



Report into market ancillary service prices above \$5000/MW

**South Australia,
23 January 2017**

1 September 2017

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1 Obligation

The Australian Energy Regulator 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 energy markets, including the annual State of the energy market report, to assist participants and the wider community.

The AER is required to monitor significant variations between forecast and actual prices and publish a report where:

- prices for a market ancillary service over a period significantly exceed the relevant spot price for energy; and
- prices for a market ancillary service exceed \$5000/MW for a number of trading intervals within that period.

In accordance with the clause 3.13.7(e) of the National Electricity Rules, the report must:

- describe the significant factors that contributed to the ancillary service prices exceeding \$5000/MW;
- identify any linkages between spot prices in the energy market and ancillary service prices contributing to the occurrence; and
- assess whether rebidding pursuant to clause 3.8.22 contributed to prices exceeding \$5000/MW.

These reports examine the reasons for the high price outcomes—they are not compliance reports. We deal separately with compliance issues that come to our attention during the preparation of these reports.

2 Summary

Lower and raise regulation frequency control ancillary services (regulation services) are used to manage small fluctuations in supply or demand.

At 5.08 am on 23 January there was an unplanned network outage on the Heywood to Mortlake power station 500kV line in Victoria. This outage put South Australia on a single contingency, which created the risk of South Australia becoming electrically isolated from the National Electricity Market (NEM). To manage this risk, and in line with its procedures, the market operator (AEMO) was required to source 35 MW of raise and lower regulation services from within South Australia for the duration of the outage.

Leading up to the unplanned outage and the imposition of the 35 MW requirement, participants had offered only 30 MW of low-priced regulation services available to meet the 35 MW requirement. As a result, when the outage occurred and the 35 MW requirement was introduced, some high-priced capacity was required. The price for local raise regulation services reached \$14 000/MW for six consecutive dispatch intervals (from 5.25 am to 5.50 am), and the price for local lower regulation services reached \$13 800/MW for seven consecutive dispatch intervals (from 5.20 am to 5.50 am). The wholesale (or spot) price for electricity for the half hour period ending at 5.30 am (or the 5.30 am trading interval) reached \$2458/MWh.

While the outage continued until 7.18 am, the price for regulation services decreased to \$75/MW in lower services and \$1950/MW in raise services at 5.55 am after Origin Energy rebid additional low priced capacity available at its Osborne and Quarantine Power Stations.

3 Analysis

The following sections explain the reasons for the high regulation services prices. To summarise, in response to an unplanned network outage in Victoria, AEMO imposed the requirement that 35 MW of regulation services be sourced locally in South Australia. However, leading up to the imposition of the 35 MW requirement, participants had offered less than 35 MW of low-priced capacity, which resulted in prices at \$13 800/MW and above as soon as the requirement was introduced.

3.1 Unplanned network outage

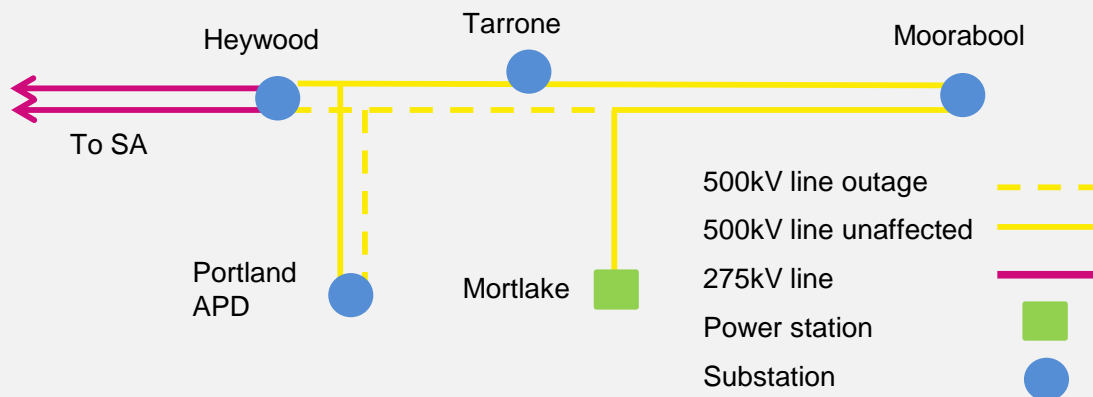
At 5.08 am on 23 January there was an unplanned network outage on the APD to Heywood to Mortlake power station 500kV line in Victoria (see Market Notice 56972, replicated in Appendix E). This meant that South Australia was on a single contingency and at risk of being electrically isolated from the rest of NEM. As a result of the increased risk, AEMO invoked a requirement that 35 MW of regulation services be sourced in South Australia. See Box 1 for further details.

The outage was over by 7.18 am and AEMO removed the 35 MW requirement for regulation services by the 7.35 am dispatch interval.¹ Market notices relating to the outage are contained in Appendix E.

¹ See the AEMO [Electricity Pricing Event Report - Monday 23 January 2017](#)

Box 1: Heywood Interconnector and line outage management

South Australia is electrically connected to Victoria by the Heywood and Murraylink interconnectors. Murraylink is a direct current interconnector that cannot provide FCAS. The Heywood Interconnector is an alternating current high voltage transmission link which can transfer FCAS from the rest of the NEM. The figure below is a simplified representation of the network around the interconnector.



When any one of the four lines going through the Heywood substation is on an outage, the South Australian region is on a single contingency. This means that South Australia is at risk of being electrically isolated from the rest of the NEM as only one line is connecting South Australia to Victoria. When this occurs AEMO invokes constraints requiring 35 MW of local regulation services. This ensures adequate regulation services are immediately available to manage the frequency (around 50Hz) within South Australia if the remaining line trips.

Further details on the 35 MW requirement can be found in Appendix B.

3.2 Regulation FCAS availability, offer prices and price outcomes

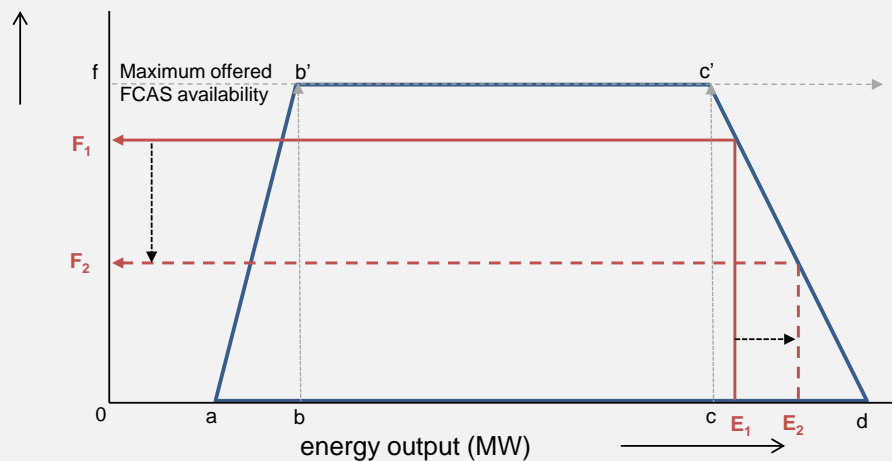
This section discusses participants' offers, rebidding and the resultant prices.

Box 2: Trade-off between generator FCAS and energy offers

Generators must register with AEMO to provide FCAS and offer FCAS capacity in a similar manner to energy into the market.

Participants offer the maximum amount of FCAS (f in the diagram below) and energy, in mega-watts (MW), they are willing to supply across ten price bands, ranging between - \$1000 and \$14 000 for a trading day. A trading day starts at 4 am each day. A participant also offers the limits by which they can be dispatched in FCAS (a, b, c, d in the diagram below). There can be a trade-off between a participant's provision of FCAS and energy, impacting the effective availability of FCAS. For example in the diagram below, if a generator's energy output is at E1 then its FCAS effective availability is F1, if its output in energy increases to E2 then its effective FCAS availability drops to F2.

For every dispatch interval the National Electricity Market Dispatch Engine (NEMDE) co-optimises market participants FCAS and energy offers to arrive at the least cost outcome while maintaining system security.



3.2.1 FCAS capacity

Of the 26 power stations (including wind farms) in South Australia, only four are registered to provide FCAS. Table 1 shows the power stations registered to provide raise and lower regulation FCAS in South Australia on the day and their maximum registered capacity. Table 1 shows each power station, if fully operational, was individually capable of providing the local requirement.

Table 1: Registered maximum regulation FCAS capacity in MW by station

Power Station	Registered Capacity (MW)	
	Lower regulation	Raise regulation
Osborne (Origin Energy)	36	36
Quarantine (Origin Energy)	50	50
Pelican Point (Engie)	100	100
Torrens Island (AGL)	200	260
Total	386	446

At the time of the high prices three units at Torrens Island power station and Pelican Point power station were unavailable. Although the registered capacity is as shown in Table 1, only around 125 MW of lower regulation and around 155 MW of raise regulation was actually offered by participants. Participant offers are reflected in Appendix D.

3.2.2 Effective offers and prices

Figure 1 and Figure 2 show actual prices (purple lines)² and effective available capacity over the high price period. Box 2 explains the concept of “effective” availability. The (constant) 35 MW requirement is shown as a red line. The blue shaded areas indicate effective available capacity priced below \$5000/MW while effective available capacity above \$5000/MW is shaded light orange.

Figure 1 Lower regulation effective offers, requirement and price

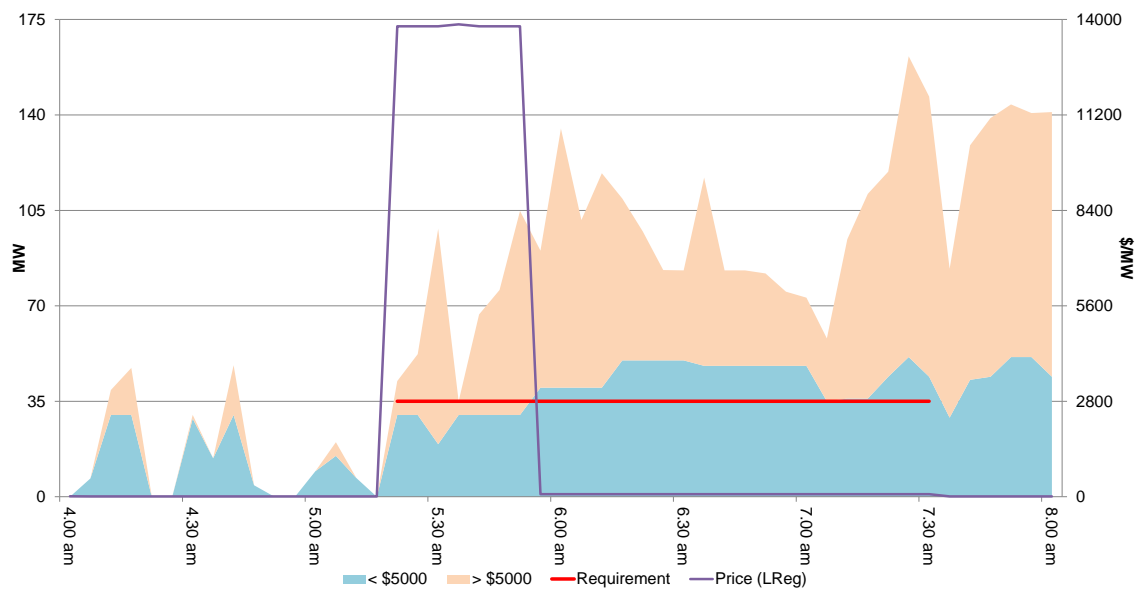


Figure 1 shows only 30 MW of low price capacity was available in lower regulation services when the requirement was first introduced at 5.20 am. This meant 5 MW of high price low regulation capacity was needed to meet the requirement, and the price spiked to \$13 800/MW for seven dispatch intervals.

² Individual prices are contained in the Price Setter at Appendix F

Figure 2 Raise regulation effective offers, requirement and price

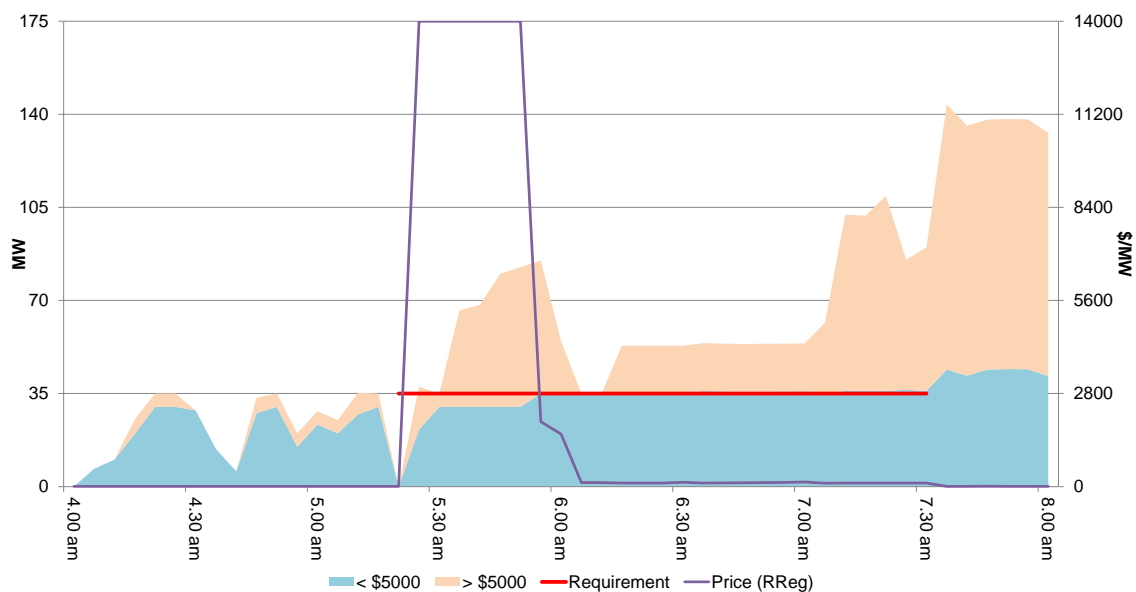


Figure 2 shows no effective raise regulation services were available when the requirement was first introduced at 5.20 am. Because no local raise regulation was dispatched in South Australia, there was no local price. Figure 2 shows that by 5.25 pm there was sufficient local raise regulation services to meet the requirement. However, the intersection of the red line with the orange shaded area indicates that high-priced capacity was needed to meet the requirement and as a result the price for raise regulation services reached the cap of \$14 000/MW for five dispatch intervals.

3.2.2.1 Price fall from 5.55 pm

Rebidding by Origin which increased the availability of low-priced capacity caused prices for both services to fall at 5.55 pm (as shown in Figure 1 and Figure 2). The rebid reasons related to constraint management.

At 5.47 am, effective from 5.55 am, Origin rebid 5 MW of additional capacity priced at \$0/MW for both regulation services at its Osborne power station. As a result there was sufficient low-priced capacity to meet the 35 MW requirement (shown by the intersection of the red line in the blue shaded areas in the figures).

At 5.38 am Origin added 46 MW of regulation services at its Quarantine power station, 10 MW of which was priced at \$0/MW. The rebid became effective at 6.15 am when the power station began generating enough energy to begin providing FCAS.

Australian Energy Regulator

September 2017

Appendix A: Explanation of FCAS

Frequency control ancillary services (FCAS) are required to maintain the frequency of the power system within the frequency operating standards. The two general categories of FCAS are:

- Regulation services, which continuously adjust to small changes in demand or supply (changes that cause the frequency to move by only a small amount away from 50 Hz). There are regulation services to increase the frequency (raise regulation or RREG) and services to decrease the frequency (lower regulation or LREG).
- Contingency services, which manage large changes in demand or supply that occur relatively rarely and move the frequency by a large amount. There are three contingency services to increase the frequency and three contingency services to decrease the frequency. Raise contingency FCAS are required to be available to correct frequency excursions that have arisen from a credible contingency event that leads to a decrease in frequency. As these contingency events usually involve step reductions in supply side, the Electricity Rules stipulate that generators pay for these services. Lower contingency FCAS are the services required to be available to correct the frequency excursions that arise from a credible contingency event that leads to an increase in frequency. As these contingency events usually involve step reductions in customer demand, the Electricity Rules stipulate that customers pay for these services.

Participants providing regulation services receive adjusted dispatch targets every 5 minutes via their automatic generation control (AGC) signals from AEMO. Participants are paid through the FCAS markets in accordance with their offered volumes. Their energy production, which may be higher or lower depending on the AGC signals they receive, are settled in accordance with energy market prices.

There are three lower and three raise contingency services:

- fast services, which arrest a frequency deviation within the first six seconds of a contingent event (L6 and R6);
- slow services, which stabilise frequency deviations within sixty seconds of the event (L60/R60); and
- delayed services, which stabilise frequency deviations within five minutes of the event (L5/R5).

Participants offering to provide contingency services are enabled in accordance with the “trapezium” supplied in their offers. While participants will not necessarily be supplying these services until a contingency occurs they are paid in accordance with their enablement.

Frequency Control Ancillary Service Settlement

AEMO settles the FCAS markets on a weekly basis, as follows³.

- Regulation FCAS: Cost recovery on a “causer pays” basis using the Causer Pays Procedure⁴ developed by AEMO in accordance with the appropriate NER procedures.
- Contingency FCAS: Generators pay for Raise Services and customers pay for Lower Services.

The ‘Causer Pays’ Procedure allocates regulation FCAS costs to those market generators, customers and small generation aggregators with facilities that have the metering capable of determining their contribution to frequency deviations at any time.

Every four weeks based on historical data AEMO calculates a causer pays contribution factor for each generator. Broadly, the contribution factor is determined from historical 4 second generator output and frequency information and is a measure of how each generator contributed to managing changes in the system frequency. If a generators’ output changes such that it supports maintaining the system frequency its contribution factor is positive. Conversely, if a generators’ output changes such that it exacerbates a frequency deviation, its contribution factor will be negative. The causer pays contribution factors for a portfolio of generators effectively represent the aggregation of the individual performance of the generators in that portfolio.

Settlement is determined by allocating the FCAS costs incurred in the current period in accordance with the causer pays contribution factor for that portfolio from the preceding period. Thus cost allocation to a participant is not dependent on the amount of energy purchased or consumed in that period but by the performance of that participant in managing system frequency in the previous period.

Consequently a portfolio of generators with a negative factor in a particular period will still pay a share of FCAS costs irrespective of how much it generates in the current period.

Since not all of the costs will be recovered from generators, the residual costs are recovered from market customers (including retailers) in the relevant region, based on the amount of energy each market customer is purchasing.

³ For a full description go to <https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Ancillary-Services/Ancillary-Services-Payments-and-Recovery>

⁴ For a full description go to <https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Ancillary-services-causer-pays-contribution-factors>

Appendix B: Local Requirement for FCAS

AEMO sets the requirement for FCAS to ensure that the frequency standard (as set by the Reliability Panel) is maintained in the event of step changes in supply or demand that results from credible contingencies. Where a credible contingency results in the loss of an interconnector it is termed a “separation event”.

The standard states that in the event of a “separation event” the frequency must be contained within 49 to 51 Hz or a wider band notified to AEMO by a relevant Jurisdictional System Security Coordinator (JSSC). In the case of South Australia the JSSC notified AEMO that the frequency band for separation of the South Australian power system is 47 to 52 Hz and that under frequency relays will operate at frequency levels in the low end of this range.

When there is a potential separation event caused by the loss of an interconnector “local frequency control ancillary services” are usually required.

If the region was exporting at the time the interconnector fails, then as a consequence of the immediate over supply situation local contingency “lower” services are required in the islanded region to lower the frequency (typically generators offer to quickly reduce output to lower frequency). In other words, the loss of the Heywood interconnector when power is flowing from South Australia, results in an oversupply of generation, increasing the frequency in South Australia. Contingency lower services are sourced from registered suppliers in South Australia (typically generators) in proportion to the flow across the interconnector from South Australia to Victoria to quickly reduce that over frequency.

A similar situation exists for contingency “raise” services for all other regions except South Australia where, in accordance with the advice from the JSSC, the raise requirement is covered by under frequency load shedding. In other words, the loss of the Heywood interconnector when power is flowing into South Australia, results in an undersupply of generation decreasing the frequency in South Australia. Under frequency load shedding reduces demand in blocks to arrest the falling frequency until supply matches demand and the frequency is restored.

In either event, in the past, in the period immediately following the separation event AEMO would invoke local regulation services and establish a local regulation reference source to manage frequency until the region can be reconnected to the rest of the NEM. It is this aspect that has been recently changed by AEMO. AEMO will now impose a requirement for local lower and raise regulation services in South Australia prior to the failure of the interconnector so that frequency after an island is formed, and after the contingency services have operated, can be smoothly maintained.

Appendix C: 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 capacity involved, the change in the price of the capacity was being offered and the rebid reason.

Table C 1: Significant rebids for 23 January – lower regulation

Submit time	Time effective	Participant	Station	Capacity rebid (MW)	Price from (\$/MW)	Price to (\$/MW)	Rebid reason
5.38 am	5.45 am	Origin	Quarantine	46	N/A	0*	0538A constraint management - F_S++HYSE_L6_1 SL
5.47 am	5.55 am	Origin	Osborne	10	N/A	>0**	0545A constraint management - F_S++HYSE_L6_1 SL

Table C 2: Significant rebids for 23 January – raise regulation

Submit time	Time effective	Participant	Station	Capacity rebid (MW)	Price from (\$/MW)	Price to (\$/MW)	Rebid reason
5.38 am	5.45 am	Origin	Quarantine	46	N/A	>0*	0538A constraint management - F_S++HYSE_L6_1 SL
5.47 am	5.55 am	Origin	Osborne	10	N/A	>0**	0545A constraint management - F_S++HYSE_L6_1 SL

*10 MW was priced at \$0/MW while 36 MW was priced above \$11 480/MW

**5 MW was priced at \$0/MW while 5 MW was priced at \$598/MW

Appendix D: Closing bids

Figures D1a to D8b highlight for each dispatch interval the lower and raise regulation services closing bids for Origin, AGL and Engie (the participants in South Australia with ancillary service capability). It also shows the dispatch level of the respective services at each station and the dispatch price.

FCAS services are co-optimised with energy offers. For example a generator that is operating at its maximum capacity cannot provide raise services so their effective available capacity for raise services would be zero. Figures denoted with an “a” refer to the quantities offered while those with a “b” refer to the *effective* quantities available to the market after accounting for the interaction between energy and FCAS (“effective available capacity”).

Lower Regulation

Figure D1a: Torrens Island (AGL) lower regulation service closing bid prices, dispatch and dispatch price – maximum offers

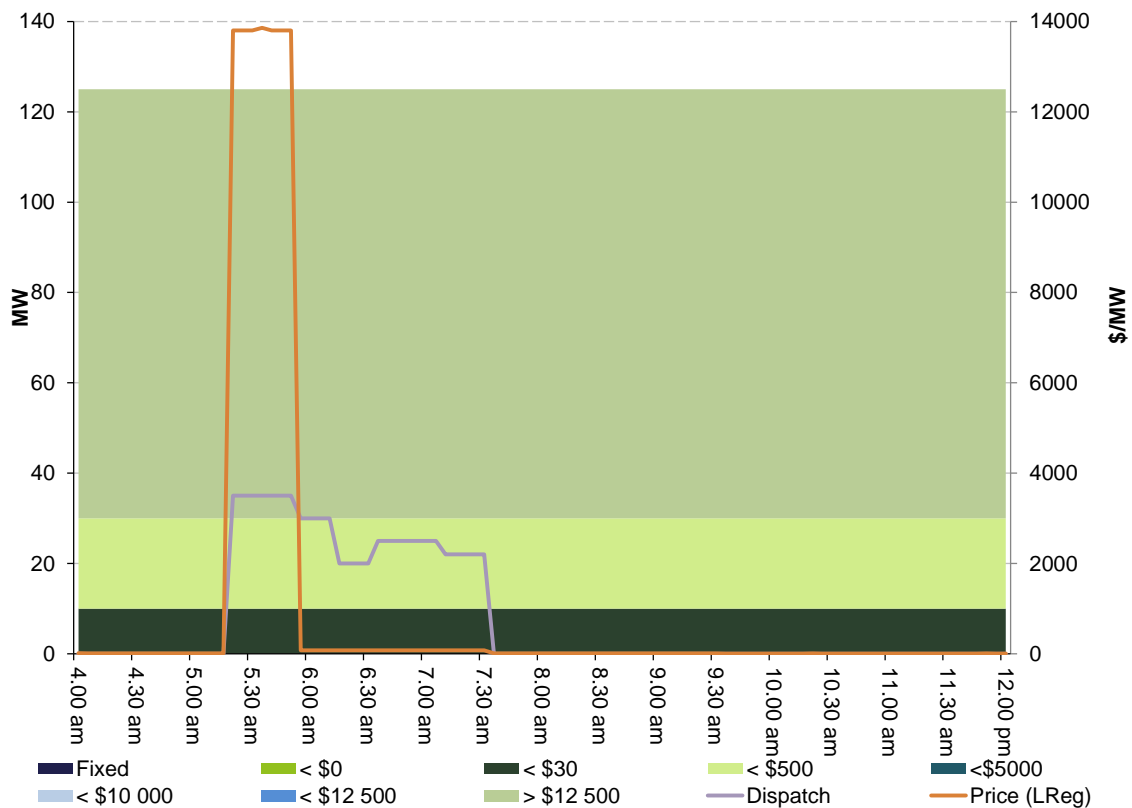


Figure D1b: Torrens Island (AGL) lower regulation service closing bid prices, dispatch and dispatch price – effective offers

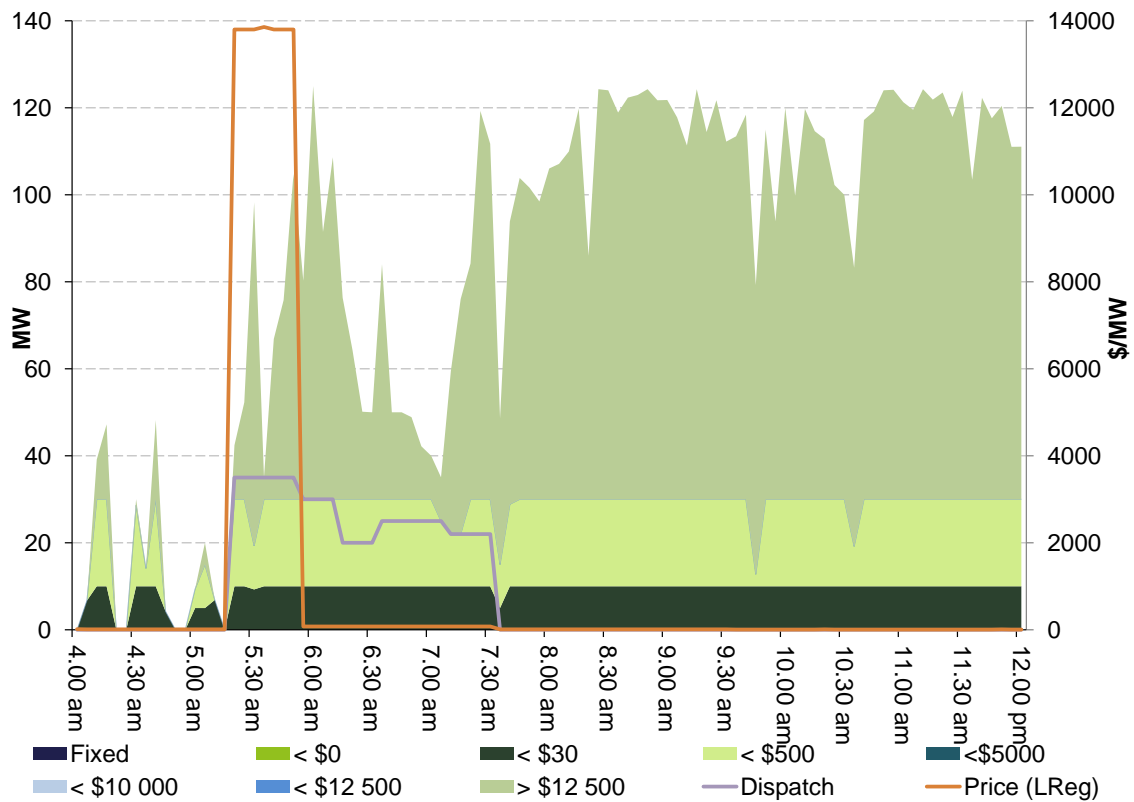


Figure D2a: Quarantine (Origin) lower regulation service closing bid prices, dispatch and dispatch price - maximum offers

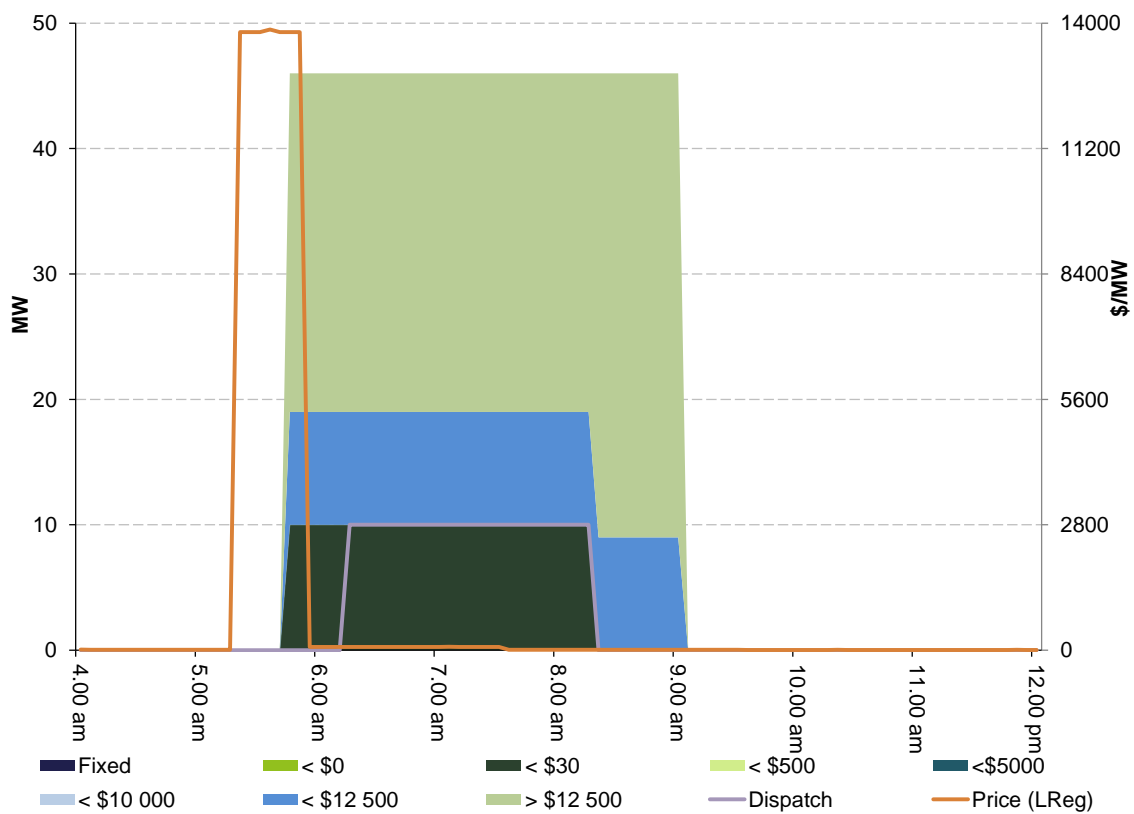


Figure D2b: Quarantine (Origin) lower regulation service closing bid prices, dispatch and dispatch price – effective offers

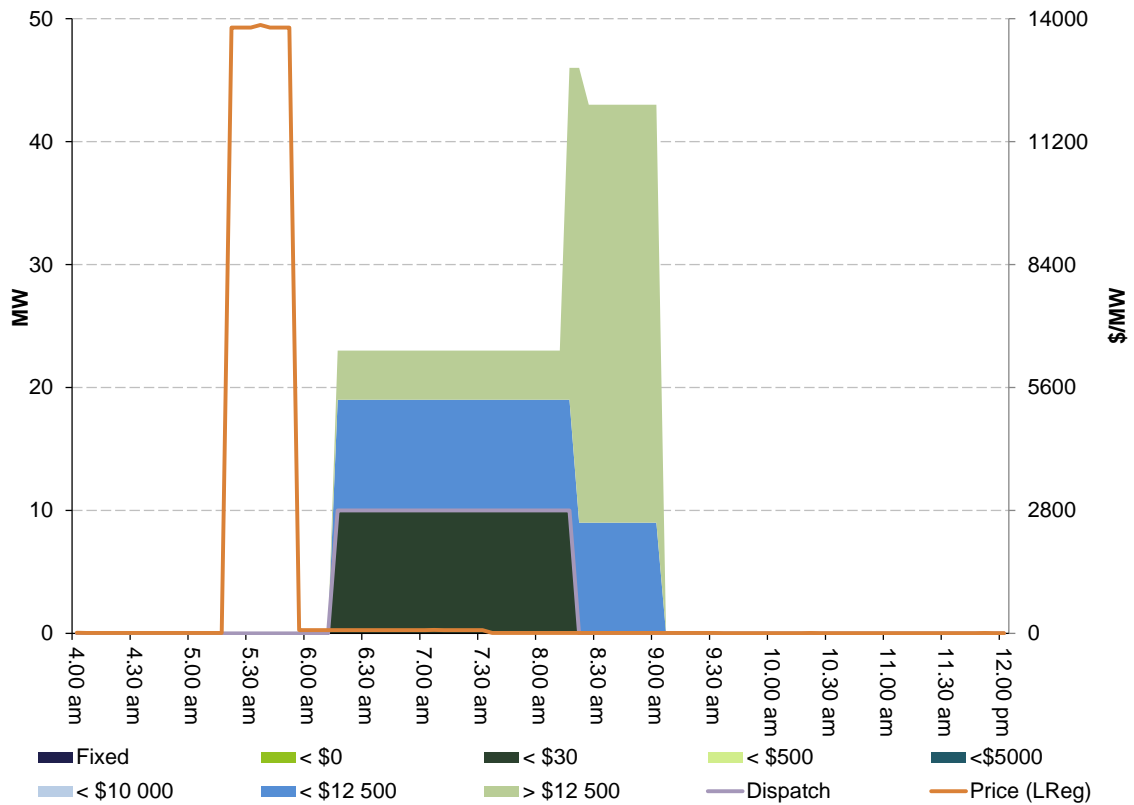


Figure D3a: Pelican Point (Engie) lower regulation service closing bid prices, dispatch and dispatch price – maximum offers

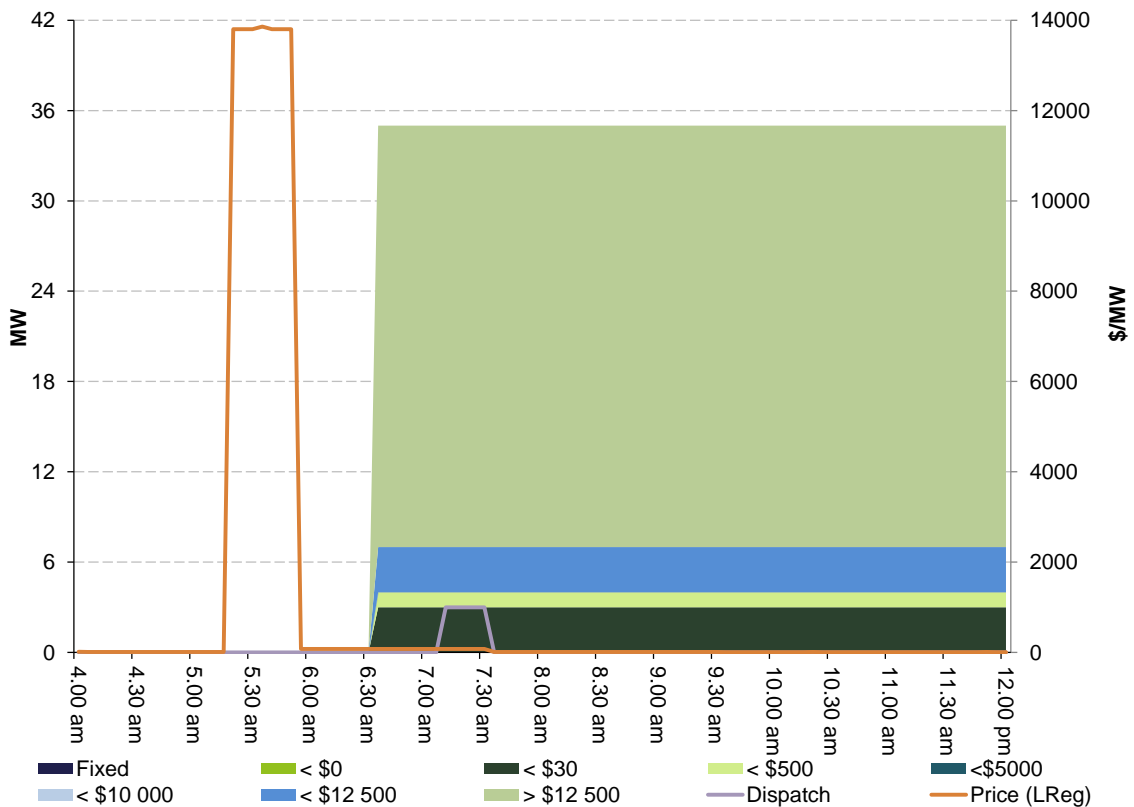


Figure D3b: Pelican Point (Engie) lower regulation service closing bid prices, dispatch and dispatch price – effective offers

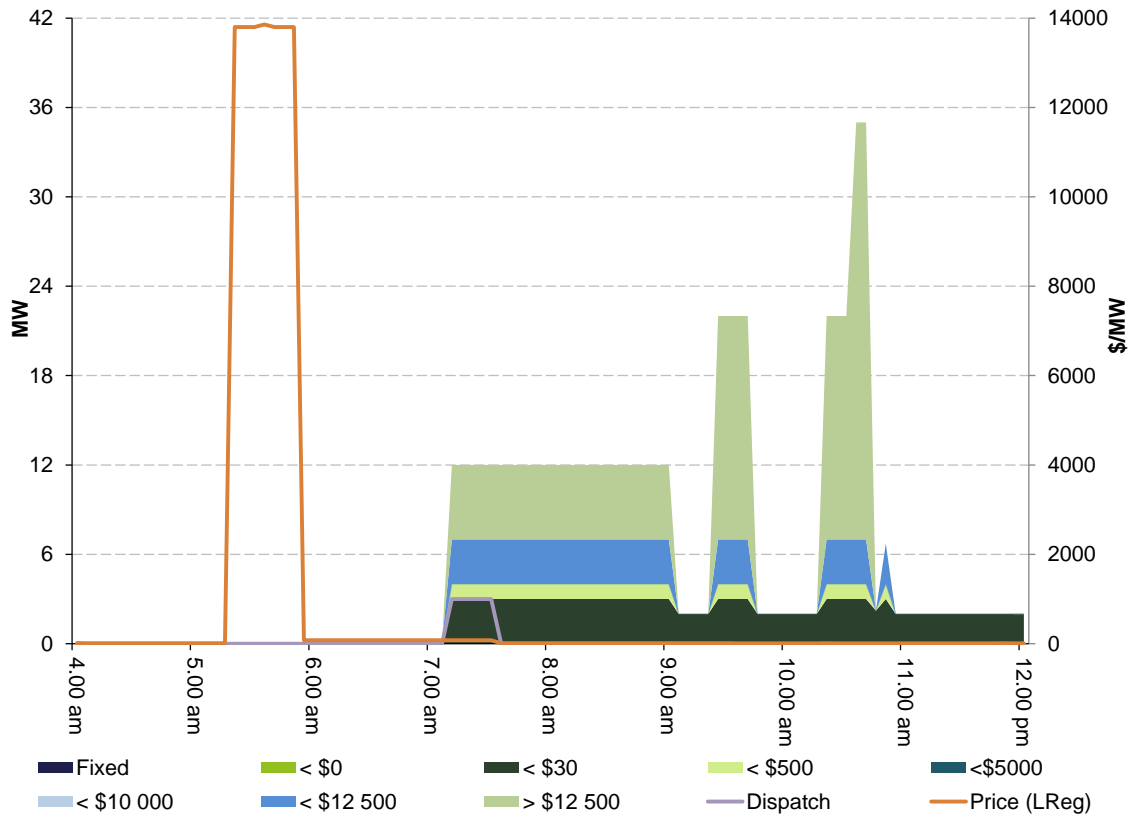


Figure D4a: Osborne (Origin) lower regulation service closing bid prices, dispatch and dispatch price – maximum offers

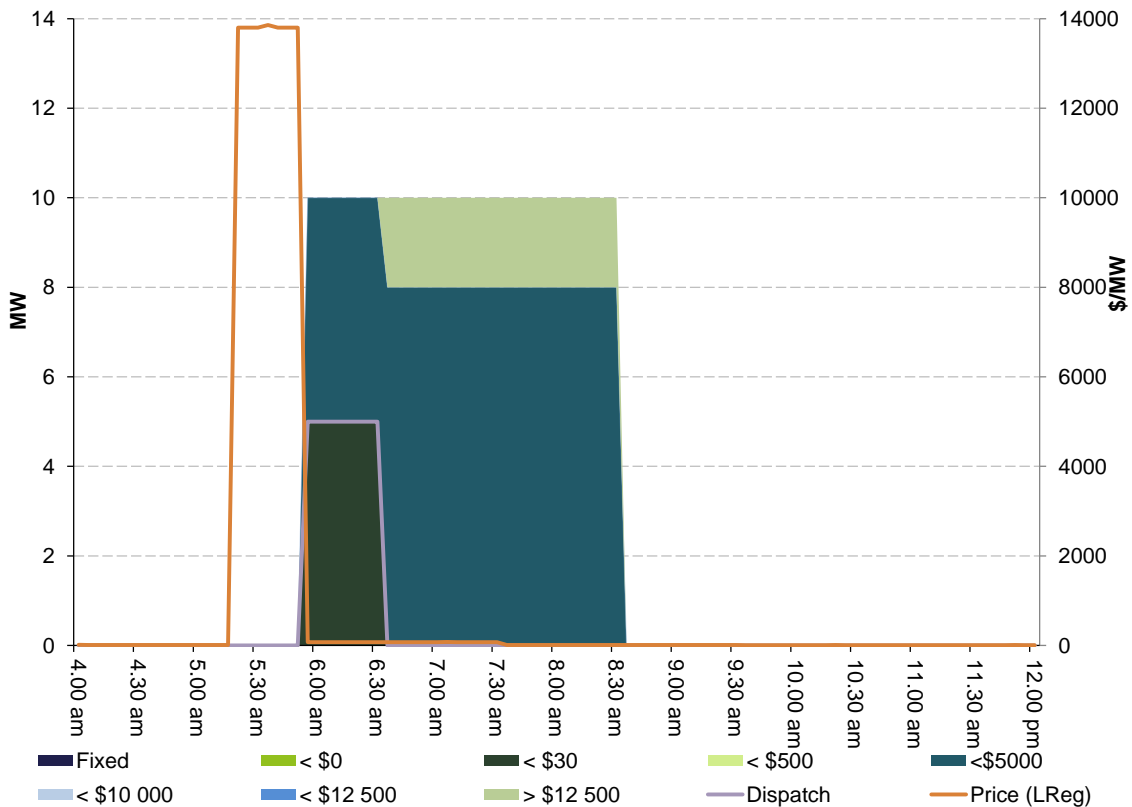
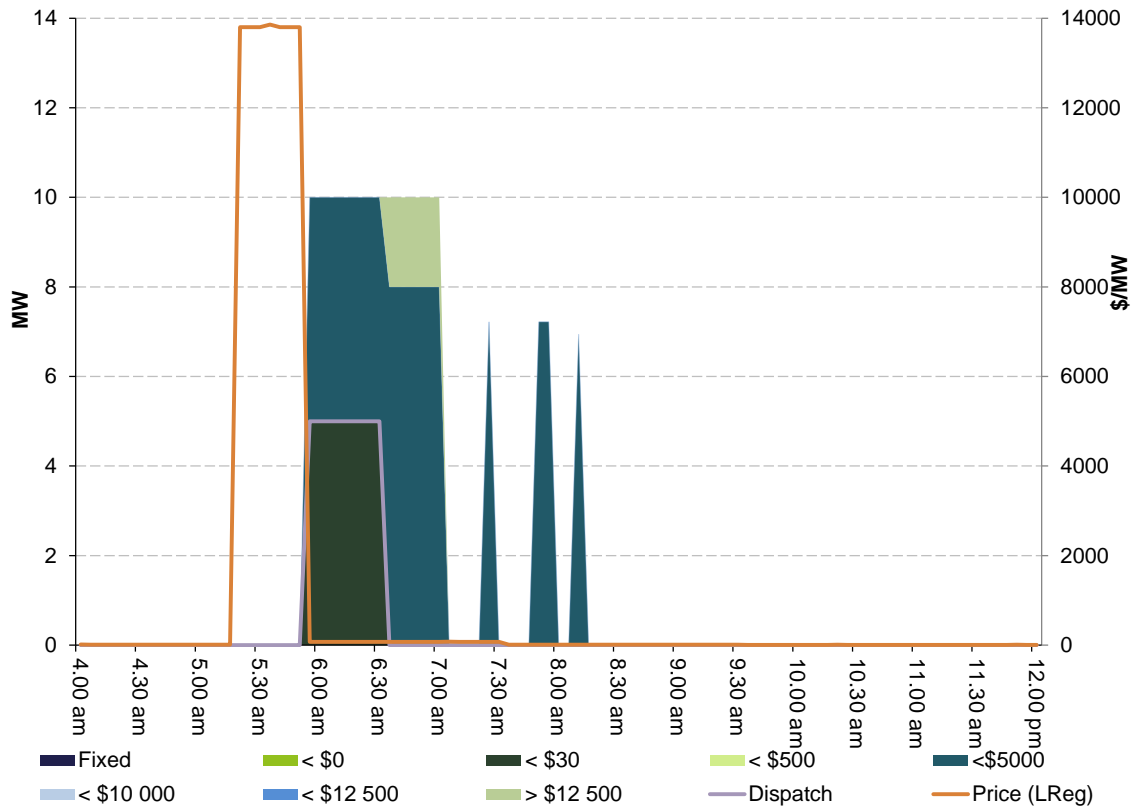


Figure D4b: Osborne (Origin) lower regulation service closing bid prices, dispatch and dispatch price – effective offers



Raise Regulation

Figure D5a: Torrens Island (AGL) raise regulation service closing bid prices, dispatch and dispatch price – maximum offers

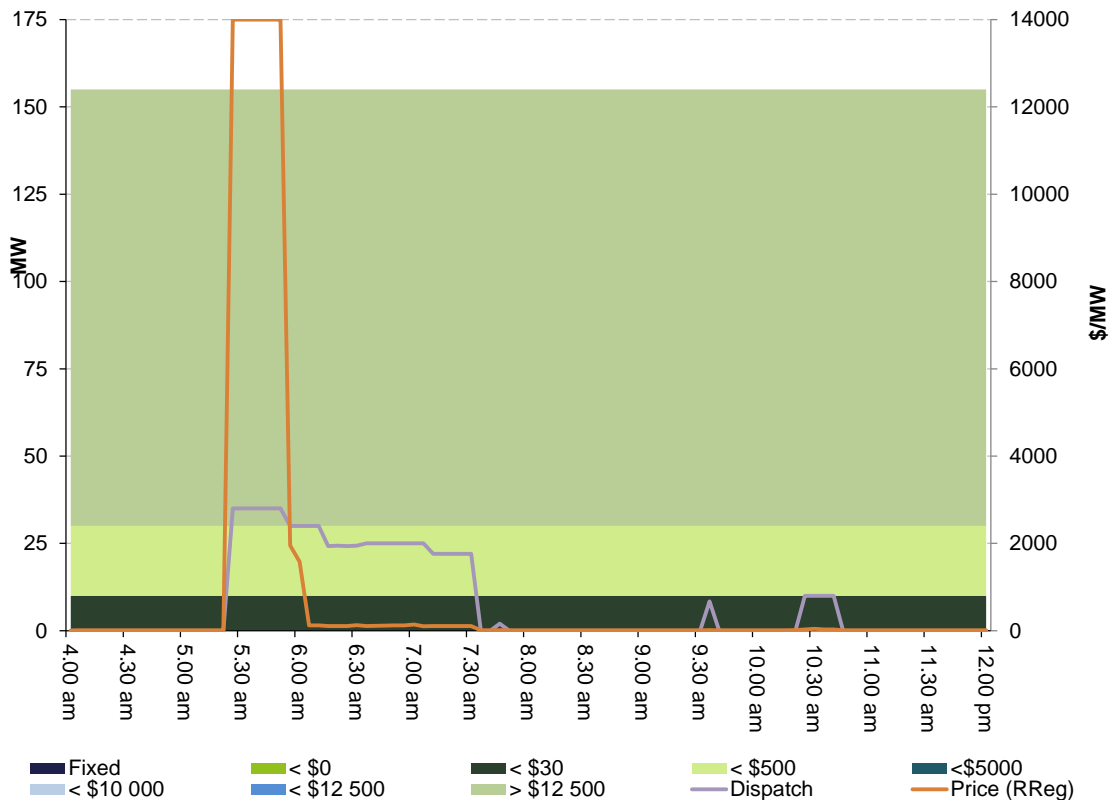


Figure D5b: Torrens Island (AGL) raise regulation service closing bid prices, dispatch and dispatch price – effective offers

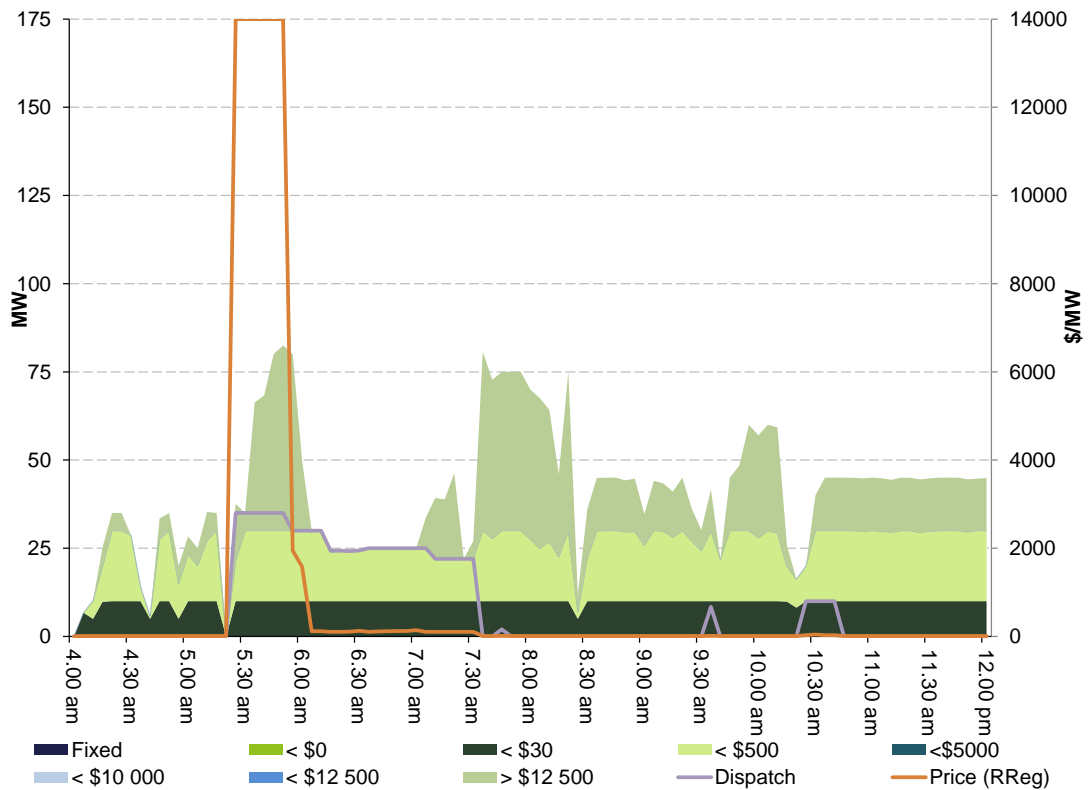


Figure D6a: Pelican Point (Engie) raise regulation service closing bid prices, dispatch and dispatch price – maximum offers

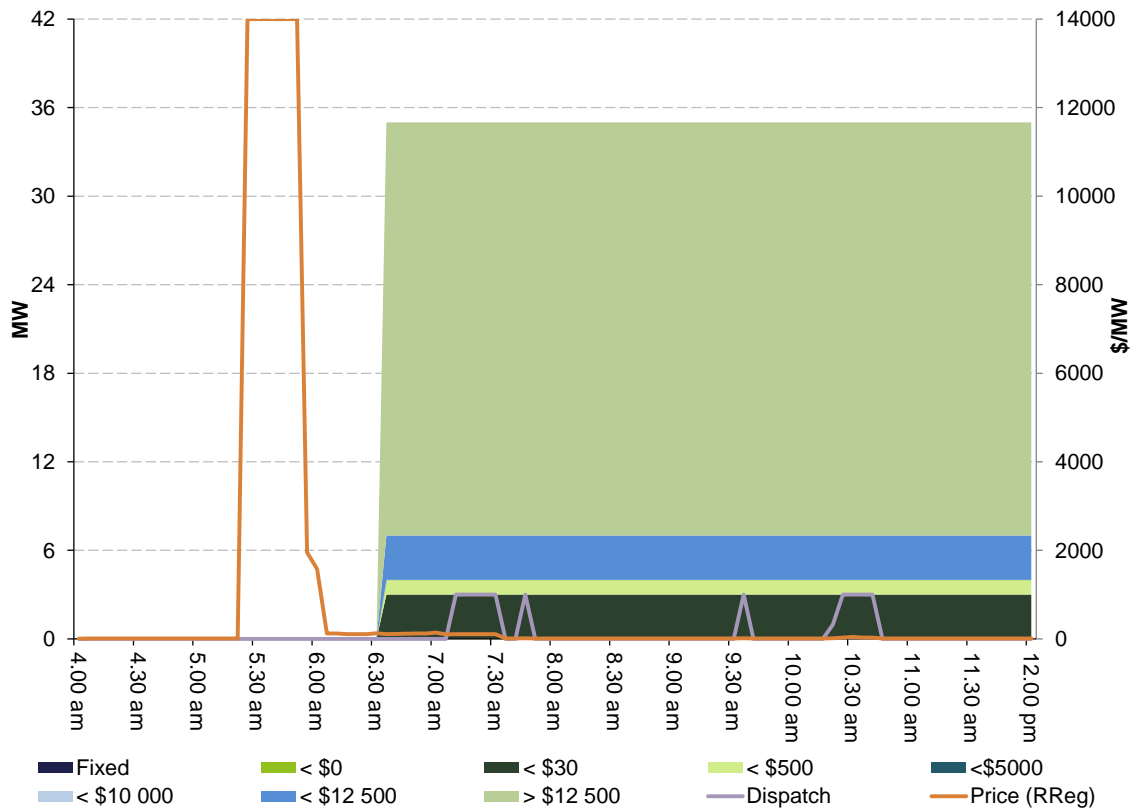


Figure D6b: Pelican Point (Engie) raise regulation service closing bid prices, dispatch and dispatch price – effective offers

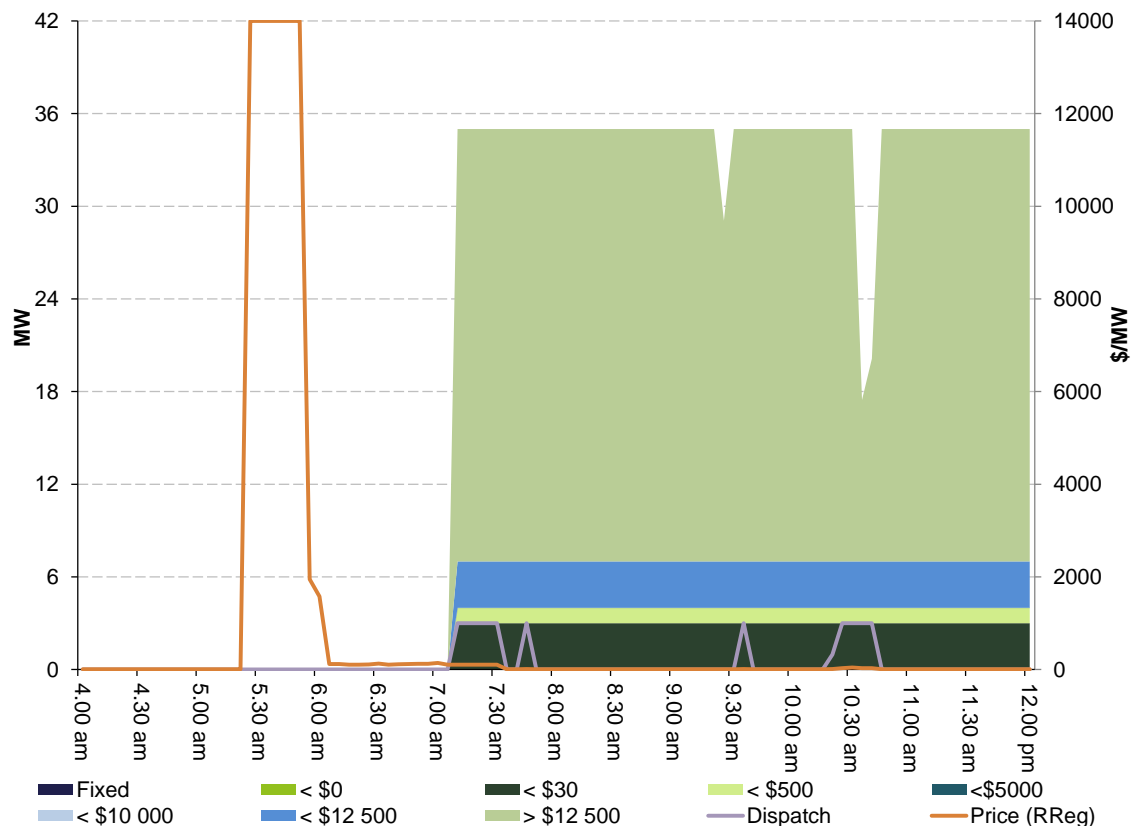


Figure D7a: Quarantine (Origin) raise regulation service closing bid prices, dispatch and dispatch price - maximum offers

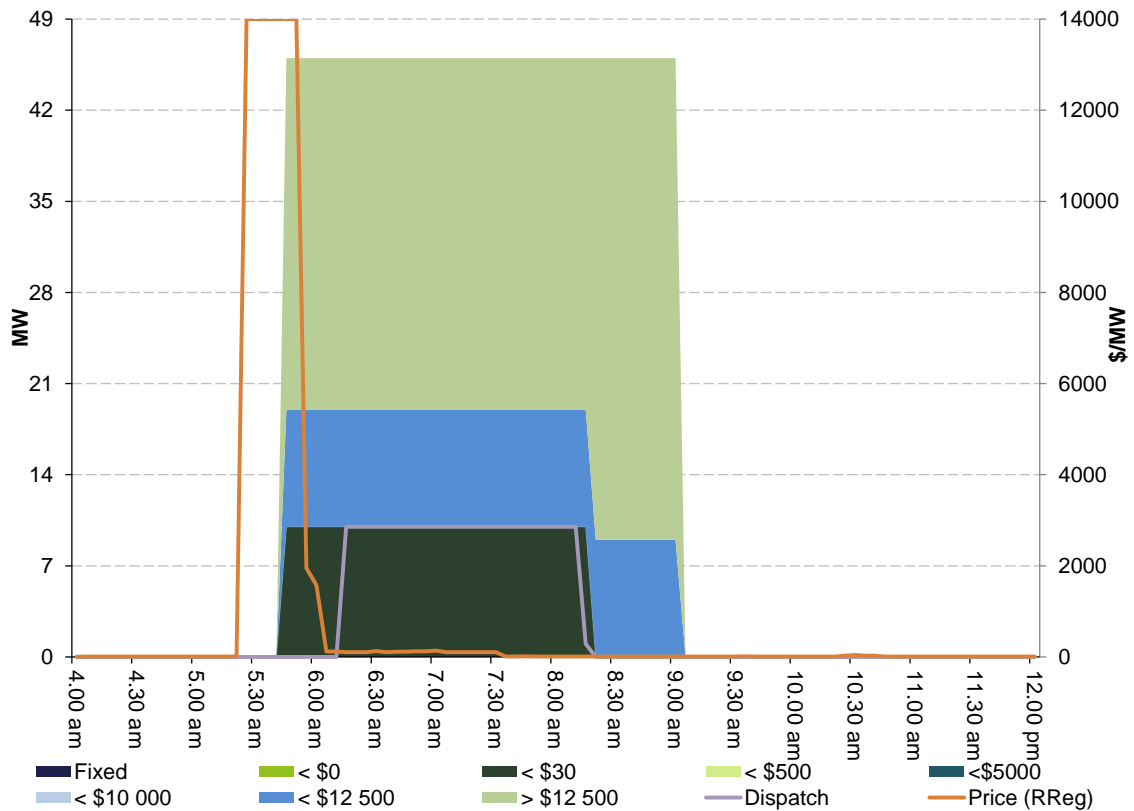


Figure D7b: Quarantine (Origin) raise regulation service closing bid prices, dispatch and dispatch price - effective offers

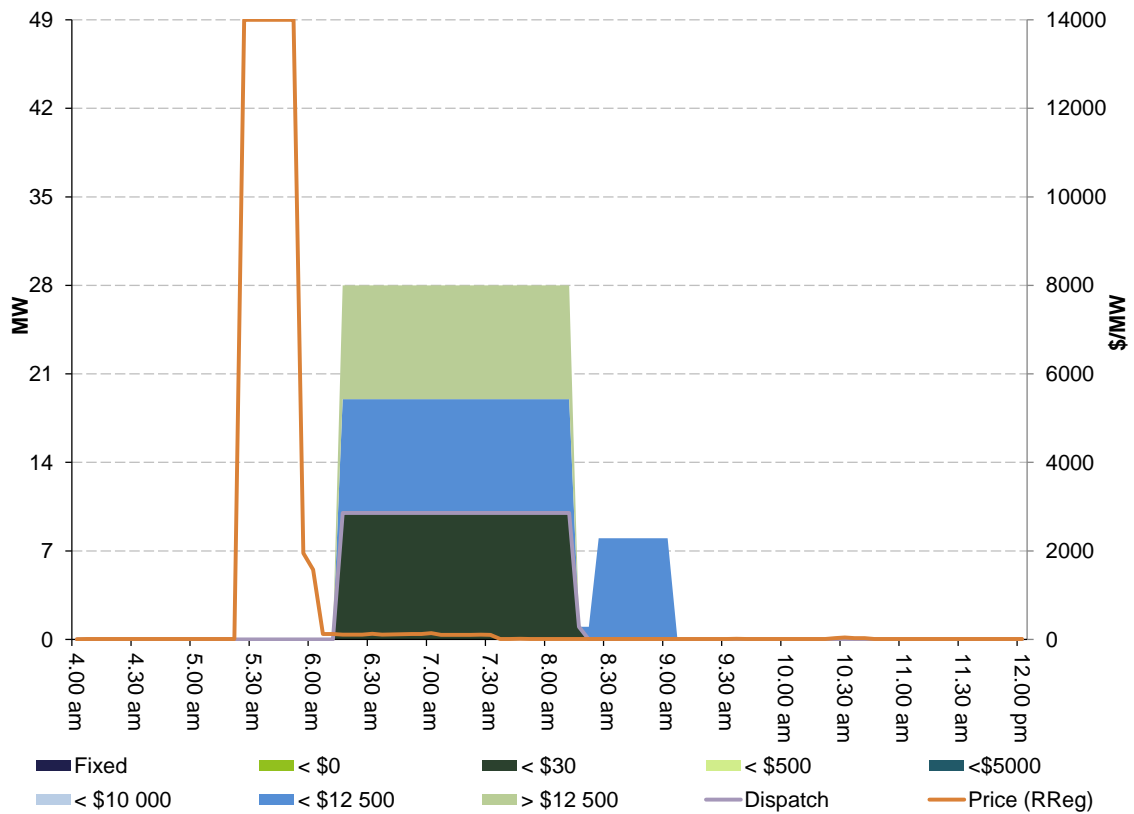


Figure D8a: Osborne (Origin) raise regulation service closing bid prices, dispatch and dispatch price - maximum offers

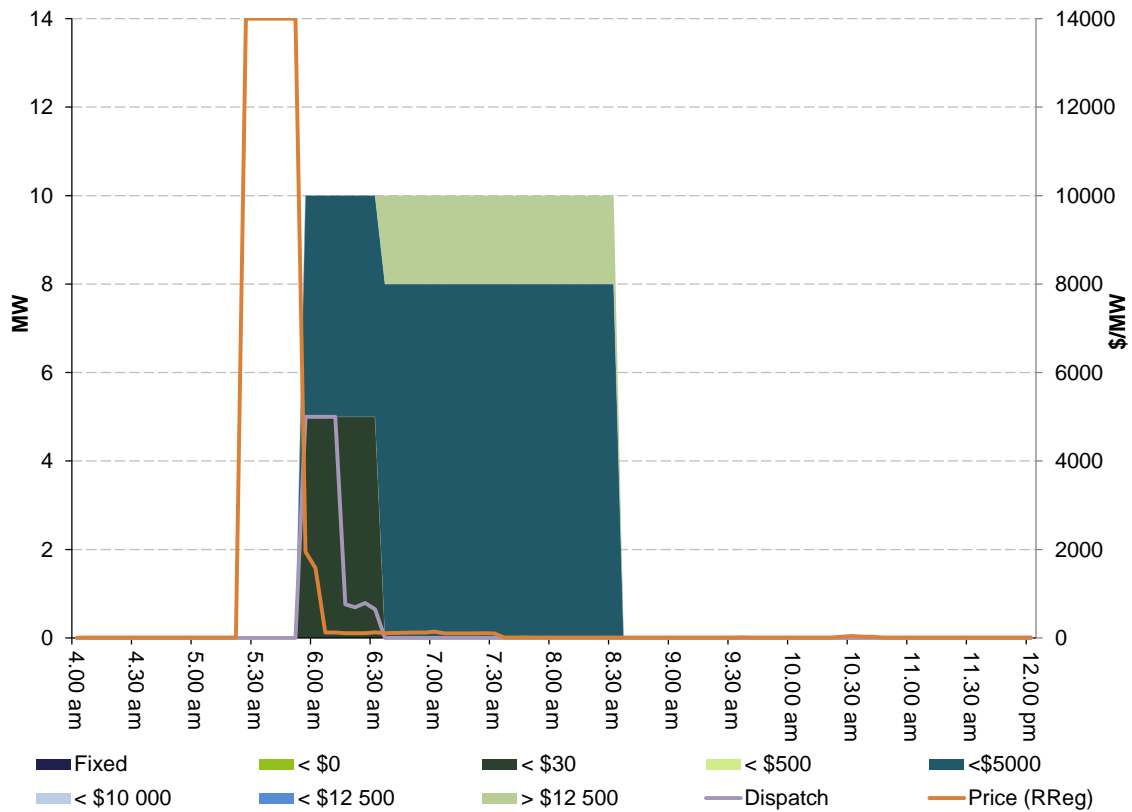
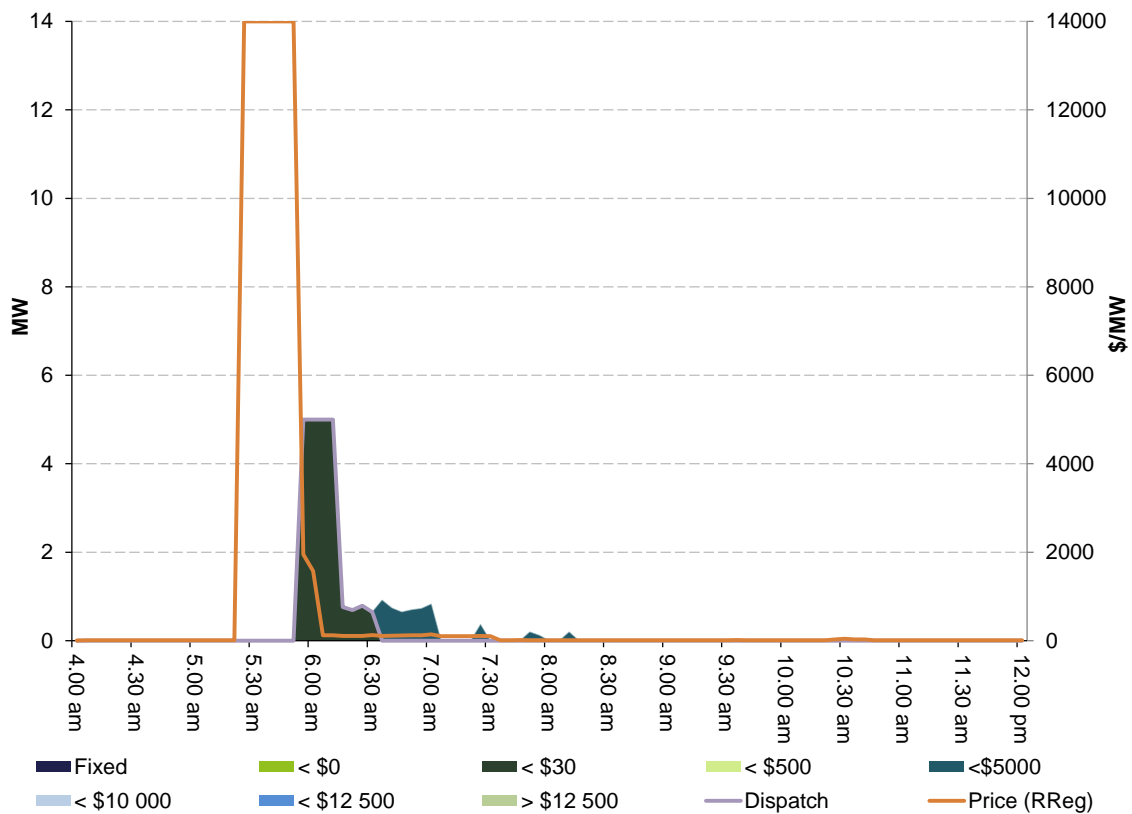


Figure D8b: Osborne (Origin) raise regulation service closing bid prices, dispatch and dispatch price - effective offers



Appendix E: Relevant Market Notices

AEMO issued the following market notices relating to events on the day.

Market Notice	Type	Date of issue	Last Changed
56972	INTER-REGIONAL TRANSFER	23/01/2017 5:31: 55	23/01/2017 5:31: 55

Reason

AEMO ELECTRICITY MARKET NOTICE

Unplanned outage of APD - Heywood - Mortlake No.2 500kV line - VIC region

An unplanned outage of the APD- Heywood - Mortlake No.2 500kV line occurred at 0508 hrs 23/1/2017

The following constraint sets was invoked at 0515 hrs:

F-V-HYMOS-X_BC_CPV-HYMO

The constraint sets contain equations with the following interconnector on the LHS:

N-Q-MNSP1

NSW1-QLD1

VIC1-NSW1

V-SAT-V-MNSP1

V-S_MNSP1

Refer to AEMO Network Outage Scheduler (NOS) for further details.

Manager NEM Real Time Operations

Market Notice	Type	Date of issue	Last Changed
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56983	RESERVE NOTICE	23/01/2017 5:53: 13	23/01/2017 5:53: 13
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Reason

AEMO ELECTRICITY MARKET NOTICE

Actual LOR2 South Australia Region - 23/1/2017

Refer AEMO Electricity Market Notice 56972.

An actual LOR2 condition has been declared for the South Australia region from 0508 hrs due to an unplanned outage of the APD - Heywood - Mortlake No.2 500k V Line in Victoria

If a credible contingency event occurs in this period the South Australia region would separate from the rest of the NEM and is likely to result in interruptions to power supplies. There are sufficient capacity reserves in the South Australia region to meet electricity demand but it may not be possible to bring the required additional capacity into service in time to avoid automatic under-frequency load shedding causing power interruptions.

Manager NEM Real Time Operations

Market Notice	Type	Date of issue	Last Changed
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56985	RESERVE NOTICE	23/01/2017 7:34: 16	23/01/2017 7:34: 16
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Reason

AEMO ELECTRICITY MARKET NOTICE

Cancellation - Actual LOR2 South Australia Region - 23/1/2017

Refer AEMO Electricity Market Notice 56983

An actual LOR2 condition has been cancelled for the South Australia region from 0730 hrs.

Manager NEM Real Time Operations

Appendix F: Price setter

The following tables identify for each five-minute dispatch interval where regulation dispatch prices were above \$5000/MW, the price and the generating units involved in setting the price for each of the regulation services in South Australia. This information is published by AEMO.⁵ Also shown are the offer prices involved in determining the dispatch price, together with the quantity of that service and the contribution to the total price. AEMO reports an increase as a negative marginal change in FCAS price setter. Generator offers which contributed zero to the price have been removed for clarity.

Lower regulation 23 January

DI	Dispatch Price (\$/MW)	Participant	Unit	Service	Offer price (\$/MW)	Marginal change	Contribution
05:20	\$13 799.99	AGL (SA)	TORRB2	Lower reg	\$13 799.99	-1	-\$13 799.99
05:25	\$13 799.99	AGL (SA)	TORRA4	Lower reg	\$13 799.99	-1	-\$13 799.99
05:30	\$13 799.99	AGL (SA)	TORRA2	Lower reg	\$13 799.99	-1	-\$13 799.99
05:35	\$13 859.18	AGL (SA)	TORRA2	Lower reg	\$13 799.99	-1	-\$13 799.99
		AGL (SA)	TORRA2	Energy	\$124.99	-1	-\$124.99
		AGL Energy	BW01	Energy	\$45.13	1.46	\$65.89
05:40	\$13 799.99	AGL (SA)	TORRA1	Lower reg	\$13 799.99	-1	-\$13 799.99
05:45	\$13 799.99	AGL (SA)	TORRB4	Lower reg	\$13 799.99	-1	-\$13 799.99
05:50	\$13 799.99	AGL (SA)	TORRB4	Lower reg	\$13 799.99	-1	-\$13 799.99

Raise regulation 23 January

DI	Dispatch Price (\$/MW)	Participant	Unit	Service	Offer price (\$/MW)	Marginal change	Contribution
05:25	\$14 000	AGL (SA)	TORRA4	Raise reg	\$14 000	-1	-\$14 000
05:30	\$15 038.77	AGL (SA)	TORRA1	Raise reg	\$14 000	-0.52	-\$7280
		AGL (SA)	TORRA4	Raise reg	\$14 000	-0.48	-\$6720
		AGL Energy	BW03	Energy	\$45.13	-0.28	-\$12.64
		AGL Energy	LYA1	Energy	\$35.21	-0.25	-\$8.80
		AGL Energy	LYA3	Energy	\$35.21	-0.25	-\$8.80
		AGL Energy	LYA4	Energy	\$35.21	-0.25	-\$8.80
		AGL (SA)	TORRA1	Energy	-\$1000	0.52	-\$520
		AGL (SA)	TORRA4	Energy	-\$1000	0.48	-\$480
05:35	\$14 000	AGL (SA)	TORRA1	Raise reg	\$14 000	-1	-\$14 000
05:40	\$14 000	AGL (SA)	TORRA2	Raise reg	\$14 000	-1	-\$14 000
05:45	\$14 000	AGL (SA)	TORRA4	Raise reg	\$14 000	-1	-\$14 000
05:50	\$14 000	AGL (SA)	TORRA1	Raise reg	\$14 000	-1	-\$14 000

⁵ Details on how the price is determined can be found at www.aemo.com.au