Electricity spot prices *above $5000/MWh*

4 February 2010
New South Wales

AUSTRALIAN ENERGY REGULATOR

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.

Summary

On Thursday 4 February 2010, the spot price in New South Wales reached $5541/MWh for the 12 pm trading interval. The price was much higher than forecast largely as a result of network congestion.

From early in the day network equipment in the Energy Australia network supplying the Sydney Central Business District (CBD) was out of service for planned maintenance. From mid-morning potential overloads were identified for flows on the 330 kV cables supplying the CBD from Sydney South. In response, at 10.25 am the Kemps Creek to Sydney South 330 kV transmission line was taken out of service by TransGrid to remedy the potential overloads on the 330 kV cables for the remainder of the day. This altered flows on the remainder of the transmission network and flows exceeded allowable limits on the Mount Piper to Wallerawang 330 kV lines for three dispatch intervals (10.30 am to 10.40 am inclusive).

The constraint used to manage flows across the Mount Piper to Wallerawang lines reduced the dispatch of low-priced generation and forced flows out of New South Wales into Victoria and Queensland, setting the dispatch price to $10 000/MWh for three dispatch intervals from 10.30 am.

In response to the high prices there appeared to be a 540 MW reduction in New South Wales demand at around 11 am and a number of New South Wales generators rebid into negative prices. This saw the New South Wales five-minute dispatch price fall to close to the price floor of $-1000/MWh from 10.55 am to 11.05 am. The apparent demand side response ended and demand returned to previous levels by 11.35 am. At the same time New South Wales generators also rebid into higher prices. The increase in demand combined with a reduction in low-priced capacity set the dispatch price close to the cap for four dispatch intervals from 11.30 am.

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

Actual and forecast demand

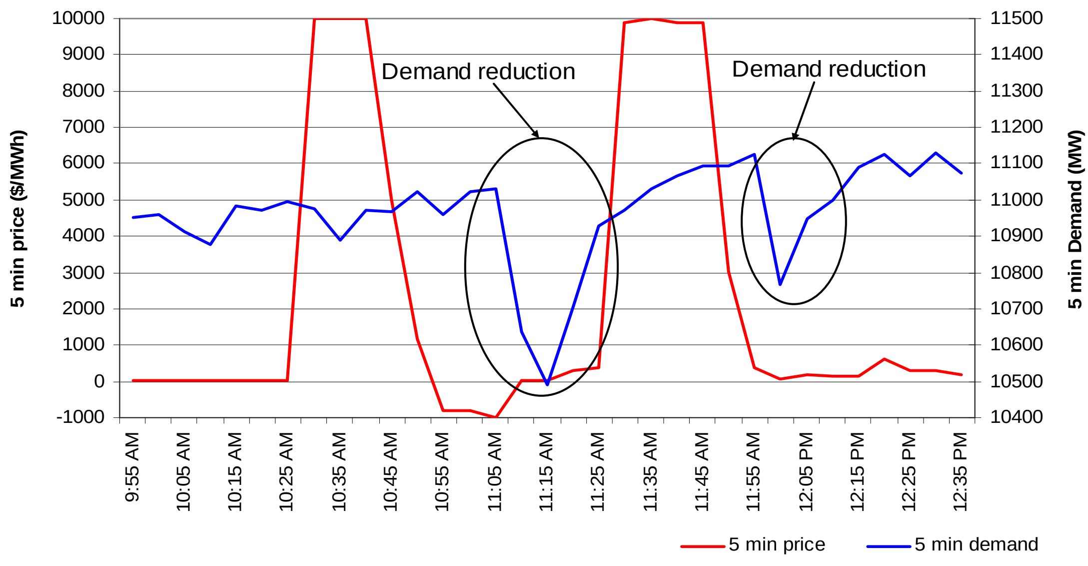
Figure 1 compares the actual demand and spot price in New South Wales with that forecast by AEMO 4 and 12 hours ahead of dispatch. The spot prices from 10.30 am to 12 pm were significantly higher than forecast.[2] Demand reached a maximum for the day of 11 205 MW at 1 pm[3]

Figure 1: Actual and forecast demand, and spot price

10.30 am	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	10 952	10 737	10 731
Spot Price ($/MWh)	1688	36	37
11 am	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	10 972	10 799	10 796
Spot Price ($/MWh)	4097	36	33
11.30 am	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	10 793	10 862	10 857
Spot Price ($/MWh)	1606	37	33
Midday	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	11 030	10 932	10 919
Spot Price ($/MWh)	5541	49	37
12.30 pm	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	11 061	10 968	10 963
Spot Price ($/MWh)	282	95	61
1 pm	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	11 120	11 045	11 029
Spot Price ($/MWh)	-99	61	61

Figure 2 shows price and demand graphically on a five-minute basis, and highlights the apparent demand side response at 11 am and midday.

Figure 2: Five-minute price and demand



[2] As part of its Weekly Market Analysis reports, the AER provides detailed analysis if the spot price exceeds three times the weekly average for a region and is above $250/MWh. On 4 February there were five trading intervals in New South Wales where this occurred (on one of these occasions the spot price exceeded $5000/MWh). As all of these high prices occurred in consecutive trading intervals (from 10.30 am to 12.30 pm inclusive), and were all caused by related events, they have been explained as part of this report.

[3] This compares to record summer demand in New South Wales of 14 097 MW on 6 February 2009.

The 5-minute price reached $10 000/MWh at 10.30 am and remained at that level until the end of the 10.40 am dispatch interval. The 5-minute price then fell dramatically, reaching the price floor of -$1000/MWh at 11.05 am which meant that the spot price did not exceed $5000/MWh for the 11 am trading interval.

There were two apparent demand side responses on the day. Demand fell from 11 029 MW to 10 491 MW between 11.05 am 11.15 am, before returning to previous levels by 11.35 am. Consequently, demand for the 11.30 am trading interval was lower than forecast four hours ahead.

However, by 11.30 am the 5-minute price had again risen to $9900/MWh, reaching $10 000/MWh at 11.35 am, and $9900/MWh at 11.40 am and 11.45 am before falling to significantly lower prices from 11.55 am onwards. The sustained high 5-minute prices were sufficient to see the spot price reach $5541/MWh for the midday trading interval.

There was another apparent demand side response when demand fell from 11 126 MW at 11.55 am to 10 768 MW at 12 pm. Demand returned to previous levels by 12.15 pm.

Generator offers and rebidding

Available capacity was close to forecast throughout the high price period.

At 9.31 am, effective from 9.40 am, Delta Electricity rebid the ramp rates of Mount Piper units one and two. The 'ramp down rate' on each unit was reduced from 5 MW/min down to the minimum allowable level of 3 MW/min[4]. At the same time, the 'ramp up rate' was increased from 5 MW/min to 10 MW/min for each unit. The reason given was "0927A Managing constraints ex12hr::ROC change".[5]

At 9.43 am, effective for the 10.30 am trading interval, Delta Electricity reduced the available capacity of Wallerawang unit seven by 280 MW (a majority of this capacity was priced below $90/MWh). The reason given was "0942P Dust Burden – ET1hrs::capacity reduced". At 10.35 am, effective from 10.45 am, Delta Electricity extended the rebid for a further three and a half hours but with a reduction in available capacity of 260 MW instead of 280 MW.

At 10.31 am, effective from 10.40 am, Snowy Hydro rebid the ramp rate of Tumut three from 200 MW/min down to the minimum allowable level of 3 MW/min. The reason given was "10:31:A prevent being constrained off at Tumut 3".

At 10.32 am, effective from 10.40 am, Macquarie Generation rebid the ramp rates across its Bayswater units. The ramp down rate was reduced from 4 MW/min down to the minimum allowable level of 3 MW/min for each unit. The ramp up rate was increased from 4 MW/min to 12 MW/min for each unit. The reason given was "1025 Management of unforecast network constraints".

[4] Clause 3.8.3A(b) of the Electricity Rules states that Scheduled Generators must provide a ramp down rate to AEMO of at least the lower of 3 MW per minute or 3 per cent of the full capacity of the Scheduled unit. Refer to the AER Rebidding and Technical Parameter Guideline for more information at www.aer.gov.au.

[5] The N>>N-NIL__S constraint commenced binding from 9.10 am. This is described further in the "Transmission Constraints" section below.

At 11.02 am, effective from 11.10 am, Snowy Hydro rebid 400 MW of negatively priced capacity to $10 000/MWh at Tumut unit three, and rebid their ramp down rate back up to 200 MW per minute. In a further rebid at 11.21 am, effective from 11.30 am, Snowy Hydro shifted 100 MW of this capacity back into negative prices. The reasons given for these rebids were "11:02:A NSW price 1020 lwr thn prev 5min pd at 11:00" and "11:19:A NSW demand higher thn exptd" respectively. Snowy Hydro again rebid the ramp down rate at 11.26 am to 3 MW per minute, with the reason "11:26 prevent being constrained off".

Over two rebids at 11.11 am and 11.19 am, effective from 11.20 am and 11.30 pm respectively, Eraring Energy rebid 240 MW of available capacity across Eraring units two, three and four from prices below $20/MWh to above $9700/MWh. The reasons given were "1005A NSW 30 min PD forecast negative prices" and "1113A dispatch 5min@11:15 $300 vs pd hhe1130 -$1000".

There was no other significant rebidding.

The generators involved in setting the price during the high-price period, and how that price was determined by the market systems is detailed in Appendix A.

The closing bids for all participants in New South Wales with capacity priced at or above $5000/MWh for the 12 pm trading interval are presented in Appendix B.

Changes to network availability

Planned network maintenance

On the day Energy Australia was undertaking planned maintenance on the 132 kV network around the Sydney CBD necessitating outages on that network. Although owned by Energy Australia, the relevant assets are classified as part of the transmission network. Approval of these outages are undertaken by Transgrid (the New South Wales transmission network service provider) on AEMO's behalf.

From mid-morning, as a result of these outages, potential overloads were identified for flows on the 330 kV cables supplying the CBD from Sydney South.

As there is no generation in the vicinity of this part of the transmission network, AEMO was unable to invoke constraints to manage the potential overload. Instead, after liaising with AEMO and in order to remedy the potential overloads on the 330 kV cables, TransGrid removed the Kemps Creek to Sydney South 330 kV transmission line from service at 10.25 am for the remainder of the day. This action altered flows on the remainder of TransGrid's transmission network and as a result flows exceeded allowable limits on the Mount Piper to Wallerawang 330 kV lines for three dispatch intervals (10.30 am to 10.40 am inclusive) until generation dispatch could adjust.

Forecast and actual import limits into New South Wales

Figure 3 compares combined import limits into New South Wales across the Terranora, QNI and the Vic-NSW interconnectors with what was forecast 4 and 12 hours ahead.

Figure 3: Combined actual and forecast import limits into New South Wales (MW)

Time	Actual	4 hr forecast	Difference	12 hr forecast	Difference
10.30 am	-407	1647	-2054	1722	-2129
11 am	-835	1677	-2512	1695	-2530
11.30 am	-1247	1726	-2973	1729	-2976
midday	-1272	1701	-2973	1285	-2557
12.30 pm	-1531	2329	-3860	2060	-3591

Immediately following the outage of the Kemps Creek to Sydney South 330 kV line, import limits into New South Wales from Queensland (across the QNI and Terranora interconnectors) and Victoria (across the VIC-NSW interconnector) fell to much lower levels than the nominal capacity[6]. Flows were in fact being forced into Queensland and Victoria. For the 12 pm trading interval flows were being forced out of New South Wales at 1272 MW and the combined import limit of 1272 MW was 2973 MW lower than the 1701 MW forecast four hours ahead.

As has been the case in the New South Wales region several times over the 2009/10 summer, the “system normal” constraint N>>N-NIL__S[7] was a factor in the high price event. The impacts, however, were amplified by the outage of the Kemps Creek to Sydney South 330 kV line. The constraint bound from the dispatch interval ending 9.10 am to the dispatch interval ending 12.30 pm. The effects of the constraint are explained in greater detail below.

Although the import limit across the QNI interconnector was forecast to be around 1050 MW into New South Wales for most of the day, from around 10 am the impact of the binding N>>N-NIL__S constraint forced flow into Queensland, by up to 446 MW. Similarly, although the import limit across the Vic-NSW interconnector into New South Wales was forecast to be up to 1135 MW four hours ahead, the impact of the binding N>>N-NIL__S constraint forced flow into Victoria by up to 1301 MW at 12.30 pm. The capability of the Terranora interconnector was close to forecast.

Transmission Constraints

In optimising economic generation dispatch and interconnector flows, the National Electricity Market Dispatch Engine (NEMDE) takes into account the maximum network capability that applies at the time. These network constraints are represented as constraint equations that describe the maximum capability of each network element and include generator and interconnector coefficients. The magnitude of a coefficient gives an indication of the significance of the generating unit or interconnector in managing the network limitation (the larger the coefficient the more significant the unit or interconnector). A

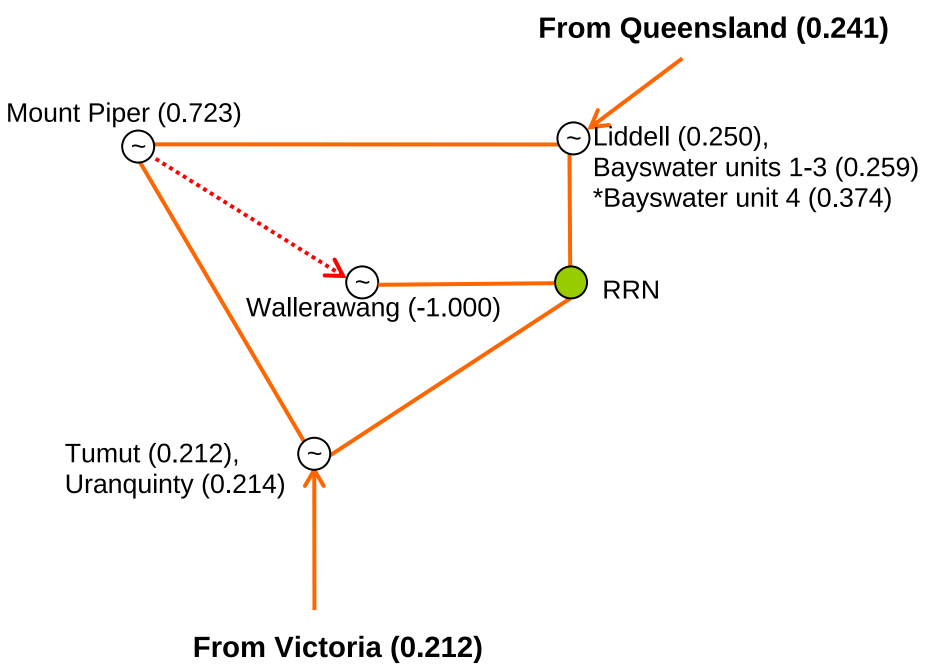
[6] Nominal limits for flows into New South Wales are: QNI 1078 MW; Terranora 245 MW and VIC-NSW 1800 MW.

[7] Constraint equations are mathematical expressions used in the dispatch engine to describe the physical limitations of the power system. System normal constraints are used when the network is operating in its normal network configuration. The N>>N-NIL__S constraint affects up to 11 700 MW of generation capacity (27 units) in New South Wales, and all three interconnectors into New South Wales.

positive coefficient means that a unit or interconnector is 'constrained-off'[8] if the constraint is binding, where a negative coefficient means a generator is 'constrained-on'[9].

The system normal constraint N>>N-NIL__S[10] bound for most of the time from the dispatch interval ending 9.10 am to the dispatch interval ending at 12.30 pm[11]. This constraint was managing flows across one of the Mt Piper to Wallerawang 330 kV lines in the event of the loss of the second Mt Piper to Wallerawang line. Figure 2 is a simplified representation of the transmission network in New South Wales, highlighting the flow paths into the regional reference node (RRN) at Sydney West, the interconnectors to Queensland and Victoria and significant generation stations. Also shown are the relevant coefficients for the stations according to the N>>N-NIL__S constraint.

Figure 2: Simplified transmission network in New South Wales



* Bayswater unit four is connected to the 500 kV network. All other Bayswater units are connected to the 330 kV network, which explains the different coefficients.

The N>>N-NIL__S constraint is designed to prevent the Mt Piper to Wallerawang line (shown as a red dotted line) from overloading, which is consistent with Wallerawang and Mount Piper having the largest coefficients. In general, power flows from Mount Piper to Wallerawang. The direction of the power flow means that, to avoid overloading, it is necessary to increase or 'constrain-on' the Wallerawang units (with a -1.000 coefficient) and reduce or 'constrain-off' the Mount Piper units (with a 0.723 coefficient). Other generators can also influence flows across this line, but to a lesser extent (e.g. Bayswater unit four with a 0.374 coefficient is likely to be 'constrained-off' ahead of the other Bayswater units and the Liddell units with coefficients of 0.259 and 0.250 respectively, as it has a larger

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

[9] This is the case where flows must be less than or equal to a given network capability.

[10] Constraint equations are mathematical expressions used in the dispatch engine to describe the physical limitations of the power system. System normal constraints are used when the network is operating in its normal network configuration. The N>>N-NIL__S constraint affects up to 11 700 MW of generation capacity (27 units) in New South Wales, and all three interconnectors into New South Wales.

[11] When a constraint binds it effects economic dispatch and causes generators to be constrained-on or off.

coefficient). The amount and rate at which a generator is ‘constrained-on’ or off is, however, limited by the availability and ramp rate offered by those generators. The interconnectors may also be ‘constrained-off’ in order to satisfy this constraint (with coefficients of 0.212 and 0.241), but unlike generators, there is no ramp rate for interconnectors.

The Mount Piper and Wallerawang units’ coefficients are much greater than those for other generators or interconnectors, given their proximity to the network elements in question. If the ability to ‘constrain-on’ or ‘constraint-off’ these units is limited (for example, due to low ramp rates), then other generators and interconnectors will need to be constrained, but by a larger amount (three to four times more) to manage flows on the network.

There were two rebids from Delta Electricity at Mount Piper and Wallerawang that are relevant to this issue:

1. At 9.31 am Delta Electricity rebid the ramp down rates of Mount Piper[12]. Due to Mount Piper’s ramp rate being lowered, other generators and interconnectors were required to be ‘constrained-off’ so that the constraint was not breached. However, the lower coefficients of other generators meant that the total impact on the efficiency of dispatch outcomes was far worse. [13]
2. From around 9.40 am Delta Electricity reduced the available capacity of Wallerawang unit seven by around 280 MW[14]. As output from Wallerawang was increasing at the time due to the constraint, a reduction in availability meant that the other generators in New South Wales and the interconnectors were required to be reduced (‘constrained off’) to avoid the constraint being breached[15]. However, the lower coefficients of other generators meant that the total impact on dispatch outcomes was far more significant.

Clause 3.8.3A(b) of the Electricity Rules states that Scheduled Generators must provide a ‘ramp down rate’ to AEMO of at least the lower of 3 MW per minute or three per cent of the full capacity of the Scheduled unit. This is a recent change to the Rules following a rule change proposal from the AER. Prior to this change, generators were permitted to bid as low as 1 MW per minute. If Delta Electricity had bid at a ‘ramp down rate’ of only 1 MW per minute, the market impact would have been even worse.

At 10.25 am the Kemps Creek to Sydney South 330 kV line was taken out of service by TransGrid to remedy potential overloads on 330 kV CBD cables. This altered flows on the remainder of the transmission network and led to flows exceeding allowable limits on the Mount Piper to Wallerawang 330 kV lines for three dispatch intervals (10.30 am to 10.40 am inclusive).

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[12] Mount Piper power station was constrained-off by up to 320 MW during the time of high prices.

[13] The coefficient of Mount Piper is 0.723 and Bayswater unit four is 0.374. The rebid reduced the rate at which Mount Piper could be constrained-off from 300 MW per hour (5 MW/min) to 3 MW/min or 180 MW per hour. If the constraint required Mount Piper to reduce by 300 MW in one hour it would only reduce Mount Piper by 180 MW (due to its limiting ramp down rate) and would need to reduce say Bayswater unit four by (0.723/0.374 x 120 MW) 232 MW, a total reduction in generation of 412 MW. Alternatively the constraint could reduce imports from Victoria by (0.723/0.212 x 120 MW) 409 MW, a total reduction in supply of 589 MW. Each of these is a greater impact on dispatch outcomes than just reducing the output of Mount Piper by 300 MW.

[14] Due to the constraint, instead of being dispatched 400 MW, the unit was dispatched for 245 MW.

[15] A 280 MW reduction in available capacity at Wallerawang meant that other generators, say Bayswater unit four would need to reduce its generation by a further (-1.000/0.374 x 280 MW) 748 MW, which is almost a three-fold increase in the impact on dispatch.

Appendix A – Price setters for 4 February 2010

The following table identifies for the 12 pm trading interval each five minute dispatch interval price and the generating units involved in setting the energy price. This information is published by AEMO[16]. Also shown is the energy offer price involved in determining the dispatch price together with the quantity of that service and the contribution to the total energy price. The 30-minute spot price is the average of the six dispatch interval prices.

New South Wales – 12 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
11:35	$25 531.44*	Eraring Energy	SHGEN	Energy	$10000.00	2.56	$25 570.30
		TRUenergy (SA)	TORRB3	Energy	$28.77	-0.67	-$19.14
		TRUenergy (SA)	TORRB4	Energy	$28.77	-0.67	-$19.14
		Eraring Energy	ER03	Raise reg	$0.70	-1.33	-$0.93
		TRUenergy (SA)	TORRB3	Raise reg	$0.25	0.67	$0.17
		TRUenergy (SA)	TORRB4	Raise reg	$0.25	0.67	$0.17
11:40	$9900.00	Eraring Energy	ER02	Energy	$9900.00	0.5	$4950.00
		Eraring Energy	ER04	Energy	$9900.00	0.5	$4950.00
11:45	$9900.00	Eraring Energy	ER02	Energy	$9900.00	0.33	$3299.97
		Eraring Energy	ER03	Energy	$9900.00	0.33	$3299.97
		Eraring Energy	ER04	Energy	$9900.00	0.33	$3299.97
11:50	$3011.52	Snowy Hydro	MURRAY	Energy	$23.99	3.38	$81.16
		Macquarie Generation	BW01	Energy	-$1000.00	-0.98	$976.79
		Macquarie Generation	BW02	Energy	-$1000.00	-0.98	$976.79
		Macquarie Generation	BW03	Energy	-$1000.00	-0.98	$976.79
11:55	$383.90	Snowy Hydro	MURRAY	Energy	$23.99	1.14	$27.28
		Delta Electricity	MP1	Energy	-$1000.00	-0.36	$356.61
12:00	$50.01	Eraring Energy	ER02	Energy	$50.01	1	$50.01
Spot price		**$5541/MWh**					

*Price capped to $10 000/MWh

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

Appendix B – Closing bids

Figures B1 – B2 highlight the half hour closing bids for participants in New South Wales with significant capacity priced at or above $5000/MWh during the trading interval in which the spot price exceeded $5000/MWh. It also shows the generation output of that participant and the spot price.

Figure B1: Eraring Energy closing bid prices, dispatch and spot price

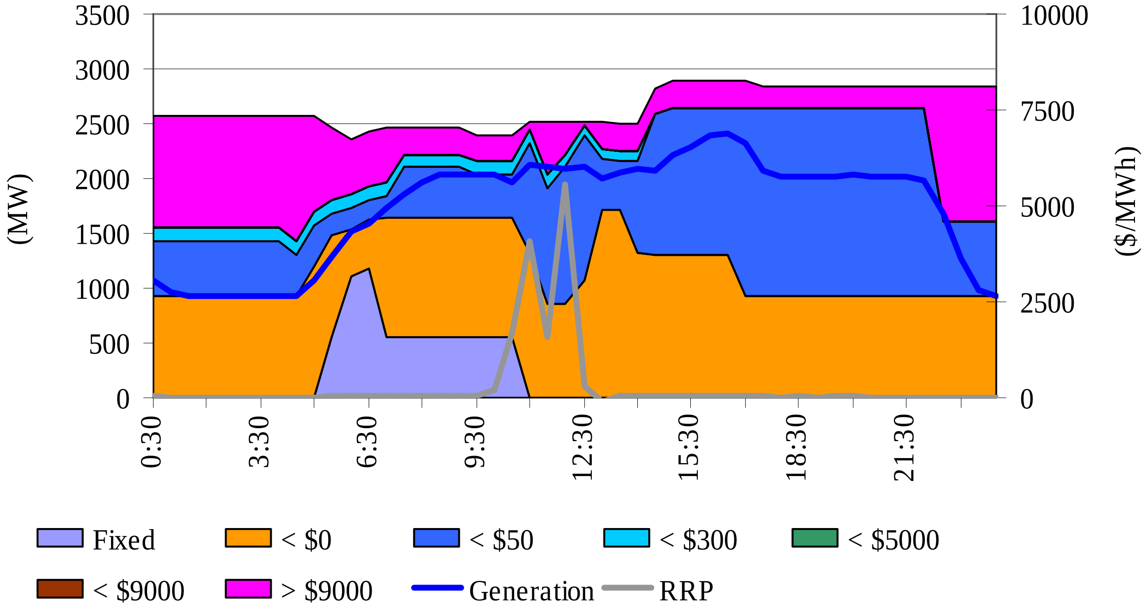

Figure B2: Origin Energy closing bid prices, dispatch and spot price