Electricity spot prices *above $5000/MWh*

17 December 2009
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 factors such as 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 17 December 2009, the spot price in New South Wales exceeded $5000/MWh for three trading intervals: 11 am, 3 pm and 4 pm. All of these above $5000/MWh prices were higher than forecast.

Temperatures in western Sydney reached 40°C driving demand to 13 485 MW[2] at 4 pm. During the time of high prices demand was up to 920 MW higher than that forecast four hours ahead.

A ‘system normal’ transmission network constraint reduced the dispatch of low-priced generation between 9.40 am and 8.25 pm. The market impact of this constraint was made worse following rebidding by Delta Electricity—initially by reducing its generator ramp rates, then by shifting capacity into higher prices and then reducing maximum availability. The effects of the constraint and Delta’s behaviour are explored in detail in this report.

In day ahead offers Eraring Energy had around a quarter (730 MW) of its capacity priced above $9000/MWh. Rebidding from low prices increased the capacity priced at above $9000/MWh to up to 1180 MW, which also contributed to the price exceeding $5000/MWh.

Actual and forecast demand and price

Figure 1 compares, for the trading intervals where the spot price exceeded $5000/MWh, the actual demand, spot price and available capacity in New South Wales with that forecast by the Australian Energy Market Operator (AEMO) four and 12 hours ahead of dispatch.

For the 11 am trading interval demand was around 920 MW higher than forecast four hours ahead, available capacity was close to forecast and the spot price was significantly greater than forecast.

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[1] This requirement is set out in clause 3.13.7 (d) of the National Electricity Rules.
[2] This compares to record summer demand in New South Wales of 14 097 MW on 6 February 2009.

For the 3 pm trading interval demand was close to forecast but available capacity was around 320 MW lower than that forecast four hours ahead and around 500 MW less than that forecast 12 hours ahead.

For the 4 pm trading interval demand was around 375 MW higher than forecast and available capacity was around 100 MW less than that forecast four hours ahead but 440 MW less than that forecast 12 hours ahead.

Figure 1: Actual and forecast demand and available capacity for intervals with spot prices above $5000/MWh

Thursday 11:00 AM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	12622	11700	11695
Spot Price	5547	22	23
Available capacity (MW)	13120	13212	13216
Thursday 3:00 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13290	13292	13114
Spot Price	8703	3406	919
Available capacity (MW)	13229	13554	13736
Thursday 4:00 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13485	13109	13123
Spot Price	5468	3406	754
Available capacity (MW)	13372	13489	13816

As part of its Weekly Market Analysis reports, the AER provides further information if the spot price exceeds three times the weekly average for a region and is above $250/MWh. On 17 December there were 14 trading intervals (see Appendix A) in New South Wales where this occurred (on three 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 5 pm inclusive), and were all most likely caused by related events, they have been explained as part of this report.

Appendix A shows that at (11.30 pm) demand was 997 MW greater than that forecast four hours ahead. For the majority of the high-priced period, prices were significantly higher than forecast. The same issues as those that caused the price to exceed $5000/MWh were responsible for the high prices between 10.30 pm and 5 pm.

Generator offers and rebidding

Day ahead offers

Around 13 540 MW of available capacity was offered through initial offers (the day ahead) for the New South Wales region. Around 11 640 MW of this capacity (86 per cent) was priced below $115/MWh, with the remainder (1900 MW) priced above $9100/MWh, 730 MW of which was offered by Eraring Energy.

With no capacity priced between $115/MWh and $9100/MWh, any reductions in import capability, rebidding of capacity into high price bands or increases in demand, had the potential to result in a significant jump in the spot price.

Rebidding

At 6.32 am Delta Electricity rebid the ramp rates of Mount Piper units one and two. The rebid took effect from 10.05 am and reduced the 'ramp down rate' on each unit from 5 MW/min, to the minimum allowable level of 3 MW/min[3]. At the same time, the 'ramp up rate' on each unit was increased from 5 MW/min to 10 MW/min. The reason given was "0629A Manage line constraint::Band shift and ROC Cha". At 9.21 am Delta electricity shifted 100 MW of capacity at Wallerawang unit seven from prices below $115/MWh to above $9600/MWh. The reason given was "0929A manage line constraint::band shift". This rebid was effective for two trading intervals from 10.35 am. At 2.28 pm Delta Electricity reduced the available capacity of Wallerawang unit seven by 100 MW (all of which was priced above $9600/MWh). The reason given was "1428P Dust Burdens – ET3hrs::capacity limit".

Over several rebids from 7.59 am, effective from the 10.30 am trading interval, Macquarie Generation reduced the available capacity of Liddell unit one by a total of 205 MW (all of which was priced at negative prices). The reasons given were related to the delay of a feed pump returning to service.

At 9.48 am Eraring Energy reduced the available capacity of Eraring unit four by 70 MW (all of which was priced below zero). The reason given was "0943P Revised commissioning capacity".

At 10.10 am, effective from 10.20 am, Eraring Energy rebid capacity at Eraring power station from prices below $25/MWh to above $9100/MWh. The reason given was "1004A Increase AEMO forecast 1000vs1030 PD $926.74 vs $3405.97". For the 10.30 am and 11 am trading intervals this rebid shifted 540 MW and for the remaining trading intervals (until 6 pm) 240 MW was shifted into high price bands. Following this, the five minute price increased from $43/MWh at 10.15 am to $9250/MWh at 10.25 am.

At 2.02 pm, effective from 2.10 pm, Eraring Energy rebid a further 210 MW at Eraring power station from prices below $20/MWh to above $9100/MWh. The reason given was "1357A change in 5min predispatch". Following this the five minute price increased from $678/MWh at 2.05 pm to $9250/MWh at 2.25 pm. This led to Eraring power station setting the price for 16 out of the 17 dispatch intervals where the dispatch price was above $5000/MWh between 10.25 am and 4 pm inclusive.

There was no other significant rebidding.

Appendix B contains details regarding the generators involved in setting the price during the high-price period, 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 period are presented in **Appendix C**.

Changes to network availability

During the period of high prices, flows into New South Wales from Queensland (across the QNI and Terranora interconnectors) and Victoria (across the VIC-NSW interconnector) were at their limits but at much lower levels than the nominal capacity[4].

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[3] 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.

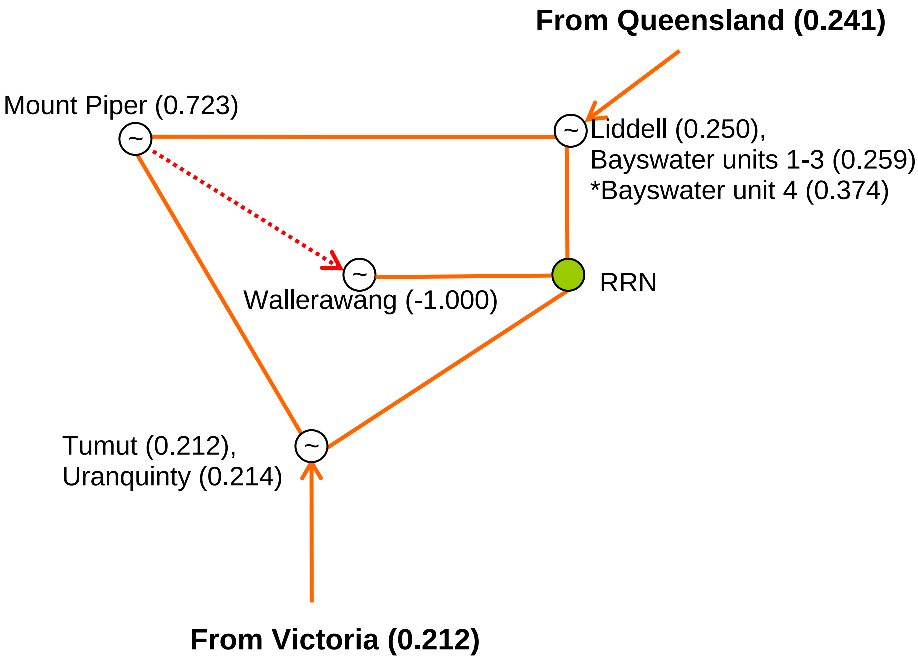
[4] Nominal limits for flows into New South Wales are: QNI 1078 MW; Terranora 245 MW and VIC-NSW 1800 MW.

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 positive coefficient means that a unit or interconnector is 'constrained-off'[5] if the constraint is binding, where a negative coefficient means a generator is 'constrained-on'[6].

The system normal constraint N>>N-NIL__S[7] bound for much of 17 December[8]. 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.

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[5] 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).

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

[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.

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

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 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 6.32 am Delta Electricity reduced the 'ramp down rates' of Mount Piper[9]. 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 dispatch outcomes was far worse.[10]
2. From around 2.30 pm Delta Electricity reduced the available capacity at Wallerawang unit seven by 100 MW[11]. 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.[12] However, the lower coefficients of other generators meant that the total impact on dispatch outcomes was far more significant.

[9] Mount Piper power station was constrained-off by up to 440 MW (with all the capacity priced below zero) between 10.20 am and 8.25 pm, inclusive.

[10] 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.

[11] Wallerawang unit seven was constrained-on between 10.35 am and 12.15 pm, inclusive, by up to 109 MW. At 2.20 pm it was constrained-on again but Delta reduced the unit's available capacity by 100 MW. When Delta increased the unit's available capacity at 3.45 pm it became constrained-on again by 11 MW

[12] A 100 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 100 MW) 267 MW, which is almost a three-fold increase in the impact on dispatch.

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.

Australian Energy Regulator
February 2010

Appendix A - Actual and forecast demand, and spot price in New South Wales

The following table compares, for the trading intervals where the spot price exceeded three times the weekly average for a region and was above $250/MWh, the actual demand and spot price in New South Wales with that forecast by the Australian Energy Market Operator (AEMO) four and 12 hours ahead of dispatch.

Thursday 10:30 AM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	12 404	11 555	11 556
Spot Price ($MW/h)	3189	25	25
Thursday 11:00 AM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	12 622	11 700	11 695
Spot Price ($MW/h)*	5547	22	23
Thursday 11:30 AM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	12 888	11 891	11 892
Spot Price ($MW/h)	1930	27	27
Thursday 12:00 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13 024	12 276	12 073
Spot Price ($MW/h)	1470	510	28
Thursday 12:30 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13 125	12 411	12 260
Spot Price ($MW/h)	992	533	30
Thursday 1:00 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13 209	12 702	12 502
Spot Price ($MW/h)	885	553	527
Thursday 1:30 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13 296	12 788	12 662
Spot Price ($MW/h)	893	527	544
Thursday 2:00 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13 271	12 890	12 884
Spot Price ($MW/h)	756	561	711
Thursday 2:30 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13 184	13 277	12 993
Spot Price ($MW/h)	3900	1065	581
Thursday 3:00 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13 290	13 292	13 114
Spot Price ($MW/h)*	8703	3406	919
Thursday 3:30 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13 410	13 247	13 192
Spot Price ($MW/h)	2420	3406	933
Thursday 4:00 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13 485	13 109	13 123
Spot Price ($MW/h)*	5468	3406	754
Thursday 4:30 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13 397	12 895	12 910
Spot Price ($MW/h)	826	925	543
Thursday 5:00 PM	**Actual**	**4 hr forecast**	**12 hr forecast**
Demand (MW)	13 288	12 646	12 815
Spot Price ($MW/h)	624	44	534

*Spot prices exceeded $5000/MWh

Appendix B – Price setters for 17 December 2009

The following table identifies, for each of the trading intervals above $5000/MWh, each five minute dispatch interval price and the generating units involved in setting the energy price. Also shown is the energy (or ancillary service) offer price involved in determining the dispatch price and the contribution to the total energy price. Frequency control ancillary services (FCAS) can contribute to the energy price when in order for a unit to be dispatched for energy its dispatch in FCAS is altered and this must be made up by another unit. The column labeled "marginal change" shows the quantity of the service that is dispatched to meet an increment of demand at the regional reference node. The 30-minute spot price is the average of the six dispatch interval prices. This information is published by AEMO[13].

New South Wales – 11 am

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
10:35	$9250.01	Eraring Energy	ER03	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER02	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER01	Energy	$9250.01	0.33	$3083.31
10:40	$9250.01	Eraring Energy	ER03	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER02	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER01	Energy	$9250.01	0.33	$3083.31
10:45	$1837.88	Delta Electricity	WW7	Energy	$9500.00	0.19	$1799.68
		Hydro Tasmania	GORDON	Energy	$38.34	1.00	$38.19
		Basslink	T-V-MNSP1,VIC1	Energy	$0.01	0.97	$0.01
10:50	$1837.46	Delta Electricity	WW7	Energy	$9500.00	0.19	$1824.86
		Tarong	TARONG#3	Energy	$16.13	0.78	$12.63
10:55	$9250.01	Eraring Energy	ER02	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER01	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER03	Energy	$9250.01	0.33	$3083.31
11:00	$1855.46	Delta Electricity	WW7	Energy	$9500.00	0.26	$2494.80
		Basslink	GORDON	Energy	$38.34	0.30	$11.39
		Snowy Hydro	MURRAY	Energy	$32.95	-0.17	-$5.72
		Basslink	T-V-MNSP1,VIC1	Energy	$0.01	0.29	$0.00
		Macquarie Generation	BW04	Energy	-$1000.00	0.65	-$645.02
Spot price		**$5547/MWh**					

New South Wales – 3 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
14:35	$9250.01	Eraring Energy	ER03	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER02	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER01	Energy	$9250.01	0.33	$3083.31
14:40	$9250.01	Eraring Energy	ER01	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER02	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER03	Energy	$9250.01	0.33	$3083.31
14:45	$9250.01	Eraring Energy	ER01	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER03	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER02	Energy	$9250.01	0.33	$3083.31
14:50	$5969.41	Tarong	TNPS1	Energy	$1000.00	3.75	$3745.35
		Macquarie Generation	BW04	Energy	-$1000.00	-2.23	$2226.06
		Stanwell	GSTONE6	Raise reg	$0.94	-2.23	-$2.09
		Macquarie Generation	BW04	Raise reg	$0.04	2.23	$0.09
14:55	$9249.02	Eraring Energy	ER01	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER03	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER02	Energy	$9250.01	0.33	$3083.31
		Delta Electricity	WW7	Lower reg	$1.00	-1.00	-$1.00
		Eraring Energy	ER03	Lower reg	$0.01	0.33	$0.00
		Basslink	ER02	Lower reg	$0.01	0.33	$0.00
		Eraring Energy	ER01	Lower reg	$0.01	0.33	$0.00
15:00	$9250.01	Eraring Energy	ER01	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER02	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER03	Energy	$9250.01	0.33	$3083.31
Spot price		**$8703/MWh**					

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

New South Wales – 4 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
15:35	$1000.00	Delta Electricity	CG3	Energy	$1000.00	0.50	$500.00
		Delta Electricity	CG2	Energy	$1000.00	0.50	$500.00
15:40	$1000.00	Delta Electricity	CG2	Energy	$1000.00	0.50	$500.00
		Delta Electricity	CG3	Energy	$1000.00	0.50	$500.00
15:45	$3056.83	Stanwell	STAN-2	Energy	$249.99	1.03	$256.85
		Stanwell	STAN-3	Energy	$249.99	2.57	$642.13
		Macquarie Generation	BW04	Energy	-$1000.00	-2.16	$2159.83
		Basslink	BW04	Raise 5 min	$0.04	2.16	$0.09
		Stanwell	STAN-2	Raise reg	$0.94	-1.03	-$0.97
		Stanwell	GSTONE1	Raise reg	$0.94	-1.13	-$1.06
		TRUenergy (Vic)	YWPS1	Raise 60 sec	$0.05	-1.31	-$0.07
		Macquarie Generation	BW04	Raise 60 sec	$0.04	1.31	$0.05
		Basslink	YWPS2	Raise 6 sec	$0.05	-1.31	-$0.07
		Macquarie Generation	BW04	Raise 6 sec	$0.04	1.31	$0.05
15:50	$9250.01	Eraring Energy	ER02	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER01	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER03	Energy	$9250.01	0.33	$3083.31
15:55	$9250.01	Eraring Energy	ER03	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER02	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER01	Energy	$9250.01	0.33	$3083.31
16:00	$9250.01	Eraring Energy	ER03	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER02	Energy	$9250.01	0.33	$3083.31
		Eraring Energy	ER01	Energy	$9250.01	0.33	$3083.31
Spot price		**$5468/MWh**					

Appendix C – Closing bids

Figures B1 to B3 highlight the half hour closing bids for participants in New South Wales with capacity priced at or above $5000/MWh during the trading intervals in which the spot price exceeded $5000/MWh. The figures also show the generation output of the relevant participants and the spot price.

Figure C1: Eraring Energy closing bid prices, dispatch and spot price

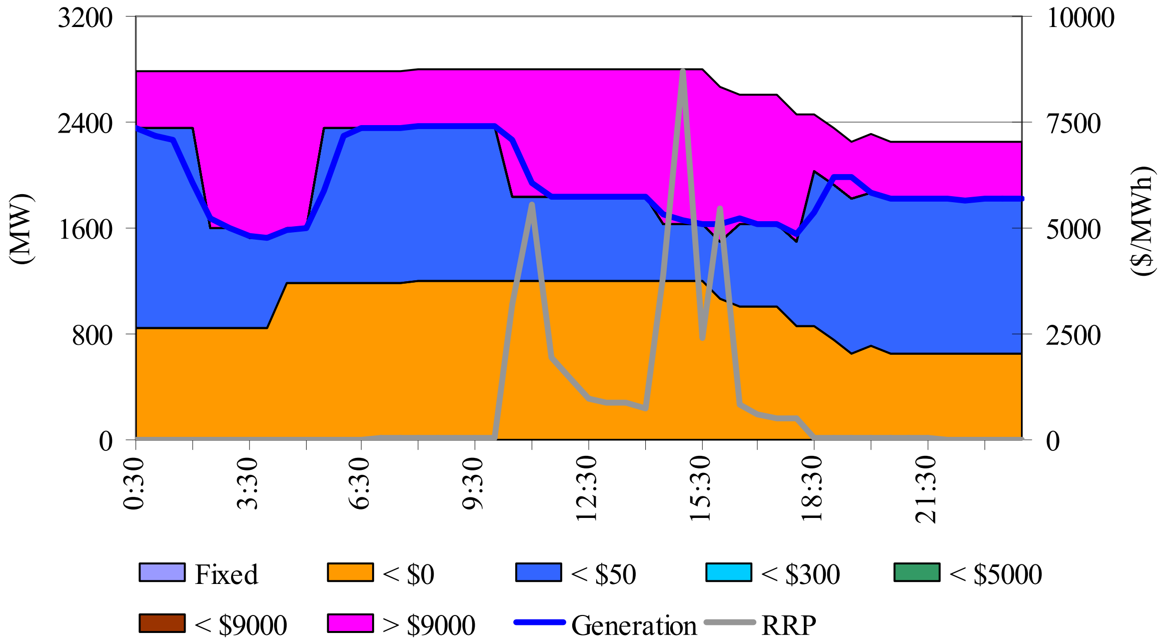

Figure C2: Delta Electricity closing bid prices, dispatch and spot price

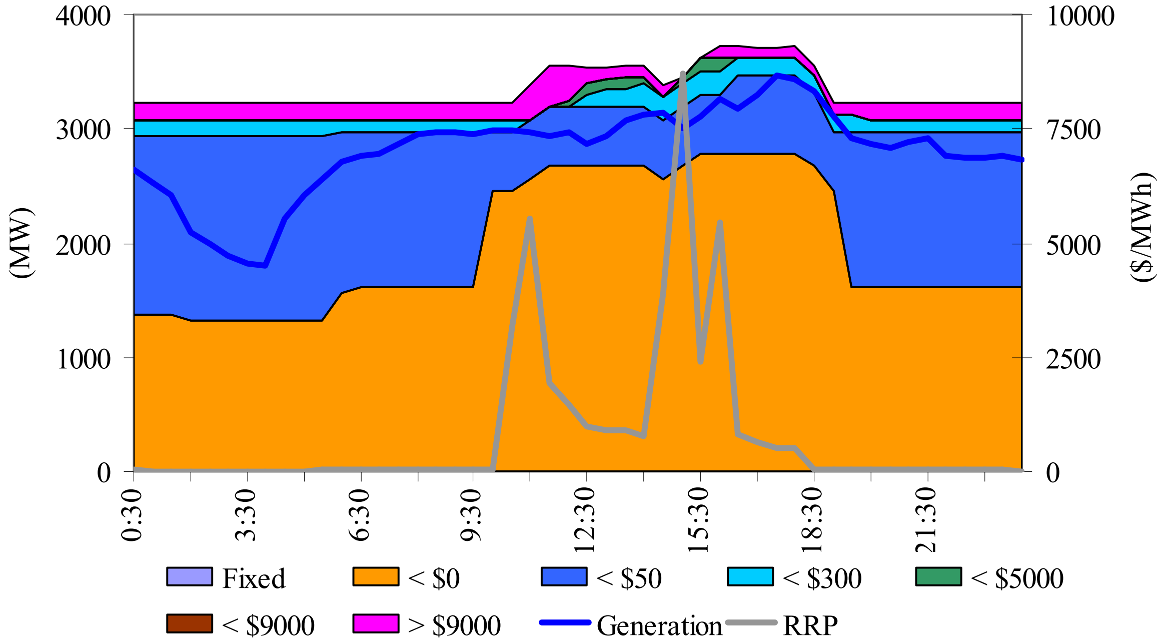

Figure C3: TRUenergy (Tallawarra) closing bid prices, dispatch and spot price