Electricity spot prices above $5000/MWh

Queensland, 13 January 2017

10 March 2017

AUSTRALIAN ENERGY REGULATOR

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Contents

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.

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

2 Summary

On Friday 13 January 2017, the spot price for electricity in Queensland exceeded $5000/MWh for one 30-minute trading interval, reaching $13 883/MWh at 5 pm. Forecasts produced earlier in the day indicated that the spot price would reach a high of $2150/MWh. The 5-minute dispatch prices, which when averaged, make up the spot price, varied significantly throughout the day exceeding $12 500/MWh on 14 occasions.

13 January was the fifth consecutive day of temperatures above 30 degrees, with the temperature in Brisbane reaching 33 degrees as forecast. According to the Bureau of Meteorology, the day prior was the hottest day of the month. Maximum total demand on the day was 9040 MW which occurred at 5 pm, just short of record demand for Queensland.[2] While high demand contributed to the high prices, adequate capacity was available.

Earlier forecasts indicated around 11 000 MW of generation capacity would be available in Queensland during the 5 pm trading interval. Plant limitations, some of which related to the high temperature, saw participants rebid, reducing generation capacity by around 600 MW. The majority of this capacity had been priced less than $100/MWh. Despite these reductions throughout the day, there was still around a 1400 MW surplus of generation at the time of the high price.

For most of the high priced periods, Queensland had reduced access to capacity from other regions, as forecast. Network limits restricted electricity flows into Queensland from New South Wales on the Queensland to New South Wales interconnector (QNI). These limits, which are in place at all times and are designed to manage the power system should the 750 MW Kogan Creek generator fail, reduced flows into Queensland to around 100 MW. Other network limitations at times forced around 95 MW of flow from Queensland into New South Wales across the Terranora interconnector – counter to the prices in those regions.

These high prices were caused by reductions in low priced capacity, network constraints and high demand.

2 The NEM operates on a range of demand definitions, the demand section of this report provides a definition of total demand.

3 Analysis

Table 1 shows the actual and forecast spot price, demand and availability for each high price trading interval. The spot price in Queensland exceeded $5000/MWh for the 5 pm trading interval (in bold) and two other trading intervals associated with the same event reached around $2400/MWh.

Generator availability was between 600 MW and 670 MW lower than forecast four hours ahead with a majority of this capacity priced below $100/MWh. Actual demand for the 4.30 pm and 5 pm trading intervals were close to the four hour ahead forecast while demand was around 180 MW higher for 5.30 pm.

The table shows that high prices were not forecast four hours ahead of dispatch and only the 4.30 pm price was close to its 12 hour forecast.

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

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
4.30 pm	2442	102	2150	8943	8965	8818	10 205	10 874	10 957
5 pm	**13 883**	**107**	**2150**	**9040**	**9004**	**8860**	**10 257**	**10 859**	**10 957**
5.30 pm	2340	86	155	8998	8816	8685	10 764	10 934	11 051

3.1 Supply and Demand

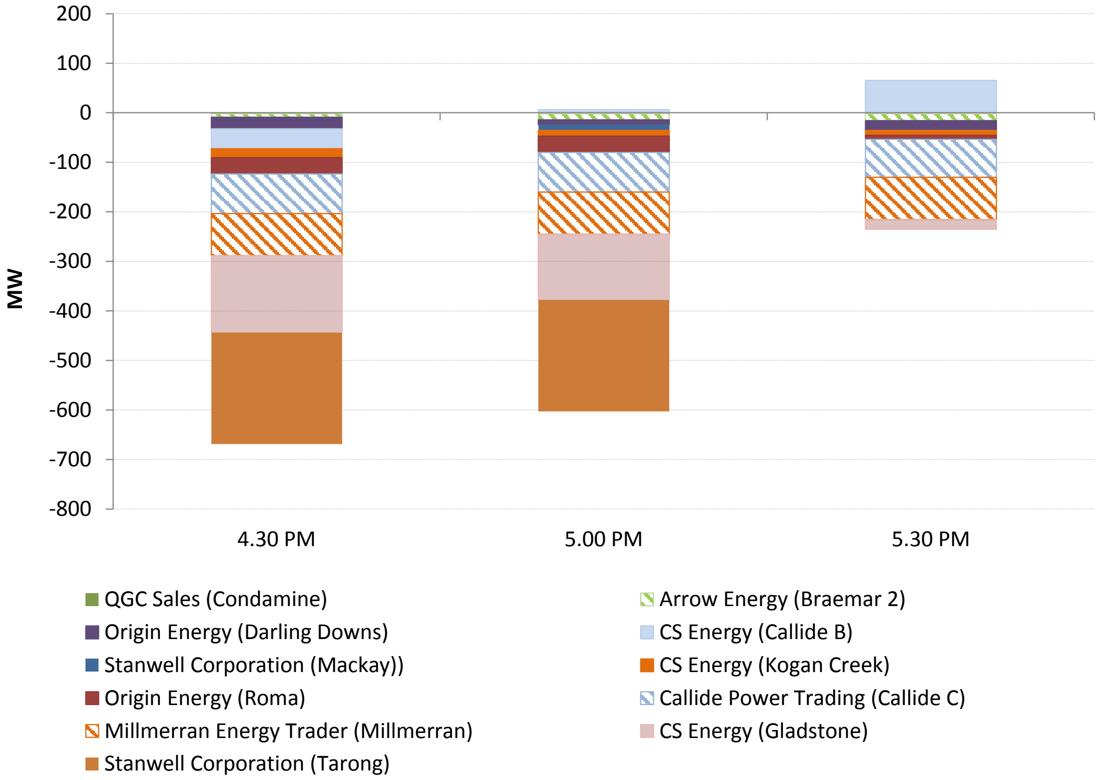
This section discusses changes to generator offered prices and capacity and market demand conditions relevant to the high price periods. It highlights that supply conditions were such that small variations in demand and limited interconnector flows had the potential to lead to large variations in price.

3.1.1 Rebidding

Figure 1 summarises the changes in generation made available to the market by generator rebids submitted within four hours of dispatch and effective for the high price periods. Areas below the horizontal axis represent a reduction in capacity; the areas above the horizontal axis represent capacity added.

There was significant capacity removed for the 4.30 pm and the 5 pm trading intervals, around 670 MW and 600 MW respectively. The reasons for the reduction primarily related to temperature or plant limitations. Around half of this capacity was priced below $100/MWh.

Figure 1: Rebidding to reduce or add capacity, by trading interval



To understand the graph, take the example for the 5 pm trading interval:

- Arrow Energy's Braemar 2 generator withdrew 13 MW of capacity (green stripes)
- Callide Power Trading's Callide C Generator withdrew 80 MW of capacity (blue stripes)

- CS Energy's Callide B generator added 6 MW of capacity (small light blue area above the line)
- CS Energy's Gladstone generator withdrew 133 MW of capacity (pink)
- CS Energy's Kogan Creek generator withdrew 12 MW of capacity (orange)
- Millmerran Energy Trader's Millmerran generator withdrew 85 MW of capacity (orange stripes)
- Origin Energy's Darling Downs generator withdrew 10 MW of capacity (purple)
- Origin Energy's Roma generator withdrew 33 MW of capacity (dark red)
- QGC Sales' Condamine generator withdrew 2 MW of capacity (green)
- Stanwell Corporation's Mackay generator withdrew 11 MW of capacity (dark blue)
- Stanwell Corporation's Tarong generator withdrew 225 MW of capacity (brown)

At around 4 pm, effective for the high prices trading intervals, Stanwell also rebid 100 MW of capacity at Tarong from prices below $160/MWh to the price cap. Stanwell quoted a change in the 5-minute forecast price between one dispatch interval and the next as the reason for the change.

Appendix A contains all significant rebids that contributed to the high prices.

3.1.2 Closing bids and supply

This section examines the relationship between supply and demand through closing bids and actual and forecast supply curves that existed during the period.

Figure 2 shows the cumulative five minute closing bids for participants in Queensland alongside the dispatch price (purple line) and local demand (blue line) and local dispatch (orange line).

Figure 2: Closing bids, dispatch prices, dispatch and demand

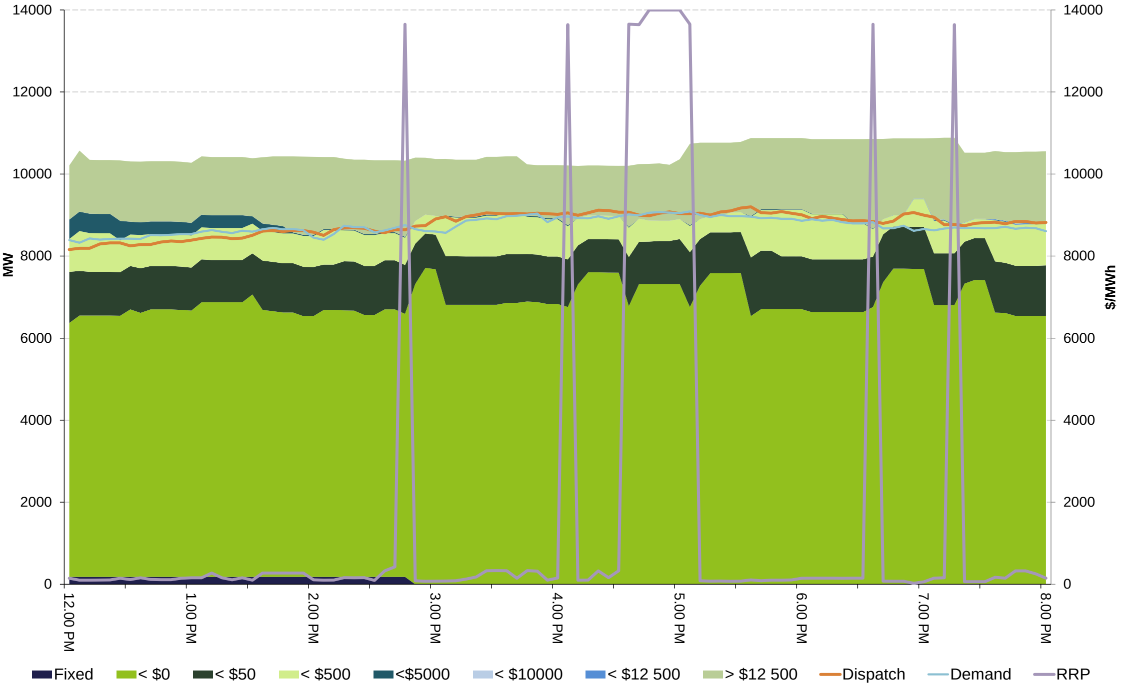


Figure 2 shows that there was almost zero generating capacity offered to the market between prices of $500/MWh and $12 500/MWh. Given the level of demand and local dispatch of generation, small changes demand, availability or network capability could see prices shift dramatically between these levels.

The increase in the bottom green section after a price spike, highlights that a significant amount of generation was rebid from higher to lower prices for that trading interval. In the 5 pm trading interval, around 536 MW was rebid into lower price bands, which was less than the 3 pm (980 MW) and 4.30 pm (836 MW) trading intervals.

Figure 3 shows the actual supply curve for the 5 pm trading interval when the price was at its highest (denoted by the solid green line), the supply curve forecast four hours ahead (i.e. 12.30 pm, denoted by the solid red line). The supply curves were derived by summing the available capacity in each price band for all generators in Queensland.

Also shown is Queensland demand less imports (denoted by the dashed lines), that is the effective target output from the generators in the region. The intersection of the effective demand line and the supply curves provides an indication of the regional price.

Figure 3: Forecast and actual supply curves for 5 pm

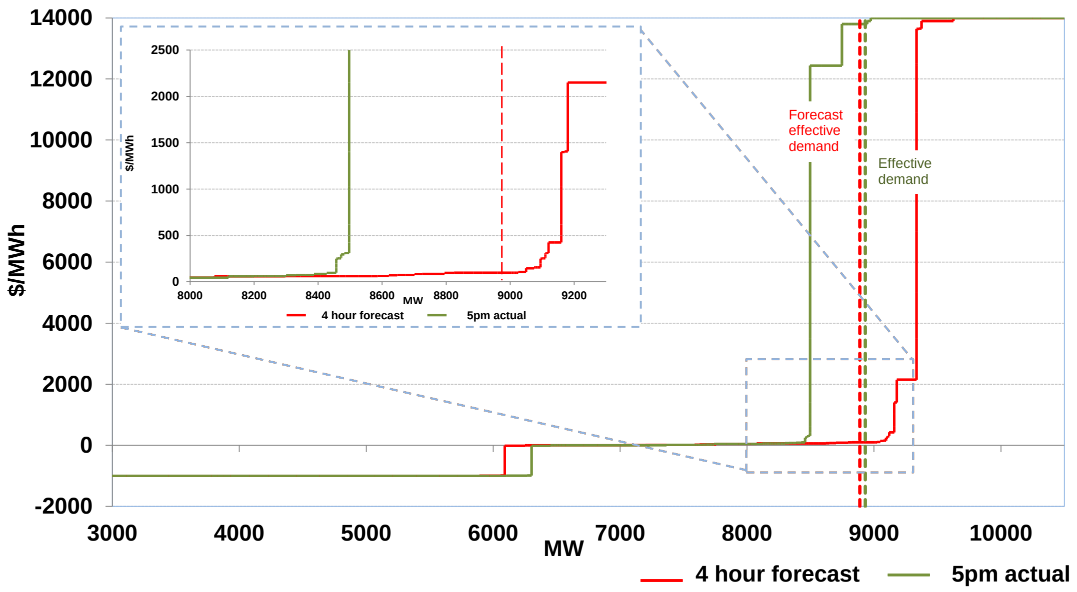


Figure 3 shows the effect of the reduction in capacity on the supply curve by the shift in the supply curve to the left of that forecast four hours earlier. The forecast price went from around $100/MWh (where the red forecast supply curve and forecast effective demand intersect) to just short of the price cap (where the green supply curve and effective demand intersect).

Both figures show with such a steep supply curve any small increase in demand, change in flows or a reduction in generator availability would lead to large changes in price.

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 Queensland with capacity priced at or above $5000/MWh for the high-price periods are set out in Appendix C.

3.1.3 Demand

AEMO uses a range of demand definitions for different purposes the two discussed in this report are total demand and native demand.[3] Total demand is used by the national electricity market dispatch engine when determining price and is the demand against which generator targets for scheduled and semi-scheduled are calculated. The industry statistics published by the AER on its website refers to native demand which includes non-scheduled and exempt generation as the measure of record demand as it is best reflects actual consumption in a region.[4]

3 See AEMO demand definition document https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Dispatch/Policy_and_Process/2016/Demand-terms-in-EMMS-Data-Model_Final.pdf

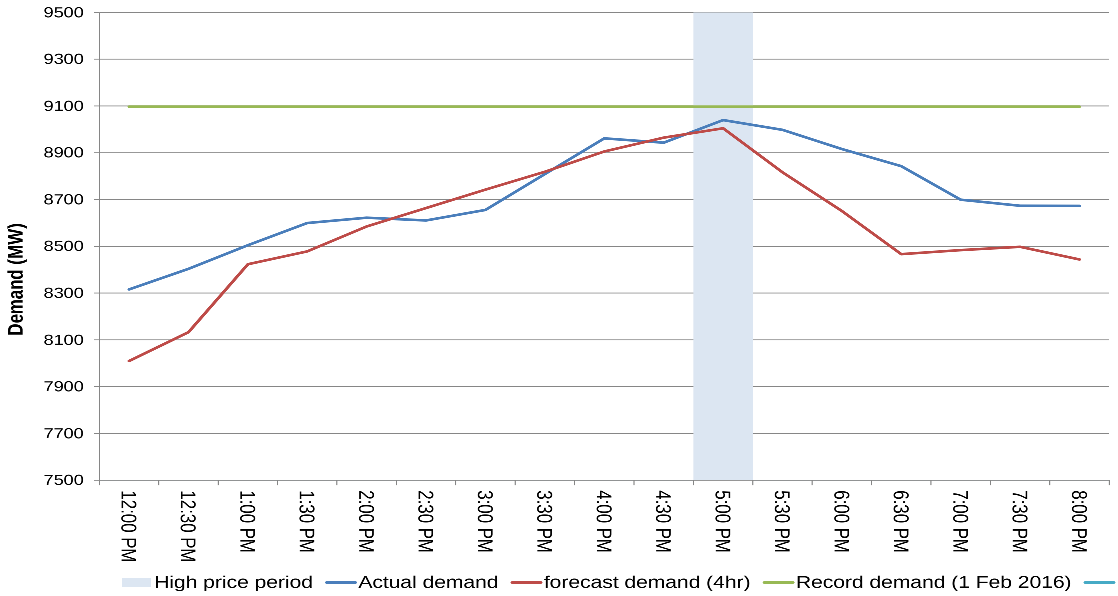
4 http://www.aer.gov.au/industry-information/industry-statistics

The maximum temperature in Brisbane reached 33 degrees, consistent with the forecast prepared by the Bureau of Meteorology. This was the fifth consecutive day of temperatures above 30 degrees. Maximum total demand for the day reached 9040 MW at 5 pm just short of the all-time maximum of 9097 MW recorded on 1 February 2016.

Native demand on the day reached 9178 MW also at 5 pm just short of the record native demand of 9260 MW on 1 Feb 2016. While demand on the day was still short of record levels there has been a material growth in electricity demand in Queensland attributable to the extraction of coal seam gas over the last few years.[5]

Figure 4 shows actual total demand (blue line) and forecast total demand (red line), prepared four hours before dispatch. The graph also shows the highest recorded total demand (green line).

Figure 4: Actual and forecast total demand

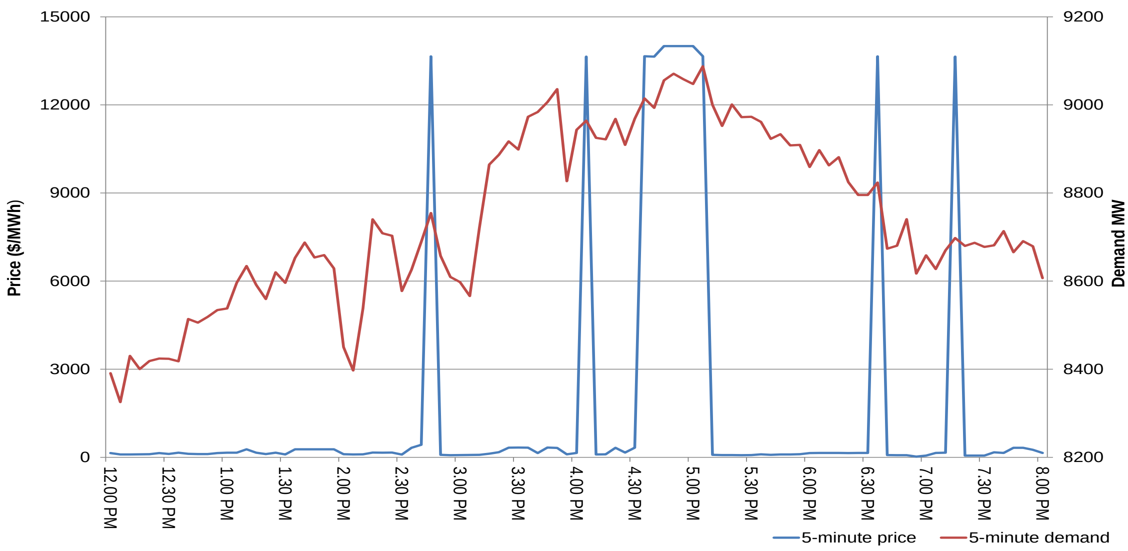


The light shaded section of the graph at 5 pm highlights the trading interval where the spot price was above $5000/MWh. As can be seen, actual total demand was close to record total demand, which ocurred in February 2016, and was close to forecast.

Figure 5 shows 5-minute demand and price over the high price period. The figure shows that, with the vertical supply curve as discussed in section 3.1.2, small increases in 5-minute demand coincided with increases in the 5-minute dispatch price. Some of the variability in 5 minute demand shown in Figure 5 may be explained by the response of a number of large industrial customers in Queensland that curtail their consumption in responds to high actual and forecast prices.

5 While the actual demand from the CSG plant is confidential an examination of the change in demand since 1 January 2014 reveals an average growth of around 620 MW which is consistent with the AEMOs 2016 National Electricity Forecasting Report.

Figure 5: Queensland 5-minute price and demand graph



3.2 Network Availability

Net imports into Queensland were limited to around 100 MW, 500 MW lower than the nominal limit of 600 MW, during the time of high prices and were close to forecast.

Table 2 shows the net import limit and the actual imports into Queensland from New South Wales.

Table 2: Actual and forecast network capability

Trading interval	Imports (MW)			Import limit (MW)		
	Actual	4 hr forecast	12 hr forecast	Actual	4 hr forecast	12 hr forecast
4.30 pm	2	20	3	127	82	3
5 pm	**98**	**85**	**3**	**98**	**85**	**3**
5.30 pm	14	94	2	104	94	9

Imports on the Queensland to New South Wales interconnector (QNI) were limited to around 200 MW by system normal constraints designed to avoid the overload of the Liddell to Muswellbrook line and potential voltage collapse in northern New South Wales on the loss of the largest generator in Queensland (in this case Kogan Creek Power Station).

Constraints on Terranora were forcing flow into New South Wales at 95 MW for the duration of high prices.

Australian Energy Regulator

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Appendix A 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 3: Significant rebids for 5 pm

Submitted time	Time effective	Participant	Station	Capacity rebid (MW)	Price from ($/MWh)	Price to ($/MWh)	Rebid reason
2.08 pm		Millmerran Energy Trader	Millmerran	-40	-1000	N/A	14:08 p: condensate polisher inlet temperature
2.13 pm		Millmerran Energy Trader	Millmerran	-5	-1000	N/A	14:13 p: plant limitation, condensate
2.36 pm		CS Energy	Callide B	-10	<17	N/A	1436p condenser vacuum limits-sl
2.50 pm		Origin Energy	Roma	-30	-983	N/A	1449p change in avail - unit trip sl
2.51 pm		Stanwell Corporation	Tarong	-225[6]	<14 000	N/A	1450p AVR switching schedule delays
2.59 pm		Origin Energy	Darling Downs	-20	70	N/A	1458p change in avail - vacuum issues sl
3.35 pm		Callide Power Trading	Callide C	-60	-1000	N/A	1533p vac unload by ICMS
3.38 pm		CS Energy	Gladstone	-115	<99	N/A	1538p condenser backflush-sl
3.39 pm		Callide Power Trading	Callide C	-20	-1000	N/A	1537p vac unload

6 175 MW of capacity in Stanwell's Tarong rebid was removed from the price cap and 50 MW was priced less than $156/MWh

Submitted time	Time effective	Participant	Station	Capacity rebid (MW)	Price from ($/MWh)	Price to ($/MWh)	Rebid reason
3.51 pm		Stanwell Corporation	Tarong	100	<156	14 000	1550a QLD 5 min pd price 1540v 1545
3.56 pm		Millmerran Energy Trader	Millmerran	-10	-1000	N/A	15:56 p: condensate polisher inlet temperature
4.00 pm		CS Energy	Kogan Creek	-10	14	N/A	1559p fd fan limits-sl
4.49 pm	5.00 pm	CS Energy	Gladstone	135	N/A	<14 000	1648p condenser backflush-complete-sl

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.[7] The 30-minute spot price of $13 883/MWh for the 5pm trading interval is the average of the six dispatch prices below.

Table 4: Price setter for the 5 pm trading interval

DI	Dispatch Price ($/MWh)	Participant	Unit	Service	Offer price ($/MWh)	Marginal change	Contribution
4:35 pm	13 654.63	Callide Power	CPP_3	Energy	13 654.63	1	13654.63
4:40 pm	13 642	B2PS	BRAEMAR6	Energy	13 642	1	13642
4:45 pm	14 000	CS Energy	W/HOE#1	Energy	14 000	0.20745	2904.3
	14 000	CS Energy	W/HOE#2	Energy	14 000	0.20745	2904.3
	14 000	Stanwell	STAN-1	Energy	14 000	0.06981	977.34
	14 000	Stanwell	STAN-2	Energy	14 000	0.06981	977.34
	14 000	Stanwell	STAN-4	Energy	14 000	0.06981	977.34
	14 000	Stanwell	TARONG#2	Energy	14 000	0.09641	1349.74
	14 000	Stanwell	TARONG#3	Energy	14 000	0.09641	1349.74
	14 000	Stanwell	TARONG#4	Energy	14 000	0.14295	2001.3
	14 000	Stanwell	TNPS1	Energy	14 000	0.03989	558.46
4:50 pm	14 000	CS Energy	W/HOE#1	Energy	14 000	0.20286	2840.04
	14 000	CS Energy	W/HOE#2	Energy	14 000	0.20286	2840.04
	14 000	Stanwell	MACKAYGT	Energy	14 000	0.02211	309.54
	14 000	Stanwell	STAN-1	Energy	14 000	0.06827	955.78
	14 000	Stanwell	STAN-2	Energy	14 000	0.06827	955.78
	14 000	Stanwell	STAN-4	Energy	14 000	0.06827	955.78
	14 000	Stanwell	TARONG#2	Energy	14 000	0.09428	1319.92
	14 000	Stanwell	TARONG#3	Energy	14 000	0.09428	1319.92
	14 000	Stanwell	TARONG#4	Energy	14 000	0.13979	1957.06
	14 000	Stanwell	TNPS1	Energy	14 000	0.03901	546.14
4:55 pm	14 000	CS Energy	GSTONE6	Energy	14 000	0.03836	537.04
	14 000	CS Energy	W/HOE#1	Energy	14 000	0.19949	2792.86
	14 000	CS Energy	W/HOE#2	Energy	14 000	0.19949	2792.86
	14 000	Stanwell	STAN-1	Energy	14 000	0.06714	939.96
	14 000	Stanwell	STAN-2	Energy	14 000	0.06714	939.96
	14 000	Stanwell	STAN-4	Energy	14 000	0.06714	939.96
	14 000	Stanwell	TARONG#2	Energy	14 000	0.09271	1297.94

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

DI	Dispatch Price ($/MWh)	Participant	Unit	Service	Offer price ($/MWh)	Marginal change	Contribution
	14 000	Stanwell	TARONG#3	Energy	14 000	0.09271	1297.94
	14 000	Stanwell	TARONG#4	Energy	14 000	0.13747	1924.58
	14 000	Stanwell	TNPS1	Energy	14 000	0.03836	537.04
5:00 pm	14 000	CS Energy	W/HOE#1	Energy	14 000	0.20745	2904.3
	14 000	CS Energy	W/HOE#2	Energy	14 000	0.20745	2904.3
	14 000	Stanwell	STAN-1	Energy	14 000	0.06981	977.34
	14 000	Stanwell	STAN-2	Energy	14 000	0.06981	977.34
	14 000	Stanwell	STAN-4	Energy	14 000	0.06981	977.34
	14 000	Stanwell	TARONG#2	Energy	14 000	0.09641	1349.74
	14 000	Stanwell	TARONG#3	Energy	14 000	0.09641	1349.74
	14 000	Stanwell	TARONG#4	Energy	14 000	0.14295	2001.3
	14 000	Stanwell	TNPS1	Energy	14 000	0.03989	558.46
Spot Price		**$13 883/MWh**					

Appendix C Closing bids

Figures C1 to C4 highlight the half hour closing bids for participants in Queensland 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 – CS Energy (Callide B, Gladstone, Kogan Creek, Wivenhoe) closing bid prices, dispatch and spot price

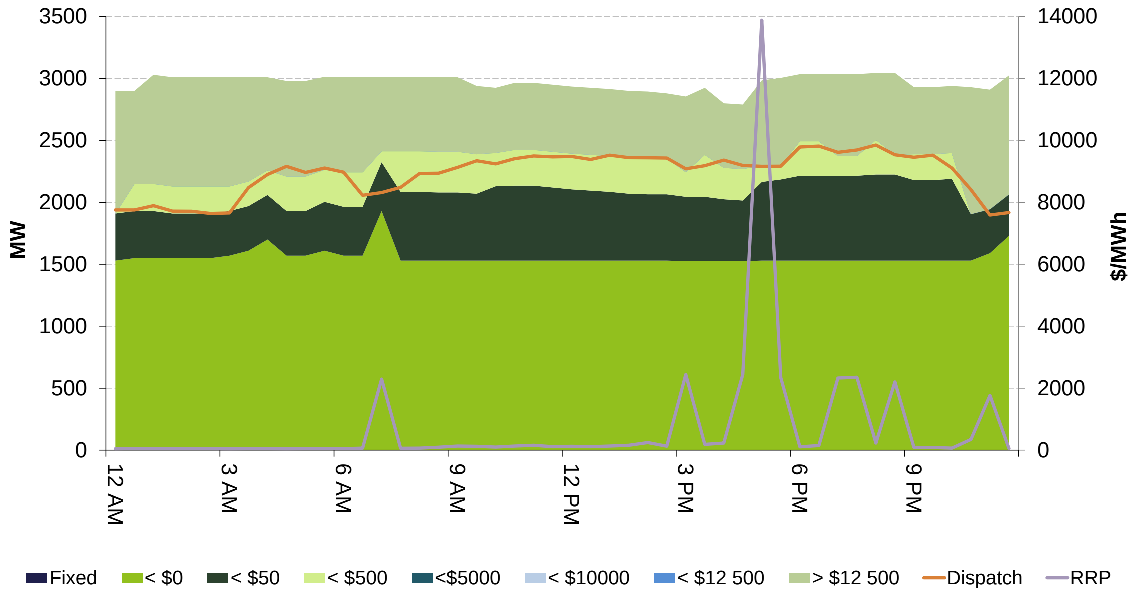

Figure C2 - Stanwell (Barron Gorge, Kareeya, Mackay, Stanwell, Tarong, Tarong North) closing bid prices, dispatch and spot price

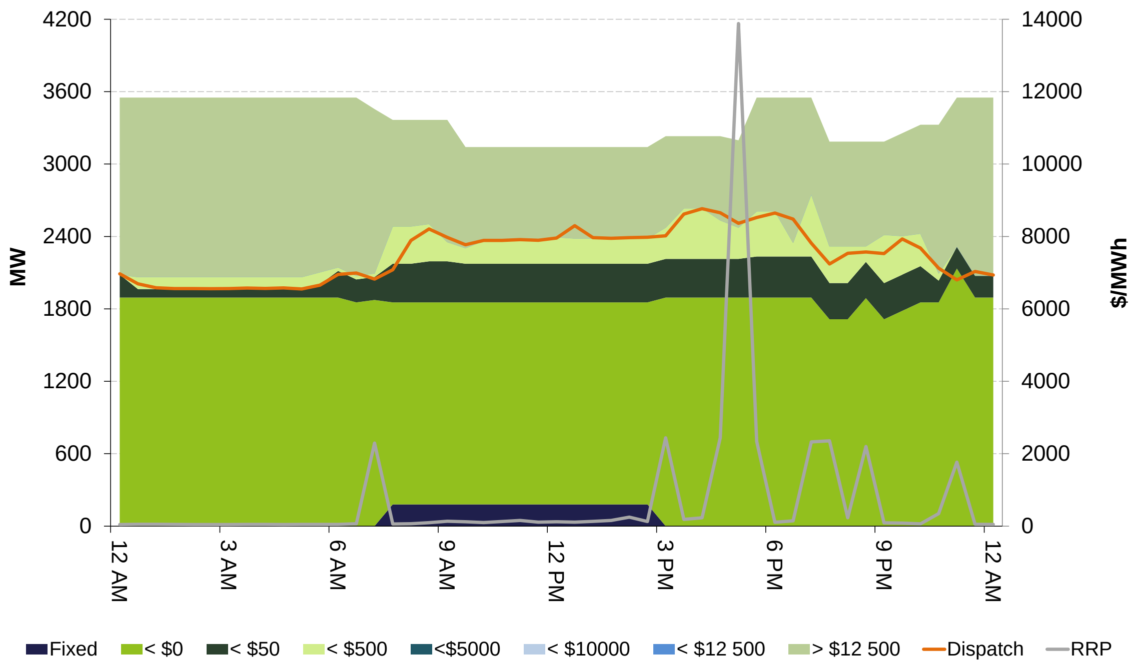

Figure C3 – Callide Power Trading (Callide C) closing bid prices, dispatch and spot price

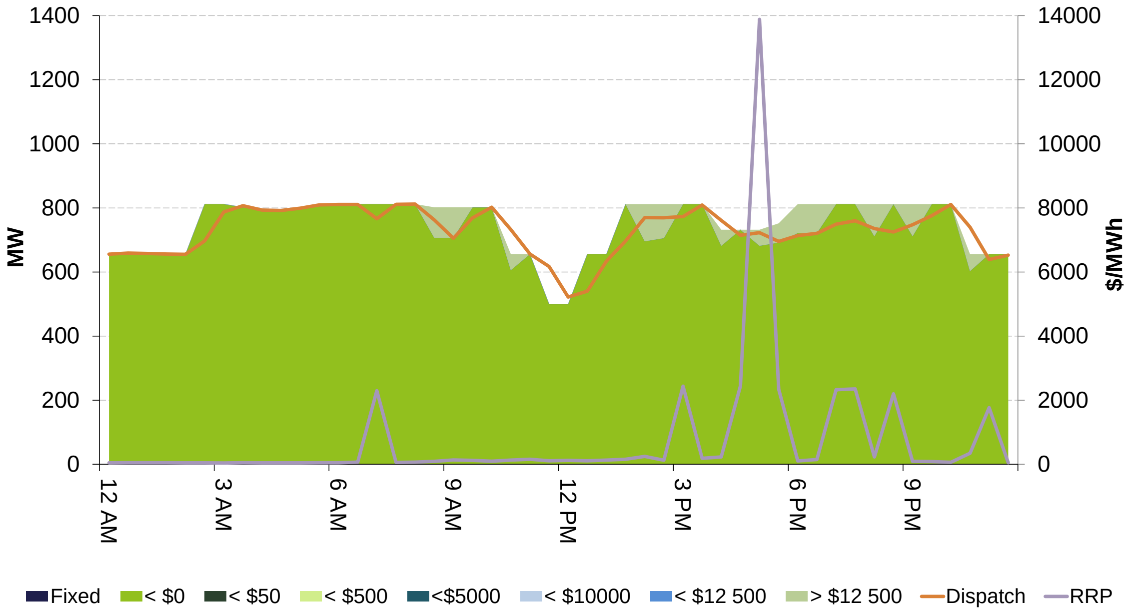

Figure C4 – Arrow Energy (Braemar 2) closing bid prices, dispatch and spot price