

Electricity spot prices above $5000/MWh

South Australia,
1 December 2016, (12.16 am event)

2 February 2017

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# Introduction

The AER is required to publish a report whenever the electricity spot price exceeds $5000/MWh.[[1]](#footnote-1) The report must:

* describe the significant factors contributing to the spot price exceeding $5000/MWh, including the withdrawal of generation capacity and network availability;
* assess whether rebidding contributed to the spot price exceeding $5000/MWh;
* identify the marginal generating units; and
* identify all generating 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 1 December the spot price for electricity in South Australia reached $13 767/MWh at 2 am, $5066/MWh at 3 am and $6674/MWh at 3.30 am, thereby exceeding the reporting threshold. This report examines the circumstances behind the spot price exceeding $5000/MWh on these occasions.

# Summary

On 1 December the spot price for electricity in South Australia reached $13 767/MWh at 2 am, $5066/MWh at 3 am and $6674/MWh at 3.30 am.

These high priced events were a result of South Australia being separated from the NEM.

Planned network outages in the south west of Victoria resulted in only one line connecting South Australia to Victoria via the Heywood Interconnector. At 12.16 am a fault occurred on this line, tripping the interconnector and separating South Australia from the NEM.[[2]](#footnote-2) Supply to Alcoa’s Aluminium Smelter at Portland was also interrupted.

In order to restore the frequency of the power system in South Australia following the separation, Under Frequency Load Shedding (UFLS), designed to manage such occurrences, was initiated with around 190 MW of load shed. A further 40 MW of load, not associated with the UFLS scheme, was also interrupted. Load was restored by 1.45 am.

Soon after the separation, AEMO invoked constraints to manage the power system, resulting in the dispatch price rising sharply. There were 16 dispatch intervals where the price was above $5000/MWh. With only 90 MW of generation capacity in South Australia priced between $0/MWh and $10 000/MWh, the sudden loss of up to 250 MW of imports from Victoria across Heywood meant high priced generation was dispatched to meet demand.

The planned network outage was recalled and returned to service at around 4 am, South Australia was reconnected to the rest of the NEM by 4.46 am.

During the separation event, in order to maintain the power system, AEMO issued three directions affecting two generators and South Australia’s largest load: BHP Billiton’s mine at Olympic Dam.

Rebidding of capacity from low to high prices did not contribute to the high prices in this event.

# Analysis

Table 1 shows the actual and forecast spot price and demand for the trading intervals during which the spot price exceeded $5000/MWh (in bold) and other relevant high-price trading intervals following the separation event at 12.16 am.

Table 1: Actual and forecast spot prices

| Trading interval | Spot Price ($/MWh) |
| --- | --- |
|  | Actual | 0.5 hr forecast | 4 hr forecast |
| 12.30 am | 2507 | 125 | 80 |
| 1 am | 1963 | 125 | 80 |
| 1.30 am | 2373 | 13 999 | 80 |
| **2 am** | **13 767** | **14 000** | **62** |
| 2.30 am | 377 | 1498 | 60 |
| **3 am** | **5066** | **1499** | **63** |
| **3.30 am** | **6674** | **14 000** | **80** |
| 4 am | 2191 | 13 300 | 80 |
| 4.30 am | 53 | 13 300 | 80 |
| 5 am | 2084 | 13 999 | 80 |

Considering that in this case the high prices were caused by an unplanned outage of the Heywood interconnector, it is not surprising that the high spot prices were not forecast four hours ahead. The majority of prices were lower than forecast 30 minutes ahead.

## Network Availability

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

Immediately prior to the incident there were two planned network outages underway:

* + Heywood No.2 500kV busbar, first notified to the market through the Network Outage Schedule (NOS) on 22 August and commenced 30 November 2016.[[3]](#footnote-3)
	+ Heywood – APD No.2 500kV line, first notified to the market through the NOS on 7 November and commenced 28 November 2016.

Both outages were due to be completed by 4 pm on 1 December 2016.

These planned outages placed South Australia on a single contingency as there was only one 500kV line connecting South Australia and Victoria. When these conditions occur, AEMO set a 35 MW requirement for local regulation services in South Australia. This would normally result in high FCAS prices, however an event several days earlier had resulted in sufficiently high FCAS prices to exceed the cumulative price threshold and FCAS prices were capped to $300/MW.

On 30 November, after both planned outages had commenced, AEMO issued market notice 55904 declaring a Lack of Reserve Condition 2 in South Australia which stated:

*“South Australia region could separate from the rest of the NEM and is likely to result in interruptions to power supplies in South Australia.*

*There are sufficient capacity reserves in the South Australia region to meet electricity demand but following the next credible contingency it may not be possible to bring the required additional capacity into service in time to avoid automatic under-frequency load shedding causing interruptions to power supplies in South Australia.”*

As a result of the two planned outages, two other lines in the vicinity were affected: the Mortlake to Heywood 500kV line and the Moorabool to Mortlake to Heywood 500kV line.

Figure 1 shows the area of the network affected before and after the fault occurred. The blue dots are the high voltage switching (or terminal) stations and the green square is the Mortlake power station, which is comprised of two units. The planned outages are represented by the short dashed lines while the longer dashed lines represent the network affected by the fault.

Figure 1: Network diagram



At 12.16 am the Heywood interconnector tripped when the remaining Moorabool to Tarrone 500kV line failed and South Australia separated from Victoria, as highlighted by the fault symbol in Figure 1.[[4]](#footnote-4) Immediately prior to the separation, South Australia was importing 250 MW from Victoria across the Heywood interconnector. Once physically separated, it takes up to two dispatch intervals for the market dispatch engine to reflect this in targets. Hence, in Figure 2 the target flow (green line) hit 0 MW by 12.30 am.

Figure 2: Heywood Interconnector import limits, target and metered flows



Prior to 12.16 am, Murraylink, the DC interconnector between Victoria and South Australia, was importing at its nominal limit of 220 MW. Once the separation event occurred, Murraylink’s import limit reduced to a maximum of 100 MW, except for four dispatch interval from around 12.45 am where flow was forced into Victoria.[[5]](#footnote-5) Figure 3 shows the target (blue line) tracking the import limit (red line) meaning Murraylink’s target followed its import limit.

Figure 3: Murraylink interconnector import limits and target flows



## Under frequency load shedding and demand

The loss of the Heywood interconnector when power is flowing into South Australia results in an undersupply of generation and consequently the frequency in South Australia will fall. Under Frequency Load Shedding (UFLS) is triggered once the frequency drops below 49 Hz and is designed to reduce demand, in blocks, to arrest the falling frequency until supply matches demand and the frequency is restored.

At 12.16 am the UFLS scheme shed around 190 MW of load in South Australia. A decrease in load is reflected as a decrease in demand in market systems. Another 40 MW reduction also occurred, not associated with the UFLS scheme.

Figure 4 shows demand in South Australia and the effect on demand of UFLS compared to a recent similar day.

Figure 4: Demand and UFLS



Figure 4 highlights the effect that the load shedding had on demand in South Australia with demand falling around 230 MW at 12.25 am. Under normal conditions, demand during this time slowly decreases as shown by the blue dotted line. Permission to restore load was given at around 12.55 am and all load interrupted by UFLS was restored by 1.45 am.

## Generator availability and rebidding

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

### Offers and rebidding

While South Australia was separated from the NEM, prices were forecast in the short-term to be high. However this was not as a result of significant rebidding of capacity from low to high prices. Significant rebidding occurred from high to low prices. Following high price dispatch intervals at the start of the trading interval, participants rebid capacity from high to low prices, making spot prices lower than what was forecast half an hour ahead for most trading intervals during the period (see Table 1). A summary of the rebids in response to the high prices can be found in Appendix A.

Figure 5 shows the dispatch price (orange line), level of local generation dispatched (grey line) and closing offers in South Australia. The red ellipses encircle the periods where spot prices exceeded $5000/MWh. This shows that following high dispatch prices at the start of a trading interval, participants in South Australia rebid capacity from high to low prices on most occasions (increase in bottom green section after a price spike), resulting in lower dispatch prices for the remainder of the trading interval.

Figure 5: Initial bids of South Australia generators and dispatch price



It is not unusual, for participants to rebid capacity following a high price event to increase their volume and hence revenue in the trading interval. Consequently, participants waited until prices actually went high before rebidding capacity to low prices in order to increase their dispatch.

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

### Availability

As a result of being separated from the rest of the NEM, AEMO invoked a series of FCAS constraints to ensure frequency stability within South Australia. As a result of these constraints being invoked, energy output of AGL’s Torrens Island B power station was constrained down to provide FCAS, for the majority of the time, by around 150 MW despite this capacity being priced at the price floor.

AEMO directed Engie’s Pelican Point power station to reduce its output by around 60 MW which was priced at $300/MWh. Two other directions were also issued:

* to Torrens Island A – to rebid provide up to 10 MW of Raise 6 Second FCAS, and
* to Olympic Dam – to reduce their demand.

Appendix E provides more detail on these directions.

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Appendix A: Rebids

The below tables show significant rebids by participants with generation in South Australia. 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 being offered and the rebid reason.

Rebids for 1 am

| Submit time | Time effective | Participant | Station | Capacity rebid(MW) | Price from ($/MWh) | Price to ($/MWh) | Rebid reason |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 12.28 am | 12.35 am | Engie | Dry Creek | 92 | >13 300 | -1000 | 0028A response to SA MPC |
| 12.31 am | 12.40 am | AGL Energy | Torrens Island | 474 | >60 | 0 | 0030~A~040 chg in AEMO disp~ic flow decrease vs PD SA 0mw v $299.69 0035 |
| 12.32 am | 12.40 am | Engie | Dry Creek | 46 | 13 300 | -1000 | 0031A response to SA MPC |
| 12.32 am | 12.40 am | Engie | Pelican Point | 65 | >80 | -1000 | 0031A response to SA MPC |
| 12.32 am | 12.40 am | Engie | Snuggery | 42 | 1499 | -1000 | 0031A response to SA MPC |
| 12.34 am | 12.45 am | Energy Australia | Hallett | 60 | >579 | -1000 | 0030~A~band ADJ due to mat change in SA price SL~ |

Rebids for 1.30 am

| Submit time | Time effective | Participant | Station | Capacity rebid(MW) | Price from ($/MWh) | Price to ($/MWh) | Rebid reason |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 12.55 am | 1.05 am | AGL | Torrens A | -10 (R6 second) | >0  | N/A | 0045~A~060 unfcast network constraint~61 constr on/off out of merit order. FCAS |
| 1.08 am | 1.15 am | Energy Australia | Hallett | 20 | >579 | -1000 | 0055~A~band adj due to mat change in sa price SL~ |
| 12.44 am | 12.50 am | Engie | Dry Creek | 123 | >13 300 | -1000 | 0044A response to SA MPC in 5MPD |
| 12.53 am | 1.05 am | Snowy Hydro | Pt Stanvac | 42 | -1004 | 14 056 | 00:51:00 A SA 5min PD price $13,928.78 lower than 30min PD 01:05@00:32 ($70.21) |
| 1.02 am | 1.10 am | Snowy Hydro | Lonsdale | 21 | 14 126 | -1009 | 00:56:00 A SA 5min PD price $13,928.78 higher than 5min PD 01:05@00:51 ($13,998.99) |
| 1.02 am | 1.10 am | Snowy Hydro | Pt Stanvac | 42 | 14 056 | -1004 | 00:56:00 A SA 5min PD price $13,928.78 higher than 5min PD 01:05@00:51 ($13,998.99) |
| 1.25 am | 1.17 am | AGL | Torrens A | 10 (R6 second) | N/A | 13 800 | 0045~A~010 AEMO direction~directed to provide r6sec services by AEMO |

Rebids for 2 am

| Submit time | Time effective | Participant | Station | Capacity rebid(MW) | Price from ($/MWh) | Price to ($/MWh) | Rebid reason |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1.13 am | 1.20 am | Engie | Dry Creek | 10 | 13 300 | -1000 | 0112P unit not responding to target change |
| 1.18 am | 2.05 am | AGL Energy | Torrens Island | 274 | 485 | -1000 | 0031~A~050 chg in AEMO PD~55 PD price increase SA +$13192 |
| 1.32 am | 1.40 am | Engie | Dry Creek | -36 | 13 300 | N/A | 0131P unit failing to respond to set point changes: maintain current load |
| 1.33 am | 1.40 am | Snowy Hydro | Angaston | 37 | N/A | -997 | 01:11:00 A SA 5min PD price $11,801.40 higher than 5min PD 01:35@01:06 ($13,300.20) |
| 1.34 am | 1.45 am | Energy Australia | Hallett | 60 | 13 999 | -1000 | 0125~A~band adj due to mat change in SA 5PD demand SL~ |
| 1.45 am | 1.55 am | Energy Australia | Hallett | 30 | 579 | 13 999 | 0140~A~band adj due to mat change in SA price SL~ |

Rebids for 2.30 am

| Submit time | Time effective | Participant | Station | Capacity rebid(MW) | Price from ($/MWh) | Price to ($/MWh) | Rebid reason |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1.13 am | 1.20 am | Engie | Dry Creek | 10 | 13 300 | -1000 | 0112P unit not responding to target change |
| 1.13 am | 2.05 am  | Snowy Hydro | Lonsdale | 21 | 14 126 | -1009 | 00:32:00 A SA 30min PD price $13,920.00 higher than 30min PD 02:05@00:02 ($13,999.99) |
| 1.13 am | 2.05 am | Snowy Hydro | Pt Stanvac | 42 | 14 056 | -1004 | 00:32:00 A SA 30min PD price $13,920.00 higher than 30min PD 02:05@00:02 ($13,999.99) |
| 1.18 am | 2.05 am | AGL Energy | Torrens Island | 274 | 485 | -1000 | 0031~A~050 chg in AEMO PD~55 PD price increase SA +$13192 |
| 1.36 am | 2.05 am | Snowy Hydro | Angaston | 37 | 13 958 | -997 | 00:32:00 A SA 30min PD price $13,920.01 higher than 30min PD 03:00@00:02 ($14,000.00) |
| 1.49 am | 2.00 am | Engie | Port Lincoln | 42 | 14 000 | -1000 | 0148A response to SA MPC |
| 1.58 am | 2.05 am | Engie | Dry Creek | 77 | >13 300 | -1000 | 0158A response to SA MPC IN 5MPD |
| 1.58 am | 2.05 am | Engie | Dry Creek | 15 | 1498 | -1000 | 0158A response to SA MPC in 5MPD |
| 2.08 am | 2.15 am | Engie | Snuggery | 10 | 1499 | -1000 | 0208A response to SA MPC in 5MPD |
| 2.12 am | 2.20 am | Energy Australia | Hallett | 20 | 579 | -1000 | 0145~A~band adj due to mat change in SA price SL~ |

Rebids for 3 am

| Submit time | Time effective | Participant | Station | Capacity rebid(MW) | Price from ($/MWh) | Price to ($/MWh) | Rebid reason |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 12.34 am | 12.45 am | Energy Australia | Hallett | 10 | 13 999 | -1000 | 0030~A~band adj due to mat change in SA price SL~ |
| 1.08 am | 1.35 am | Energy Australia | Hallett | 20 | 13 999 | -1000 | 0055~A~band adj due to mat change in SA price SL~ |
| 1.09 am | 1.35 am | Energy Australia | Hallett | 20 | -1000 | 13 999 | 0105~A~band adj due to mat change in SA 5PD prices SL~ |
| 1.25 am | 1.35 am | Energy Australia | Hallett | 40 | 13 999 | 579 | 0120~E~correcting trader error in previous bid SL~ |
| 1.36 am | 2.05 am | Snowy Hydro | Angaston | 37 | 13958 | -997 | 00:32:00 A SA 30min PD price $13,920.01 higher than 30min PD 03:00@00:02 ($14,000.00) |
| 1.36 am | 2.05 am | Snowy Hydro | Lonsdale | 20 | 14126 | -1009 | 00:32:00 A SA 30min PD price $13,920.01 higher than 30min PD 03:00@00:02 ($14,000.00) |
| 1.36 am | 2.05 am | Snowy Hydro | Pt Stanvac | 34 | 14 056 | -1004 | 00:32:00 A SA 30min PD price $13,920.01 higher than 30min PD 03:00@00:02 ($14,000.00) |
| 2.22 am | 3.05 am | Energy Australia | Hallett | 40 | 579 | 13 999 | 0215~A~band adj for mat change in sa 5PD prices SL~ |
| 2.31 am | 2.40 am | Engie | Dry Creek | -36 | 13 300 | N/A | 0231P unit still not responding to load changes. maintain current load. |
| 2.34 am | 2.45 am | Engie | Port Lincoln | 42 | 14 000 | -1000 | 0234A respond to SA MPC |
| 2.34 am | 2.45 am | Energy Australia | Hallett | 70 | 13 999 | -1000 | 0220~a~band adj due to mat change in SA price SL~ |
| 2.46 am | 2.55 am | Engie | Dry Creek | 87 | >1498 | -1000 | 0245A response to SA MPC in 5MPD |
| 2.46 am | 2.55 am | Engie | Snuggery | 32 | 1499 | -1000 | 0245A response to SA MPC in 5MPD |

Rebids for 3.30 am

| Submit time | Time effective | Participant | Station | Capacity rebid(MW) | Price from ($/MWh) | Price to ($/MWh) | Rebid reason |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 2.32 am | 2.40 am | Engie | Mintaro | 30 | 14 000 | -1000 | 0232A respond to SA MPC and extended heywood outage |
| 2.34 am | 2.45 am | Engie | Port Lincoln | 12 | 14 000 | -1000 | 0234A respond to SA MPC |
| 2.40 am | 3.05 am | Snowy Hydro | Angaston | 37 | 13 958 | -997 | 02:32:00 A SA 30min PD price $12,501.20 higher than 30min PD 03:00@02:02 ($14,000.00) |
| 2.40 am | 3.05 am | Snowy Hydro | Lonsdale | 20 | 14 126 | -1009 | 02:32:00 A SA 30min PD price $12,501.20 higher than 30min PD 03:00@02:02 ($14,000.00) |
| 2.40 am | 3.05 am | Snowy Hydro | Pt Stanvac | 42 | 14 056 | -1004 | 02:32:00 A SA 30min PD price $12,501.20 higher than 30min PD 03:00@02:02 ($14,000.00) |
| 2.40 am | 2.50 am | Engie | Dry Creek | 15 | N/A | -1000 | 0239P unit in local control: site manned |
| 2.46 am | 2.55 am | Engie | Dry Creek | 10 | >13 300 | -1000 | 0245A response to SA MPC in 5MPD |
| 3.09 am | 3.20 am | Energy Australia | Hallett | 35 | 13 999 | -1000 | 0240~A~band adj due to mat chagne in SA 30PD prices SL~ |
| 3.12 am | 3.20 am | Engie | Dry Creek | 83 | >1498 | -1000 | 0311A response to SA MPC |
| 3.12 am | 3.20 am | Engie | Snuggery | 32 | 1499 | -1000 | 0311A response to SA MPC |

Rebids for 4 am

| Submit time | Time effective | Participant | Station | Capacity rebid(MW) | Price from ($/MWh) | Price to ($/MWh) | Rebid reason |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 2.32 am | 2.40 am | Engie | Mintaro | 30 | 14 000 | -1000 | 0232A respond to SA MPC and extended heywood outage |
| 2.40 am | 3.05 am | Snowy Hydro | Angaston | 37 | 13 958 | -997 | 02:32:00 A SA 30min PD price $12,501.20 higher than 30min PD 03:00@02:02 ($14,000.00) |
| 2.40 am | 3.05 am | Snowy Hydro | Lonsdale | 20 | 14 126 | -1009 | 02:32:00 A SA 30min PD price $12,501.20 higher than 30min PD 03:00@02:02 ($14,000.00) |
| 2.40 am | 3.05 am | Snowy Hydro | Pt Stanvac | 42 | 14 056 | -1004 | 02:32:00 A SA 30min PD price $12,501.20 higher than 30min PD 03:00@02:02 ($14,000.00) |
| 2.46 am | 2.55 am | Engie | Dry Creek | 25 | >13 300 | -1000 | 0245A response to SA MPC in 5MPD |
| 3.09 am | 3.20 am | Energy Australia | Hallett | 15 | 13 999 | -1000 | 0240~A~band adj due to mat chagne in SA 30PD prices SL~ |

Rebids for 5 am

| Submit time | Time effective | Participant | Station | Capacity rebid(MW) | Price from ($/MWh) | Price to ($/MWh) | Rebid reason |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 2.42 am | 4.05 am | Snowy Hydro | Angaston | 37 | 13 958 | -997 | 02:32:00 A SA 30min PD price $13,920.01 higher than 30min PD 04:30@02:02 ($14,000.00) |
| 2.42 am | 4.05 am | Snowy Hydro | Lonsdale | 20 | 14 126 | -1009 | 02:32:00 A SA 30min PD price $13,920.01 higher than 30min PD 04:30@02:02 ($14,000.00) |
| 2.42 am | 4.05 am | Snowy Hydro | Pt Stanvac | 42 | 14 056 | -1004 | 02:32:00 A SA 30min PD price $13,920.01 higher than 30min PD 04:30@02:02 ($14,000.00) |
| 3.13 am | 4.05 am | Energy Australia | Hallett | 15 | 13 999 | -1000 | 0310~A~band adj for mat change in SA 30PD prices SL~ |
| 4.32 am | 4.40 am | Engie | Dry Creek | 138 | >1498 | -1000 | 0432A response to SA MPC |
| 4.32 am | 4.40 am | Engie | Mintaro | 84 | 14 000 | -1000 | 0432A response to SA MPC |
| 4.32 am | 4.40 am | Engie | Snuggery | 42 | 1499 | -1000 | 0432A response to SA MPC |

Appendix B: Price setter

The following table identifies for the trading intervals 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.[[6]](#footnote-6) The 30-minute spot price is the average of the six dispatch interval prices. Prices in italics are capped at the Market Price Cap of $14 000/MWh.

Table 2: price setter for the 2 am trading interval

| DI | Dispatch Price ($/MWh) | Participant | Unit | Service | Offer price ($/MWh) | Marginal change | Contribution |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 01:35 | $13 300.40 | Engie | DRYCGT1 | Energy | $13 300.40 | 1.00 | $13 300.40 |
| 01:40 | $13 300.30 | Engie | DRYCGT2 | Energy | $13 300.30 | 1.00 | $13 300.30 |
| 01:45 | $153 260.27 | Generation deficit constraint |  | $16 800.00 | 0.79 | $132 720.00 |
|  |  | Origin Energy | QPS5 | Energy | $14 000.00 | 0.57 | $7980.00 |
|  |  | EnergyAustralia | AGLHAL | Energy | $578.81 | 0.57 | $329.92 |
|  |  | Snowy Hydro | UPPTUMUT | Energy | $49.51 | 0.55 | $27.23 |
|  |  | Engie | LOYYB1 | Energy | $10.50 | 0.05 | $0.53 |
|  |  | Engie | LOYYB2 | Energy | $10.50 | 0.05 | $0.53 |
|  |  | Origin Energy | QPS5 | Lower reg | $14 000.00 | 0.57 | $7980.00 |
|  |  | Engie | PPCCGT | Lower reg | $14 000.00 | -0.57 | -$7980.00 |
|  |  | EnergyAustralia | YWPS1 | Lower 60 sec | $0.08 | -0.09 | -$0.01 |
|  |  | Engie | LOYYB1 | Lower 60 sec | $0.02 | 0.05 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 60 sec | $0.02 | 0.05 | $0.00 |
|  |  | EnergyAustralia | MP2 | Lower 6 sec | $0.03 | -0.09 | $0.00 |
|  |  | Engie | LOYYB1 | Lower 6 sec | $0.02 | 0.05 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 6 sec | $0.02 | 0.05 | $0.00 |
|  |  | Origin Energy | QPS5 | Raise reg | $14 000.00 | -0.57 | -$7980.00 |
|  |  | AGL (SA) | TORRB2 | Raise reg | $14 000.00 | -0.57 | -$7980.00 |
|  |  | AGL (SA) | TORRB3 | Raise reg | $14 000.00 | -0.57 | -$7980.00 |
|  |  | AGL (SA) | TORRB4 | Raise reg | $14 000.00 | 1.71 | $23 940.00 |
|  |  | AGL (SA) | TORRA1 | Raise 6 sec | $13 799.99 | 0.79 | $10 901.99 |
|  |  | AGL (SA) | TORRA1 | Energy | -$1000.00 | -2.38 | $2380.00 |
|  |  | AGL (SA) | TORRB2 | Energy | -$1000.00 | 0.57 | -$570.00 |
|  |  | AGL (SA) | TORRB3 | Energy | -$1000.00 | 0.57 | -$570.00 |
|  |  | AGL (SA) | TORRB4 | Energy | -$1000.00 | 0.57 | -$570.00 |
| 01:50 | $14 000.00 | Origin Energy | LADBROK1 | Energy | $14 000.00 | 0.50 | $7000.00 |
|  |  | Origin Energy | LADBROK2 | Energy | $14 000.00 | 0.50 | $7000.00 |
| 01:55 | $13 300.30 | Engie | DRYCGT2 | Energy | $13 300.30 | 1.00 | $13 300.30 |
| 02:00 | $13 300.20 | Engie | DRYCGT3 | Energy | $13 300.20 | 1.00 | $13 300.20 |
| **Spot Price** | **$13 767/MWh** |  |  |  |  |

Table 3: price setter for the 3 am trading interval

| DI | Dispatch Price ($/MWh) | Participant | Unit | Service | Offer price ($/MWh) | Marginal change | Contribution |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 02:35 | $13 300.40 | Engie | DRYCGT1 | Energy | $13 300.40 | 1.00 | $13 300.40 |
| 02:40 | $13 998.99 | EnergyAustralia | AGLHAL | Energy | $13 998.99 | 1.00 | $13 998.99 |
| 02:45 | $1498.80 | Engie | SNUG1 | Energy | $1498.80 | 1.00 | $1498.80 |
| 02:50 | $1498.80 | Engie | SNUG1 | Energy | $1498.80 | 1.00 | $1498.80 |
| 02:55 | $53.97 | AGL Energy | BW02 | Energy | $55.96 | 0.47 | $26.30 |
|  |  | AGL Energy | BW03 | Energy | $55.96 | 0.16 | $8.95 |
|  |  | AGL Energy | BW04 | Energy | $55.96 | 0.31 | $17.35 |
|  |  | Engie | LOYYB1 | Energy | $10.50 | 0.09 | $0.95 |
|  |  | Engie | LOYYB2 | Energy | $10.50 | 0.09 | $0.95 |
|  |  | Hydro Tasmania | TUNGATIN | Lower 5 min | $0.39 | -0.17 | -$0.07 |
|  |  | EnergyAustralia | MP2 | Lower 60 sec | $0.15 | -0.17 | -$0.03 |
|  |  | Hydro Tasmania | GORDON | Lower 6 sec | $0.12 | -0.17 | -$0.02 |
|  |  | Engie | LOYYB1 | Lower 5 min | $0.02 | 0.09 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 5 min | $0.02 | 0.09 | $0.00 |
|  |  | Engie | LOYYB1 | Lower 60 sec | $0.02 | 0.09 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 60 sec | $0.02 | 0.09 | $0.00 |
|  |  | Engie | LOYYB1 | Lower 6 sec | $0.02 | 0.09 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 6 sec | $0.02 | 0.09 | $0.00 |
| 03:00 | $44.50 | Delta Electricity | VP5 | Energy | $49.00 | 0.29 | $14.21 |
|  |  | Delta Electricity | VP6 | Energy | $49.00 | 0.59 | $28.91 |
|  |  | EnergyAustralia | YWPS2 | Energy | $16.15 | 0.07 | $1.13 |
|  |  | EnergyAustralia | YWPS3 | Energy | $16.15 | 0.06 | $0.97 |
|  |  | Engie | LOYYB1 | Energy | $10.50 | -0.03 | -$0.32 |
|  |  | Engie | LOYYB2 | Energy | $10.50 | -0.03 | -$0.32 |
|  |  | Hydro Tasmania | JBUTTERS | Lower 5 min | $0.39 | 0.07 | $0.03 |
|  |  | EnergyAustralia | MP2 | Lower 60 sec | $0.15 | 0.07 | $0.01 |
|  |  | Hydro Tasmania | POAT110 | Lower 6 sec | $0.12 | 0.07 | $0.01 |
|  |  | Engie | LOYYB1 | Lower 5 min | $0.02 | -0.03 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 5 min | $0.02 | -0.03 | $0.00 |
|  |  | Engie | LOYYB1 | Lower 60 sec | $0.02 | -0.03 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 60 sec | $0.02 | -0.03 | $0.00 |
|  |  | Engie | LOYYB1 | Lower 6 sec | $0.02 | -0.03 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 6 sec | $0.02 | -0.03 | $0.00 |
| **Spot Price** | **$5066/MWh** |  |  |  |  |

Table 4: price setter for the 3.30 am trading interval

| DI | Dispatch Price ($/MWh) | Participant | Unit | Service | Offer price ($/MWh) | Marginal change | Contribution |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 03:05 | $13 300.20 | Engie | DRYCGT3 | Energy | $13 300.20 | 1.00 | $13 300.20 |
| 03:10 | $13 300.10 | Engie | MINTARO | Energy | $13 300.10 | 1.00 | $13 300.10 |
| 03:15 | $13 300.10 | Engie | MINTARO | Energy | $13 300.10 | 1.00 | $13 300.10 |
| 03:20 | $48.77 | Snowy Hydro | UPPTUMUT | Energy | $49.51 | 0.97 | $48.02 |
|  |  | Engie | LOYYB1 | Energy | $10.50 | 0.03 | $0.32 |
|  |  | Engie | LOYYB2 | Energy | $10.50 | 0.03 | $0.32 |
|  |  | Hydro Tasmania | TUNGATIN | Lower 5 min | $0.39 | -0.05 | -$0.02 |
|  |  | Engie | LOYYB1 | Lower 5 min | $0.19 | 0.03 | $0.01 |
|  |  | Engie | LOYYB2 | Lower 5 min | $0.19 | 0.03 | $0.01 |
|  |  | EnergyAustralia | YWPS3 | Lower 60 sec | $0.08 | -0.05 | $0.00 |
|  |  | EnergyAustralia | YWPS1 | Lower 6 sec | $0.03 | -0.05 | $0.00 |
|  |  | Engie | LOYYB1 | Lower 60 sec | $0.02 | 0.03 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 60 sec | $0.02 | 0.03 | $0.00 |
|  |  | Engie | LOYYB1 | Lower 6 sec | $0.02 | 0.03 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 6 sec | $0.02 | 0.03 | $0.00 |
| 03:25 | $48.89 | Delta Electricity | VP5 | Energy | $49.00 | 0.33 | $16.17 |
|  |  | Delta Electricity | VP6 | Energy | $49.00 | 0.65 | $31.85 |
|  |  | Engie | LOYYB1 | Energy | $10.50 | 0.04 | $0.42 |
|  |  | Engie | LOYYB2 | Energy | $10.50 | 0.04 | $0.42 |
|  |  | Hydro Tasmania | TUNGATIN | Lower 5 min | $0.39 | -0.07 | -$0.03 |
|  |  | Engie | LOYYB1 | Lower 5 min | $0.19 | 0.04 | $0.01 |
|  |  | Engie | LOYYB2 | Lower 5 min | $0.19 | 0.04 | $0.01 |
|  |  | EnergyAustralia | YWPS3 | Lower 60 sec | $0.08 | -0.07 | -$0.01 |
|  |  | EnergyAustralia | YWPS3 | Lower 6 sec | $0.03 | -0.07 | $0.00 |
|  |  | Engie | LOYYB1 | Lower 60 sec | $0.02 | 0.04 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 60 sec | $0.02 | 0.04 | $0.00 |
|  |  | Engie | LOYYB1 | Lower 6 sec | $0.02 | 0.04 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 6 sec | $0.02 | 0.04 | $0.00 |
| 03:30 | $47.88 | Delta Electricity | VP5 | Energy | $49.00 | 0.32 | $15.68 |
|  |  | Delta Electricity | VP6 | Energy | $49.00 | 0.65 | $31.85 |
|  |  | Engie | LOYYB1 | Energy | $10.50 | 0.02 | $0.21 |
|  |  | Engie | LOYYB2 | Energy | $10.50 | 0.02 | $0.21 |
|  |  | AGL Energy | LYA1 | Lower 5 min | $0.50 | -0.03 | -$0.02 |
|  |  | EnergyAustralia | YWPS2 | Lower 60 sec | $0.17 | -0.03 | -$0.01 |
|  |  | EnergyAustralia | MP2 | Lower 6 sec | $0.14 | -0.03 | $0.00 |
|  |  | Engie | LOYYB1 | Lower 60 sec | $0.02 | 0.02 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 60 sec | $0.02 | 0.02 | $0.00 |
|  |  | Engie | LOYYB1 | Lower 6 sec | $0.02 | 0.02 | $0.00 |
|  |  | Engie | LOYYB2 | Lower 6 sec | $0.02 | 0.02 | $0.00 |
| **Spot Price** | **$6674/MWh** |  |  |  |  |

Appendix C: Closing bids

Figures C1 to C4 highlight the half hour closing bids for participants in South Australia 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 – Origin Energy (Ladbroke, Quarantine and Osborne) closing bid prices, dispatch and spot price



Figure C2 - EnergyAustralia (Hallett, Waterloo) closing bid prices, dispatch and spot price



Figure C3 - Engie (Dry Creek, Mintaro, Port Lincoln, Snuggery) closing bid prices, dispatch and spot price



Figure C4 – Snowy Hydro (Lonsdale, Pt Stanvac and Angaston) 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 South Australia.

|  |  |  |  |
| --- | --- | --- | --- |
| Market Notice | Type | Date of issue | Last Changed |
| 55515 | GENERAL NOTICE | 31/10/2016 09:42:56 | 31/10/2016 09:42:56 |
| **External Reference** |
| Planned outage of Heywood No.2 500kV Bus in Victoria region from 30/11/2016 0600 hrs to 01/12/2016 1600 hrs |
| **Reason** |
| AEMO ELECTRICITY MARKET NOTICE.This market notice is FOR INFORMATION ONLY.The Heywood No.2 500 kV busbar in Victoria Region is planned out of service from 0600 hrs on 30 November 2016 to 1600 hrs on 1 December 2016. During this outage, Heywood 500/275 kV M2 transformer will be off-loaded and Heywood - Mortlake - Alcoa Portland No.2 500 kV line will be opened at Heywood.During this outage, a credible contingency can separate South Australia region from the rest of the NEM. Under these circumstances, 35 MW of Raise and Lower regulation FCAS will be sourced from South Australia for the duration of this outage. In addition, consistent with AEMO existing procedures, adequate contingency FCAS lower requirements will also be sourced from South Australia at times when power transfer is from South Australia to Victoria. The following constraint sets have been invoked for this outage:F-I\_HYSE (includes F-S\_LREG\_0035 and F-S\_RREG\_0035) S-X\_BC\_CPV-HYTX\_M12 V-HY\_500BUSRefer AEMO Network Outage Schedule (NOS) for further details. AEMO will continue monitoring this proposed outage and will update the Market accordingly.Edmund HonAEMO Operations |

|  |  |  |  |
| --- | --- | --- | --- |
| Market Notice | Type | Date of issue | Last Changed |
| 55867 | RESERVE NOTICE | 28/11/2016 13:43:08 | 28/11/2016 13:43:08 |
| **External Reference** |
| Forecast Lack Of Reserve Level 2 (LOR2) in South Australia Region - 30 Nov to 01 Dec 2016 |
| **Reason** |
| AEMO ELECTRICITY MARKET NOTICERefer to AEMO Market Notice 55515Forecast Lack Of Reserve Level 2 (LOR2) in South Australia Region - from 0600 hrs on 30/11/2016 to 1600 hrs on 01/12/2016. AEMO declares Forecast LOR2 conditions for the South Australia region during the planned outage of Heywood No.2 500 kV busbar from 0600 hrs on 30/11/2016 to 1600 hrs on 01/12/2016.On the occurrence of a credible contingency during these planned outage, South Australia region could separate from the rest of the NEM and is likely to result in interruptions to power supplies in South Australia.There are sufficient capacity reserves in the South Australia region to meet electricity demand but following the next credible contingency it may not be possible to bring the required additional capacity into service in time to avoid automatic under-frequency load shedding causing interruptions to power supplies in South Australia.Operations PlanningBhishma Chhetri |

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| --- | --- | --- | --- |
| Market Notice | Type | Date of issue | Last Changed |
| 55904 | RESERVE NOTICE | 30/11/2016 07:48:43 | 30/11/2016 07:48:43 |
| **External Reference** |
| Actual LOR2 South Australia Region - 30/11/16 |
| **Reason** |
| AEMO ELECTRICITY MARKET NOTICEActual LOR2 South Australia Region - 30/11/16Refer AEMO Electricity Market Notice 55867An actual LOR2 condition has been declared for the South Australia region from 0700 hrs and is forecast to continue until 1600 hrs 01/12/16 during a planned outage of the Heywood No2 500 kV bus in Victoria.If a credible contingency event occurs in this period the South Australia region would separate from the rest of the NEM and is likely to result in interruptions to power supplies.There are sufficient capacity reserves in the South Australia region to meet electricity demand but it may not be possible to bring the required additional capacity into service in time to avoid automatic under-frequency load shedding causing power interruptions.Manager NEM Real Time Operations |

|  |  |  |  |
| --- | --- | --- | --- |
| Market Notice | Type | Date of issue | Last Changed |
| 55958 | POWER SYSTEM EVENTS | 1/12/2016 12:31:57 AM | 1/12/2016 12:31:57 AM |
| **External Reference** |
| AEMO advises that South Australia has seperated from the NEM |
| **Reason** |
| AEMO ELECTRICITY MARKET NOTICEPOWER SYSTEM EVENT At 0016 hrs 1st December 2016 the SA power system seperated from the NEM but remains operating as a separate entity. AEMO are investigating the cause and will develop and implement a reconnection plan as soon as practical.Manager NEM Real Time Operations |

|  |  |  |  |
| --- | --- | --- | --- |
| Market Notice | Type | Date of issue | Last Changed |
| 55973 | MARKET INTERVENTION | 1/12/2016 2:34:54 AM | 1/12/2016 2:34:54 AM |
| **External Reference** |
| Direction - South Australia region 01/12/2016 |
| **Reason** |
| AEMO ELECTRICITY MARKET NOTICE.Direction - South Australia region 01/12/2016In accordance with clause 4.8.9 of the National Electricity Rules AEMO has issued directions to participants in the South Australia region. The directions were necessary to maintain the power system in a secure operating state.The directions was issued from 0130 hrs 01/12/2016 and will remain in place until further notice.Manager NEM Real Time Operations |

|  |  |  |  |
| --- | --- | --- | --- |
| Market Notice | Type | Date of issue | Last Changed |
| 55972 | MARKET INTERVENTION | 1/12/2016 2:37:42 AM | 1/12/2016 2:37:42 AM |
| **External Reference** |
| Direction - Torrens Island A1 01/12/16 |
| **Reason** |
| AEMO ELECTRICITY PARTICIPANT NOTICE.Direction - Torrens Island A1 01/12/16In accordance with clause 4.8.9 of the National Electricity Rules AEMO is issuing a direction to Torrens Island A1 to take the following action. Provide up to 10 MW of Raise FCAS. The following constraints were invoked:#TORRA1\_OF#TORRA1\_PFThe direction is issued subject to the Registered Participant's best endeavours to comply with it unless compliance would be a hazard to public safety or materially risk damaging equipment or contravene any other law.The direction is issued at 0130 hrs 01/12/16 and will remain in place until further noticeManager NEM Real Time Operations |

|  |  |  |  |
| --- | --- | --- | --- |
| Market Notice | Type | Date of issue | Last Changed |
| 56015 | MARKET INTERVENTION | 1/12/2016 5:02:31 AM | 1/12/2016 5:02:31 AM |
| **External Reference** |
| Cancellation of Directions - South Australia region 01/12/2016 |
| **Reason** |
| AEMO ELECTRICITY MARKET NOTICE.Cancellation of Directions - South Australia region 01/12/2016In accordance with clause 4.8.9 of the National Electricity Rules AEMO had issued directions to participants in the South Australia region. The directions were necessary to maintain the power system in a secure operating state.The directions are no longer required and have been cancelled from 0500 hrs 01/12/2016 Manager NEM Real Time Operations |

|  |  |  |  |
| --- | --- | --- | --- |
| Market Notice | Type | Date of issue | Last Changed |
| 56016 | MARKET INTERVENTION | 1/12/2016 5:08:19 AM | 1/12/2016 5:08:19 AM |
| **External Reference** |
| Cancellation of Direction - Torrens Island A1 01/12/16 |
| **Reason** |
| AEMO ELECTRICITY PARTICIPANT NOTICE.Cancellation of Direction - Torrens Island A1 01/12/16AEMO has cancelled the direction to Torrens Island A1 at 0500 hrs 01 Dec 2016The following constraints were revoked:#TORRA1\_OF#TORRA1\_PFManager NEM Real Time Operations |

|  |  |  |  |
| --- | --- | --- | --- |
| Market Notice | Type | Date of issue | Last Changed |
| 56021 | MARKET INTERVENTION | 1/12/2016 6:09:57 AM | 1/12/2016 6:09:57 AM |
| **External Reference** |
| Direction - Pelican Point Power Ltd 01/12/16 |
| **Reason** |
| AEMO ELECTRICITY PARTICIPANT NOTICE.Direction - Pelican Point 01/12/16In accordance with clause 4.8.9 of the National Electricity Rules AEMO is issuing a direction to Pelican Point to take the following action. Reduce to 165 MW to reduce risk (reduce Raise FCAS requirement). The following constraint was invoked:#PPCCGT\_OEThe direction is issued subject to the Registered Participant's best endeavours to comply with it unless compliance would be a hazard to public safety or materially risk damaging equipment or contravene any other law.The direction is issued at 0230 hrs 01/12/16 and was cancelled at 0500 hrsManager NEM Real Time Operations |

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| --- | --- | --- | --- |
| Market Notice | Type | Date of issue | Last Changed |
| 56025 | RESERVE NOTICE | 1/12/2016 9:06:57 AM | 1/12/2016 9:06:57 AM |
| **External Reference** |
| Update - Actual LOR2 South Australia Region - 1/12/16 |
| **Reason** |
| AEMO ELECTRICITY MARKET NOTICEActual LOR2 South Australia Region - 1/12/16Refer AEMO Electricity Market Notice 55867 and 55904An actual LOR2 condition has been declared for the South Australia region from 0700 hrs 30/11/16 and is forecast to continue until further notice following the unplanned outage of the Moorabool Tarone 500 kV line in Victoria.If a credible contingency event occurs in this period the South Australia region would separate from the rest of the NEM and is likely to result in interruptions to power supplies.There are sufficient capacity reserves in the South Australia region to meet electricity demand but it may not be possible to bring the required additional capacity into service in time to avoid automatic under-frequency load shedding causing power interruptions.See Network Outage Schedule (NOS) for further details Manager NEM Real Time Operations |

|  |  |  |  |
| --- | --- | --- | --- |
| Market Notice | Type | Date of issue | Last Changed |
| 56079 | RESERVE NOTICE | 1/12/2016 9:50:14 PM | 1/12/2016 9:50:14 PM |
| **External Reference** |
| Cancellation - Actual LOR2 South Australia Region - 01 Dec 2016 |
| **Reason** |
| AEMO ELECTRICITY MARKET NOTICECancellation - Actual LOR2 South Australia Region - 01 Dec 2016Refer AEMO Electricity Market Notices 55867, 55904 and 56025.The Actual LOR2 condition in the South Australia Region is cancelled at 2145 hrs 01 Dec 2016Manager NEM Real Time Operations |

Appendix E: Directions

Once South Australia separated from the NEM, the power system was in an insecure state due a shortage of FCAS. Raise and Lower constraints violated. In response, AEMO directed two generators and load to maintain the power system in a secure operating state.

At around 1.15 am AEMO directed Torrens Island A1 to provide up to 10 MW of raise FCAS[[7]](#footnote-7). This was as a result of AGL withdrawing all of its FCAS availability at Torrens A unit one through a rebid. The rebid was effective from 1.05 am and the reason given was “0045~A~060 unfcast network constraint~61 constr on/off out of merit order. FCAS”. Effective 1.25 am, AGL reversed this rebid for Raise 6 services and the reason given was “0045~A~010 AEMO direction~directed to provide r6sec services by AEMO”. Other FCAS services were rebid available effective 2 am.

At around 2 am AEMO directed Electranet to reduce the demand at BHP’s Olympic Dam’s South Australian facility by approximately 70 MW down to 100 MW to maintain system security. At the time, Olympic Dam was the biggest single load in South Australia and was therefore the greatest contributor to the requirement of FCAS lower services. If Olympic Dam was to trip unexpectedly, there would be an increase in the requirement for lower services as the frequency of the South Australian system would increase and risk system security.

At 2.30 am AEMO directed Pelican Point to reduce its output to 165 MW, from around 215 MW[[8]](#footnote-8). As Pelican Point was the biggest single generator in the South Australian region at the time, they were also the greatest contributor to the requirement of FCAS raise services. If Pelican Point was to trip unexpectedly, there would be an increase in the requirement for raise services as the frequency of the South Australian system would decrease.

All directions were revoked at around 5 am, when the South Australian region was no longer separated from the NEM.

AEMO has published a preliminary operating incident report into this event and will publish their final report by February 28 2017 detailing these directions.

1. This requirement is set out in clause 3.13.7 (d) of the National Electricity Rules. [↑](#footnote-ref-1)
2. Murraylink continued to operate at around 100 MW for a majority of the incident but it does not provide a synchronous connection to the rest of the NEM. [↑](#footnote-ref-2)
3. There was also notification to the market through market notice 55515 on 31 October 2016. [↑](#footnote-ref-3)
4. AEMO has published a preliminary report into events on the day <http://www.aemo.com.au/-/media/Files/Media_Centre/2016/1-December-SA-separation-report---081216_AEMO.pdf>, the final report is due 28 February 2017 [↑](#footnote-ref-4)
5. Murraylink is a DC interconnector and cannot transfer FCAS from the rest of the NEM into South Australia as it is not a synchronous link. [↑](#footnote-ref-5)
6. Details on how the price is determined can be found at [www.aemo.com.au](http://www.aemo.com.au) [↑](#footnote-ref-6)
7. See market notices 55972 and 56016 in Appendix D [↑](#footnote-ref-7)
8. See market notice 56021 in Appendix D [↑](#footnote-ref-8)