# Electricity spot prices *above $5000/MWh*

***22 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 Monday 22 February 2010, the spot price in New South Wales reached $8345/MWh at 4 pm, which was much higher than forecast. Demand in New South Wales was high, reaching a maximum for the day of 13 412 MW at 4.30 pm[2].

The unplanned outage of Delta Electricity's Wallerawang unit eight at 3.33 pm led to a significant change in dispatch in order to manage network constraints in the vicinity. This reduced the dispatch of low-priced generation in New South Wales and imports into New South Wales. This resulted in low reserves in New South Wales and the 5-minute price reached the price cap. In response, Transgrid increased the rating of and rearranged the network to improve network capability. This alleviated the reserve shortfall and the 5-minute price returned to previous levels by 4.05 pm.

## 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. Demand was close to forecast.

***Figure 1: Actual and forecast demand, and spot price***

| 4 pm | Actual | 4 hr forecast | 12 hr forecast |
|---|---|---|---|
| Demand (MW) | 13 384 | 13 223 | 13 235 |
| Spot Price ($/MWh) | 8364 | 111 | 297 |
| Available capacity (MW) | 13 133 | 13 268 | 13 623 |

[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.

## Generator offers and rebidding

At 3.33 pm Delta Electricity's Wallerawang unit eight tripped from 380 MW. In response to this, at 3.34 pm, effective from 3.40 pm, Delta Electricity rebid the unit's available capacity from 500 MW to zero (380 MW of this capacity was priced below zero). This reduction in the availability of Wallerawang led to a violation of the constraint managing the Mt Piper to Wallerawang 330 kV lines (explained in the "Changes to network availability" section). The 5-minute price increased from $75/MWh at 3.35 pm to $10 000/MWh at 3.40 pm. The price remained at the cap until 4 pm, after which it fell significantly (the 5-minute price for the 4.05 pm dispatch interval was $17/MWh).

At 3.35 pm, effective from 3.45 pm, Delta Electricity rebid the ramp rates at Mount Piper units one and two. The rebid reduced the ramp down rate on each unit from 5 MW/min to the minimum allowable of 3 MW/min[3]. At the same time the ramp up rate was increased by 5 MW/min to 10 MW/min on each unit. The reason given was related to the trip of Wallerawang unit eight.

At 3.43 pm, effective from 3.50 pm, Macquarie Generation rebid the ramp down rate of Bayswater units one, two, three and four by 1 MW/min to the minimum allowable level of 3 MW/min. In another rebid at 3.47 pm, effective from 3.55 pm, it increased the ramp up rates of each of the units by 8 MW/min. The reason given was "1535 management of unforecast constraint".

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**.

## Transmission Constraints

Following the loss of Wallerawang unit eight, the system normal constraint[4] N>>N-NIL__S violated[5] from 3.40 pm to 4 pm inclusive. This constraint manages 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.

The violation of this constraint led to flows into New South Wales across all interconnectors (QNI, Terranora and Vic-NSW) exceeding their import limits for the same period.

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

[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] 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.

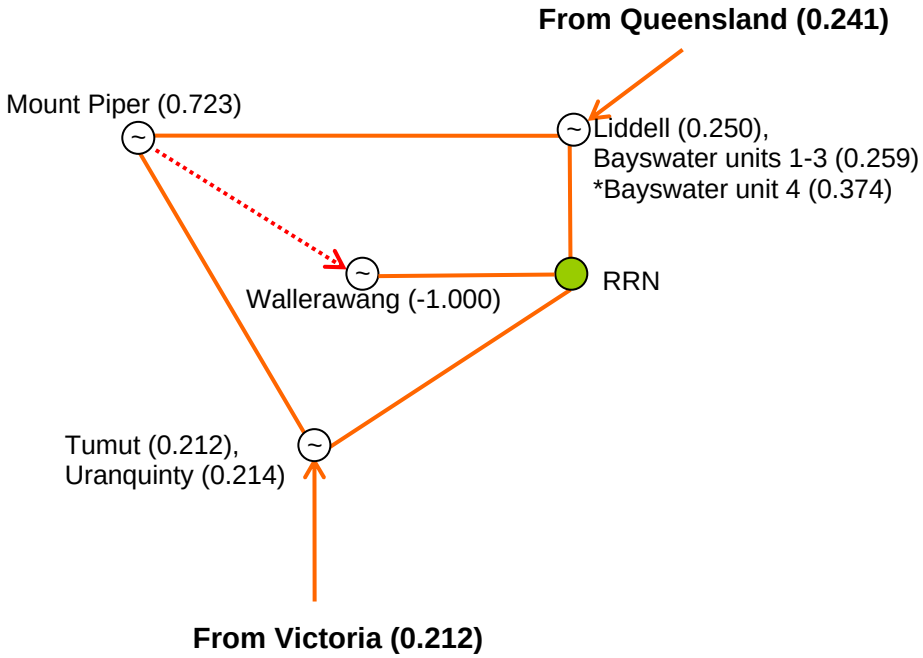
[5] A constraint is deemed to be violating when the mathematical inequality describing the constraint cannot satisfied.

positive coefficient means that a unit or interconnector is 'constrained-off'[6] if the constraint is binding, where a negative coefficient means a generator is 'constrained-on'[7].

The system normal constraint N>>N-NIL__S has repeatedly bound since December 2009[8]. On this day, the constraint did not bind until the loss of Wallerawang unit eight, despite the demand in New South Wales being significantly higher than on other days when the constraint bound. The difference on this day was that up until 3.35 pm there were two Wallerawang units in service. Between 4 December 2009 and 19 February 2010 there was a maximum of one unit in service at Wallerawang.

Figure 1 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.

[6] 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).

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

[8] When a constraint binds it effects economic dispatch and causes generators to be constrained-on or off. See also *Spot prices above $5000/MWh* reports for 7 December 2009, 17 December 2009 and 4 February 2010.

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 or a reduction in the availability of Wallerawang), 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 three rebids from Delta Electricity at Mount Piper and Wallerawang and Macquarie Generation at Bayswater that are relevant to this issue:

1. At 3.34 pm Delta Electricity (in response to the unit trip) reduced available capacity at Wallerawang unit eight by around 500 MW (dispatch was around 380 MW at the time). To avoid the N>>N-NIL__S constraint being violated[9], generators in New South Wales were 'constrained-off' and flows across the interconnectors were reduced. However, the lower coefficients of other generators according to the N>>N-NIL__S constraint meant that the total impact on the efficiency of dispatch outcomes was far more significant. The constraint violated from 3.40 pm to 4 pm, inclusive.

2. At 3.35 pm Delta Electricity rebid the ramp down rate of Mount Piper units one and two[10]. Due to Mount Piper's ramp down rate being reduced, other generators were 'constrained-off' and flows across the interconnectors were reduced to prevent the constraint from being breached. However, the lower coefficients of other generators meant that the total impact on the efficiency of dispatch outcomes was far worse. [11]

[9] A 380 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 380 MW) 1016 MW, which is almost a three-fold increase in the impact on dispatch.

[10] Mount Piper power station was constrained-off by up to 69 MW during the time of high prices.

[11] 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.

3. At 3.43 pm, after the dispatch interval after the N>>N-NIL__S constraint started to violate (and significantly change dispatch outcomes) Macquarie Generation rebid the ramp down rates of all Bayswater units[12]. To prevent the N>>N-NIL__S constraint being violated the other generators in New South Wales were further 'constrained off' and the flows across the interconnectors reduced. However, the lower coefficients of other generators meant that the total impact on the efficiency of dispatch outcomes was far more significant.

Clause 3.8.3A(b) of the Electricity Rules state that Scheduled Generators must provide a 'ramp down rate' to AEMO of at least the lower of 3 MW/min 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/min. If Delta Electricity had bid at a 'ramp down rate' of only 1 MW/min, the market impact would have been even worse.

## Re-rating and rearranging of the transmission network

Following the loss of Wallerawang unit eight, reserve shortfalls (LOR2[13]) were forecast to occur from 3.40 pm. In order to remedy this AEMO discussed possible solutions with TransGrid and as a result TransGrid rearranged and re-rated the network. This allowed increased flows across the Mt Piper to Wallerawang (70 and 71) transmission lines.

AEMO published a market notice (30547) at 8 pm to explain the actions taken:

> ***Inter regional transfer limit variation, Mt Piper to Wallerawang (70 & 71) transmission lines (NSW) - Monday 22 February 2010***.
> *Due to system security requirements associated with system normal constraint N>>N-NIL__S, the TNSP performed system reconfiguration switching and provided increased real time ratings for Mt Piper to Wallerawang (70 & 71) transmission lines (NSW).*
> *The increased ratings applied from 1555 hrs to 1920 hrs Monday 22 February 2010*

The rearrangement and re-rating applied from around 4 pm. By 4.05 pm the violations on the N>>N-NIL__S constraint ceased and prices returned to previous levels. This resolved the LOR2 condition without AEMO having to intervene in the market.

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[12] Bayswater power station was constrained-off by up to 220 MW during the time of high price.
[13] LOR2 means that in the event of loss of the largest New South Wales generator customer load would have been required to be interrupted.

## Appendix A – Price setters for 22 February 2010

The following table identifies for the 4 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[14]. 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 – 4 pm

| Time | Dispatch price | Participant | Unit | Service | Offer price | Marginal change | Contribution |
|---|---|---|---|---|---|---|---|
| 15:35 | $74.76 | AGL Hydro | MCKAY1 | Energy | $61.86 | 1.41 | $87.12 |
| | | Ecogen Energy | NPS | Energy | $44.70 | -0.28 | -$12.37 |
| 15:40 | $10 000.00* | Stanwell | GSTONE2 | Energy | $87.65 | 291.78 | $25 574.37 |
| | | Mac Gen | BW01 | Energy | $22.00 | -81.55 | -$1794.12 |
| | | Mac Gen | BW02 | Energy | $22.00 | -81.55 | -$1794.12 |
| | | Mac Gen | BW03 | Energy | $22.00 | -81.55 | -$1794.12 |
| 15:45 | $10 000.00* | Eraring Energy | SHGEN | Energy | $10 000.00 | 1.85 | $18 491.00 |
| | | Stanwell | GSTONE3 | Energy | $85.74 | -0.61 | -$51.89 |
| | | Stanwell | GSTONE4 | Energy | $85.74 | -0.61 | -$51.89 |
| | | Hydro Tasmania | DEVILS_G | Energy | $40.22 | 0.23 | $9.25 |
| | | Basslink | T-V-MNSP1,VIC1 | Energy | $0.01 | 0.22 | $0.00 |
| | | Hydro Tasmania | TRIBUTE | Lower reg | $1.30 | 1.21 | $1.57 |
| | | Stanwell | GSTONE3 | Lower reg | $0.99 | -0.61 | -$0.60 |
| | | Stanwell | GSTONE4 | Lower reg | $0.99 | -0.61 | -$0.60 |
| | | Hydro Tasmania | DEVILS_G | Raise reg | $0.50 | -0.23 | -$0.12 |
| | | Hydro Tasmania | TRIBUTE | Raise reg | $0.50 | 0.23 | $0.12 |
| 15:50 | $10 000.00* | Tarong Energy | TNPS1 | Energy | $15.05 | 28.73 | $432.38 |
| | | Mac Gen | BW03 | Energy | -$1000.00 | -25.65 | $25 648.40 |
| 15:55 | $10 000.00* | Eraring Energy | SHGEN | Energy | $10 000.00 | 1.93 | $19 292.00 |
| | | Aurora Energy | TVCC201 | Energy | $24.52 | 0.25 | $6.08 |
| | | Braemar | BRAEMAR1 | Energy | $9.00 | -0.41 | -$3.66 |
| | | Braemar | BRAEMAR2 | Energy | $9.00 | -0.38 | -$3.45 |
| | | Braemar | BRAEMAR3 | Energy | $9.00 | -0.38 | -$3.45 |
| | | Basslink | T-V-MNSP1,VIC1 | Energy | $0.01 | 0.23 | $0.00 |
| | | Hydro Tasmania | CETHANA | Lower 60 sec | $0.99 | 0.23 | $0.22 |
| | | Hydro Tasmania | POAT110 | Lower 6 sec | $0.35 | 0.23 | $0.08 |
| 16:00 | $10 000.00* | Braemar | BRAEMAR1 | Energy | $9.00 | 9.12 | $82.09 |
| | | Braemar | BRAEMAR2 | Energy | $9.00 | 8.59 | $77.35 |
| | | Braemar | BRAEMAR3 | Energy | $9.00 | 8.59 | $77.35 |
| | | Mac Gen | LD03 | Energy | -$1000.00 | -25.43 | $25 425.40 |
| **Spot price** | | **$8346/MWh** | | | | | |

*Price capped to $10 000/MWh

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

## Appendix B – Closing bids

Figure B1 highlights 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***