

Electricity spot prices above \$5000/MWh

New South Wales, 14 January 2016

11 March 2016



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Inquiries about this publication should be addressed to:

Australian Energy Regulator GPO Box 520 MELBOURNE VIC 3001

Tel: (03) 9290 1444 Fax: (03) 9290 1457

Email: <u>AERInquiry@aer.gov.au</u> AER Reference: 59133-D16/13752

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1 Introduction

The AER is required to publish a report whenever the electricity spot price exceeds \$5000/MWh.¹ 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.

On 14 January 2016 at 2 pm, the spot price for energy in New South Wales exceeded \$5000/MWh. This report presents our analysis of the events in accordance with this obligation.

Electricity spot prices above \$5000/MWh

This requirement is set out in clause 3.13.7 (d) of the National Electricity Rules.

2 Summary

On Wednesday, 14 January 2016, the spot price in New South Wales exceeded \$5000/MWh for the 2 pm trading interval. While the four hours ahead spot price forecast was around \$321/MWh, the dispatch price for the 1.35 pm and 1.40 pm dispatch intervals exceeded \$13 000/MWh leading to a 2 pm spot price of \$5022/MWh.

Weather conditions on the day were highly changeable with temperatures in Sydney and its surrounding suburbs reaching, or exceeding, 39 degrees in the early afternoon, followed by a dramatic weather change after about 2.30 pm that produced strong winds, lightening and heavy rain. Energy demand was higher than normal but spot prices in the region, for the majority of the day, varied between \$50/MWh and \$140/MWh.

The weather conditions led to near record demand for that time of year. While almost all of the generators in New South Wales were operating to meet demand, system normal network constraints acted to constrain-off some local generation and reduce flows into New South Wales from neighbouring regions. Supply demand conditions were tight and AEMO issued Lack of Reserve (LOR) notices warning that a single credible contingency could result in involuntary load shedding. The situation was further exacerbated by the forced shutdown of Liddell unit 3.

Capacity rebidding by participants had little impact on pricing outcomes during the event however, rebids that reduced unit ramp down rates prolonged its duration.

3 Analysis

Table 1 shows the actual and forecast spot price, demand and generator availability for the 2 pm trading interval.

Table 1: Actual and forecast spot price, demand and available capacity

Trading interval	Price (\$/MWh)		D	Demand (MW)			Generator 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	5023	290	63	12 635	12 491	11 789	12 293	12 706	12 676

Actual demand was close to forecast four hours ahead, and around 900 MW greater than forecast 12 hours ahead while actual availability was around 400 MW lower for the same periods.

System normal network constraints were an important factor affecting price, generation and interconnector flows. These are discussed in greater detail in section 3.1. From about 11 pm conditions were changing and higher price forecasts appeared. At 11.12 am AEMO declared an LOR1 condition for New South Wales for the period 11 am to 2.30 pm (market notices 51358 and 51359) citing reserve levels down to 693 MW.²

From 11.30 am the pre-dispatch price forecasts for 2 pm increased from around \$500/MWh to \$13 400/MWh, coinciding with N>>N-NIL__S, a system normal network constraint, binding and import limits and flows into New South Wales being reduced by around 700 MW.

At 1.47 pm, AEMO published market notice 51362 which declared an LOR2 condition for the period from 1.30 pm to 2.30 pm, indicating reserves had dropped to 515 MW; less than the 680 MW reserve required to avoid involuntary load shedding in the event of a single credible contingency.^{3,4}

Market notice 51368 published by AEMO at 2.15 pm indicated that reserves had dropped to 449 MW however by that time the temperature and demand were dropping.

3.1 Network Availability

This section examines the change in network capability approaching the event and its contribution to price outcomes.

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An LOR1 condition exists during the period when AEMO considers there are insufficient short-term capacity reserves available to provide complete replacement of the contingency capacity reserve (1360 MW in NSW at this time) when a critical single credible contingency event occurs in the nominated period.

An LOR2 condition exists during the period when AEMO considers that the occurrence of a critical single credible contingency (680 MW in NSW at this time) event is likely to require involuntary load shedding.

Relevant market notices are listed in Appendix D.

During the 2 pm trading interval four system normal constraints were binding, reducing imports into New South Wales and constraining down local generation. Table 2 shows actual and forecast net import limit into New South Wales for the 2 pm trading interval. Both the net import limit and net flows into New South Wales were lower than that forecast four hours ahead, by 881 MW and 560 MW, respectively.

Table 2: Actual and forecast net network capability

Trading interval	Net Imports (MW)			Ne	et Import limit (I	MW)
	Actual	4 hr forecast	12 hr forecast	Actual	4 hr forecast	12 hr forecast
2 pm	1202	1762	1133	1392	2272	2033

Network availability and supply-demand conditions were such that small variations in demand or interconnector limits or flows had the potential to lead to large variations in price. This is discussed in greater detail in the following sections.

Table 3 lists the relevant system normal network constraints that were binding during the high priced period. Table 4 shows the net import and limit across the three interconnectors into New South Wales.

Table 3: Relevant binding network constraints

Constraint	Description	Total NSW Generation Affected (MW)	Interconnectors Affected
N>>N-NIL_S	No Outages - avoid overload on Mt Piper to Wallerawang on trip of parallel Mt Piper to Wallerawang line	10 411	VIC-NSW QNI Terranora
N>>N-NIL_64	No Outages - avoid overload on Bannaby to Sydney West on trip of Dapto to Sydney South line	15 335	VIC-NSW QNI Terranora
N>>N-NILB_15M	No Outages - avoid Overload of Upper Tumut to Canberra using 15 mins rating on trip of parallel Lower Tumut to Canberra line	3960	VIC-NSW
N^^N_NIL_1	No Outages - manage voltage stability - manages flows on lines between Sydney and Murray limiting northerly flows.	2936	VIC-NSW
N_X_MBTE2_B	Outage of two Directlink cables, limits flows on Terranora from Qld to NSW	-	Terranora

Binding system normal constraints and in particular N>>N-NIL_S and N>>N-NIL_64 could affect all three interconnectors into New South Wales and the output of almost all generation in New South Wales.⁵

Together these constraints reduced the lower priced generator output in the region by around 340 MW and reduced flows on the interconnectors from Queensland.

Four system normal constraints, which limit the dispatch of generation to maintain normal network thermal limits, were also reducing network flows from Victoria into New South Wales and increasing, to a lesser extent, flows from Queensland into New South Wales. As shown in Table 4, imports into New South Wales on the Vic-NSW interconnector were around 1000 MW less than forecast four hours ahead. QNI and Terranora were around 370 MW and 36 MW more than forecast four hours ahead respectively. The net impact of these constraints was a reduction of 560 MW of import capability into New South Wales compared to that forecast four hours ahead.

Table 4: Actual and forecast network capability for 2 pm

Interconnector	Imports Flow (MW)			lm	Import limit (MW)		
	Actual	4 hr forecast	12 hr forecast	Actual	4 hr forecast	12 hr forecast	
Vic-NSW	269	1232	1047	307	1232	1155	
QNI	833	465	61	968	946	765	
Terranora	101	65	25	116	94	112	

Figure 1 shows the import limit, and target flows of the Vic-NSW and QNI interconnectors which connect New South Wales to neighbouring regions. New South Wales was importing around 800 MW from Queensland over QNI at the time of the high price. Imports into New South Wales from Victoria over the VIC –NSW interconnector were around 250 MW. The figure shows the reduction in imports over the duration of the event.

Electricity spot prices above \$5000/MWh

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N>>N-NIL_64 includes terms for around 15 300 MW of NSW generation only excluding Nyngan solar farm and the Smithfield cogen plant.

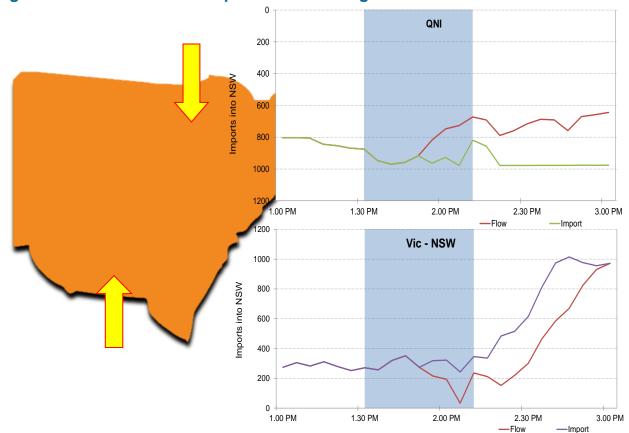


Figure 1: New South Wales import limits and target flows

3.2 Supply and Demand

This section discusses changes to the price and capacity offered by generators, and demand conditions relevant to the pricing event.

3.2.1 Supply curve

Supply curves illustrate any potential sensitivity to changes in key factors affecting both demand and supply. The supply curve is derived by summing the available capacity in each price band for all generators in New South Wales.

We have examined the supply curve for the 1.40 pm dispatch interval (shown in Figure 2) as it is typical of the situation for the period of high prices and reflects the situation in New South Wales before market systems reflected the trip of Liddell unit 3.

The red line in Figure 2 shows the actual supply curve for all generators in New South Wales based on their offers. The vertical section of the curve at about 11 700 MW shows there was no capacity priced between \$300/MWh and \$12 900/MWh (\$300/MWh was the price forecasts four hours ahead).

As discussed above, the binding network constraints effected low-priced generation in the south of New South Wales reducing the capacity available for dispatch (effective capacity). While Liddell unit 3 tripped at around 1.30 pm, its rebid did not become effective until 1.45 pm meaning that its 450 MW of availability was still being reflected

in the supply curve at 1.40 pm even though it was out of service.⁶ These reductions in effective capacity shift the supply curve to the left by up to 770 MW during the period of high prices (represented by the blue line in Figure 2).⁷

The green dotted line in Figure 2, represents New South Wales demand minus imports, that is the effective target output from the generators in the region.

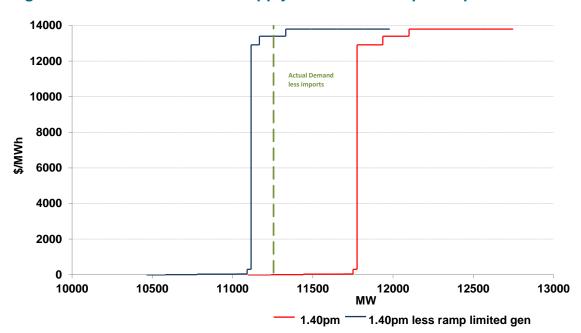


Figure 2: Actual and effective supply curves for 1.40 pm dispatch interval

The intersection of the effective demand line and the supply curves provides an indication of the regional price. Had all the capacity offered been available to meet the effective demand the dispatch price would have been lower. However, with a supply curve with these characteristics small changes in demand, interconnector capability or rebidding may have a large effect on price. Shifting the supply curve to the left increases the probability of a high price outcome, as the demand approached 11 100 MW.

3.2.2 Rebidding

There was no significant rebidding of capacity from low to high prices that contributed to the high priced outcomes. Rebidding that did affect the high prices was the rebidding of ramp down rates to the minimum allowed without a technical reason to minimise the impacts of the network constraints.⁸

In response to the network constraints binding, participants progressively rebid their ramp down rates to the minimum allowable starting at around 11 am.

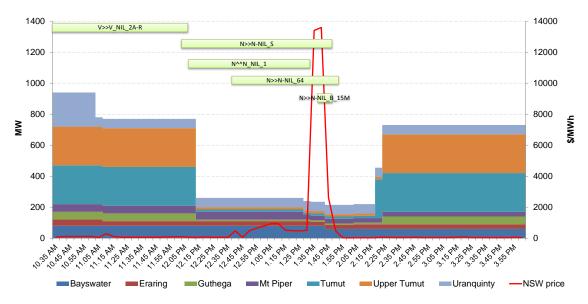
⁶ Liddell unit 3 received a target for the 1.40 pm dispatch interval of 20 MW as its metered output for that period was 0 MW after its trip and its ramp up rate was 4 MW/min. It was only excluded from dispatch after its rebid became effective at 1.45 pm.

³⁴⁰ MW was generation constrained down and 430 MW was from the trip of Liddell unit 3.

The current requirement under the Electricity Rules that generators specify a ramp rate that is greater than or equal to the lower of three megawatts per minute, or three per cent of maximum capacity, unless there is a physical or safety limitation on their plant.

Figure 3 shows the cumulative ramp down rate in MW/min of stations in New South Wales that had been changed. The horizontal green bars show the times when the system normal network constraints were binding, highlighting that the reductions in ramp rate coincided with the constraints binding. At times these units were being ramped down out of merit order. The reduction in offered ramp rates prolonged the effect of the constraint by taking longer to ramp the units down to the point where the constraint is relieved and prices reduce.

Figure 3: Cumulative ramp down rates stations in New South Wales that were rebid.



Note: Ramp rates as per offer

Figure 4 shows the closing bids for participants in New South Wales as well as the total generation output in the region and the dispatch price.

Network constraints can cause generators to be dispatched at a price that is lower than the offer price (constrained-on) or generators to not be dispatched even though its offer price is lower than the regional price (constrained-off).

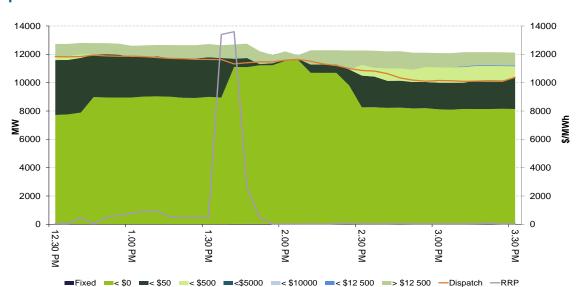


Figure 4: Closing bids of New South Wales generators, output and spot price

Snowy Hydro rebid 125 MW of capacity at Colongra from low to high prices at 1 pm to manage changing gas supply conditions. A second rebid by Snowy Hydro at 1.48 pm for Colongra increased its available capacity at the price floor.

The rebids considered to have been material to the event are listed in Appendix A.

Appendix B details the generators involved in setting the price during the high-price periods, and how that price was determined by the market systems.

The closing bids for all participants in New South Wales with capacity priced at or above \$5000/MWh for the high-price periods are set out in Appendix C.

Australian Energy Regulator

March 2016

Appendix A: 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.

Significant energy rebids for 2 pm

Submit time	Time effective	Participant	Station	Capacity rebid (MW)	Price from (\$/MWh)	Price to (\$/MWh)	Rebid reason
1 pm		Snowy Hydro	Colongra	125	0	13800	12:59:P MANAGE FUEL, JEMENA COMPRESSOR OOS
1.34 pm	1.45 pm	AGL Energy	Liddell	-450	-1000	N/A	1330~P~020 REDUCTION IN AVAIL CAP~204 UNIT TRIP 450MW
1.48 pm	1.55 pm	Snowy Hydro	Colongra	324	N/A	-1000	13:50 A NSW: ACT PRICE \$13,326.69 LWR THN 5MPD 13:50@13:41

Significant ramp rate rebids for 2 pm

Submit time	Time effective	Participant	Station	Capacity rebid (MW/min)	Ramp down rate from (MW/min)	Ramp down rate to (MW/min)	Rebid reason
10.58 pm		Origin Energy	Uranquinty	-32	44	12	1056A CONSTRAINT MANAGEMENT - V>>V_NIL_2A_ R SL
11 pm		Origin Energy	Eraring	-4	10	6	1100P PLANT CONDITIONS - UNIT STABILITY SL
11.51 am		Snowy Hydro	Tumut 3 Upper Tumut Guthega	-102	110	8	11:31 A NSW: 30MPD PRICE \$12,901.73 HGR THN 30MPD 14:00@11:02

Submit time	Time effective	Participant	Station	Capacity rebid (MW/min)	Ramp down rate from (MW/min)	Ramp down rate to (MW/min)	Rebid reason
1.21 pm		Energy Australia	Mt Piper	-4	10	6	13:19 A BAND AND ROC ADJ DUE TO MAT CHANGE IN NSW 30PD PRICES SL
1.24 pm	1.35 pm	Origin Energy	Eraring	-1	3	2	1320P CHANGE IN AVAIL - ID FAN ISSUES - ROC 2MW/MIN SL
1.37 pm	1.45 pm	AGL Energy	Bayswater	-4	16	12	1335~A~060 UNFCAST NETWORK CONSTRAINT~ 61 CONSTR OFF OUT OF MERIT ORDER N>>N-NIL_S

Appendix B: Price setter

The following table identifies 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. ¹⁰ The 30-minute spot price is the average of the six dispatch interval prices.

2 pm

DI	Dispatch Price	Participant	Unit	Service	Offer price	Marginal change	Contribution
13:35	\$13 400.00	Delta Electricity	VP5	Energy	\$13 400.0	1.00	\$13 400.00
13:40	\$13 594.71	Delta Electricity	VP5	Energy	\$13 400.0	1.00	\$13 400.00
		Delta Electricity	VP6	Raise reg	\$300.00	0.24	\$72.00
		CS Energy	GSTONE4	Energy	\$299.91	0.08	\$23.99
		CS Energy	GSTONE5	Energy	\$299.91	0.08	\$23.99
		CS Energy	GSTONE6	Energy	\$299.91	0.08	\$23.99
		CS Energy	GSTONE4	Raise reg	\$0.50	-0.08	-\$0.04
		CS Energy	GSTONE5	Raise reg	\$0.50	-0.08	-\$0.04
		CS Energy	GSTONE6	Raise reg	\$0.50	-0.08	-\$0.04
		New Gullen Range	GULLRWF1	Energy	\$0.00	-0.21	\$0.00
			ENOF,GULLR		\$0.00	-9.75	\$0.00
			ENOF,GULLR		\$0.00	-6.22	\$0.00
			ENOF,GULLR		\$0.00	-6.22	\$0.00
			ENOF,BLOW		\$0.00	-15.55	\$0.00
			ENOF,GSTO		\$0.00	4.79	\$0.00
			ENOF,GSTO		\$0.00	4.79	\$0.00
			ENOF,GSTO		\$0.00	4.79	\$0.00
			ENOF,GSTO		\$0.00	3.59	\$0.00
			ENOF,GSTO		\$0.00	3.59	\$0.00
			ENOF,GSTO		\$0.00	3.59	\$0.00
			ENOF,GSTO		\$0.00	4.79	\$0.00
			ENOF,GSTO		\$0.00	4.79	\$0.00
			ENOF,GSTO		\$0.00	4.79	\$0.00
13:45	\$2620.56	Delta Electricity	VP6	Raise reg	\$300.00	3.08	\$924.00
		CS Energy	CALL_B_1	Energy	\$16.80	3.08	\$51.74
		CS Energy	CALL_B_1	Raise reg	\$0.01	-3.08	-\$0.03
			ENOF,BOCO		\$0.00	185.74	\$0.00
			ENOF,BROK		\$0.00	87.12	\$0.00
			ENOF,BW01,		\$0.00	1068.44	\$0.00

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

Price price change ENOF,BW02, \$0.00 1052.00	
	\$0.00
ENOF,BW03, \$0.00 1068.44	\$0.00
ENOF,BW04, \$0.00 1084.87	\$0.00
ENOF,CALL_ \$0.00 308.34	\$0.00
ENOF,ER01,1 \$0.00 1117.75	\$0.00
ENOF,ER02,1 \$0.00 1134.19	\$0.00
ENOF,GUTH \$0.00 110.13	\$0.00
ENOF,HVGT \$0.00 82.19	\$0.00
ENOF,LD01,1 \$0.00 361.62	\$0.00
ENOF,LD04,1 \$0.00 821.87	\$0.00
ENOF,MP1,1, \$0.00 1052.00	\$0.00
ENOF,MP2,1, \$0.00 1101.31	\$0.00
ENOF,ER03,1 \$0.00 -345.19	\$0.00
ENOF,ER04,1 \$0.00 -345.19	\$0.00
ENOF,LD02,1 \$0.00 -361.62	\$0.00
ENOF,LD03,1 \$0.00 -739.69	\$0.00
ENOF,NYNG \$0.00 351.76	\$0.00
ENOF,NYNG \$0.00 682.16	\$0.00
ENOF,NYNG \$0.00 174.24	\$0.00
ENOF,NYNG \$0.00 2958.75	\$0.00
ENOF,NYNG \$0.00 922.14	\$0.00
ENOF,NYNG \$0.00 272.86	\$0.00
ENOF,NYNG \$0.00 904.06	\$0.00
ENOF,NYNG \$0.00 904.06	\$0.00
ENOF,NYNG \$0.00 78.90	\$0.00
NYNGAN1 Energy -\$1000.00 -1.64	\$1640.00
13:50 \$473.31 CS Energy GSTONE6 Energy \$299.91 1.68	\$503.85
AGL (SA) TORRB2 Energy \$45.99 -0.50	-\$23.00
Delta Electricity VP6 Lower reg \$5.00 -1.17	-\$5.85
AGL (SA) TORRB2 Lower reg \$0.45 -0.50	-\$0.23
CS Energy GSTONE6 Lower reg \$0.01 1.68	\$0.02
ENOF,GSTO \$0.00 -159.19	\$0.00
ENOF,GSTO \$0.00 -159.19	\$0.00
ENOF,TORR \$0.00 20.16	\$0.00
ENOF,TORR \$0.00 -20.16	\$0.00

DI	Dispatch Price	Participant	Unit	Service	Offer price	Marginal change	Contribution
			ENOF,GSTO		\$0.00	100.54	\$0.00
			ENOF,GSTO		\$0.00	75.41	\$0.00
			ENOF,GSTO		\$0.00	100.54	\$0.00
			ENOF,TORR		\$0.00	20.16	\$0.00
13:55	\$27.62	Origin Energy	DDPS1	Energy	\$25.55	1.08	\$27.59
14:00	\$20.26	GDF Suez	LOYYB1	Energy	\$16.20	0.51	\$8.26
		GDF Suez	LOYYB2	Energy	\$16.20	0.51	\$8.26
		Delta Electricity	VP5	Lower reg	\$5.00	1.22	\$6.10
		AGL (SA)	TORRB2	Raise 6 sec	\$2.00	1.02	\$2.04
		EnergyAustralia	YWPS4	Raise 60 sec	\$1.80	-1.09	-\$1.96
		GDF Suez	LOYYB1	Raise 6 sec	\$1.69	-0.51	-\$0.86
		GDF Suez	LOYYB2	Raise 6 sec	\$1.69	-0.51	-\$0.86
		GDF Suez	LOYYB1	Raise 60 sec	\$1.43	-0.51	-\$0.73
		GDF Suez	LOYYB2	Raise 60 sec	\$1.43	-0.51	-\$0.73
		AGL (SA)	TORRB2	Lower reg	\$0.90	-1.22	-\$1.10
		AGL (SA)	TORRB2	Raise 60 sec	\$0.89	2.10	\$1.87

Spot Price \$5023/MWh

Appendix C: Closing bids

Figures C1 to C4 highlight the half hour closing bids for participants in New South Wales with significant 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 C1 - Delta (Vales Point) closing bid prices, dispatch and spot price

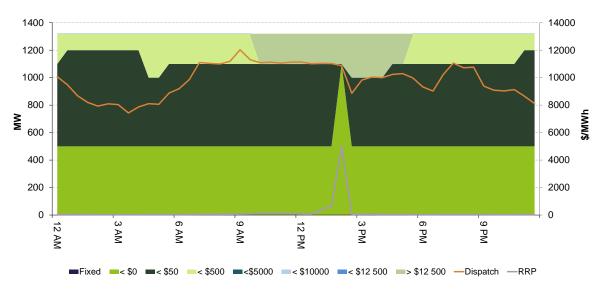


Figure C2 - EnergyAustralia (Mt Piper, Tallawarra) closing bid prices, dispatch and spot price

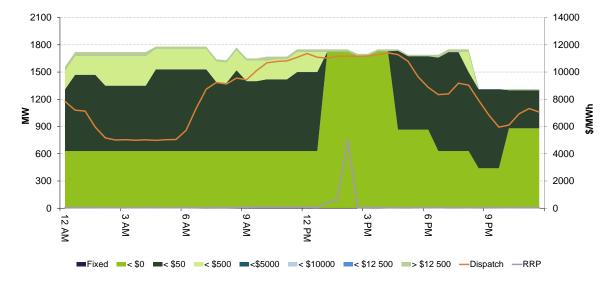


Figure C3 - Origin (Eraring, Shoalhaven, Uranquinty) closing bid prices, dispatch and spot price

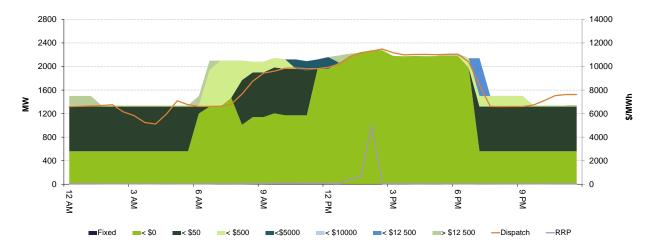
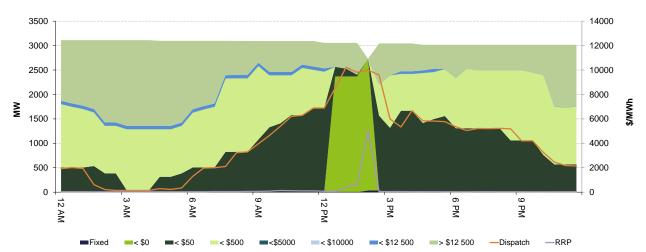


Figure C4 – Snowy Hydro (Colongra, Tumut, Upper Tumut, Guthega, Blowering) closing bid prices, dispatch and spot price



Appendix D: Relevant Market Notices

The following market notices either were notifying the market of the network issues in New South Wales.

Market Notice	Туре	Date of issue	Last Changed
51358	Reserve Notice	14/01/2016 11:12	14/01/2016 11:12

External Reference

Actual Lack Of Reserve Level 1 (LOR1) in the NSW Region.- 14/01/16

Reason

AEMO ELECTRICITY MARKET NOTICE

Actual Lack Of Reserve Level 1 (LOR1) in the NSW Region.- 14/01/16

An Actual LOR1 condition has been declared for the NSW Region from 1100 hrs.

The Actual LOR1 condition is forecast to exist until 1600 hrs

The contingency capacity reserve required is 1360 MW

The minimum reserve available is 821 MW

Manager NEM Real Time Operations

Market Notice	Туре	Date of issue	Last Changed
51359	Reserve Notice	14/01/2016 11:40	14/01/2016 11:40

External Reference

UPDATE Actual Lack Of Reserve Level 1 (LOR1) in the NSW Region.- 14/01/16

Reason

AEMO ELECTRICITY MARKET NOTICE

UPDATE Actual Lack Of Reserve Level 1 (LOR1) in the NSW Region.- 14/01/16

Refer to Market Notice 51358

An Actual LOR1 condition has been declared for the NSW Region from 1100 hrs.

The Actual LOR1 condition is forecast to exist until 1630 hrs

The contingency capacity reserve required is 1360 MW

The minimum reserve available is 693 MW

Manager NEM Real Time Operations

Market Notice	Туре	Date of issue	Last Changed	
51362	Reserve Notice	14/01/2016 13:47	14/01/2016 13:47	

External Reference

Actual Lack Of Reserve Level 1 (LOR2) in the NSW Region.- 14/01/16

Reason

AEMO ELECTRICITY MARKET NOTICE

Actual Lack Of Reserve Level 2 (LOR2) in the NSW Region - 14/01/16

An Actual LOR2 condition has been declared for the NSW region from 1330 hrs.

The Actual LOR2 condition is forecast to exist until 1530 hrs

The contingency capacity reserve required is 680 MW

The minimum reserve available is 515 MW

AEMO is seeking a market response.

AEMO does not intend to intervene through a AEMO intervention event.

Manager NEM Real Time Operations

Market Notice	Туре	Date of issue	Last Changed
51368	Reserve Notice	14/01/2016 14:15	14/01/2016 14:15

External Reference

UPDATE Actual Lack Of Reserve Level 2 (LOR2) in the NSW Region - 14/01/16

Reason

AEMO ELECTRICITY MARKET NOTICE

UPDATE Actual Lack Of Reserve Level 2 (LOR2) in the NSW Region - 14/01/16

Refer to Market Notice 51362

An Actual LOR2 condition has been declared for the NSW region from 1330 hrs.

The Actual LOR2 condition is forecast to exist until 1630 hrs

The contingency capacity reserve required is 680 MW

The minimum reserve available is 449 MW

AEMO is seeking a market response.

AEMO does not intend to intervene through a AEMO intervention event.

Manager NEM Real Time Operations