falling in the light green area (where the capacity offered is priced less than $5000/MWh). However the dispatch price reached the market price cap of $14 700/MWh between 1.55 pm and 2.15 pm because up to 815 MW of capacity, priced less than $5000/MWh, was constrained (see the previous section), effectively reducing the light green area by up to 815 MW. Furthermore, some participants were providing FCAS instead of energy, reducing the available supply of low priced generation further and pushing the red line higher into the dark green area.

The closing bids for all participants in South Australia with capacity priced at or above $5000/MWh for the high-price periods are set out in *Appendix A: Closing bids*.

3.2.3.1 Generator rebidding

Shortly after 1 pm, around 550 MW of generation at five windfarms was rebid from prices between the floor and $299/MWh to the market price cap of $14 700/MWh. The table below summarises these rebids and rebid reasons.

[1] https://thehub.agl.com.au/articles/2019/05/transition-at-torrens-island

Table 4: Rebidding from low to high prices

Participant	Capacity rebid from less than $330/MWh to the cap (MW)		Reason given
	2 pm	2.30 pm	
EnergyAustralia	130	0	Change in forecast price
Pacific Hydro	57	57	Change in forecast price
Trustpower	369	369	Change in forecast price and high raise 6 second prices
Total	**556**	**426**	

These rebids further reduced the available supply of low priced capacity and contributed to the dispatch price reaching $14 700/MWh for five dispatch intervals.

Significant rebids are contained in *Appendix B: Significant rebids*.

Figure 2: Forecast and actual generation mix in South Australia

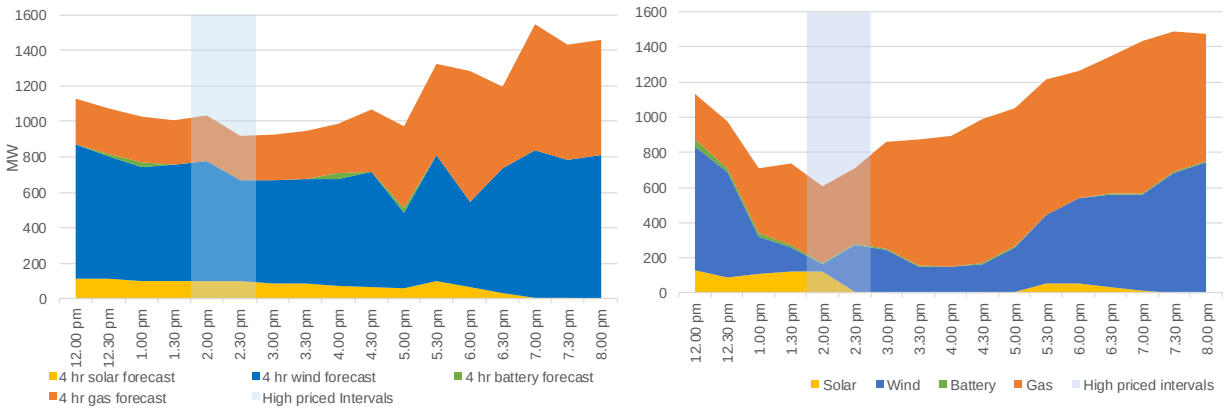


Figure 2 compares the expected generation mix by fuel type in South Australia four hours prior to the actual mix that was dispatched. The four hour forecast was published before the trip of the Heywood interconnector to show the expected unconstrained dispatch of generation. Prior to the trip low cost wind generation was expected to meet over 60 per cent of the demand, and gas less than 30 per cent of demand. However, after the trip of Heywood, once constraints, directions and rebidding took place, wind provided as little as seven per cent of the demand and gas generators increased output to provide as much as 72 per cent of the demand.

At 8.05 pm the Heywood interconnector was returned to service and all outstanding interventions were cancelled.

The generators involved in setting the price during the high-price periods, and how that price was determined by the market systems are detailed in *Appendix C: Price Setter.*

Australian Energy Regulator

April 2020

Appendix A: Closing bids

Figure A1 to A8 highlight the half hour closing bids for participants in South Australia with capacity priced at or above $5000/MWh during the periods in which the spot price exceeded $5000/MWh. They also show generation output and the spot price.

Figure A1: EnergyAustralia (Hallett, Waterloo Wind Farm) closing bids, dispatch and spot price

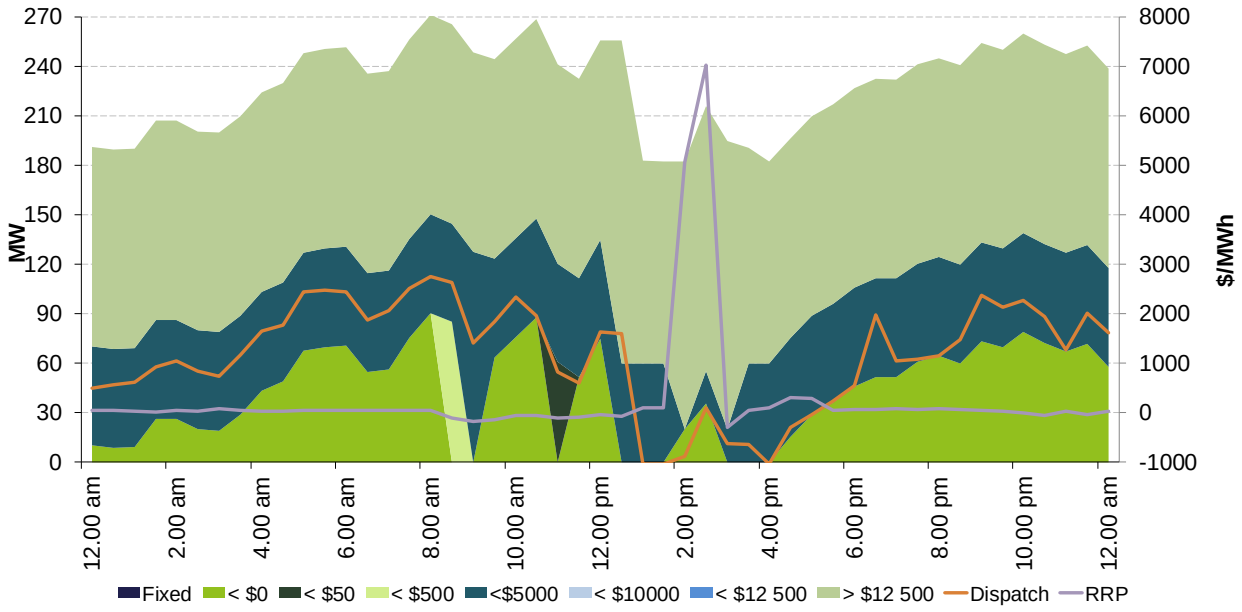


Figure A2: Engie (Dry Creek, Mintaro, Pelican Point, Port Lincoln, Snuggery, Willogoleche Wind Farm) closing bids, dispatch and spot price

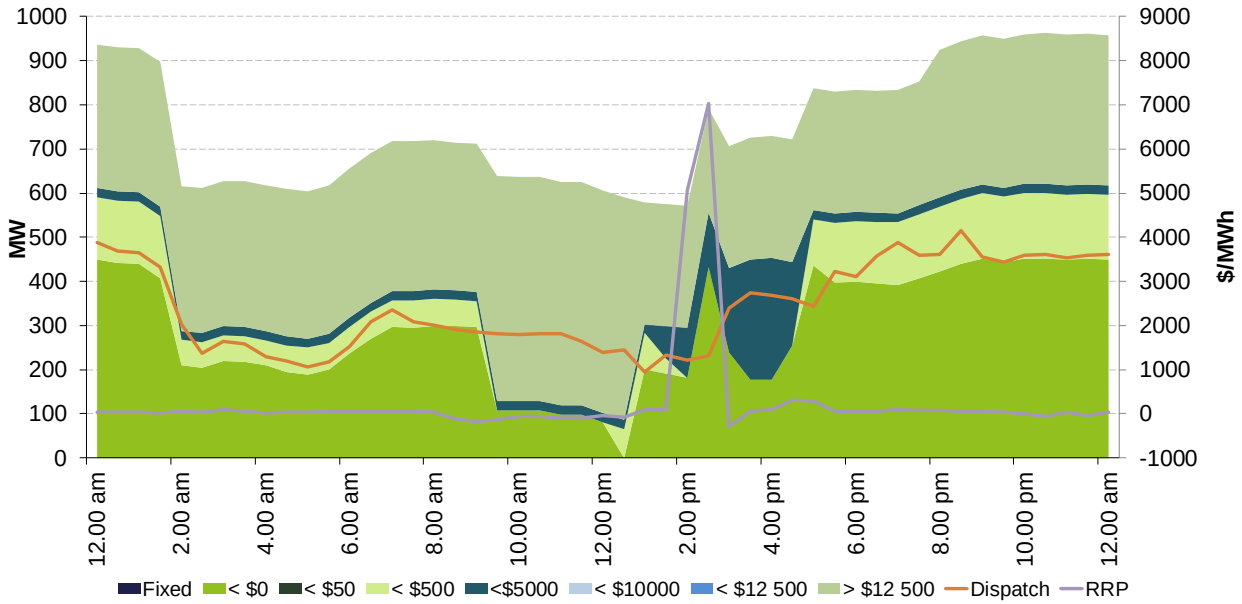


Figure A3: Greentricity (Dalrymple North Battery) closing bids, dispatch and spot price

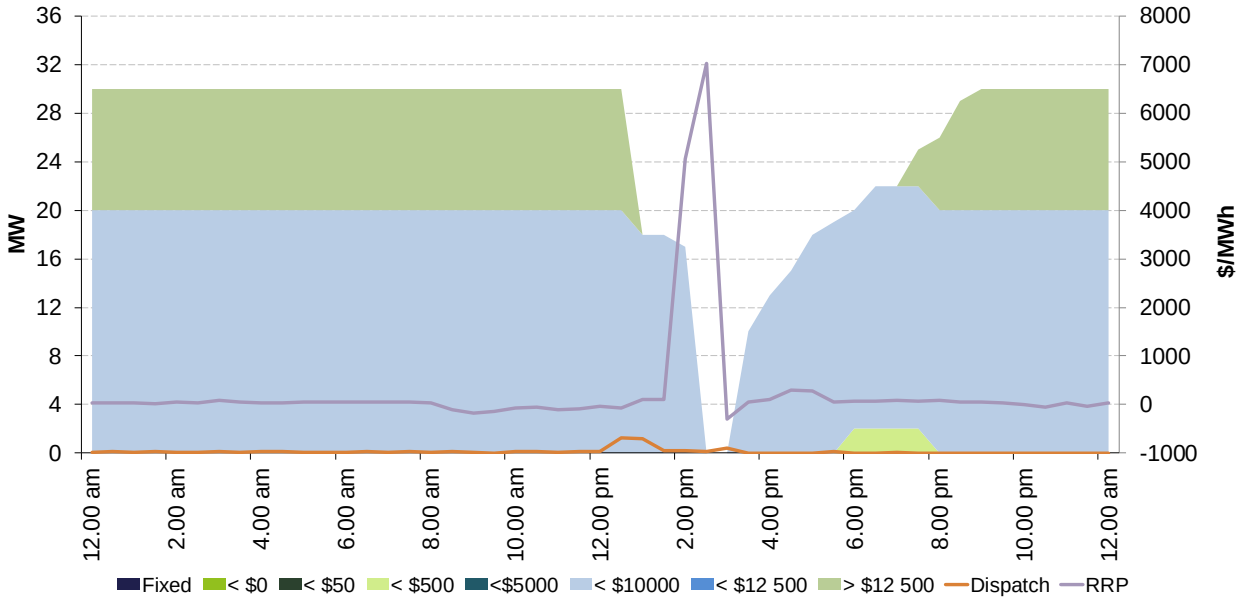


Figure A4: Infigen (Lake Bonney BESS, Lake Bonney 2 Wind Farm, Lake Bonney 3 Wind Farm) closing bids, dispatch and spot price

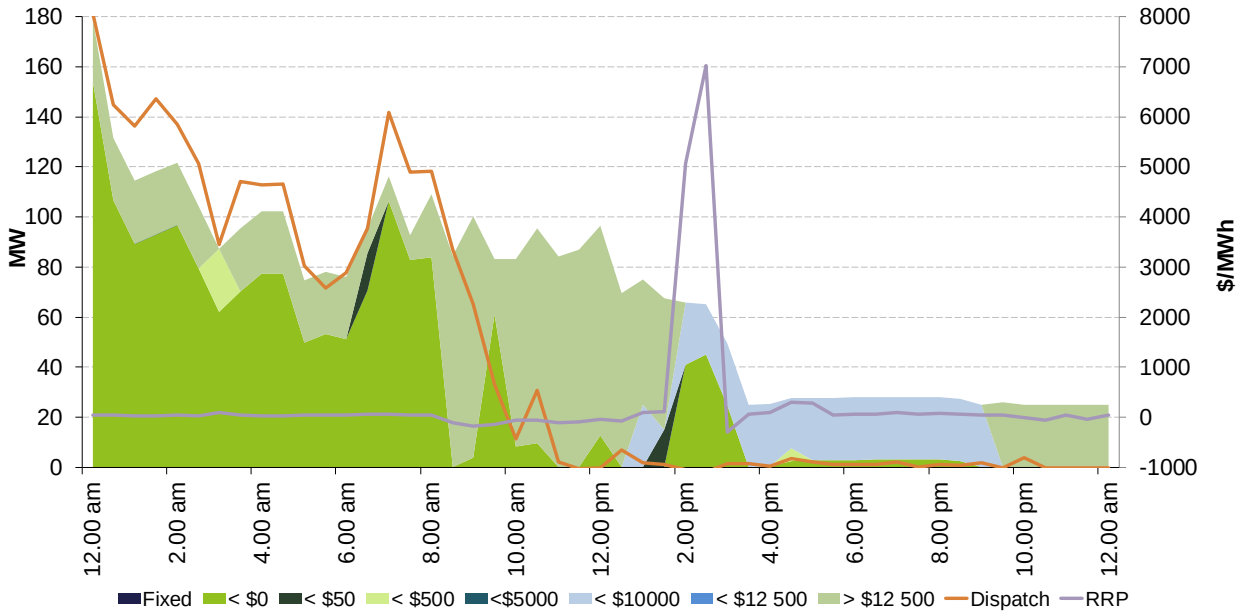


Figure A5: Neoen (Hornsdale Wind Farm, Hornsdale Power Reserve) closing bids, dispatch and spot price

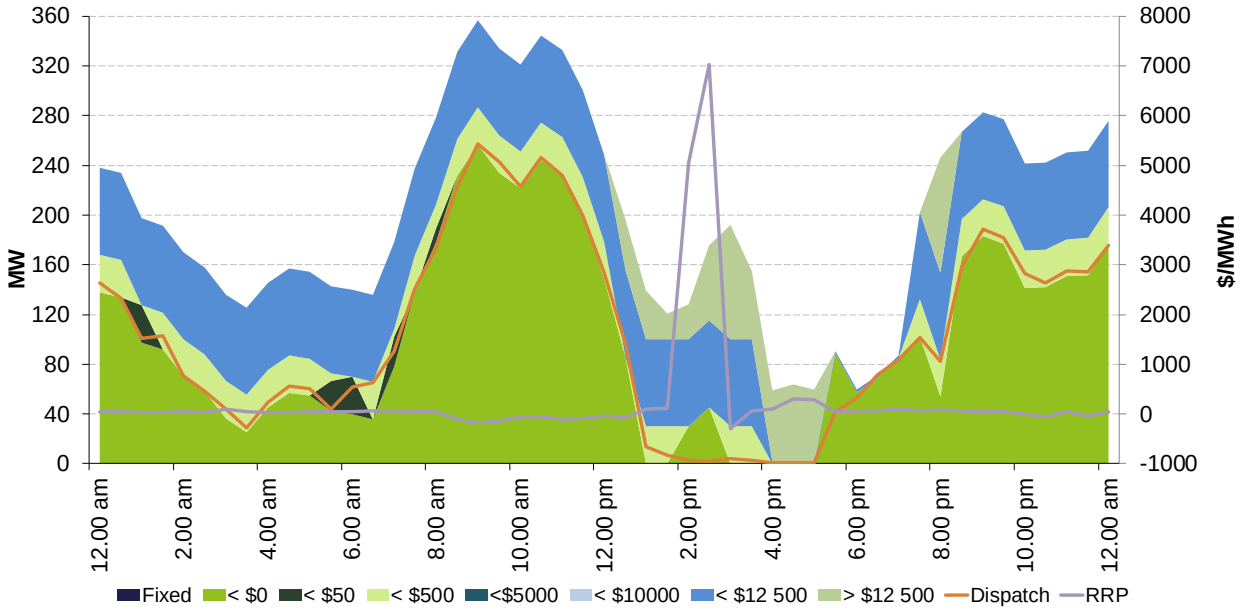


Figure A6: Origin (Ladbroke Grove, Osborne, Quarantine) closing bids, dispatch and spot price

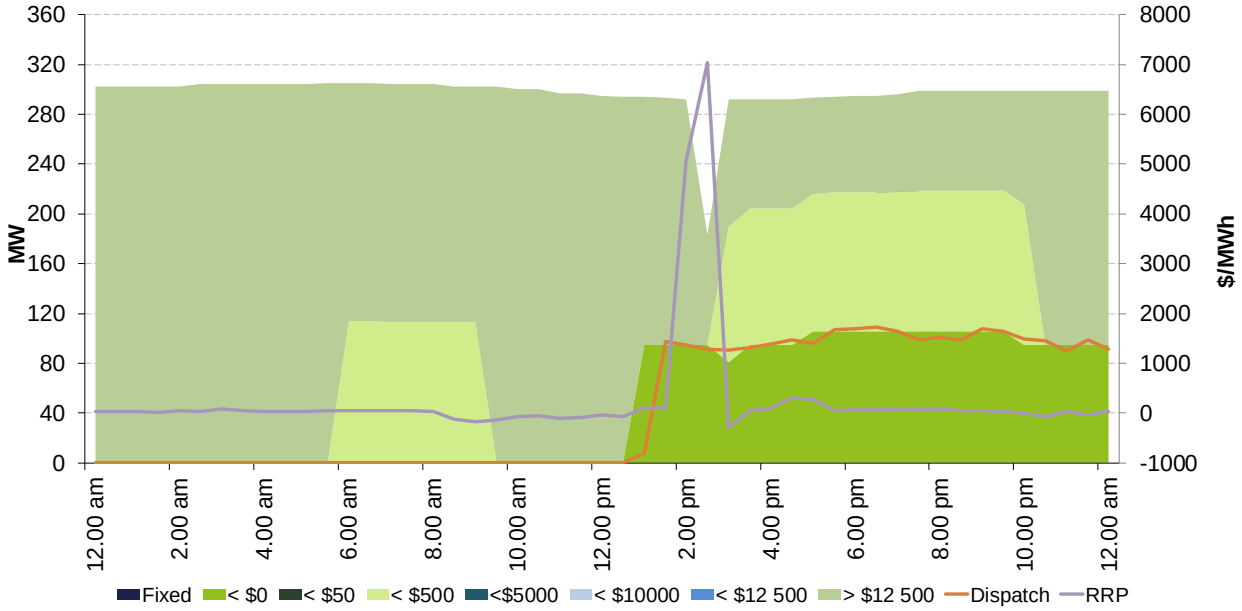


Figure A7: Pacific Hydro (Clements Gap Wind Farm) closing bids, dispatch and spot price

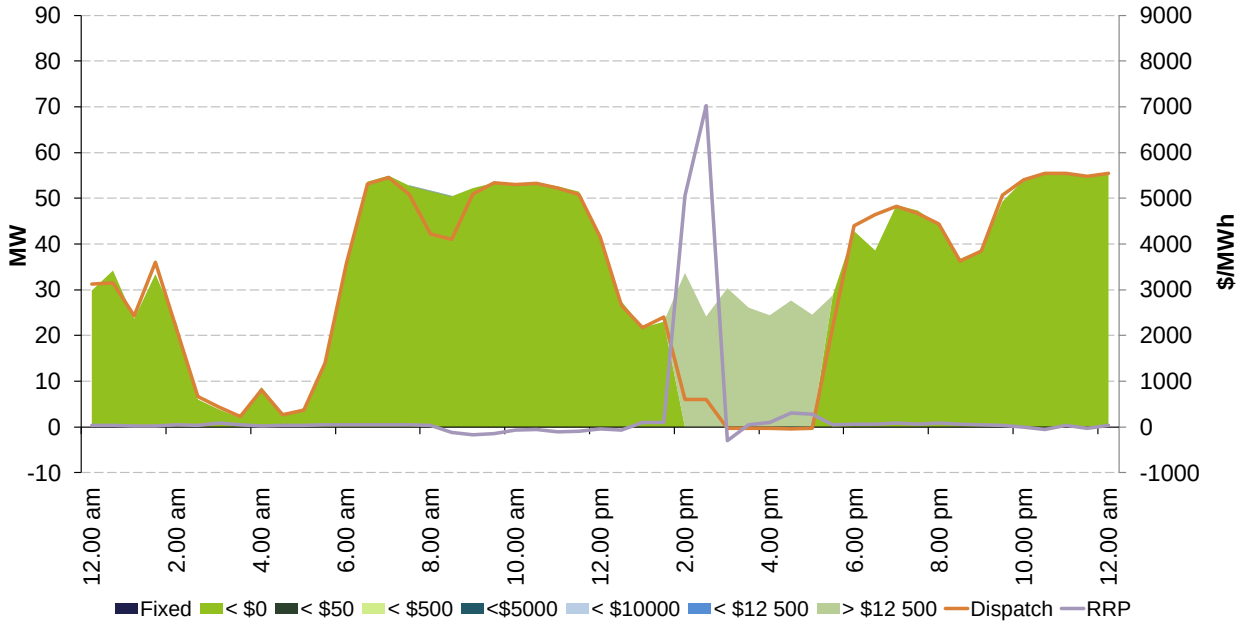


Figure A8: Trustpower (Snowtown North, Snowtown South and Snowtown wind farms) closing bids, dispatch and spot price

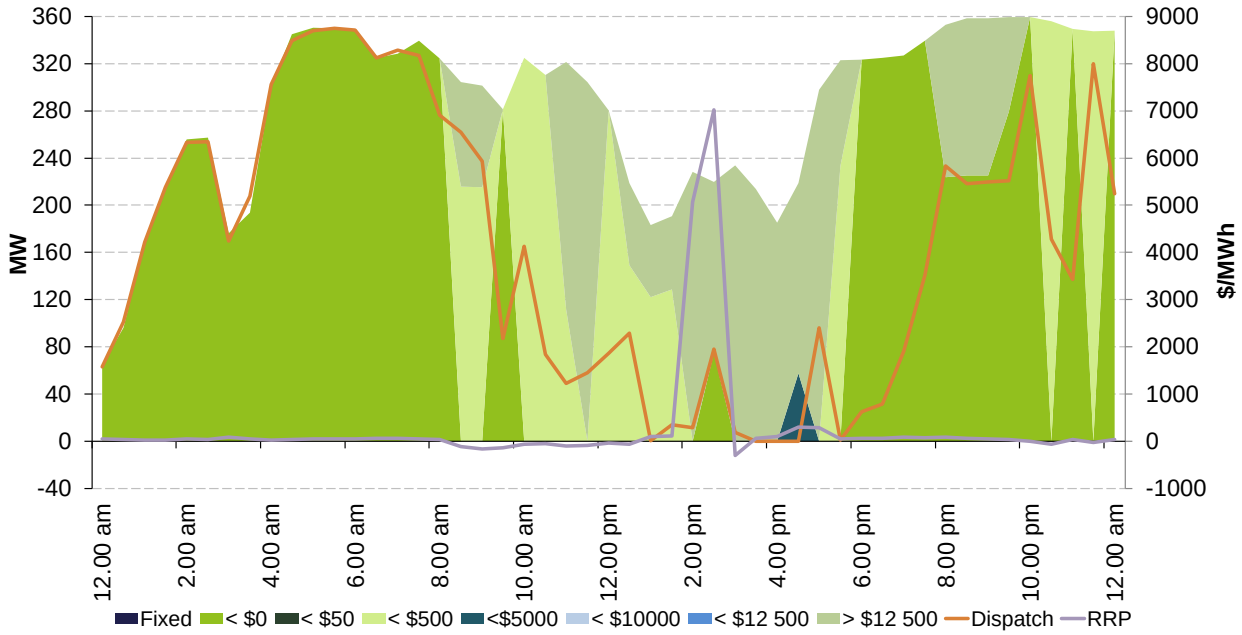
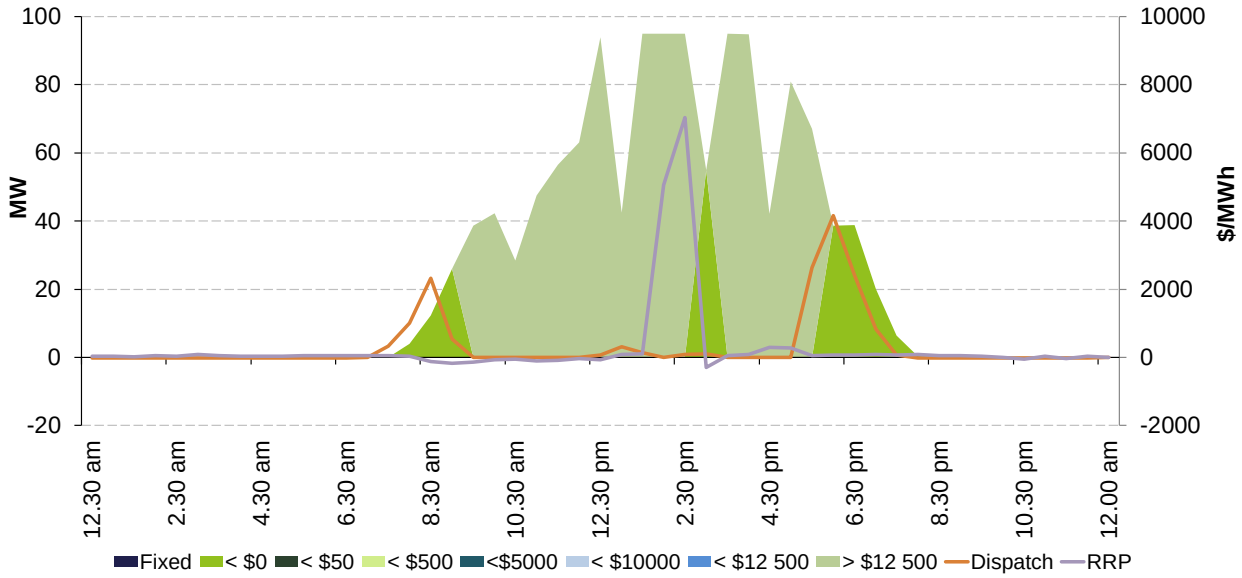


Figure A9: Vena Energy (Tailem Bend Solar Project) closing bids, dispatch and spot price



Appendix B: Significant rebids

The rebidding tables highlight the relevant rebids submitted by generators that impacted on market outcomes during the time of high prices. It details the time the rebid was submitted and used by the dispatch process, the maximum capacity involved, the change in the price of the capacity being offered, and the rebid reason.

Table 5: Significant rebids for 2 pm trading interval

Submit time	Time effective	Participant	Station	Capacity rebid (MW)	Price from ($/MWh)	Price to ($/MWh)	Rebid reason
1.13 pm		Trustpower	Snowtown WF	99	-1000	14 700	1310 A SA1 5min pd rrp for 1320 ($40.98) published at 1310 is 309.79% higher than 5min pd rrp published at 1305 ($0.0) - time of alert: 1313
1.23 pm		Pacific Hydro	Clements Gap WF	57	-35	14 700	1420 A rebid due to change in forecast from 1420h to 1600h
1.28 pm	1.35 pm	EnergyAustralia	Waterloo WF	130	-1000	14 700	1328 A band adj to manage 30min pd for pe 1400 sl
1.43 pm	1.50 pm	Trustpower	Snowtown North WF	144	299	14 700	1337 F high raise 6 sec price at 1335hrs - sl
1.43 pm	1.50 pm	Trustpower	Snowtown South WF	126	299	14 700	1344 F high raise 6 sec price at 1345hrs - sl
1.51 pm	2.00 pm	Snowy Hydro	Lonsdale	10	14 774	-1005	13:50:06 A SA 5min actual price $14,400.00 higher than 5min pd 13:55@13:46 ($14,700.00)
1.51 pm	2.00 pm	Snowy Hydro	Pt Stanvac	63	14 744	-1003	13:50:06 A SA 5min actual price $14,400.00 higher than 5min pd 13:55@13:46 ($14,700.00)

Table 6: Significant rebids for 2.30 pm trading interval

Submit time	Time effective	Participant	Station	Capacity rebid (MW)	Price from ($/MWh)	Price to ($/MWh)	Rebid reason
1.13 pm		Trustpower	Snowtown WF	99	-1000	14 700	1310 A SA1 5min pd rrp for 1320 ($40.98) published at 1310 is 309.79% higher than 5min pd rrp published at 1305 ($0.0) - time of alert: 1313
1.23 pm		Pacific Hydro	Clements Gap WF	57	-35	14 700	1420 A rebid due to change in forecast from 1420H to 1600H

Submit time	Time effective	Participant	Station	Capacity rebid (MW)	Price from ($/MWh)	Price to ($/MWh)	Rebid reason
1.46 pm		Trustpower	Snowtown North WF	144	299	14 700	1344 F high raise 6 sec price at 1345hrs - sl
1.48 pm		Trustpower	Snowtown South WF	126	299	14 700	1344 F high raise 6 sec price at 1345hrs - sl
2.03 pm	2.10 pm	Trustpower	Snowtown WF	99	14 700	-1000	1400 A SA1 5min pd rrp for 1430 ($14700) published at 1400 is 44679.5% higher than 30min pd rrp published at 1331 ($32.83) - time of alert: 1403

Appendix C: Price setter

The following tables identify for the trading interval in which the spot price exceeded $5000/MWh, each five minute dispatch interval price and the generating units involved in setting the energy price. This information is published by AEMO.[2] The 30-minute spot price is the average of the six dispatch interval prices.

Table 7: price setter 2 pm

DI	Dispatch Price ($/MWh)	Participant	Unit	Service	Offer price ($/MWh)	Marginal change	Contribution
13:35	$81.21	Snowy Hydro	MURRAY	Energy	$75.01	1.08	$81.01
13:40	$299	Trustpower	SNOWNTH1	Energy	$299	0.53	$158.47
		Trustpower	SNOWSTH1	Energy	$299	0.47	$140.53
13:45	$299	Trustpower	SNOWNTH1	Energy	$299	0.53	$158.47
		Trustpower	SNOWSTH1	Energy	$299	0.47	$140.53
13:50	$300	AGL (SA)	BARKIPS1	Energy	$300	0.71	$213
		AGL (SA)	HALLWF2	Energy	$300	0.29	$87
13:55	$14 700	Pacific Hydro	CLEMGPWF	Energy	$14 700	1	$14 700
14:00	$14 700	Pacific Hydro	CLEMGPWF	Energy	$14 700	0.17	$2499
		Trustpower	SNOWNTH1	Energy	$14 700	0.44	$6468
		Trustpower	SNOWSTH1	Energy	$14 700	0.39	$5733
Spot Price		**$5063/MWh**					

Table 8: price setter 2:30 pm

DI	Dispatch Price ($/MWh)	Participant	Unit	Service	Offer price ($/MWh)	Marginal change	Contribution
14:05	$14 700	Pacific Hydro	CLEMGPWF	Energy	$14 700	0.13	$1911
		Trustpower	SNOWNTH1	Energy	$14 700	0.34	$4998
		Trustpower	SNOWSTH1	Energy	$14 700	0.30	$4410
		Trustpower	SNOWTWN1	Energy	$14 700	0.23	$3381
14:10	$14 700	Pacific Hydro	CLEMGPWF	Energy	$14 700	0.17	$2499
		Trustpower	SNOWNTH1	Energy	$14 700	0.44	$6468
		Trustpower	SNOWSTH1	Energy	$14 700	0.39	$5733
14:15	$14 700	Pacific Hydro	CLEMGPWF	Energy	$14 700	0.17	$2499
		Trustpower	SNOWNTH1	Energy	$14 700	0.44	$6468
		Trustpower	SNOWSTH1	Energy	$14 700	0.39	$5733
14:20	$61.02	Snowy Hydro	MURRAY	Energy	$75.01	0.81	$60.76
14:25	-$1000	Engie	PPCCGT	Energy	-$1000	0.79	-$790
		Trustpower	SNOWTWN1	Energy	-$1000	0.21	-$210
	-$1000	Trustpower	SNOWTWN1	Energy	-$1000	1	-$1000
Spot Price		**$7027/MWh**					

[2] Details on how the price is determined can be found at www.aemo.com.au

Appendix D: Market Notices

The following relevant market notices notified the market of the events on the day as they unfolded.

Market Notice	Type	Date of issue	Last Changed
74593	Market Intervention	1/03/2020 06:52:17 PM	1/03/2020 06:52:17 PM

External Reference

Direction - SA Region - 01/03/2020

Reason

AEMO ELECTRICITY MARKET NOTICE.

Direction - SA Region - 01/03/2020

In accordance with section 116 of the National Electricity Law, AEMO has issued a direction to a participant in the SA region. For the purposes of the National Electricity Rules this is a direction under clause 4.8.9(a).

The direction was necessary to maintain the power system in a secure operating state.

AEMO may issue or revoke additional directions in order to meet the current requirement, unless sufficient market response is provided. A further market notice will be issued when all directions related to this requirement have been cancelled.

The issue of the direction commences an AEMO intervention event. AEMO declares all dispatch intervals during the event to be intervention dispatch intervals, commencing from the interval ending 1850 hrs on 01/03/2020.

Intervention pricing does not apply to this AEMO intervention event.

Manager NEM Real Time Operations

Market Notice	Type	Date of issue	Last Changed
74613	Power system events	2/03/2020 12:22:27 PM	2/03/2020 12:22:27 PM

External Reference

Separation of the Victorian and South Australian Regions 02 Mar 2020

Reason

AEMO ELECTRICITY MARKET NOTICE.

POWER SYSTEM EMERGENCY CONDITIONS

Separation of the Victorian and South Australian Regions 02 Mar 2020

At 1200 hrs the Victorian and South Australian regions separated at Heywood Terminal.

The following Constraint sets were invoked to manage the situation from 1215 hrs

F-ESTN_ISLE

F-SA_ESTN_ISLE_REG

F-SA_MOPS_ISLE

SA_ESTN_ISLE

Manager NEM Real Time Operations

Market Notice	Type	Date of issue	Last Changed
74648	Power system events	2/03/2020 8:20:28 PM	2/03/2020 8:20:28 PM

External Reference

Update - Separation of the Victorian and South Australian Regions 02 Mar 2020

Reason

AEMO ELECTRICITY MARKET NOTICE.

Update to Market Notice 74613

At 2005 hrs the South Australian region was synchronised to Victoria at Heywood Terminal.

The following Constraint sets were revoked at 2020 hrs

F-ESTN_ISLE

F-ESTN_TL_0600

F-SA_ESTN_ISLE_REG

F-SA_MOPS_ISLE

SA_ESTN_ISLE

Manager NEM Real Time Operations

Market Notice	Type	Date of issue	Last Changed
74651	Market intervention	2/03/2020 8:56:40 PM	2/03/2020 8:56:40 PM

External Reference

Cancellation - AEMO Intervention Event - Intervention price dispatch intervals - Direction SA region 01/03/2020

Reason

AEMO ELECTRICITY MARKET NOTICE

Refer Market Notices 74593

The AEMO Intervention Event and all associated directions are cancelled from 2020 hrs 02/03/2020.

Manager NEM Real Time Operations
