SYSTEM EVENT REPORT SOUTH AUSTRALIA, 8 FEBRUARY 2017

REVIEWABLE OPERATING INCIDENT REPORT FOR THE NATIONAL ELECTRICITY MARKET

INFORMATION AS AT 9.00 AM, FRIDAY 9 FEBRUARY 2017

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AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

IMPORTANT NOTICE

Purpose

AEMO has prepared this report in accordance with clause 4.8.15(c) of the National Electricity Rules, using information available as at the date of publication, unless otherwise specified.

Disclaimer

Any analysis and conclusions in these findings are preliminary in nature.

AEMO's investigations are incomplete and the findings expressed in this report may change as further information becomes available and further analysis is conducted. Any views expressed in this report are those of AEMO unless otherwise stated, and may be based on information given to AEMO by other persons.

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1. INTRODUCTION

This report provides information on the operation of the National Electricity Market (NEM) and national power grid on Wednesday 8 February during a heatwave in eastern Australia.

AEMO will release a second report on 22 February, focused on the events of 10 February.

During this heatwave period, involuntary load reduction was necessary on two occasions to preserve system security:

- On 8 February 2017 in South Australia, the power system was not in a secure operating state for over 30 minutes. AEMO directed interruption of supply to 100 megawatts (MW) of customer load in South Australia and gave clearance to restore that load 27 minutes later. Following this direction, approximately 300 MW was interrupted. The reason for the additional interruption is being investigated.
- On 10 February, in New South Wales, AEMO directed Transgrid to shed one of the Tomago Aluminium smelter potlines (290 MW), and cancelled the direction one hour later.

This report focuses on South Australia's electricity supply on Wednesday 8 February 2017.

Actions and outcomes over the heatwave period are outlined in Table 1.

Table 1 Outcomes over heatwave period

Day	Region most at risk	Load shedding directed
8 February	South Australia	100 MW for 27 minutes
9 February	South Australia	None
10 February	New South Wales	290 MW for 60 minutes
11 February	New South Wales	None
12 February	New South Wales	None
12 February	Queensland	None

All times in this report are market time (AEST). In February, Adelaide local time is market time plus 30 minutes.

AEMO is still undertaking investigations into the reviewable operating incident on 8 February 2017, including seeking information and clarification from participants. If required, an additional report will be published.

2. SOUTH AUSTRALIA, 8 FEBRUARY 2017

In summary:

- Demand and supply from renewable and thermal generation were changing rapidly in the period just prior to a loss of system security. At the peak:
  - Demand was higher than forecast
  - Wind generation was lower than forecast, and
  - Thermal generation capacity was reduced due to forced outages.
- 165 MW of Pelican Point capacity had been notified as unavailable. The operator advised AEMO of a start-up time which would not have enabled AEMO to meet the system security requirements under the National Electricity Rules.
- Load shedding then became the only available option for AEMO to restore system security.
- AEMO directed load shedding of 100 MW, and gave clearance to restore that load 27 minutes later. Actual load shedding by the local network operator was approximately 300 MW.

2.1 Sequence of events

AEMO's market systems continually inform the market, every five and 30 minutes.

Table 2 Timeline of events on 8 February 2017

Time hhmm	Events/comments
1500	Pre Dispatch (PD) Projected Assessment of System Adequacy (PASA)[A] indicates a forecast lack of reserve Level 1 (LOR 1 – insufficient reserves for the largest contingency event)[B] for the SA region from 1630 – 1900 hrs. Market Notice 57276 issued at 1518 hrs.
1607	Engie advises AEMO that the Port Lincoln generating units (73 MW total) are not available due to a communications system problem.
1610	PD PASA forecasts an LOR 1 for the SA region from 1600 – 1900 hrs. Market Notice 57277 issued at 1613 hrs.
1700	PD PASA indicates an actual LOR2 for the SA region from 1700 – 1900 hrs. Market Notice 57279 issued at 1713 hrs. Should a market response prove inadequate AEMO has the authority to direct any available generation on.
1718	Origin Energy advises AEMO that Quarantine unit 4 (20 MW) is not available.
1725	Constraint equation V^SML_NSWRB_2 violates. This constraint manages flow on Murraylink to prevent voltage collapse in western Victoria for the loss of the New South Wales Buronga – Darlington Point 220 kV transmission line. Murraylink flow is above its limit of 78 MW by over 100 MW. The power system is not in a secure operating state. AEMO must take all reasonable actions, including intervention if necessary, to return the power system to a secure operating state within 30 minutes. AEMO conducts studies to determine actions to alleviate the insecure operating state of the power system including off market options such as non-scheduled generation or load reductions and direction of capacity not available within the PASA 24 hour availability.
1739	AEMO seeks advice from Engie on the availability of the off line generating unit at Pelican Point.[C] Engie advises AEMO that they don't have the gas to run the unit and if gas was available it would be a four hour minimum run up time. AEMO asks Engie to explore options and advise further.
1742	AGL advises AEMO that: • Torrens Island A1 (120 MW) will not be not available until Monday due to a tube leak being repaired. • Torrens Island B1 is operating at reduced capacity (50 MW reduction) due to high ambient temperatures.
1749	Origin advises Quarantine unit 4 is available.
1755	Quarantine Unit 4 receives signal to synchronise.
1800	Constraint equation V^SML_NSWRB_2 is still violating. The power system has been insecure for 35 minutes. AEMO concludes that all supply-side options to return the power system to a secure operating state have been exhausted.

Time hhmm	Events/comments
1801	Engie informs AEMO that if directed the off line unit could be available to synchronise by 1900 hrs and then be at full output by 1945 for a 4 – 8 hrs run time. AEMO determines the unit will not be available in time to restore power system security.
1803	AEMO declares actual LOR3 for the SA region. AEMO issues a Direction under clause 116 of the National Electricity Law (NEL) to ElectraNet to reduce load by 100 MW to reduce the flow on Murraylink and restore system security. ElectraNet instructs SA Power Networks (SAPN)[D] to shed 100 MW of load.
1810	Load reduction commences and reaches approximately 300 MW reduction by 1820 hrs. AEMO becomes aware the demand reduction appears to exceed the directed level of 100 MW.
1815	Flow on Murraylink falls below system security limits. Power system is now returned to a secure state.
1818	AEMO confirms with ElectraNet that load has been shed as directed and that approximately 200 MW more has been shed than AEMO directed.
1820	Market Price Cap is applied from Dispatch Interval ending 1825 hrs.
1830	AEMO advises ElectraNet that 100 MW of load can be restored over next 10 minutes.
1840	AEMO advises ElectraNet to restore all remaining load as it appears over 300 MW was shed in total.
1849	AEMO confirms ElectraNet have asked SAPN to restore all load.
1850	Market Price Cap is removed.
1900	LOR3 in South Australia is cancelled.
1908	ElectraNet confirms all load has been restored.

A PASA is AEMO's reserve assessment tool.
B Refer to Appendix A for an explanation of reserve levels.
C Pelican Point power station consists of two gas turbines and a steam turbine. One gas turbine and the steam turbine were already on line.
D SA Power Networks (SAPN) is the Distribution Network Service Provider in South Australia.

2.2 Electricity supply

Electricity in South Australia is supplied by a combination of:

- Generation in South Australia, comprising gas, diesel, wind, and rooftop solar photovoltaic (PV).
- Imports from Victoria via interconnections (the Heywood and Murraylink interconnectors).

Table 3 Generation contribution to demand at time of peak demand

Generation source	Contribution to peak demand (MW) at 1800 hrs	Available capacity (MW) at 1800 hrs	Installed capacity (MW)
Net import from Victoria (Heywood interconnector and Murraylink)	765	668	820
Wind	96	96	1,595
Diesel	113	121	128
Gas	2,111	2,161	2,614
Total	**3,085**	**3,046**	**5,157**
Solar PV contribution	157	**157**	**705**
Total including rooftop PV	**3,242 MW**	**3,203 MW**	**5,862 MW**

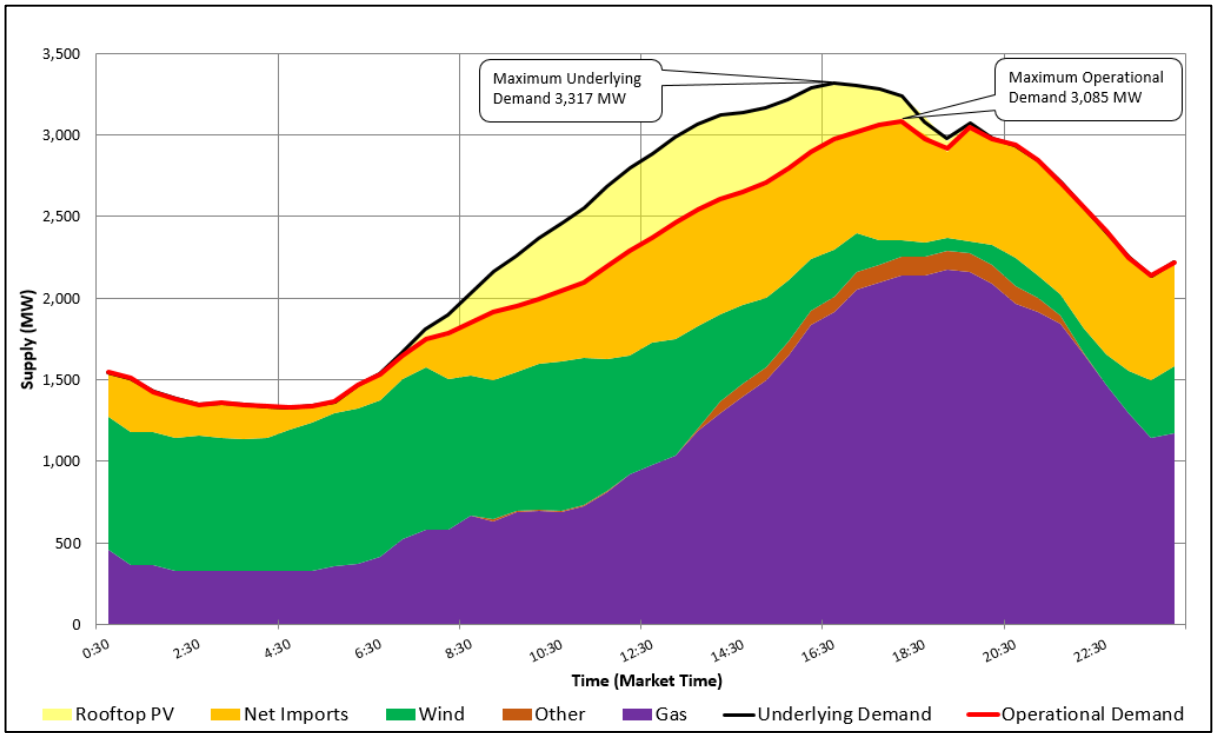
Of the installed operational capacity in South Australia of 5,157 MW, a total of 3,046 MW was available at 1800 hrs on 8 February to contribute to the operational peak demand of 3,085 MW.

The shortfall was being transferred across the interconnectors and reserve being held across the interconnectors, breaching the interconnector limits. To relieve interconnector limits, demand must be reduced or supply must be increased.

Figure 1 shows the actual generation and import mix, and operational and underlying demand[1], for Wednesday 8 February 2017, based on the average values for each 30-minute trading interval.

The peak operational demand on Wednesday 8 February was 3,085 MW, occurring at 1800 hrs.

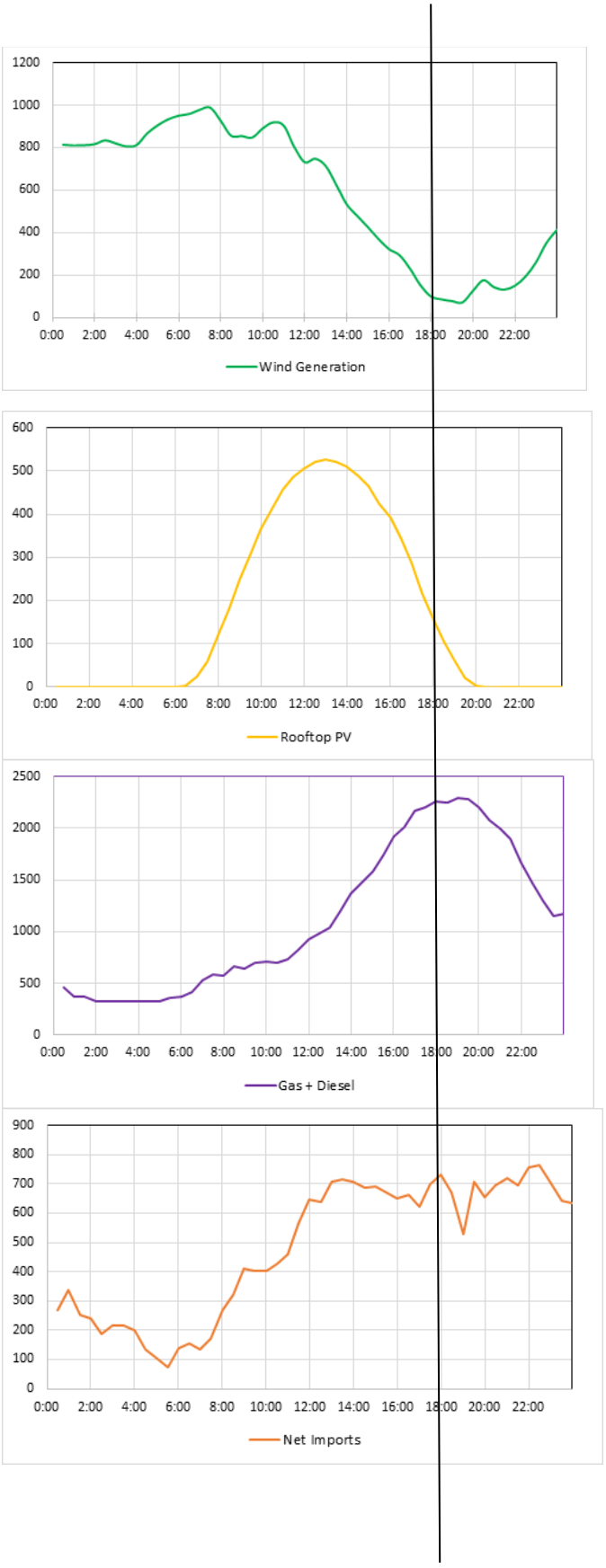
Figure 1 South Australia's electricity supply mix on 8 February 2017

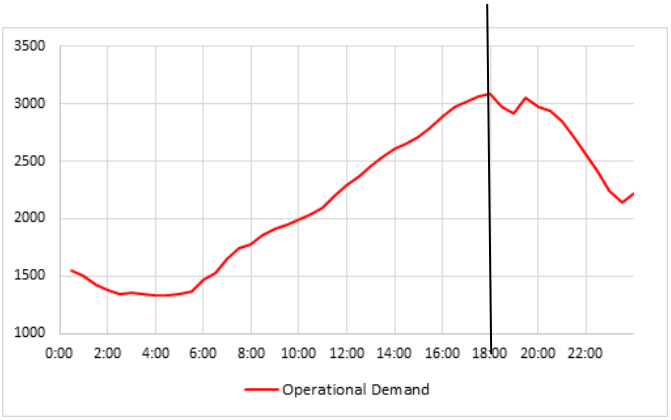


The following set of graphs (Figure 2) shows each source of supply throughout the day on 8 February. The vertical line indicates the time of load reduction to enable system security to be restored.

[1] Operational demand in a region is defined as the demand met by scheduled, semi-scheduled, and significant non-scheduled generation plus net imports from other regions. The underlying demand is the operational demand plus the estimate of demand met by rooftop solar generation.

Figure 2 Source of supply throughout 8 February





2.2.1 Thermal generation

Thermal generation in South Australia is generation from gas-fired or diesel-fired generating units.

At 1800 hrs on 8 February 2017, when load shedding commenced, all thermal generating units in South Australia were on line and operating at or near full capacity, except for those shown in Tables 4 and 5.

Table 4 South Australian thermal generation – outages pre-existing

Generating unit	Normal capacity	Actual capacity	Bid status	Reason
Torrens Island A1	120 MW	0 MW	Declared unavailable ahead of the day	Long term outage: boiler tube leak.
Pelican Point Gas turbine 12	165 MW	0 MW	Unavailable	Market participant bid as unavailable; confirmed unavailable at 1739 hrs with minimum start time of four hours.
Total capacity unavailable = 285 MW				

Table 5 South Australian thermal generation – forced outages on 8 February

Generating unit	Normal capacity	Actual capacity	Bid status	Reason
Torrens Island B1	200 MW	150 MW	Available	Market participant reduced capacity bid at 1742 hrs 8 February due to high ambient temperatures
Torrens Island B4	200 MW	190 MW	Available	
Quarantine 4	20 MW	0 MW	Available	Market participant bid unavailable at 1718 hrs 8 February
Port Lincoln 1	50 MW	0 MW	Unavailable	Market participant bid unavailable 1607 hrs 8 February as a result of a control signal fault, caused by failure of electronics in the communications system.
Port Lincoln 3	23 MW	0 MW	Unavailable	
Total capacity reduction after 1600 hrs on 8 February = 153 MW				

Table 6 shows the output of all thermal generating units in South Australia at 1800 hrs[2], compared to their capacity. All available units were operating at or near full capacity.

Table 6 Thermal generating units in South Australia – capacity and output (MW)

Generating unit	Available capacity (MW)	Output (MW)
Hallett	190	191
Angaston	40	39
Dry Creek 1	35	34
Dry Creek 2	35	35
Dry Creek 3	39	40
Ladbroke Grove 1	36	35
Ladbroke Grove 2	36	36
Lonsdale	18	18
Mintaro	71	71
Osborne	170	172
Port Lincoln 1	0	0
Port Lincoln 3	0	0
Pelican Point Gas Turbine (GT) 11	160	160
Pelican Point GT 12	0	0
Pelican Point Steam Turbine 18	75[A]	76
Port Stanvac	61	59
Quarantine 1	20	19
Quarantine 2	20	19
Quarantine 3	20	18
Quarantine 4	20[B]	0
Quarantine 5	110	110
Snuggery	34	34
Torrens Island A1	0	0
Torrens Island A2	120	120
Torrens Island A3	110	106
Torrens Island A4	120	116
Torrens Island B1	150	150
Torrens Island B2	200	200
Torrens Island B3	200	198
Torrens Island B4	190	192
Total	**2,280**	**2,246**

A Pelican Point power station consists of two gas turbines and a steam turbine. One gas turbine and the steam turbine were already on line.
B Quarantine unit 4 commenced generating at 1810 hrs.

[2] Based on results from the 1800 hrs dispatch run.

2.2.2 Wind generation

Figure 3 shows the actual wind generation in South Australia, and the forecast wind generation, for 8 February.

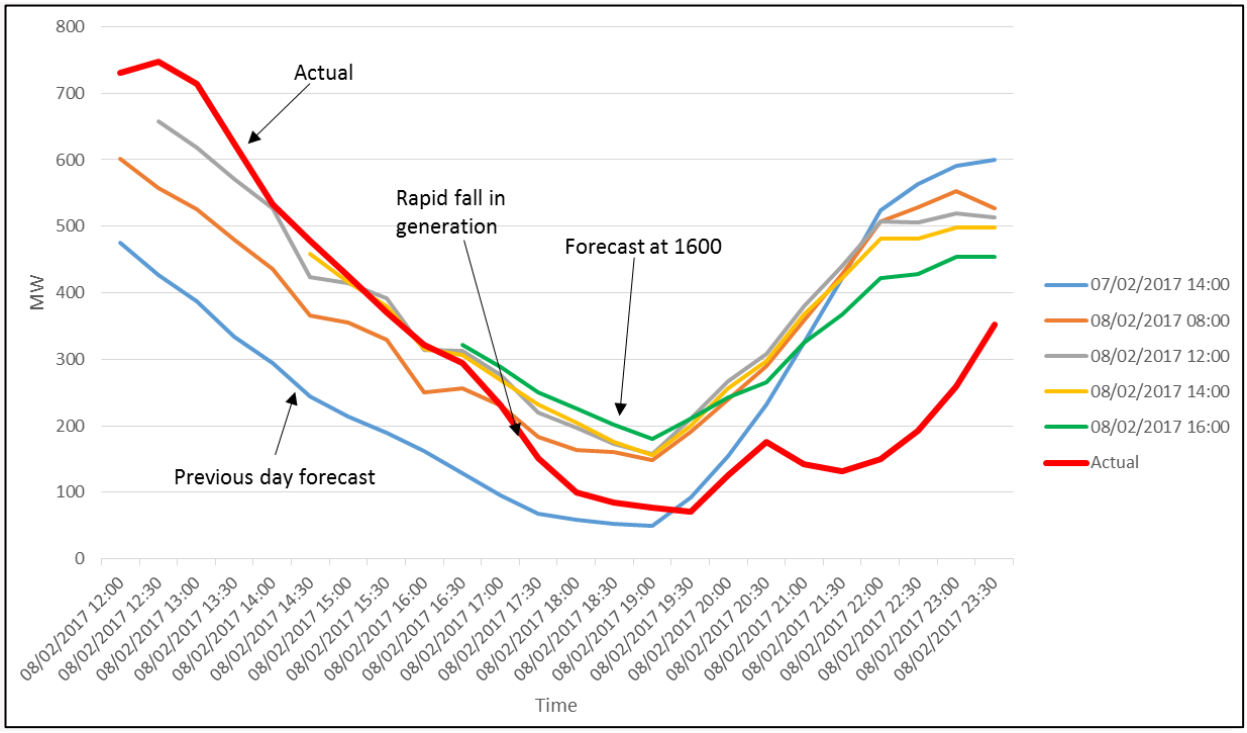
The actual wind generation matched the forecast up to 1600 hrs.

From 1600 hrs onwards, actual wind generation declined more rapidly than forecast, as a result of a sharp drop in wind speed between 1600 hrs and 1800 hrs.

As a result:

- The forecast issued at 1400 hrs was for about 175 MW of wind generation for the trading interval ending at 1830 hrs.
- The forecast issued at 1600 hrs was for about 200 MW of wind generation for the same trading interval.
- At 1800 hrs, the actual wind generation was about 100 MW and falling.

Figure 3 South Australia wind generation, forecast and actual output, 8 February

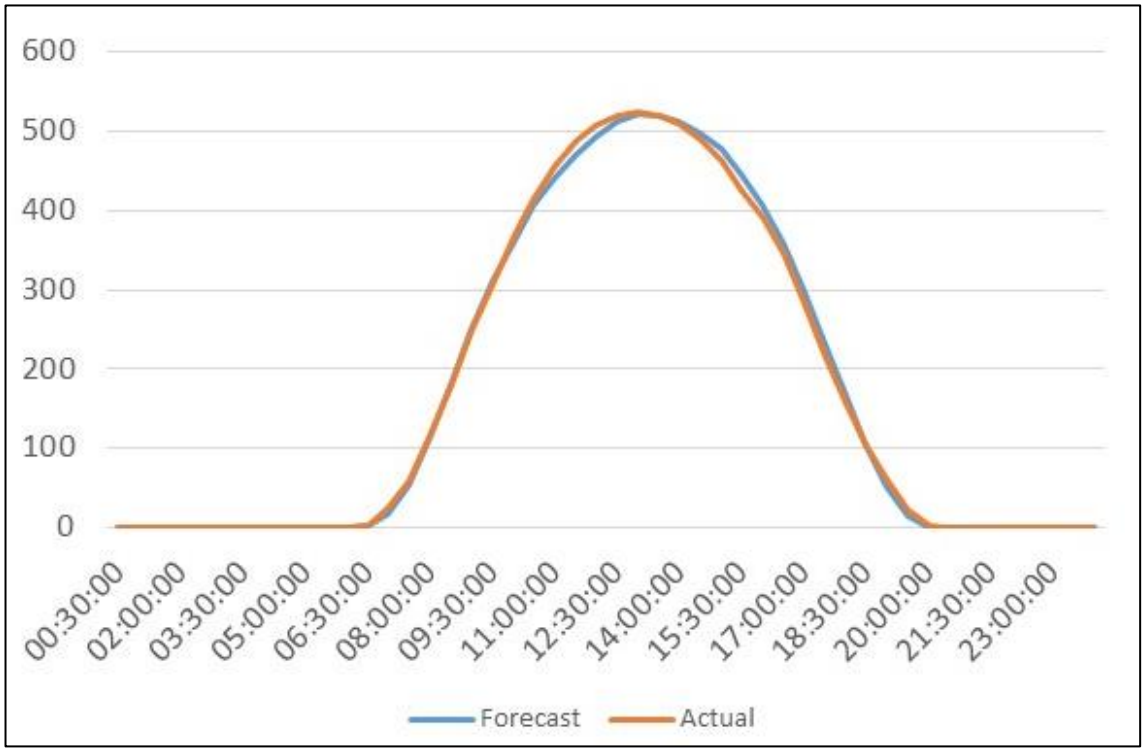


2.2.3 Rooftop solar generation

Figure 4 shows the forecast generated at 0130 hrs on Wednesday 8 February, and estimated actual rooftop solar generation for 8 February based on AEMO's Australian Solar Energy Forecasting System Phase 2 (ASEFS2).[3]

This shows that estimated actual rooftop solar generation was close to the forecast, with solar generation peaking at 525 MW at 1300 hrs and reducing to approximately 157 MW at 1800 hrs. Solar generation continued to decline to 0 MW at 2030 hours.

Figure 4 South Australian rooftop solar, forecast and estimated actual output



2.3 Transmission network flows

There were no transmission network outages affecting electricity supply to South Australia on 8 February.

2.3.1 Interconnectors

The Heywood interconnector has a maximum capacity of 600 MW[4] to import electricity to South Australia from Victoria. Figure 6 shows that the Heywood interconnector was operating at or near its full capacity prior to the event. The flow cannot be precisely controlled and the degree of variation above and below the limit shown in the chart prior to 1800 hrs is normal.

The Murraylink interconnector has a nominal capacity of 220 MW to import electricity to South Australia. Figure 5 shows the flow on Murraylink on 8 February 2017.

[3] ASEFS2 samples solar generation data from up to 5,000 systems from PvOutput, combines this with installation location information and capacity from the Clean Energy Regulator, and produces a forecast and estimated actual – refer to http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Solar-and-wind-energy-forecasting.

[4] The limit is under review and may be increased following assessment.

The flow into South Australia on the Murraylink interconnector was restricted by AEMO to 78 MW to manage grid voltage constraints (constraint equation V^SML_NSWRB_2). The power system was in a secure operating state prior to 1720 hrs.

The deteriorating supply/demand balance in South Australia pushed the flow into South Australia on Murraylink above AEMO's target limit from 1720 hrs to 1820 hrs, meaning the power system was not in a secure operating state. AEMO must take all reasonable actions to return the power system to a secure operating state as soon as practicable and in any event within 30 minutes, that is, by 1750 hrs.

When load was shed to manage the security violation, Murraylink interconnector flow reduced as the dispatch system moved flows back within limits. As more than 100 MW of load was shed, Heywood interconnector flows reduced also in response.

The vertical line on both figures indicates the time of load reduction to enable system security to be restored.

Figure 5 Murraylink interconnector flow

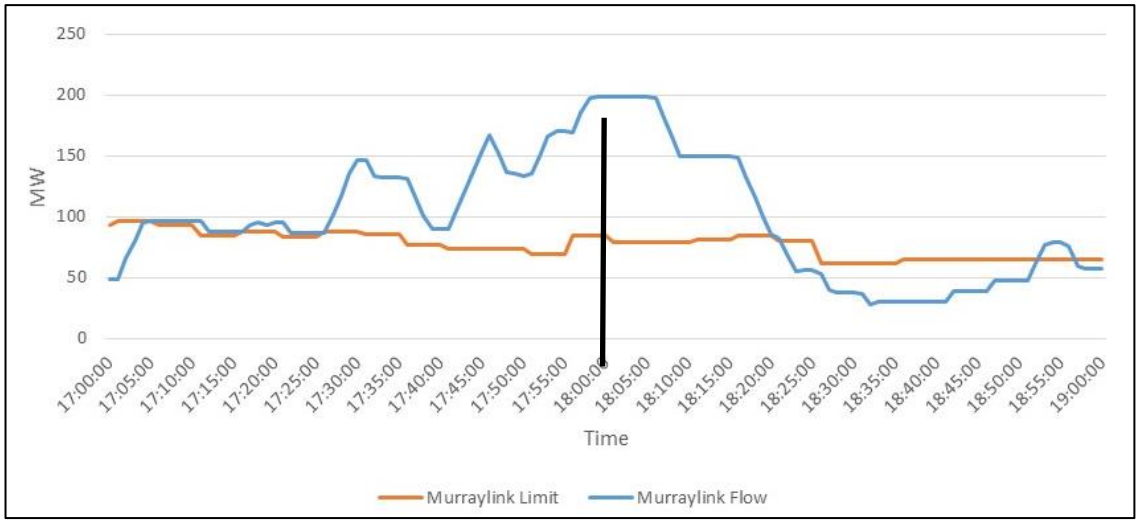
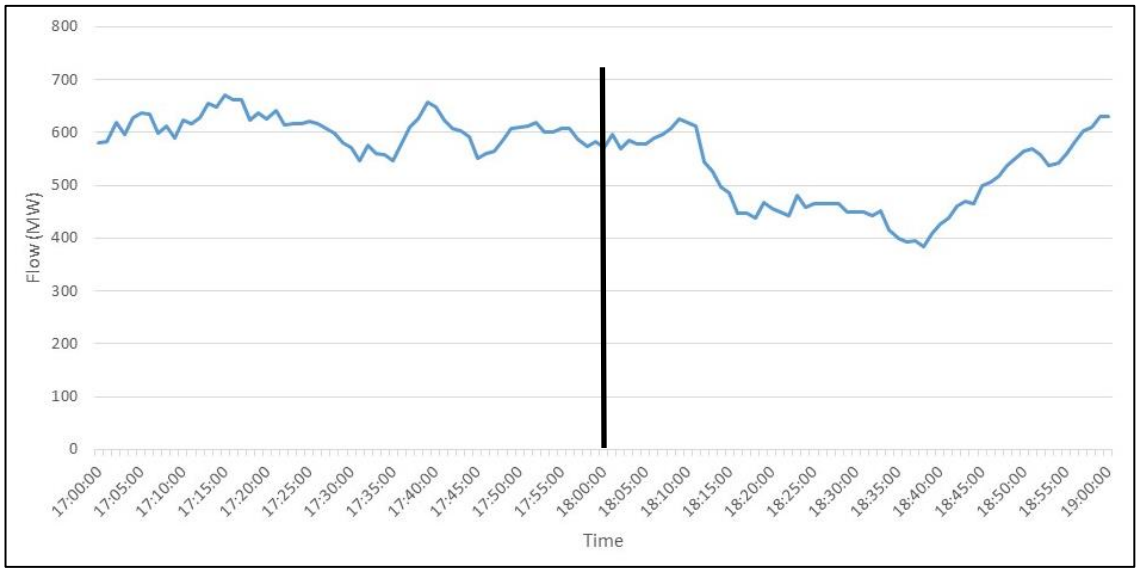


Figure 6 Heywood interconnector flow



2.4 Demand forecasts

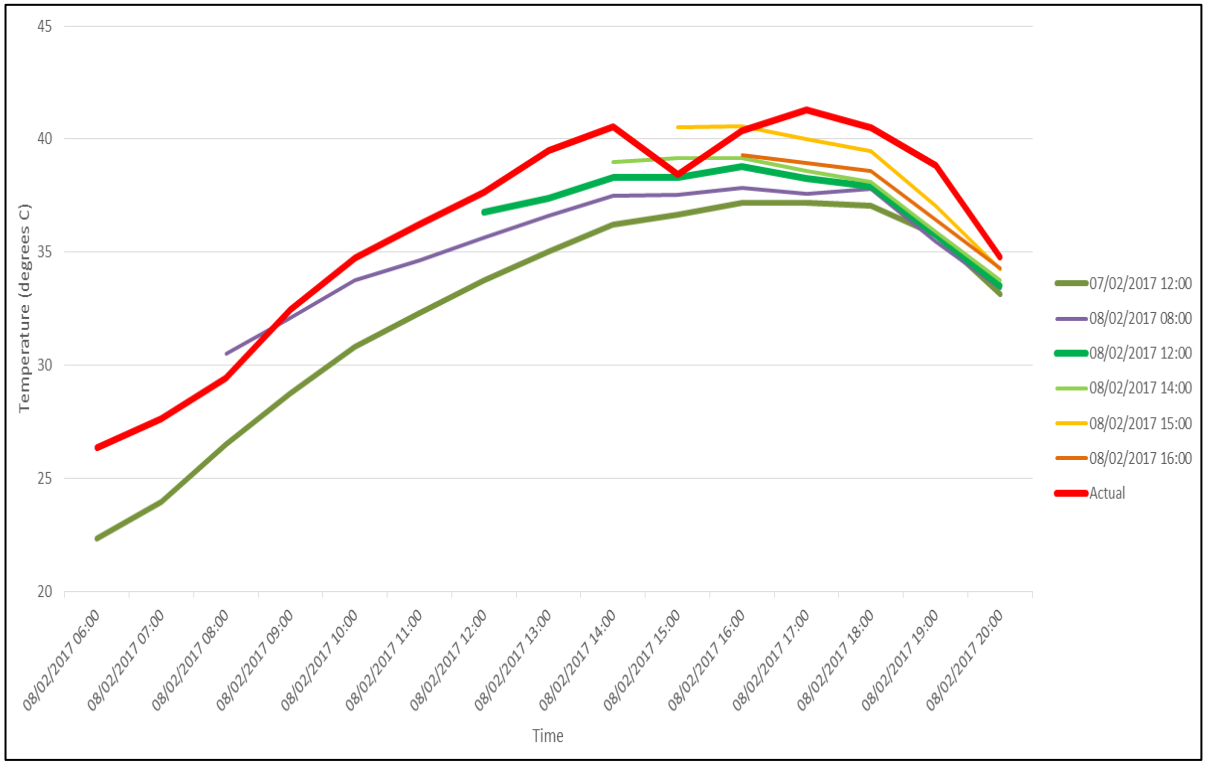
2.4.1 Temperature

Energy use in summer is highly dependent on ambient temperatures, with increased energy use for cooling increasing actual and forecast demand.

For South Australia demand forecasting, AEMO uses an equal weighted average of hourly weather forecasts provided by WeatherZone and Telvent[5] based on measurements taken at Bureau of Meteorology (BoM) weather stations at Adelaide Airport and Adelaide. AEMO's demand forecasting models use a 50/50 combination of forecast and actual temperatures from the same weather stations. Temperatures quoted in this report are calculated as averages of both weather station and weather information provider.

These forecasts are updated hourly and were used to forecast the operational demand for Wednesday 8 February. Figure 7 shows the evolution of the temperature forecast during the day. Errors in the temperature forecasts led to errors in the demand forecast.

Figure 7 Forecasts and actual South Australia temperatures during 8 February



^ Actual temperatures illustrated are the average of temperatures at the Adelaide and Adelaide Airport weather stations.

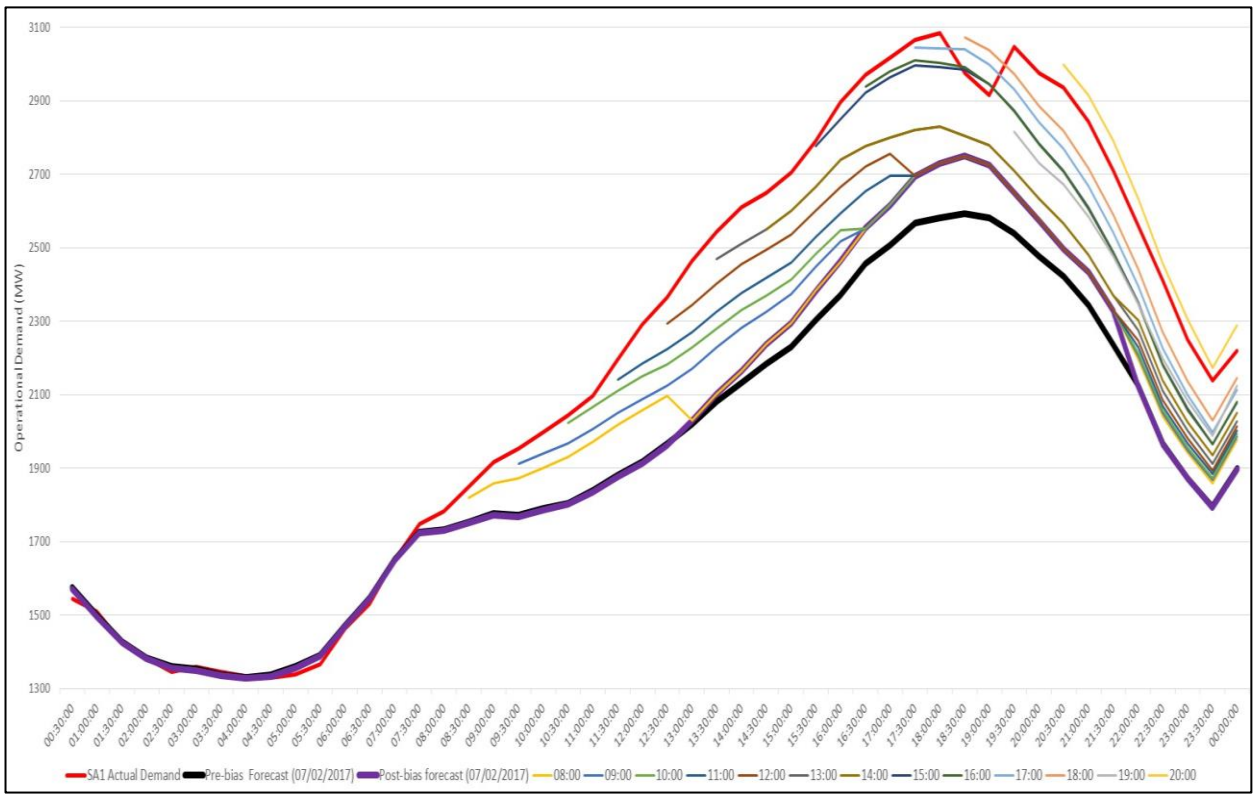
The actual temperatures at the Adelaide weather station peaked at 41.6 C at 1600 hrs. The actual temperatures at the Adelaide Airport weather station fell from 40.7 at 1400 hrs to 35.8 at 1500 hrs with a wind shift and sea breeze bringing cooler air in for a short period. The temperature at Adelaide Airport then recovered to levels above 40 degrees.

[5] Telvent and Weatherzone use actual temperatures from the BoM as one of the inputs in their modelling to produce the temperature forecasts published to AEMO.

2.4.2 Demand

Using the hourly temperature forecasts, AEMO forecast the expected demand for Wednesday 8 February. The forecasts and updates throughout the day are illustrated in Figure 8.

Figure 8 South Australia operational demand, forecast and actual, 8 February

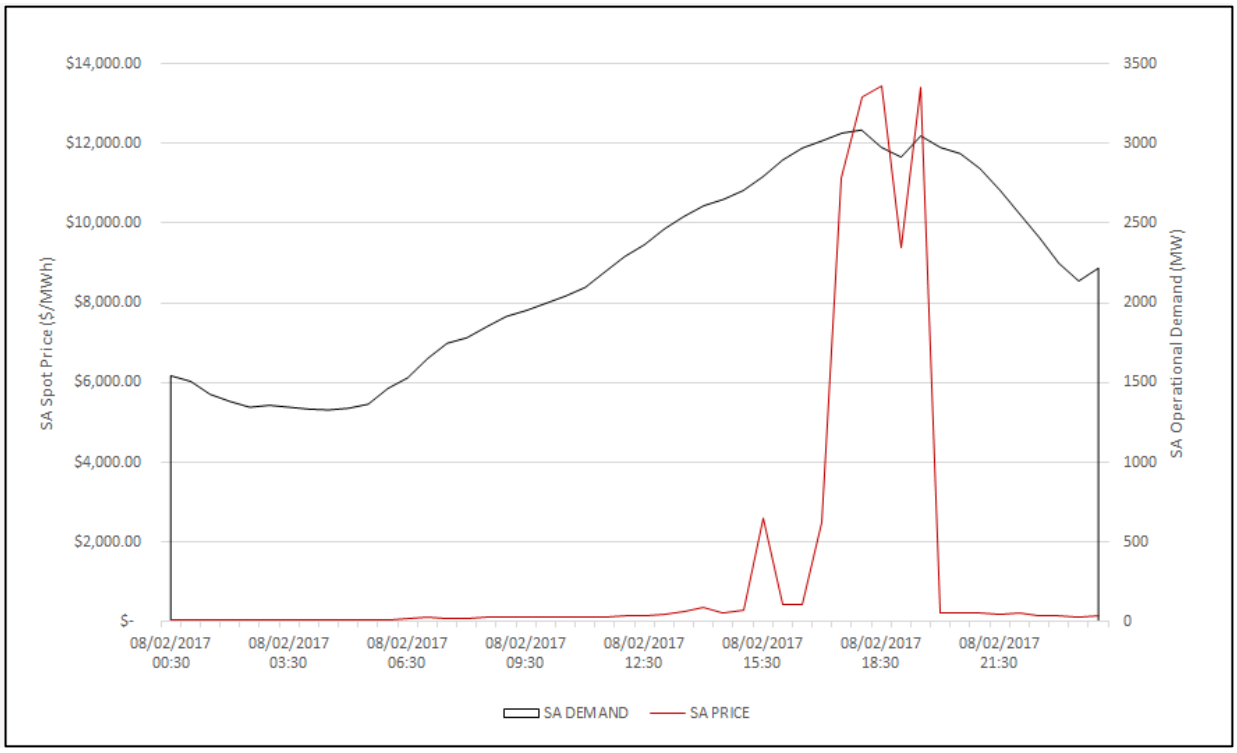


2.5 Spot prices

The dispatch price (highest accepted bid price) reached $14,000 per megawatt-hour. The spot price (the price actually used to buy and sell energy in the market) reached $13,440.01 per megawatt-hour.

Spot prices are shown in Figure 9.

Figure 9 Spot price and operational demand, 8 February



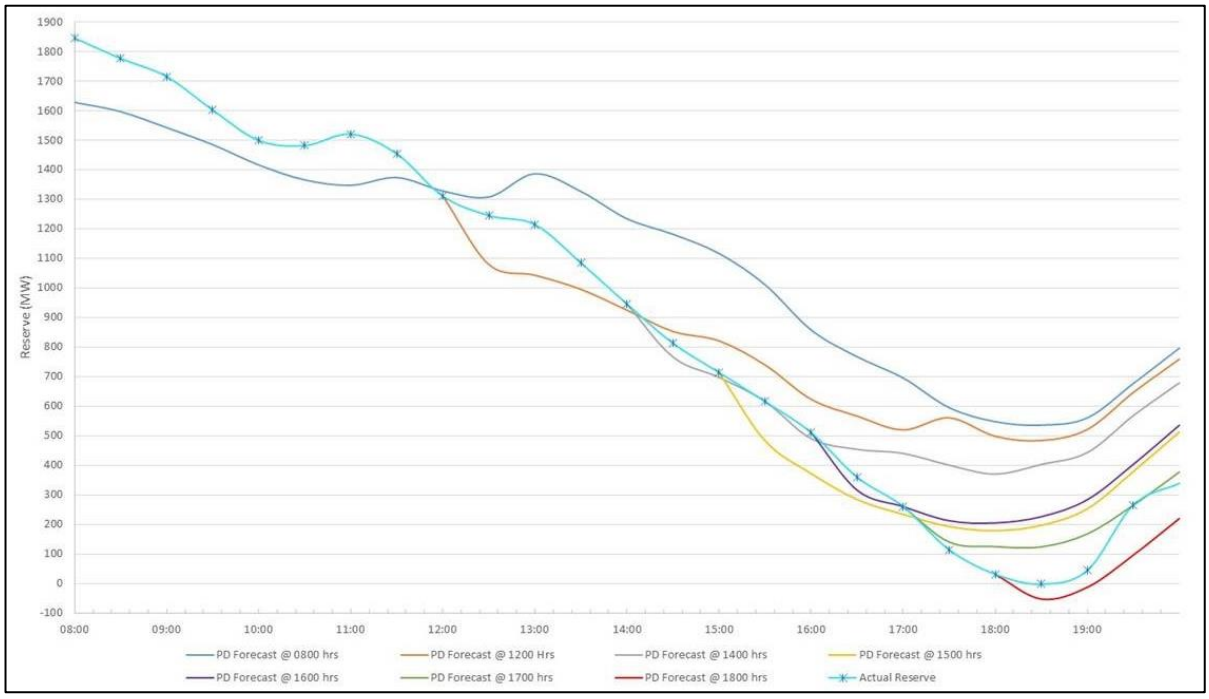
2.6 System reserves

AEMO uses forecasts of available generation capacity and demand to calculate the reserve available in the power system. If there is insufficient reserve to maintain a secure and reliable power system, AEMO will take operational action to restore it.

AEMO notifies the market of lack of reserve conditions: LOR 1, LOR 2, and LOR 3. If reserves are at LOR 2 or LOR 3 levels, AEMO can intervene in the market to maintain power system security. Appendix A explains lack of reserve conditions and AEMO's directions powers under the National Electricity Rules.

An actual LOR 2 condition occurred in South Australia on 8 February at 1700 hrs, with the LOR 2 condition forecast to last until 1900 hrs. AEMO issued Market Notice 57279 to this effect at 1713 hrs. The progressive decline in reserve forecasts during the day is shown in Figure 10.

Figure 10 Reserve forecasts and actual reserve, 8 February



Once the constraint equation on the Murraylink interconnector violated, AEMO identified that increased supply in South Australia was the best way to restore power system security. It contacted generators to explore options to increase supply. No additional generation supply was able to be brought on line within 30 minutes.

AEMO directed ElectraNet to interrupt 100 MW of customer supply to restore system security and avoid the risk of wider scale disruption.

SA Power Networks (SAPN) implemented the shedding of customer load in response to AEMO's direction to ElectraNet.

The following charts illustrate the supply/demand balance as forecast at times throughout the day.

Figure 11 Demand and available generation – 0800 hrs

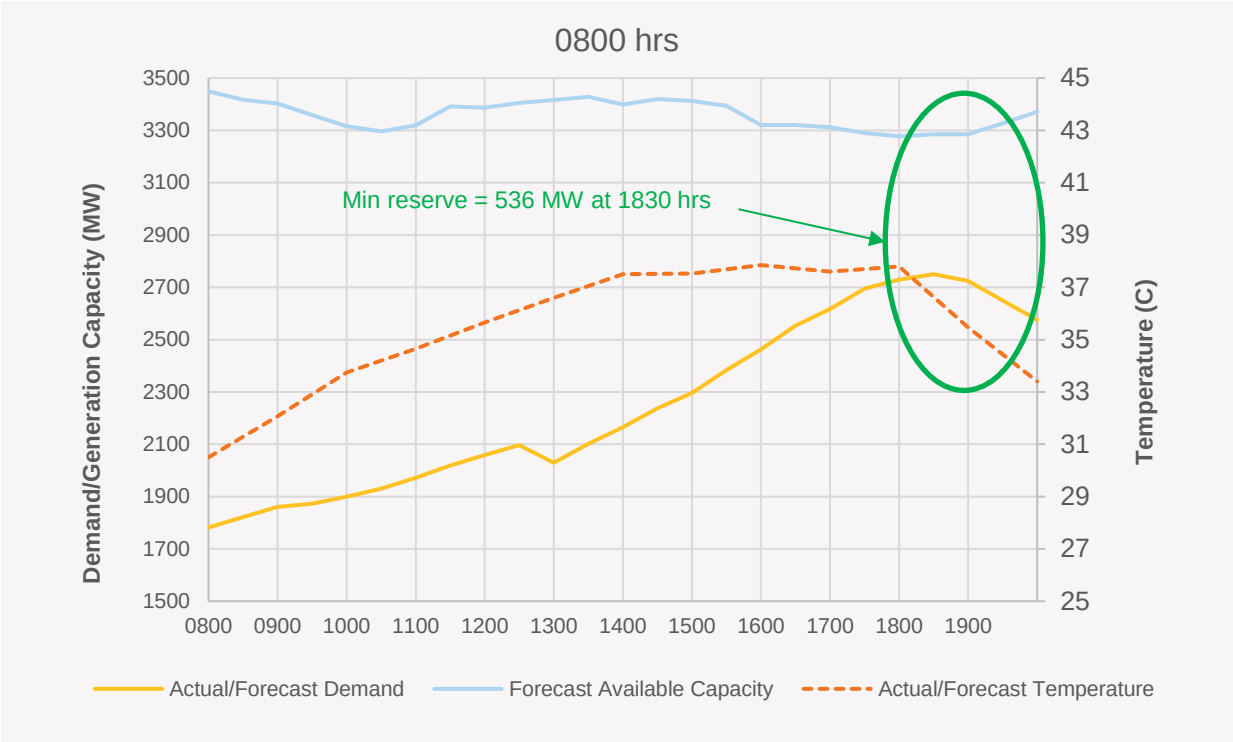


Figure 12 Demand and available generation – 1200 hrs

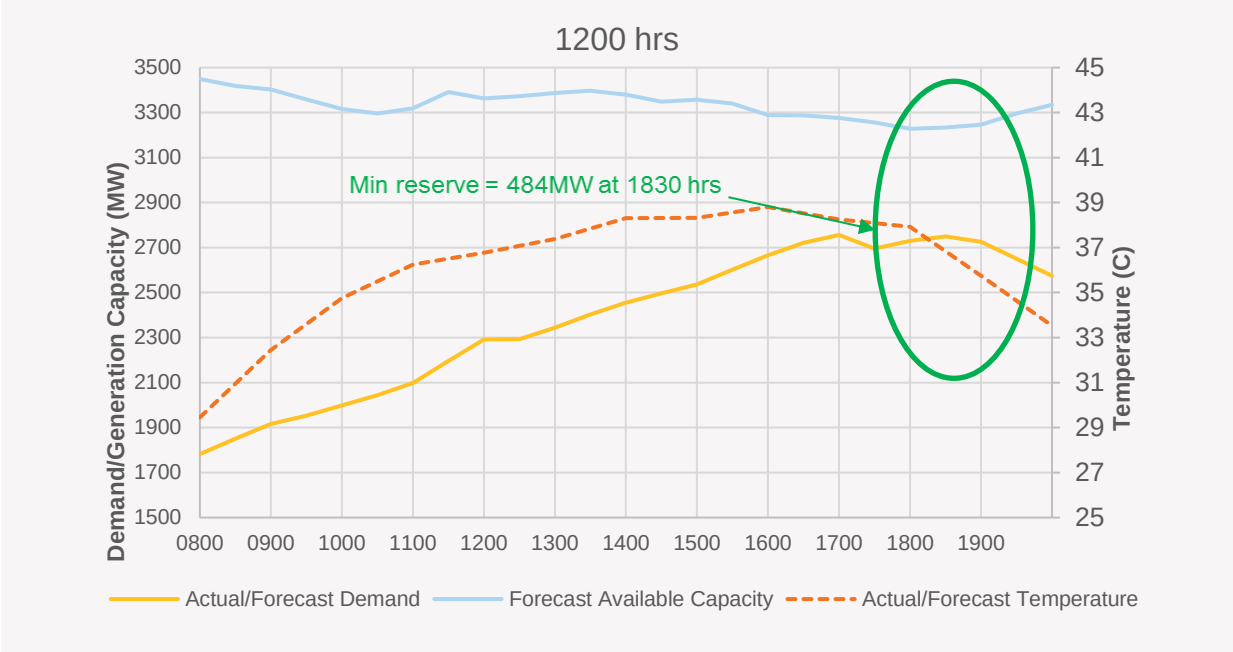


Figure 13 Demand and available generation – 1600 hrs

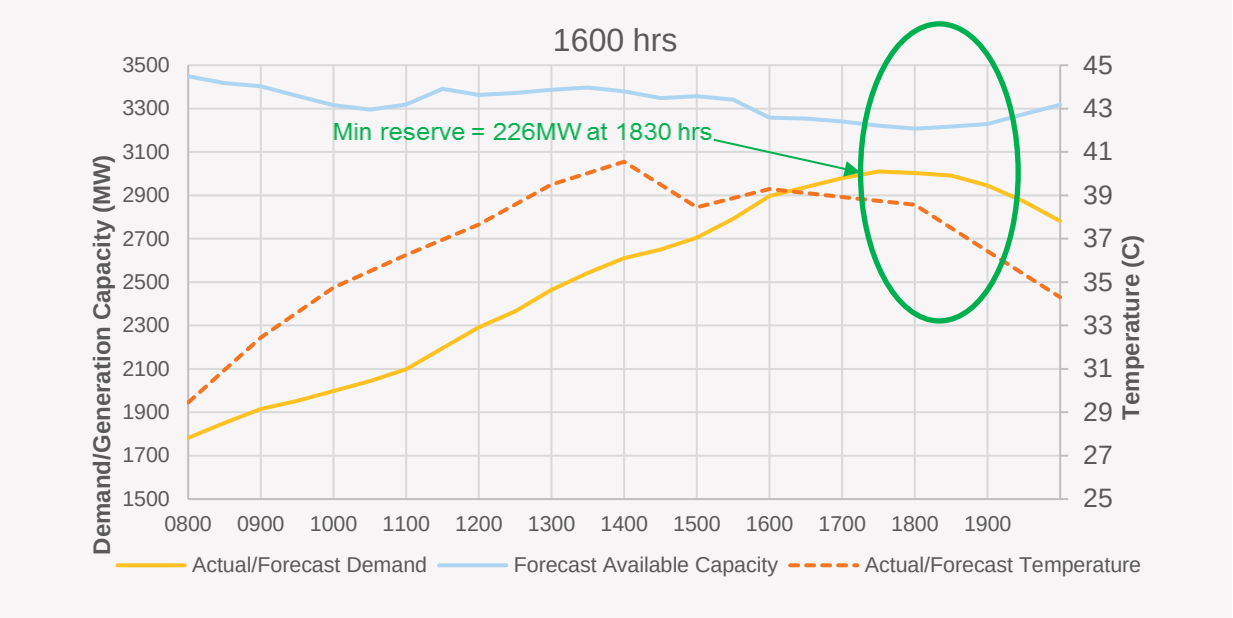


Figure 14 Demand and available generation – 1700 hrs

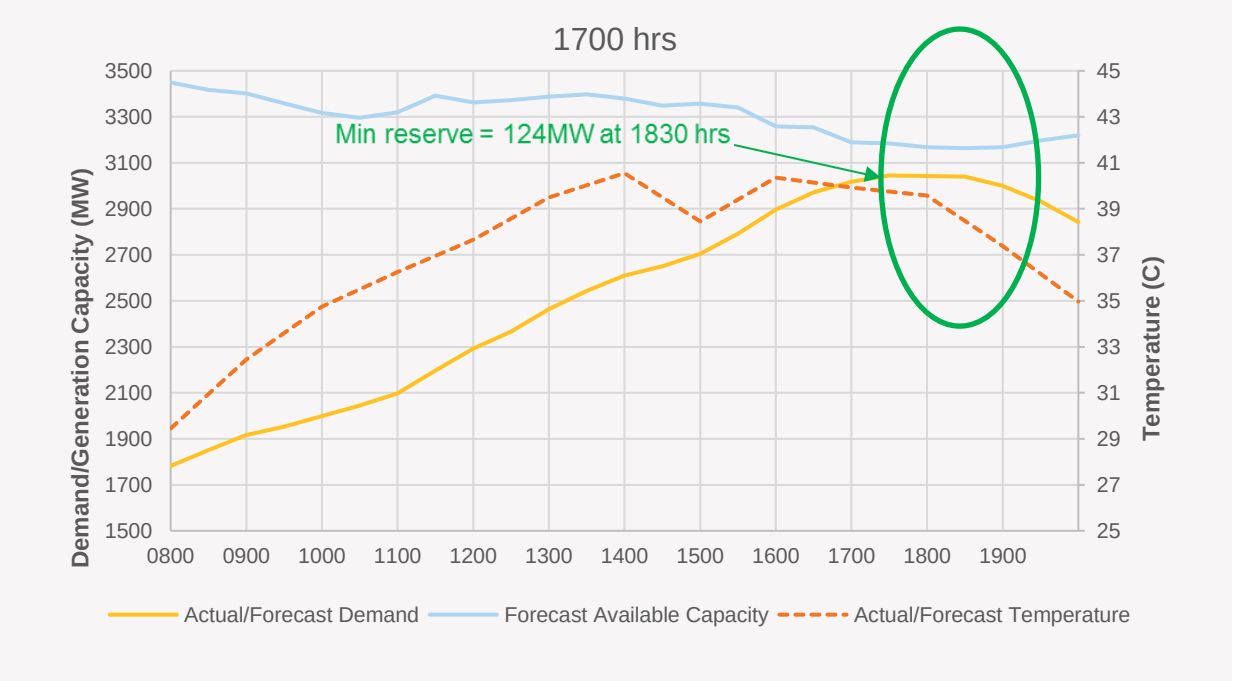
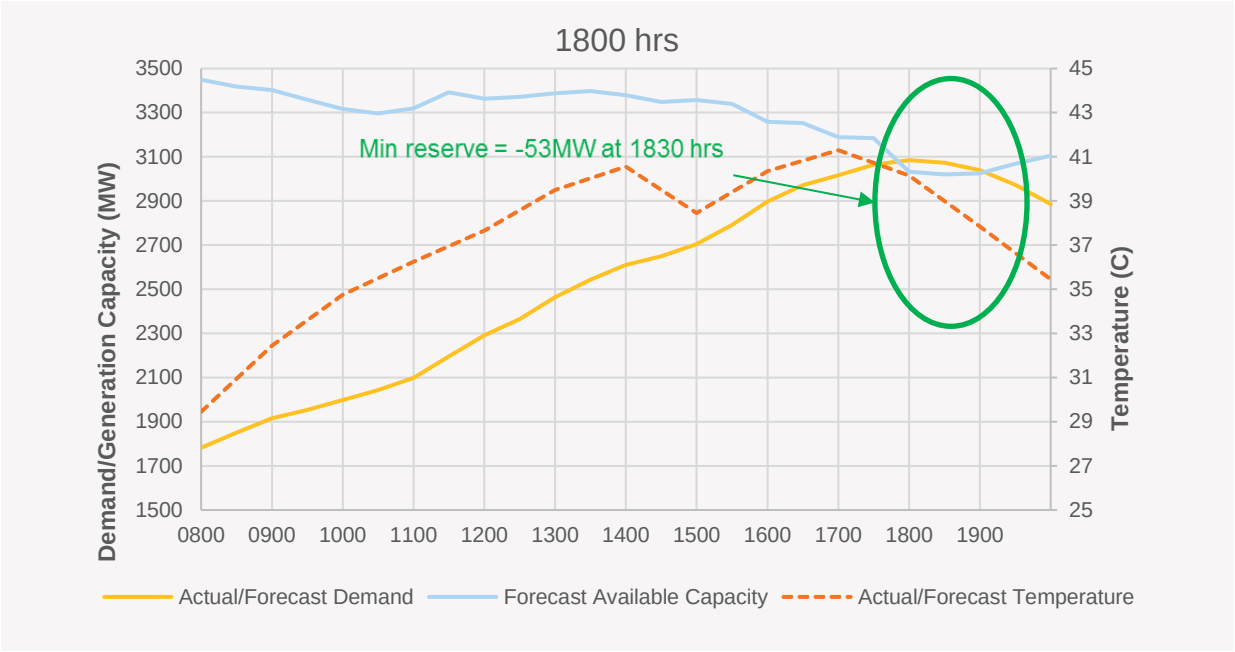


Figure 15 Demand and available generation – 1800 hrs



2.7 Supply interruption

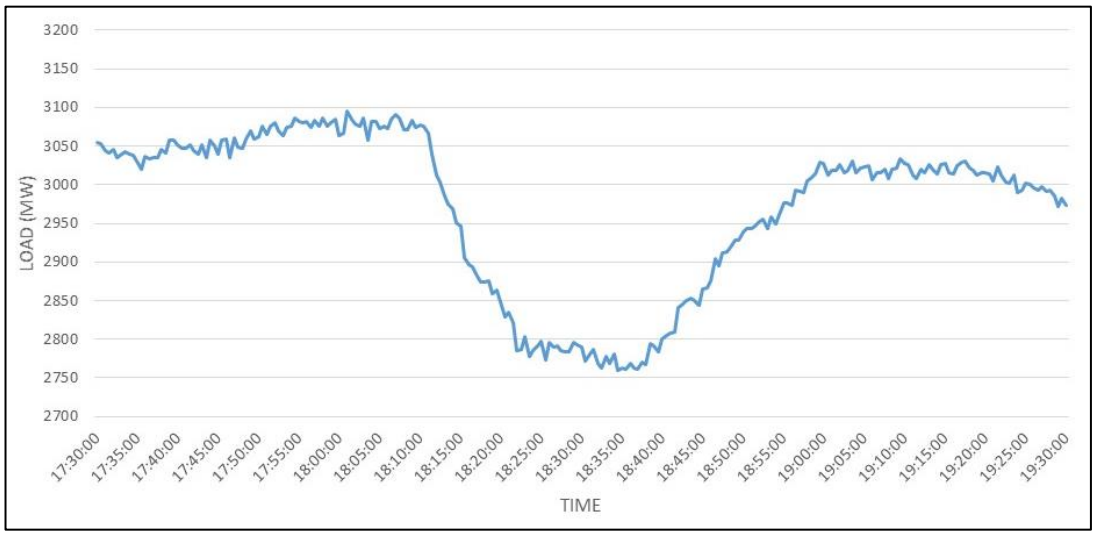
At 1803 hrs, AEMO directed ElectraNet to shed 100 MW of load. By 1830 hrs, it was apparent that there had been a demand reduction of about 300 MW, and spare capacity was available on generating units in South Australia and on the Heywood interconnector.

At 1830 hrs, AEMO requested ElectraNet to restore 100 MW of load over the next 10 minutes. By 1840 hrs, AEMO had determined that sufficient generation and interconnector capacity was available to restore all load, and it instructed ElectraNet accordingly.

Figure 16 shows the operational demand in South Australia during this incident.

AEMO is working with SAPN to determine why more load was shed than the 100 MW directed.

Figure 16 South Australia operational demand, 8 February



APPENDIX A. EXPLANATION OF RESERVE LEVELS AND DIRECTIONS

A.1 Lack of reserve (LOR) conditions

The 'capacity reserve' at any point in time is the surplus of available generation in the market. This is capacity notified to AEMO as available for dispatch, but not currently required to meet the level of forecast demand.

As the level of available capacity reserve reduces, 'lack of reserve' or 'LOR' conditions may arise. These are described in clause 4.8.4 of the National Electricity Rules. A simplified explanation is provided below.

Lack of reserve level 1 (LOR 1)

When AEMO considers there is insufficient capacity reserves available to completely replace the contingency capacity reserve on the occurrence of the credible contingency event that has the most significant potential impact on the power system (such as the loss of the largest generating unit, or the loss of an interconnector).

Lack of reserve level 2 (LOR 2)

If the most significant credible contingency event were to occur, it's unlikely the amount of capacity reserve would be enough to prevent involuntary load shedding.

Lack of reserve level 3 (LOR 3)

Involuntary load shedding has commenced or is imminent to maintain or restore power system security.

A.2 Directions powers

Under the National Electricity Rules, AEMO can direct a generator to run if satisfied that the direction is necessary to maintain or re-establish a secure power system or reliability of supply.

The rules effectively require AEMO to be satisfied of two fundamental elements before issuing a direction:

- Direction is necessary to achieve the required security or reliability outcome. In other words, the market will not resolve the situation unless AEMO intervenes in this way.
- Any directed action will actually achieve the required outcome, either by itself or in conjunction with other measures, in the required timeframe.

In conditions that could ultimately result in AEMO issuing a direction (including declared LOR situations), the National Electricity Rules require AEMO to follow a process to call for a market response if time permits, and assess whether the condition is likely to subside without AEMO intervention.

If a contingency event results in potential or actual supply shortfalls, AEMO must issue the directions or instructions it considers necessary to restore the power system to a secure and reliable state as soon as is reasonably practicable.