Summer 2017-18 operations review

May 2018

A report for the National Electricity Market

Important notice

PURPOSE

AEMO has prepared this document to provide information in relation to the operation of the National Electricity Market over summer 2017-18. It includes information to meet reporting requirements under National Electricity Rules (NER) clause 3.20.6, relating to the Reliability and Emergency Reserve Trader (RERT) provisions of the NER.

Annexure B reports on a NEM event in which RERT was activated in Victoria and South Australia on 19 January 2018, in accordance with NER clause 3.20.6(a). Annexure A, relating to a NEM event in which RERT was activated in Victoria on 30 November 2017, updates the event report AEMO provided to participants in February 2018 in accordance with NER clause 3.20.6(a).

This publication has been prepared by AEMO using information available at end of March 2018, although more recent information has been included where it is available (with dates noted in the report).

DISCLAIMER

This document or the information in it may be subsequently updated or amended. This document does not constitute legal or business advice, and should not be relied on as a substitute for obtaining detailed advice about the National Electricity Law, the National Electricity Rules, or any other applicable laws, procedures or policies. AEMO has made every reasonable effort to ensure the quality of the information in this document but cannot guarantee its accuracy or completeness.

Accordingly, to the maximum extent permitted by law, AEMO and its officers, employees and consultants involved in the preparation of this document:

- make no representation or warranty, express or implied, as to the currency, accuracy, reliability or completeness of the information in this document; and
- are not liable (whether by reason of negligence or otherwise) for any statements or representations in this document, or any omissions from it, or for any use or reliance on the information in it.

VERSION CONTROL

Version	Release date	Changes
1	23/5/2018	

Introduction

Summer is always a critical time for the power system in the National Electricity Market (NEM). It is the period of highest electricity use across all NEM regions except Tasmania, and the time when high demand, high temperatures, and climatic events like bushfires and storms place the power system at highest stress, increasing the risk of failure. AEMO prepares an annual plan with generators, network owners, and relevant government agencies to prepare for every summer and take all reasonable actions to secure the system.

For summer 2017-18, AEMO planned more extensively because it was the NEM's first summer after the rapid withdrawal of Hazelwood Power Station in March 2017, and following load shedding events in summer 2016-17. The comprehensive summer plan included sourcing additional resources in the NEM (including a strategic reserve of off-market resources) to manage the risk to consumers' supply of electricity, increasing availability of generation and transmission, and making operational improvements[1].

During summer 2017-18, despite Australia experiencing its second-warmest summer on record, the system performed well and no NEM consumers experienced interruptions to their electricity supply due to insufficient supply being available[2]. This was achieved after thorough planning and an increased level of co-operation between AEMO, the energy industry, and governments. The reserve procured to mitigate supply risks was also delivered at a lower cost than AEMO had estimated.

This review summarises how the NEM operated over summer 2017-18 and how extensive and collaborative planning helped mitigate the identified risks. It also identifies lessons learned and emerging challenges AEMO is considering in preparation for summer 2018-19 and future years.

Summer 2017-18 was the second-warmest summer on record nationally. All NEM regions experienced prolonged widespread warm weather and had mean temperatures among the ten warmest on record. This warmer than average weather posed challenges, from both increased demand and risks of failure of generation and transmission assets.

As AEMO predicted pre-summer, the supply and demand balance was tight over summer in Victoria and South Australia. The projected risks of load shedding in these two regions were managed effectively, in accordance with the summer plan. In the highest risk periods which materialised during summer for these two regions (late November 2017 and January 2018), additional reserves were procured, which were sufficient to be able to manage at least one large generation contingency without the need to interrupt customer load. The NEM did not experience any major losses of generation or transmission assets which required the contingency buffer to be activated during peak periods (a departure from events which materialised in summer 2016-17), so only small amounts of the total reserves procured needed to be dispatched.

Meeting the objectives of AEMO's *Summer Operations 2017-18* plan

- **Increasing generation and demand resources in the NEM before summer.**

In March 2017, Hazelwood Power Station in Victoria closed, reducing supply capacity in the NEM by 1,600 megawatts (MW). In response, based on AEMO's published assessments of forecast unserved energy (USE)[3] in South Australia and Victoria:

---

[1] AEMO, *Summer Operations 2017-18*, November 2017, available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Summer-operations-report.

[2] Some consumers were impacted at times by local distribution network outages, unrelated to supply.

[3] Unserved energy is energy that cannot be supplied to consumers, resulting in involuntary load shedding (loss of customer supply), because there is not enough generation capacity, demand side participation, or network capability to meet demand.

  - The market provided 833 MW of additional generation capacity at Pelican Point (one additional unit in South Australia), Swanbank E (Queensland), and Tamar Valley (Tasmania). All three generators were previously mothballed and not commercially available to the market, and all returned to operation and contributed supply during summer.
  - AEMO secured 1,141 MW of off-market reserves through the Reliability and Emergency Reserve Trader (RERT) provisions of the National Electricity Rules (NER), including both generation and demand resources. RERT was activated in Victoria on 30 November 2017 and in Victoria and South Australia on 19 January 2018, when reserve levels were forecast to reduce to a point that would trigger a lack of reserve (LOR) 2 declaration.
  - The total resources available under RERT included 141 MW of demand response in New South Wales, South Australia, and Victoria through the joint demand response pilot program operated by AEMO and the Australian Renewable Energy Agency (ARENA).
- **Increasing the availability of generation**.
  - AEMO worked with generators so planned maintenance was scheduled outside summer months. This approach enabled a higher level of capacity to be available across the summer period. While there were unplanned outages of thermal generators, the NEM coal generation fleet recorded its fourth-highest summer availability for the past 10 years (some 250 MW more capacity was available than the long-term average for this period).
  - AEMO worked with industry participants to secure fuel supplies for coal, gas, and hydro generation. Actions to protect fuel supply during summer included AEMO intervening in the Victoria gas market when a major gas production facility tripped on 30 November 2017. AEMO rescheduled the Victorian gas market during this event to ensure sufficient gas for gas-powered generation of electricity (GPG) in Victoria. This event coincided with high electricity demand and a forecast LOR 2, and the dispatching of RERT.
- **Maximising transmission network availability.**
  - AEMO worked with Transmission Network Service Providers (TNSPs) in all NEM regions to maximise their pre-summer maintenance activities and minimise planned maintenance outages during the summer period.
  - During summer, unplanned outages did not impact reserve levels, system security, or reliability. Unplanned transmission outages during the summer period also reduced, compared to summer 2016-17.
  - A reduction in the Basslink interconnector's continuous rating in early summer reduced some supply capacity in Victoria, however this risk was managed with the RERT AEMO procured as part of summer preparedness. Basslink's capacity reduced from 594 MW to 478 MW, and it remains at this level until further notice.
- **Implementing planned operational improvements.**

  AEMO implemented a range of initiatives to enhance operation of the power system:
  - Close collaboration with weather service providers, including embedding a Bureau of Meteorology officer in our Operations team, to deliver more accurate weather and demand forecasting.
  - Improvements in reserve management, including a Rule change approved by the Australian Energy Market Commission (AEMC) to update LOR thresholds and the management of uncertainty during peak demand periods. This was implemented in February 2018.
  - Enhanced operator training, with a focus on managing uncertainty and high-risk events such as bushfires, severe storms, and heatwaves.
- **Extensive contingency planning, collaboration, and communication across AEMO, the energy industry, and federal and state governments.**

  A range of emergency preparedness activities with industry and governments were conducted in preparation for summer. These activities focused on risk identification, communication between stakeholders and with the community, and rehearsing emergency response plans.

  During summer 2017-18, AEMO declared forecast LOR conditions 31 times. None deteriorated into a load shedding event (LOR 3), because in each case either the weather changed, demand decreased, supply increased, or there were enough RERT resources available to manage the risk after any potential contingency.

Table 1 summarises performance in summer 2017-18 across all the areas which were identified in AEMO's plan and are discussed in more detail in this report.

Table 1 Summer 2017-18 performance

Focus area		Planned/predicted [A]	Performance/actual
Weather (see Chapter 1 in this report)		Higher likelihood of heatwaves and above average maximum temperatures.	Above average maximum and minimum temperatures, higher than forecast in New South Wales and Queensland – prolonged, widespread, low-intensity warm weather rather than heatwaves.
Improving forecasting of demand and supply-demand balance (Chapter 2)		Initiatives including increased weather forecasting advice and alerts, more real-time alerts for power system controllers, and updating forecast models.	Improved accuracy of forecasts, and controllers had information and tools to intervene when necessary for unexpected changes.
Supply adequacy – generation and fuel availability and system readiness (Chapter 3)	Extra market generation	833 megawatts (MW)	As planned
	Increased generation availability	• Minimal planned outages. • Prompt communication to manage unplanned outages. • Improved forecasting by generators of likely unit performance under high ambient conditions.	As planned. Generation reduction forecasts during very high ambient conditions improved compared to summer 2016-17, which improved reserve management.
	Supplies of fuel for generation	Monitor and intervene if necessary to support availability of sufficient quality fuel.	Sufficient supplies of coal and water. AEMO intervened once to increase gas supplies for GPG in Victoria after outage at Longford Gas Plant on 30 November 2017.
	Increased transmission network availability	• Minimal planned outages. • Prompt communication to manage unplanned outages.	• Largely as planned. • Reduced rating on Basslink in early summer reduced reserves in Victoria, and further reductions expected for Basslink affected reserves and LOR forecasts in Victoria on 19 and 28 January 2018. • Unplanned outages on transmission improved across the NEM during the summer compared to summer 2016-17.
Reserve adequacy and Reliability and Emergency Reserve Trader (RERT) (Chapter 4 and Annexures A and B)	Off-market reserves available if needed through RERT	1,054 MW available. Estimated cost $67 million.	• 1,141 MW available. • 32 MW activated pre-contingency on 30 November 2017. • 136.5 MW activated pre-contingency on 19 January 2018. • Additional 440 MW contracted for post-contingency activation on 19 January 2018. • Actual cost $51.26 million.
Operational improvements (Chapter 5)	Update Lack of Reserve (LOR) thresholds	Update definitions to address range of risks that now exist, including forecast uncertainties (especially related to weather).	Rule change in December 2017, applied from 15 February 2018.
	Operator training	Enhanced training, especially for managing uncertainty about demand, supply, and reserves in real time, and preparing for high-risk events.	Feedback from control room staff and observations indicate an increased level of awareness and faster response times to events.
Contingency planning, collaboration, and communication (Chapter 6)		Regular, frequent communications with industry participants, governments, and the public, before and during summer.	As planned, proactive communication with participants improved short-term forecasting and real-time operations, while regular communication with governments and the public (directly and through media) supported accurate, timely understanding of events.

A. As published in AEMO's *Summer Operations 2017-18* report in November 2017.

Conclusions and next steps

As the market and system operator, AEMO's objective for summer was to enable sufficient resources to support the operation of a secure, reliable, and cost-efficient power system. AEMO is satisfied that this objective was met, with broad collaboration and support from industry participants and governments.

Based on summer 2017-18 in the NEM and other contemporary experiences operating markets internationally, AEMO believes further work is required and appropriate adjustments must be made to the markets to continue to support security, reliability, and affordability. AEMO highlighted these areas for improvement in our recently published *AEMO Observations: Operational and Market Challenges to Reliability and Security in the NEM*[4]. This summer review report includes additional observations.

For summer 2018-19 and future years, AEMO aims to pursue a more encompassing and holistic view of the needs of the future energy system. Specifically, we will continue to consider, and discuss with industry and government, the potential benefits of:

- An operational reliability standard beyond the existing reliability standard, which factors in a level of reserve to manage power system reliability during extreme conditions. In real time, sufficient operational reserves need to be available from flexible, dispatchable resources to respond to variable resources, changes in consumer demand, and plant contingencies. Machine learning techniques introduced into AEMO's systems in February 2018 for the identification and establishing of reserves (LOR) levels will further guide the quantification and identification of reserves levels.
- Continued work with the Energy Security Board (ESB) and the AEMC to develop a fair and accurate market incentive that will pay for resources' dispatchability (controllability, firmness, and flexibility) and predictability[5] – attributes that are vital to AEMO's ability to operate the system efficiently and deliver secure and reliable supply of electricity to Australian businesses and households.
- Strategic reserves that sit outside the market (that respond quickly and are available when we need them), should a gap in supply and demand arise in a planning horizon. These reserves will be procured in the most efficient manner possible to reduce costs to consumers.
- Enhancing visibility and transparency of the performance of AEMO's operational and longer-term forecasts, through establishment of a Short-Term Forecasting Reference Group. An early agenda item for this group will be the creation and publication of forecasting metrics and information, enabling a process that will engage Market Participants and other stakeholders in reviewing AEMO's forecasting techniques, using experts sourced from the broader market.
- Unlocking the potential of distributed resources, and enabling, through the regulatory regime, robust competition between supply and demand side resources in the wholesale market which will help deliver an efficient, lower-cost market outcome that supports the delivery of a reliable and secure energy future.

---

[4] Available at https://www.aemo.com.au/Media-Centre/AEMO-observations---operational-and-market-challenges.

[5] The attributes are described in more detail in AEMO's *Power system requirements* paper, published March 2018, available at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability.

Contents

Tables

Figures

1. Summer 2017-18 weather

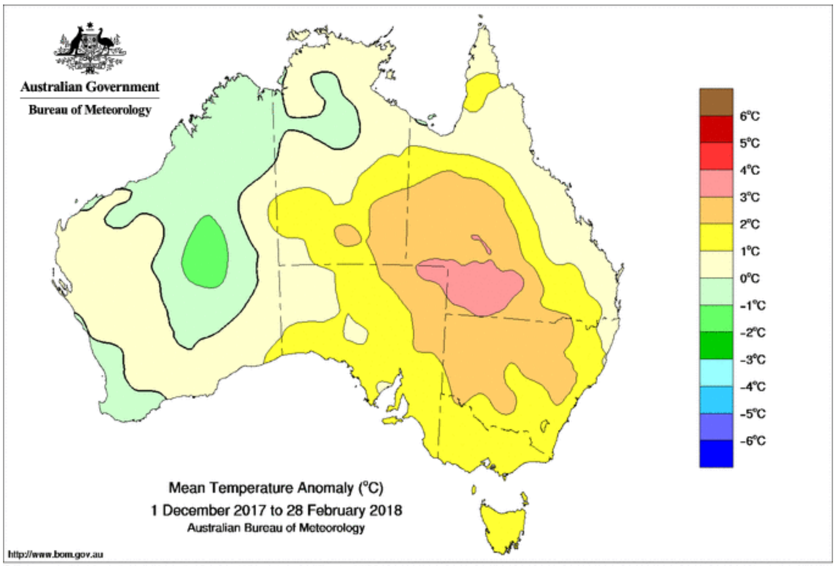
Hot weather drives increased demand for electricity for air-conditioning, and places generation and transmission assets under higher levels of stress or risk of failure. Weather forecasting is also increasingly important for predicting wind and solar generation availability.

Small changes in forecast weather conditions can have a material impact on either or both the supply side and demand side of the energy equation. Given this, one of AEMO's key initiatives leading up to summer 2017-18 was improved weather forecasting services to enhance power system operation, including decision-making around procurement and activation of reserves under Reliability and Emergency Reserve Trader (RERT).

1.1 Weather experienced over summer 2017-18

According to the Australian Bureau of Meteorology (BoM), summer 2017-18 was nationally the second-warmest summer on record, and all National Electricity Market (NEM) regions experienced mean temperatures among the ten warmest on record, as shown in Figure 1.

Figure 1 Mean temperature anomaly, summer 2017-18



© Commonwealth of Australia 2018, Australian Bureau of Meteorology ID code: AWAP Issued: 03/03/2018

Other key BoM observations in reviewing summer 2017-18 include:

- Both maximum and minimum temperatures were above average for Australia, with the warmest minimum temperatures (0.96 °C above average), and the fourth-warmest maximum temperatures (1.04 °C above average) on record for summer.
- Summer's exceptional warmth was the result of prolonged, widespread, low-intensity warm weather, rather than individual heatwaves.
- All capital cities in the NEM exceeded their average number of days over 30°C, as shown in Table 2.
- Penrith in New South Wales experienced 14 days over 40°C, exceeding the average by 9.2 days.

- In early January, very hot days were observed around the Sydney region, including a maximum of 47.3°C at Penrith Lakes weather station on 7 January 2017 (Greater Sydney's second-warmest day on record for any time of year).
- At the end of January, some very warm mornings saw multiple stations in northern Tasmania set summer records for highest daily minimum temperature, with a few weather stations also setting records in Victoria.
- A prolonged warm spell during February saw a number of stations in Queensland set February records, and Queensland observed its warmest February day (in area-averaged terms), with a state-wide mean maximum temperature of 40.46°C on 12 February 2017.

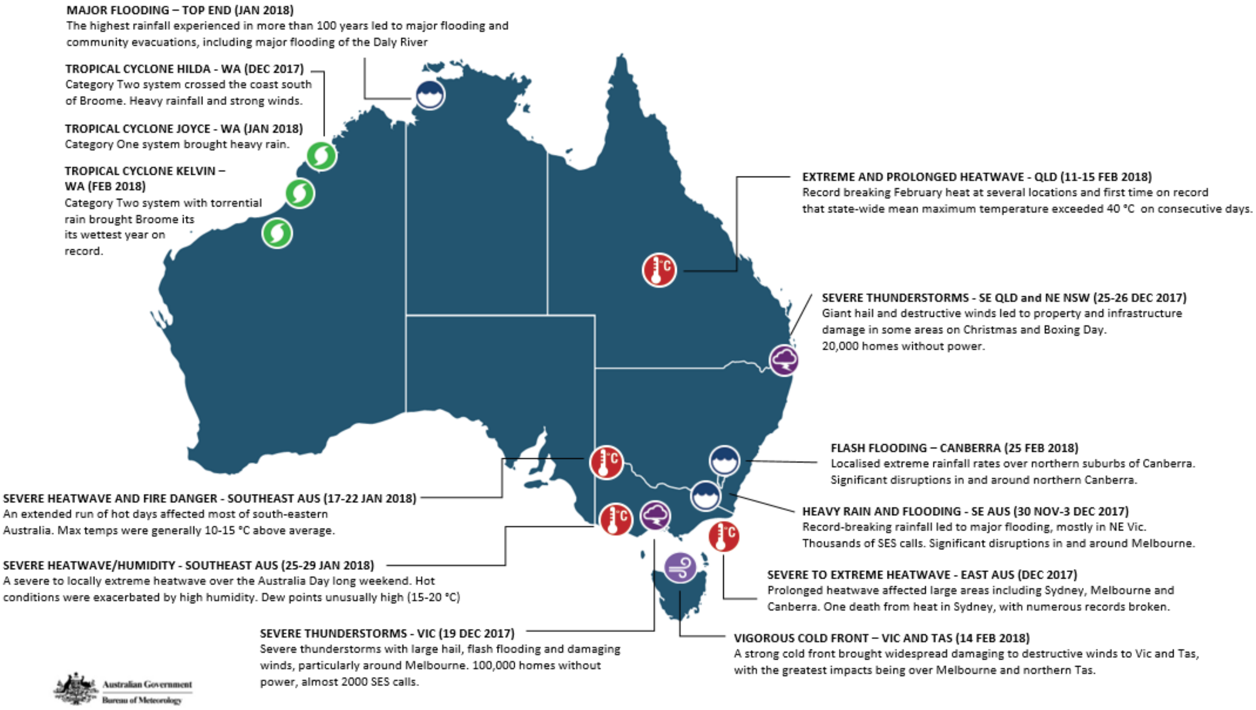
Table 2 Count of days above threshold temperatures in summer (1 December 2017 to 28 February 2018)

		Days exceeding 30 °C			Days exceeding 35 °C			Days exceeding 40 °C		
State	**Station name**	**2017-18**	**Average**	**Difference**	**2017-18**	**Average**	**Difference**	**2017-18**	**Average**	**Difference**
SA	Adelaide (West Tce)	41	33	8	20	13.9	6.2	4	3.3	0.7
QLD	Townsville Aero	85	74.2	10.8	4	3.3	0.7	0	1.2	-1.2
	Archerfield Airport	65	43.1	21.9	6	3.9	2.1	0	1.7	-1.7
NSW/ACT	Sydney Airport	30	14	16	8	3.9	4.1	3	1.5	1.5
	Bankstown Airport	46	24.3	21.7	15	7.1	7.9	4	2	2
	Penrith Lakes	63	42.2	20.8	38	14.9	23.1	14	4.3	9.7
	Canberra Airport	48	29.8	18.2	10	8.5	1.6	1	1.9	-0.9
VIC	Melbourne	24	21.1	2.9	7	9.2	-2.2	3	2	1
TAS	Hobart Airport	8	5.2	2.8	2	1.6	0.4	0	1	-1

Pink highlights places where there were more days over the temperature thresholds last summer than the average, with darker pink indicating larger differences from average. Blue highlights places where there were fewer days than average over the threshold temperatures last summer.

NEM regions also experienced severe weather events in summer 2017-18, with prolonged heatwaves experienced across the east of the country, as shown in Figure 2.

Figure 2 Major severe weather events, summer 2017-18



MAJOR FLOODING – TOP END (JAN 2018)
The highest rainfall experienced in more than 100 years led to major flooding and community evacuations, including major flooding of the Daly River

TROPICAL CYCLONE HILDA - WA (DEC 2017)
Category Two system crossed the coast south of Broome. Heavy rainfall and strong winds.

TROPICAL CYCLONE JOYCE - WA (JAN 2018)
Category One system brought heavy rain.

TROPICAL CYCLONE KELVIN – WA (FEB 2018)
Category Two system with torrential rain brought Broome its its wettest year on record.

EXTREME AND PROLONGED HEATWAVE - QLD (11-15 FEB 2018)
Record breaking February heat at several locations and first time on record that state-wide mean maximum temperature exceeded 40 °C on consecutive days.

SEVERE THUNDERSTORMS - SE QLD and NE NSW (25-26 DEC 2017)
Giant hail and destructive winds led to property and infrastructure damage in some areas on Christmas and Boxing Day.
20,000 homes without power.

FLASH FLOODING – CANBERRA (25 FEB 2018)
Localised extreme rainfall rates over northern suburbs of Canberra. Significant disruptions in and around northern Canberra.

HEAVY RAIN AND FLOODING - SE AUS (30 NOV-3 DEC 2017)
Record-breaking rainfall led to major flooding, mostly in NE Vic. Thousands of SES calls. Significant disruptions in and around Melbourne.

SEVERE HEATWAVE AND FIRE DANGER - SOUTHEAST AUS (17-22 JAN 2018)
An extended run of hot days affected most of south-eastern Australia. Max temps were generally 10-15 °C above average.

SEVERE HEATWAVE/HUMIDITY - SOUTHEAST AUS (25-29 JAN 2018)
A severe to locally extreme heatwave over the Australia Day long weekend. Hot conditions were exacerbated by high humidity. Dew points unusually high (15-20 °C)

SEVERE TO EXTREME HEATWAVE - EAST AUS (DEC 2017)
Prolonged heatwave affected large areas including Sydney, Melbourne and Canberra. One death from heat in Sydney, with numerous records broken.

SEVERE THUNDERSTORMS - VIC (19 DEC 2017)
Severe thunderstorms with large hail, flash flooding and damaging winds, particularly around Melbourne. 100,000 homes without power, almost 2000 SES calls.

VIGOROUS COLD FRONT – VIC AND TAS (14 FEB 2018)
A strong cold front brought widespread damaging to destructive winds to Vic and Tas, with the greatest impacts being over Melbourne and northern Tas.

Australian Government
Bureau of Meteorology

1.2 Comparing actual weather to pre-summer weather forecasts

The seasonal outlook for summer 2017-18, issued by the BoM in November 2017, forecast a high chance of much of south-eastern Australia exceeding median maximum temperatures (see Figure 3[6]). Figure 4 shows the actual maximum temperature deciles recorded, highlighting that most of eastern Australia did experience above average maximum temperatures throughout summer.

Figure 3 BoM outlook for summer 2017-18 – chance of exceeding median maximum temperatures, issued November 2017

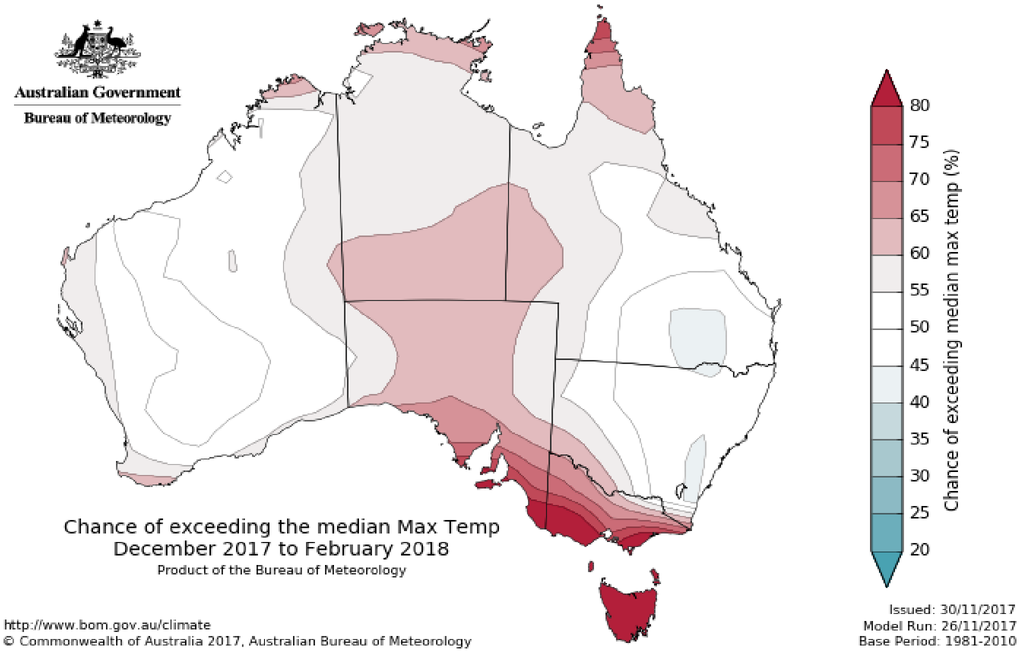
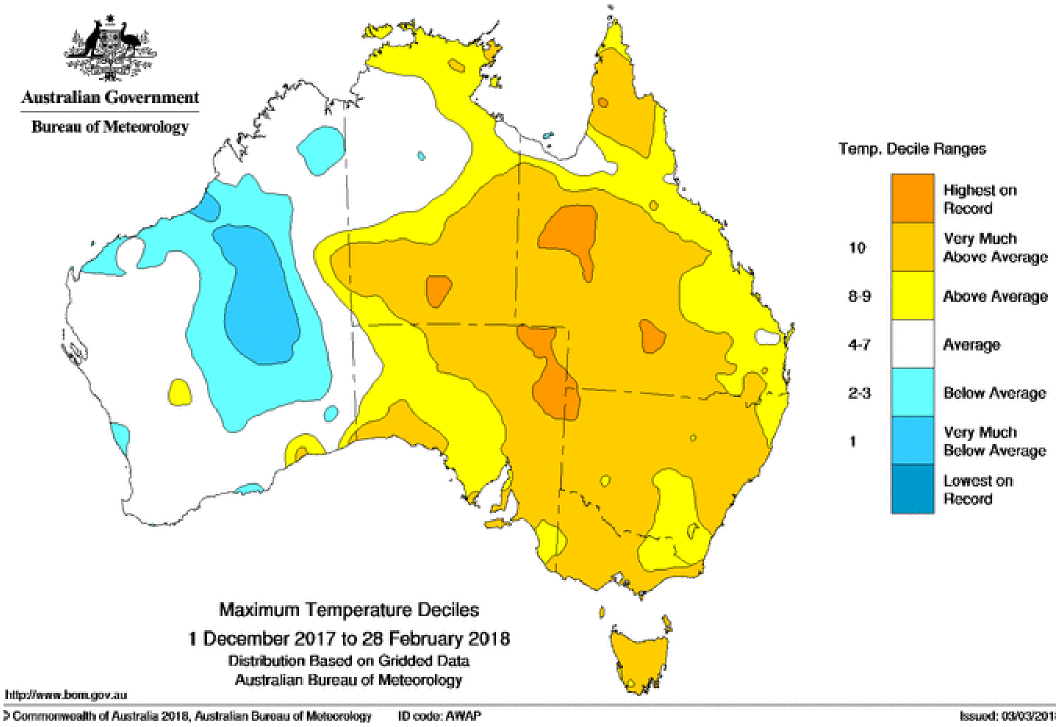


Figure 4 Summer 2017-18 maximum temperature deciles



---

[6] BoM published this forecast on 30 November 2017, and it is available at http://www.bom.gov.au/climate/ahead/archive/outlooks/20171130-outlook.shtml. This forecast was released after the 16 November 2017 forecast which AEMO included in our November 2017 summer operations report.

The key difference between the forecast and actual summer weather was the higher than average temperatures experienced over summer throughout New South Wales and Queensland. In the week of 12-16 February 2018, for example, Queensland record electricity demand was broken on three consecutive days, as high temperatures and humidity drove demands beyond any levels which had been experienced in the past.

Noting this exception of higher than average temperatures in New South Wales and Queensland, AEMO is satisfied the BoM forecast issued in November 2017 was an accurate reflection of the types of conditions experienced throughout the summer period.

2. Forecasting demand and adequacy of supply and reserves

AEMO forecasts demand and supply, using models and data from industry participants and weather service providers, over timeframes from 20 years to the next five minutes. The more accurately we can forecast, the better the advice we can provide to the market for efficient responses that meet reliability and security needs.

2.1 Improving demand forecasting

Actions before summer

AEMO made a range of targeted improvements to the demand forecasting process before summer 2017-18.

The improvements included adding a BoM meteorologist embedded at AEMO's office, and sourcing additional weather information from a variety of weather service providers, to improve weather forecasting. Weather forecasts – including wind variability, solar irradiance, and bushfire conditions – are becoming increasingly critical to forecasting consumption and peak demand, potential impacts to transmission and generation assets, and supply from renewable resources.

As there is now more variability in the system, because the weather is the fuel source for a larger proportion of the generation fleet than ever before, AEMO also developed tools and systems for real-time alerts and provided training for our forecast analysts to increase their situational awareness and skills, so we can adjust demand and supply forecasts in real time when prudent.

AEMO also updated demand forecasting models for severe conditions and proposed changes to lack of reserve (LOR) thresholds to account better for forecasting uncertainties (see Section 2.3.2).

Performance during summer

Demand forecasting accuracy is critical for the management of reserves and security in the NEM, particularly in the summer period.

Figure 5 shows the average demand forecast deviation across each region over the past two summers for different forecast horizons, with the scale in megawatts (MW).

Demand forecast deviations are in large part a function of weather forecast variances. Negative deviations indicate a tendency for AEMO's model to under-forecast demand on average over the summer period. As would be expected, forecast accuracy normally improves as the forecast horizon decreases from 24 hours ahead to one hour ahead, because more accurate weather information is available.

The under-forecasting depicted in the chart, across all regions except Victoria in 2017-18, principally occurred during periods of severe or unseasonal heat. Sources of variance in these situations are the impact of weather forecast variance (particularly cool changes and sea-breezes, which are difficult for meteorologists to time accurately), and modelling the build-up of heat in building fabric (thermal lag) over extended periods and extreme solar heating on buildings (solar gain). The largest errors, in megawatt terms, occurred in the more populated states, particularly New South Wales and Victoria, because the magnitude of electricity demand in these states is much greater.

Figure 5 Average regional forecast deviation in MW, comparing summer 2016-17 and summer 2017-18, by NEM region

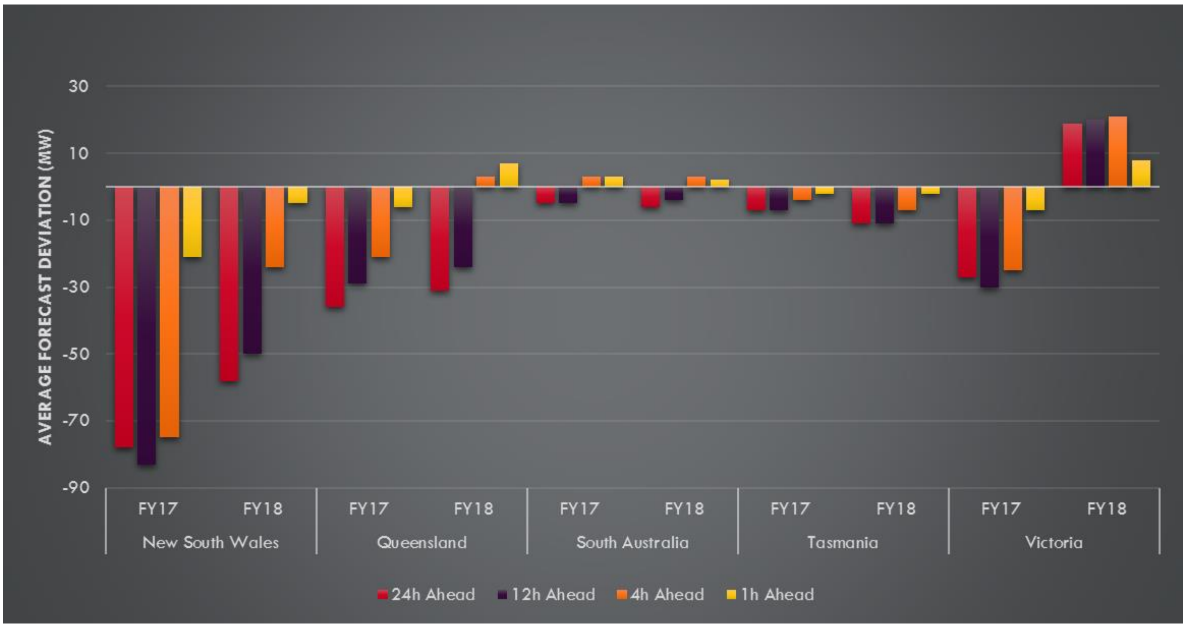


Table 3 (again in megawatts) provides a direct comparison of this summer's forecast accuracy to the previous summer, 2016-17. A positive value indicates that the demand forecast accuracy for the given forecast horizon has improved summer-on-summer.

New South Wales and Victorian forecasts improved across all time horizons, due to modelling improvements implemented for summer 2017-18. These improvements enhanced the forecasting of coastal sea breeze effects in Sydney and Melbourne, and improved the forecasting of apparent temperature effects on demand under high temperature and high humidity conditions. The Victorian forecast model was the only model to over-forecast on average in 2017-18. The improvement in Queensland forecasts was the result of enhanced modelling of humidity in the demand forecasts. South Australian and Tasmanian demand forecasting was similar across this summer and last.

Table 3 Improvement in regional average forecast deviation (MW), comparing summer 2016-17 and summer 2017-18, by NEM region

	NSW	Queensland	South Australia	Tasmania	Victoria
24 hours ahead	31	4	1	-2	54
12 hours ahead	41	4	2	-2	57
4 hours ahead	55	21	1	-2	49
1 hour ahead	17	10	0	-1	16

2.2 MT PASA and summer demands

The Medium Term Projected Assessment of System Adequacy (MT PASA)[7] assesses power system security and reliability under a 10% probability of exceedance (POE)[8] and 50% POE demand conditions, based on generator availabilities submitted by market participants, with due consideration to planned transmission outages[9]. It is designed to inform generators and Transmission Network Service Providers (TNSPs) when planned outages should be scheduled to minimise the risk of unserved energy (USE).

---

[7] The PASA is the principal method of indicating to the NEM a forecast of power system security and supply reliability for up to two years. The Rules require AEMO to administer the PASA for two timeframes:

- Medium Term PASA (MT PASA) which covers a 24- month period commencing from the Sunday after the day of publication with a daily resolution; and
- Short Term PASA (ST PASA) which covers the period of six trading days starting from the end of the trading day covered by the most recently published pre-dispatch schedule with trading interval resolution.

[8] POE is the likelihood that a demand forecast will be met or exceeded. A 10% POE maximum demand projection is expected to be exceeded, on average, one year in 10, while a 50% POE forecast is based on average weather and is expected to be exceeded, on average, every second year.

[9] AEMO's MT PASA forecasting methodology is discussed in our response to the Australian Energy Market Commission (AEMC) Reliability Frameworks Review Directions Paper, May 2018.

The MT PASA daily peak demand profile is a 24-month 10% POE forecast of daily maximum demand for each region. This forecast is based on AEMO's latest regional maximum demand forecasts, then calculates daily peak demands based on historical relationships between season peak demand and:

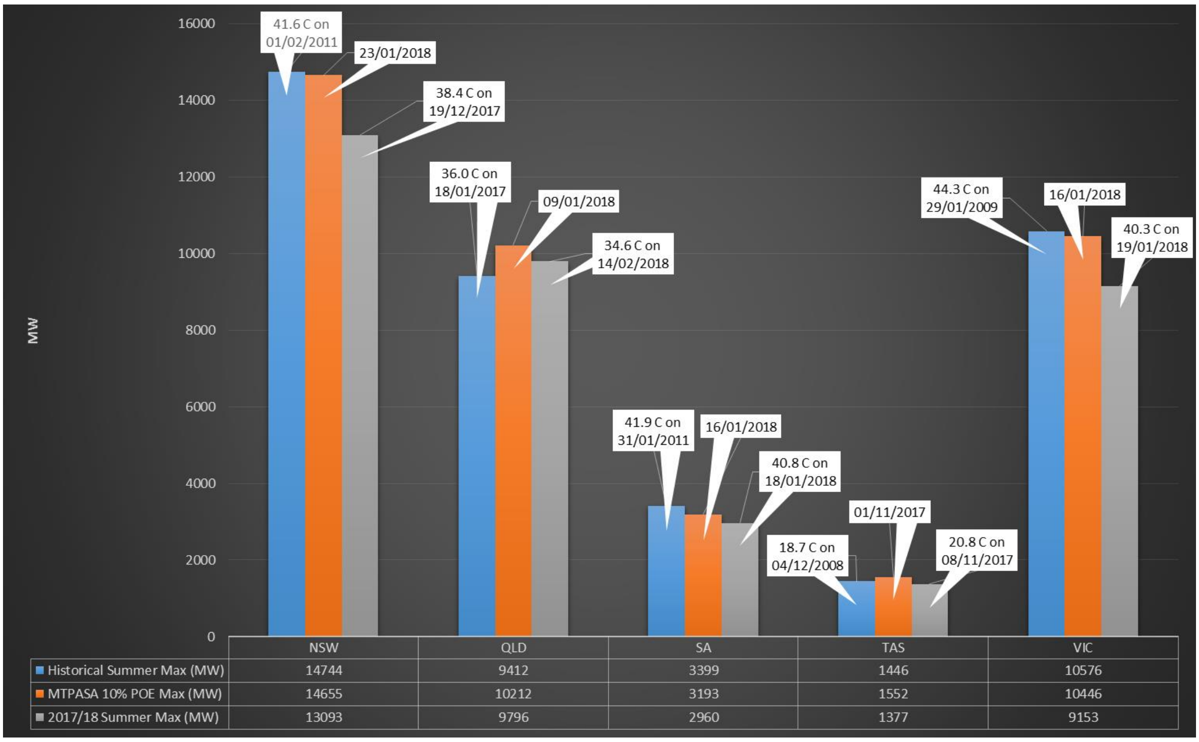
- Seasonal weather variations such as seasonal temperature.
- Day type profiles such as weekday, weekend, school holidays, and public holidays.
- Daylight saving.
- Large industrial load demand and consumption expectations.

The 10% POE demand forecast is based on the conditions AEMO would expect under very high temperatures, at the major loads centres (normally CBD locations), on a weekday in January or February when industrial and commercial businesses have returned from the Christmas holiday period. The 10% POE temperatures in each region vary, as follows:

- Queensland – 37°C.
- New South Wales – 42°C.
- Victoria – 41°C.
- Tasmania (winter peaking) – 7.7°C.
- South Australia – 43°C.

Figure 6 shows 10% POE demands that could be expected to occur over the summer period, actual peak demands recorded over summer 2017-18, and historical record demand for each region. While there were very hot temperatures recorded during summer, no 10% POE demands or corresponding temperatures were recorded during the peak of summer, although South Australia came close on 18 January 2018.

Figure 6 **Comparison of historical summer demand, MT PASA 10% POE forecast for summer 2017-18, and actual demand in summer 2017-18, by NEM region**



	NSW	QLD	SA	TAS	VIC
🟦 Historical Summer Max (MW)	14744	9412	3399	1446	10576
🟧 MTPASA 10% POE Max (MW)	14655	10212	3193	1552	10446
⬜ 2017/18 Summer Max (MW)	13093	9796	2960	1377	9153

Clearly the probability of a 10% POE demand resulting from 10% POE temperature is high, particularly if high temperatures persist over a number of days (resulting in latent heat load in buildings), if there is co-incident high humidity, and if the heat event occurs on a weekday outside of holiday periods. This indicates that higher demands are plausible, if not probable, should 10% POE temperatures occur.

Lessons for future

AEMO will pursue further enhancements to modelling techniques to improve demand forecasting at all time horizons, with particular emphasis on development and testing before next summer. AEMO's new MT PASA, which uses a range of new probabilistic assessments, went live in May 2018.

AEMO looks forward to working closely and transparently with market participants to improve the accuracy and enhance the visibility of the performance of both our short-term and medium-term forecasts, through a range of engagement activities:

- Through a new Short-Term Forecasting Reference Group, we will seek input and feedback on an operational forecasting strategy and specific initiatives to improve our short-term forecasting techniques.
- The existing Forecasting Reference Group comprises industry subject matter experts, government officials, and representatives from the Australian Energy Market Commission (AEMC) and Australian Energy Regulator (AER). We will continue working with this group to provide transparency on medium-term forecasting, continuous analysis and improvement, and updated approaches based on information and reviews. AEMO is also examining a range of alternative indicators that will inform the market of changes or trends on key dependent variables.
- AEMO will increase reporting in the next cycle (commencing with the publication of the 2018 *Electricity Statement of Opportunities* (ESOO) and will consult with stakeholders on preferred forecasting metrics.
- We are also working with external experts to address the issue of reporting forecast accuracy where we are dealing with probabilistic (POE) forecasts.

As the accuracy of weather information has a critical impact on electricity supply and demand forecasting, AEMO will continue working closely with the BoM and our other commercial forecasting service providers to further refine weather inputs into electricity supply and demand forecasts. This includes the provision of new, near real-time, data streams for weather observations, which are expected to improve the accuracy of AEMO's shorter-term forecasts.

AEMO is already undertaking further action to address the changing climate, resource mix, and challenges associated with predictability of resources on the system. We will continue working on further improvements to all demand and supply forecasting models, including enhancing models for forecasting peak demand during sustained heat or humidity events, and a greater introduction of machine learning techniques.

In summer 2017-18, AEMO introduced new machine learning models to improve our reserves management. We are now adapting these techniques and introducing other improvements to:

- Five-minute demand forecast models.
- Day(s)-ahead and intra-day demand forecasts, specifically around severe weather events.
- Streaming of one-minute weather observation data from all capable BoM weather stations to enhance the performance of machine learning models, compared to the 30-minute resolution data currently used.
- Engaging external forecast services to complement, augment, and benchmark AEMO forecasts.
- Procuring solar generation forecasts for 100 kilowatts (kW) to 30 MW facilities, a key generation growth area in the NEM.
- Developing a Market Participant 5-minute forecast interface (MP5F) that will enable solar and wind facilities to submit five-minute self-forecasts.

Wind forecasting continues to be challenging, and AEMO is working with industry and a range of international experts to understand and improve forecast accuracy in wind generation, given the prominence of this generation type now in the NEM.

Similarly, we are refining refine our systems for solar forecasts – the Australian Solar Energy Forecasting System (ASEFS) and ASEFS 2 systems, which forecast for large-scale solar farms and residential rooftop photovoltaic (PV) generation in the NEM. We implemented a project which went live in March 2018 to improve ASEFS 2 using satellite imagery, and anticipate further improvements to solar generation forecasting for 2018-19 and future summers.

The rapid and persistent deployment of distributed energy resources (DER) in the NEM, and the orchestration of DER by third parties, for example in Virtual Power Plants (VPPs), present a new challenge for short-term forecasting. At the time of writing there are several hundred MW of proposed VPPs in the NEM.

It is essential that AEMO gain visibility of this resource so it can be factored into demand forecasting models. We are currently commencing a trial, in Western Australia, for an interface with VPP providers (similar to the MP5F self-forecasting Application Programming Interface (API) for large-scale intermittent renewables noted above).

In concert with industry, we are also examining:

- Techniques for enhancing visibility and forecasting for large (greater than 30 MW) block loads.

- Modelling price elasticity for non-orchestrated (but synchronised) DER and demand response which responds to price signals.

2.3 Forecasting supply and reserves adequacy

2.3.1 Reliability standard

AEMO produces long-term supply and demand forecasts to highlight any times a NEM region is at risk of not meeting the reliability standard set by the AEMC's Reliability Panel. The standard says each region must have enough resources to meet 99.998% of its consumer demand each year. This can include imports from another region, if that other region is forecast to have enough spare energy at the time.

AEMO's assessment against the reliability standard identifies potential gaps and opportunities for market response. It does not relate to balancing supply and demand at peak times, and does not help AEMO assess the operational risks of imbalances between supply and demand in real time.

2.3.2 Lack of reserve (LOR) conditions

For more short-term assessments, AEMO assesses reserves by using information about generator availability, forecast operational demand, forecast wind and solar generation, and the capacity and limits of interconnection between NEM regions. If this assessment identifies that forecast supply may not be adequate to meet forecast demand and provide a necessary buffer, AEMO is required to declare LOR[10] conditions to give market participants the opportunity to respond.

LOR conditions indicate the system may not have enough spare capacity if something major and unexpected happens, like the loss of a generator or interconnector.

Power systems around the world are built and operated with a certain level of reserve – a 'buffer' to assist with maintaining power system reliability for energy consumers. Pre-determined reserves in the NEM refer to spare capacity to provide this buffer, over and above the level of electricity demand that is forecast at any given time.

AEMO informs the market of LOR conditions when forecasts indicate these pre-determined reserve levels are at risk, to encourage a response from market participants:

- Generators may offer in more supply.
- Consumers (generally large industrial or commercial consumers) can reduce their demand.
- Planned transmission outages may be recalled into service, if this is constraining electricity supply.

All three responses have the effect of improving the reserve margins, and maintaining power system reliability.

AEMO will issue both forecast (to encourage a response) and actual LOR condition notifications. LOR notices are tiered:

- LOR 1 signals a reduction in pre-determined electricity reserve levels, and LOR 1 notification simply provides an indication to the market to encourage more generation. At this level, there is no impact to power system security or reliability.
- LOR 2 signals a tightening of electricity supply reserves, and notification provides an indication to the market to encourage more generation. At this level, there is still no impact to power system security, however a loss of the largest generator in a region, or a serious constraint on the transmission network, could result in an LOR 3 condition. AEMO will bring in available additional resources, such as demand response and support generation (such as diesels if required) where we determine the market is unable to meet the system need. These resources may fall into the category of RERT.
- LOR 3 signals a deficit in the supply-demand balance, in which, if there is no market response, controlled load shedding may be required. AEMO views load shedding as an absolute last resort to securely manage the wider power system.

When a low reserve period is identified, AEMO will declare a low reserve condition and go to the market seeking a response from participants using the tiered notifications described above. If the market does not respond, then AEMO may choose to use reserve contracts through RERT.

---

[10] Lack of Reserve (LOR) is described in clause 4.8.4 of the NER. Section 4.4 outlines tiered LOR thresholds (LOR 1,2, and 3) in more detail.

Updating LOR thresholds

Until February 2018, LOR 1 and LOR 2 levels were determined solely on the basis of the largest credible contingencies in a region (for example, the loss of the largest generator). These values, while not static, were generally relatively constant.

AEMO reviewed how these thresholds could better account for risks of unexpected reductions in reserves due to factors that exist now in the changing power system, but were not covered in the existing NER.

A change to the NER, in December 2017, revised the principles for determining LOR in the NEM[11]. In conjunction with the rule change, AEMO developed the Reserve Level Declaration Guidelines to set out how the new determinations will be made[12].

The new process, which went live on 15 February 2018, introduced a probabilistic element into the determination, which allows for the impact of estimated reserve forecasting uncertainty in the prevailing conditions. These estimates are now made on the basis of past reserve forecasting performance for:

- Demand (which includes weather conditions at different levels of demand).
- Output of intermittent generation (wind and solar).
- Availability of scheduled generation (coal, gas, hydro and diesel).

This change means LOR 1 and LOR 2 levels will now tend to vary with operating conditions and over different forecasting horizons, and thus the levels will be more changeable than in the past. AEMO has recently published an initial assessment of the performance of the new arrangements, which noted that all LOR conditions declared in the first quarter of 2018 occurred before the new arrangements were introduced[13].

2.4 Reserve forecasts for summer 2017-18

AEMO's forecasts for summer 2017-18 highlighted reduced reserves after the closure of Hazelwood Power Station in Victoria in March 2017. As a result, the NEM could experience load shedding in severe (and very possible) summer conditions such as heatwaves, where there were insufficient reserves to cover the loss of generation or transmission capacity. If generation capacity was not available due to unplanned outage, and/or plant or transmission outages at other times, load shedding may also be possible without sufficient reserves. Targeted action was taken by AEMO (through the RERT function) to avoid the risk of supply interruptions for consumers. These actions were detailed in AEMO's November 2017 *Summer Operations 2017-18* report.

To identify the conditions where additional reserves may be required, AEMO provides a range of forecast information under a range of operating conditions on both supply and demand to assist industry and governments in their decision-making. From an operational perspective, these forecasts include information provided under AEMO's:

- MT PASA – two-year outlook for supply and demand, based on historical and projected demand, as well as average and more severe summer weather conditions.
- Short Term Projected Assessment of System Adequacy (ST PASA) – seven-day outlook for supply and demand, based on forecast weather conditions at the time.
- Pre-dispatch forecast – up to a 40-hour outlook in 30-minute horizons, based on the most current weather, supply, and demand information.
- Dispatch forecast – a 30-minute outlook in five-minute increments, based on real-time demand and supply information using telemetered data from the power system.

The purpose of these forecasts is to assess the likelihood of electricity demand and the supply availability across a range of time horizons, to inform planning on the adequacy of reserves, or operational decisions in real time on actions that may need to be taken to improve reserve margins, or improve power system operating conditions.

Before summer 2017-18, AEMO assessed the accuracy of these forecasts, and updated them as more detailed information around demand, generation and transmission assets, and more specific weather forecast information, became available. As these forecasts were updated, AEMO worked collaboratively with industry and government to support sufficient reserves being available during summer 2017-18 to meet the expected conditions.

---

[11] See http://www.aemc.gov.au/Rule-Changes/Declaration-of-lack-of-reserve-conditions.

[12] Available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation.

[13] Available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation.

2.5 Additional reserves for summer 2017-18

In the June 2017 Energy Supply Outlook, AEMO noted we were seeking up to 670 MW of additional reserves across Victoria and South Australia from supply and demand sources. This amount was calculated in April 2017, using the MT PASA and Energy Adequacy Assessment Projection (EAAP)[14] to inform the projected reserve shortfall.

Before executing contracts between August and October 2017, AEMO updated the projected reserve shortfall for the upcoming summer, using the latest information, to ensure the appropriate level of reserve was procured so reliability of supply met the required standard. As well as the latest MT PASA, AEMO also used modelling for our 2017 ESOO[15], and modelling used to support AEMO's advice to the Commonwealth Government on dispatchable generation[16], in this assessment.

Based on this analysis, AEMO identified that:

- Reserves needed for summer 2017-18 were in the range of 700-1,000 MW across South Australia and Victoria for the period December 2017 to March 2017.
- The distribution of USE indicated that the majority of the projected shortfall fell in January to March 2018.

Through the RERT and joint AEMO/Australian Renewable Energy Agency (ARENA) demand response pilot, AEMO procured up to 1,141 MW in Victoria, South Australia, and New South Wales for summer 2017-18 (see Chapter 4 for more information).

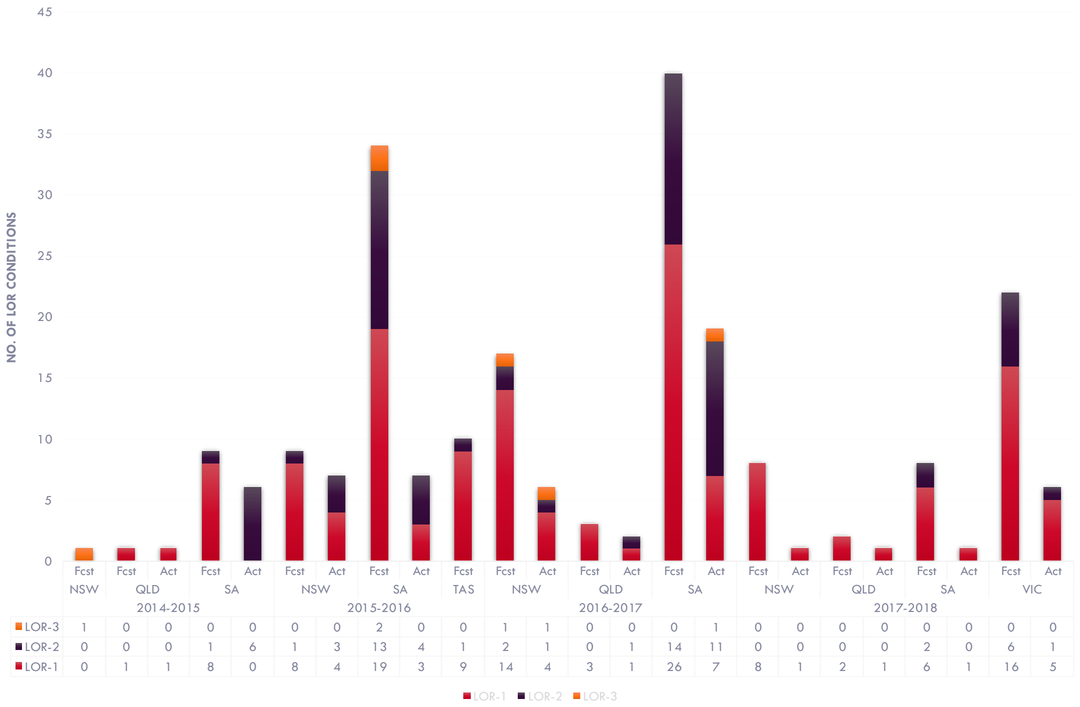
2.6 Lack of Reserve declarations in summer 2017-18

During the summer from 30 November 2017 to 31 March 2018, AEMO declared a total of 31 LOR conditions (either forecast or actual). All 31 LOR conditions:

- Were declared before the implementation of the Reserve Level Declaration Guidelines, and thus were declared based on the previous credible contingency declaration guidelines, which applied at the time.
- Coincided with high temperatures in the region where the LOR was declared.

0 compares the number of forecast and actual LORs in summer 2017-18 with the previous three summers.

Figure 7 Forecast and actual LORs for summer, 2014-15 to 2017-18, by NEM region



	2014-2015					2015-2016					2016-2017						2017-2018							
	NSW	QLD		SA		NSW		SA		TAS	NSW		QLD		SA		NSW		QLD		SA		VIC	
	Fcst	Fcst	Act	Fcst	Act	Fcst	Act	Fcst	Act	Fcst	Fcst	Act	Fcst	Act	Fcst	Act	Fcst	Act	Fcst	Act	Fcst	Act	Fcst	Act
🟧 LOR-3	1	0	0	0	0	0	0	2	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0
■ LOR-2	0	0	0	1	6	1	3	13	4	1	2	1	0	1	14	11	0	0	0	0	2	0	6	1
🟥 LOR-1	0	1	1	8	0	8	4	19	3	9	14	4	3	1	26	7	8	1	2	1	6	1	16	5

---

[14] The EAAP report provides information on the impact of potential energy constraints, such as water storages during drought conditions or constraints on fuel supply for thermal generation, on supply adequacy in the NEM.

[15] Available at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Statement-of-Opportunities.

[16] Provided in September 2017 and available at http://www.aemo.com.au/Media-Centre/AEMO-advice-to-the-Commonwealth-government.

It highlights a rising trend in the number of reserve conditions, as reserves reduce when capacity is withdrawn from the NEM (until it is replaced over time). Based on new generation expected to enter the market in the coming years, AEMO expects this trend to reverse in the coming years.

2.6.1 Lessons for the future

AEMO continues to review the performance of the new reserve level declaration arrangements on an ongoing basis to analyse how the framework has been operating to date. If potential changes to the guidelines are identified, AEMO will initiate a consultation with stakeholders.

3. Supply adequacy - increased generation and transmission availability in the NEM for summer

In the *Electricity Supply Outlook* released in June 2017 and the ESOO for the NEM released in September 2017[17], AEMO identified the need for additional resources for summer 2017-18 to reduce the risk of load shedding. AEMO's plan highlighted actions to bring some 2,000 MW of additional resources to the NEM, both supply and demand side, to mitigate the identified risk.

This additional capacity consisted of resources which were not available in the 2016-17 summer, and ultimately 1,974 MW of additional resources were made available. This included 833 MW of mothballed generation returned to operation (Pelican Point Power Station in South Australia, Swanbank E Power Station in Queensland, and Tamar Valley Power Station in Tasmania). AEMO also had 1,141 MW of off-market generation and demand reserves available. Accounting for the closure of Hazelwood's 1,600 MW in March 2017, this improved the starting capacity of the NEM's electricity supply by some 450 MW compared to summer 2016-17.

Across the NEM, generation availability was generally higher than average, especially during peak demand times, and fuel supplies were adequate to meet the needs of the generation fleet. AEMO intervened once, on 30 November 2017, to ensure sufficient gas for gas-powered generation of electricity (GPG) in Victoria at a time of high electricity demand, a forecast LOR 2, and RERT dispatch. This intervention in the market was successful in securing additional gas for electricity generation.

Pre-summer collaboration with TNSPs resulted in the transmission system experiencing fewer unplanned network outages in all NEM regions compared to the previous summer. No security or reliability issues occurred as a result of either planned or unplanned outages of transmission during summer 2017-18.

3.1 Total additional generation and demand resources

AEMO's modelling in 2017 identified that, given some generation capacity was withdrawn from the NEM for commercial reasons and some had been "mothballed" (temporarily taken out of service, again for commercial reasons), there may be a range of operating conditions where there was insufficient supply to avoid load shedding in two NEM regions (Victoria and South Australia) in summer 2017-18[18].

---

[17] Both reports are available at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Statement-of-Opportunities.

[18] For example, in the 2017 ESOO published August 2017 and available at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Statement-of-Opportunities.

While new generation capacity, mostly new wind and solar, was being developed, AEMO's modelling highlighted the need for additional capacity in the system in summer 2017-18 – generation and demand reduction – to keep supply and demand balanced, to both meet consumers' energy needs and keep the system operating securely[19].

Figure 8 and Table 4 below show that 1,974 MW of total additional resources – market supply and off-market reserves – were ultimately available for summer operations.

Figure 8 Total additional resources available in summer 2017-18 (MW, by region)

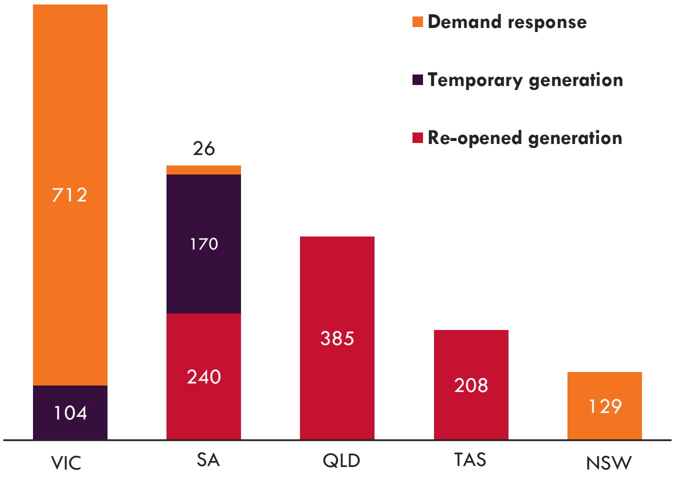


Table 4 Total additional resources available in summer 2017-18

	Source	Capacity	Comparison to plan
Market generation	Pelican Point Power Station, South Australia	240 MW	Same
Market generation	Swanbank E Power Station, Queensland	385 MW	Same
Market generation	Tamar Valley Power Station CCGT, Tasmania	208 MW	Same
	Total market generation resources	**833 MW**	**Same**
RERT demand	AEMO/ARENA trial	141 MW	- 2 MW
RERT demand	Other tendered demand resources	726 MW	- 15 MW
	Total RERT demand resources	867 MW	- 17 MW
RERT generation	South Australia diesel generators	170 MW	Same (nominal capacity was 277 MW)
	Victoria diesel generators	104 MW	+ 8 MW (confirmed and increased after report publication)
	Total RERT generation resources	274 MW	+ 8 MW
	Total RERT (off-market) reserves	**1,141 MW**	**+ 87 MW**
	Total additional resources	**1,974 MW**	**+ 87 MW**

3.2 Market generation resources

AEMO informed the market during 2017 about potential supply shortfalls in summer 2017-18, and the market responded by returning previously mothballed GPG capacity to service. Pelican Point Power Station (South Australia)

---

[19] For more information about how AEMO maintains power system security and reliability, see https://www.aemo.com.au/Media-Centre/AEMO-publishes-Power-System-Requirements-paper.

returned to full capacity from July 2017 (adding 240 MW), and Tamar Valley Power Station (Tasmania) returned its combined-cycle gas turbine (CCGT) plant to service from May 2017 (adding 208 MW).

Swanbank E Power Station (Queensland, 385 MW) was also expected to be operational during summer, from 1 January 2018. It was operational earlier than projected, from December 2017[20].

3.3 Increasing generation availability

3.3.1 Preparing for summer

Generators co-operated with AEMO to minimise the amount of time generation was unavailable during summer due to planned maintenance outages. This process including identifying planned outages and moving them to either before or after summer where possible, depending on the level of risk, cost, and potential reliability concerns.

AEMO and generators also reached agreement on lead times under which outages that could not be moved outside the summer period would be cancelled under an AEMO direction, if conditions presented themselves where this was warranted.

For unplanned outages, AEMO and generators worked to identify and mitigate risks to plant availability.

3.3.2 Performance during summer

As well as working to identify and reduce the risks of plant outages during summer, AEMO and generators also focused on:

- Plant availability being reflected as accurately as possible in AEMO's market systems when generators were bidding to supply to the market. In most cases, bids were accurate, taking into account weather conditions and any plant issues. AEMO observed a noticeable improvement in the accuracy of generator bidding of capacity under high ambient temperatures compared to summer 2016-17, which improved AEMO's confidence as summer progressed in the adequacy of forecast reserves.
- Communicating promptly, frequently, accurately, and with as much notice as possible about any availability issues with plant or units. In general, generator bids and plant/unit availability issues were communicated with AEMO well in advance. AEMO also communicated more frequently and proactively with generators, so they were aware of forecast temperatures that could affect their operations, and could review and update bids as necessary.

AEMO's review identified an increase in unplanned partial generation outages during peak demand/high temperature summer days, compared to other summer days. This was largely consistent across most black and brown coal-fired generation assets, generally as a result of ambient temperature restrictions or cooling water limitations. As noted above, most of these issues were identified before the peak periods and accurately reflected in their bids, which improved AEMO's confidence in the reliability of reserves.

In South Australia, where no coal assets are in operation and the individual gas-fired generation units are smaller, unplanned outages have less significant effects on availability. Aggregate reliability issues which presented operational challenges in summer 2016-17 in South Australia were not as prevalent this year.

Some media coverage in the summer period highlighted potential reliability concerns with the coal fleet. While there were unplanned unit outages this summer (typical for thermal generators during warmer weather), the NEM coal fleet recorded its fourth-highest summer availability in the last 10 years, with around 250 MW more capacity available than the long-term average for this period.

Figure 9 shows the coal-fired generation fleet's availability over summer 2017-18 compared to previous years, and to the historical average across the past decade.

---

[20] See AEMO's Generation Information webpage, 29 December 2017 update, at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information.

Figure 9 Coal generation availability over summer, 2008-09 to 2017-18

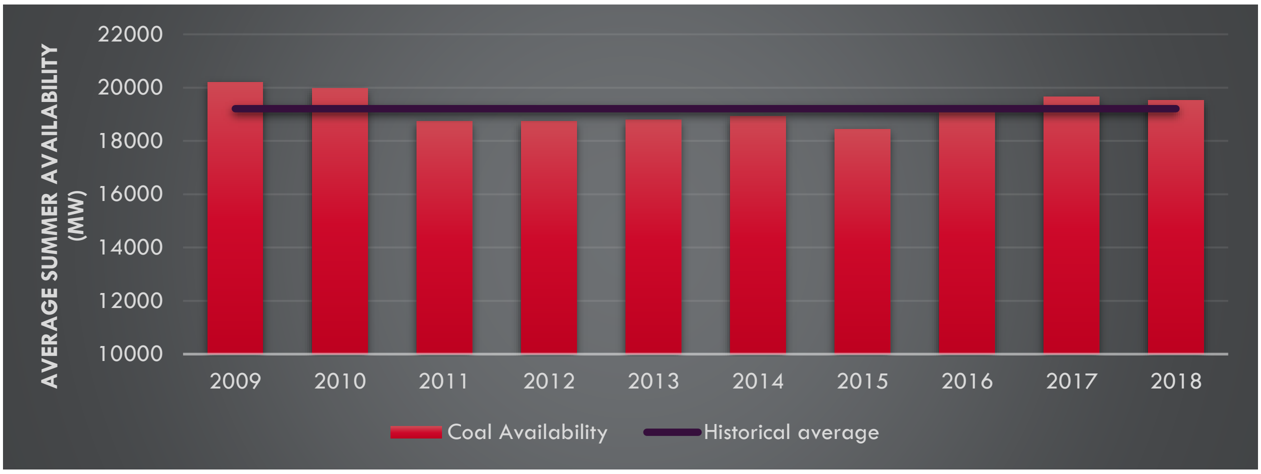
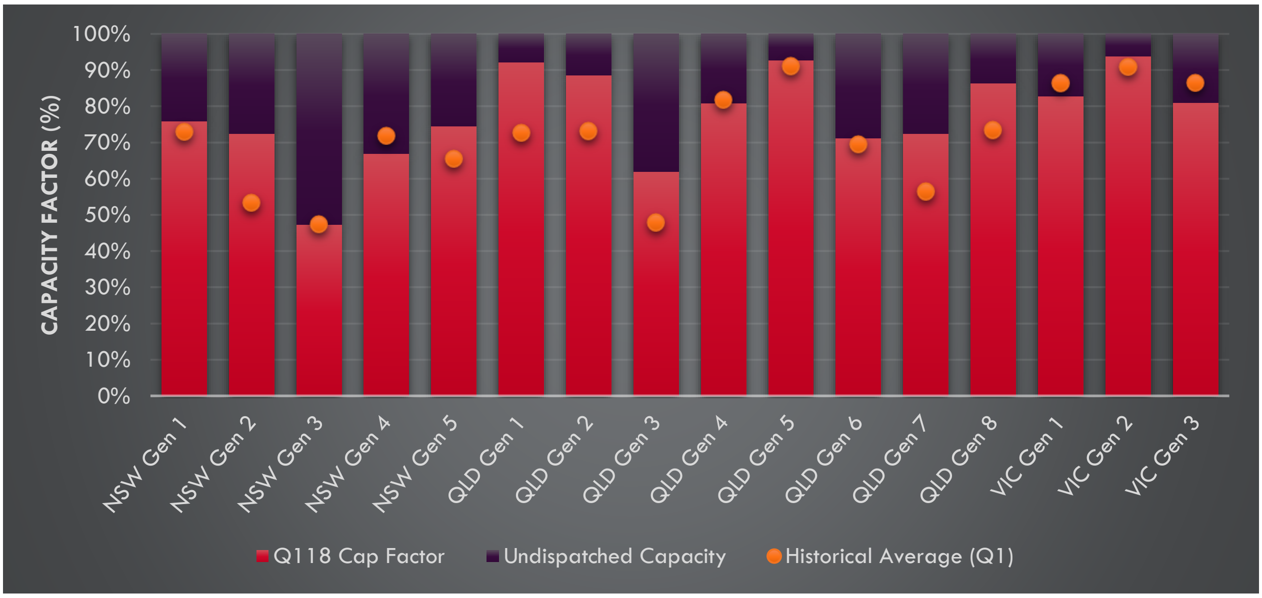


Figure 10 highlights the capacity factor[21] of the coal fleet during the first quarter of 2018, with power station names kept confidential. Most generators' capacity exceeded their historical average. The VIC Gen 1, VIC Gen 3, NSW Gen 3, and NSW Gen 4 power stations had some issues associated with returning specific units to service from long-term outages (not uncommon after extensive outages and maintenance periods), or coal reliability issues. These issues have now largely been resolved.

Figure 10 Coal generator availability in summer 2017-18 compared to capacity and historical average



3.3.3 Lessons for the future

The increased availability of generation over summer reflects generators' efforts in preparing their assets for the summer period. AEMO intends to continue working with generators to further enhance:

- Communication with generators about plant availability, to improve market transparency and short-term reserve management.
- Reviewing high temperature triggers which prompt generators to review their capacities under forecast temperatures. This will further improve AEMO's confidence in the adequacy of reserves under these operating conditions, and reduce the potential risk of market interventions.

---

[21] The capacity factor of a generator is the ratio of its actual output over a period of time, to its potential output if it were possible for it to operate at full nameplate capacity continuously over the same period of time.

3.4 Maximising generator fuel availability

3.4.1 Preparing for summer

Generators and AEMO already communicate frequently to identify and mitigate any risks to supply of appropriate quality fuel. Leading into summer 2017-18, AEMO also worked closely with the gas industry and governments to monitor any potential issues and prepare intervention plans, given identified risks to gas supply adequacy[22].

3.4.2 Performance during summer

Throughout summer, AEMO closely monitored supplies of coal, gas, and liquid fuel (diesel), and communicated frequently with generators and governments.

Over summer, generators had sufficient fuel supply to operate, and any limits were reflected accurately in their bids.

Gas

To supply GPG requires reliable gas supplies, but gas supply is highly variable given other demand. Table 5 shows consumption of gas in terajoules (TJ) per day in each state for GPG. Note the average consumption in each region is, in some instances, a third of peak day requirements, highlighting the need for adequate flexibility in gas pipeline and production capacity to meet the needs of gas-fired electricity generation under high electricity demand conditions.

Table 5 Average and peak day gas requirements for GPG (TJ)

	New South Wales	Queensland	South Australia	Tasmania	Victoria
Average daily gas consumption	43	159	182	36	94
Peak day consumption	137	316	326	52	393
Peak date in summer	20/12/2017	15/2/2018	24/11/2017	24/12/2017	22/11/2017

Longford Gas Plant in Victoria provided the four southern NEM regions (excluding Queensland) with more than twice the amount of gas as all other south-east Australian gas plants combined during the past summer. The most significant threat to supply of gas for GPG occurred on 30 November 2017, when an unplanned outage at Longford reduced gas supplies to Victoria by 185 TJ, on a day when AEMO had already forecast an LOR 2 condition in the region. The scheduled supply of gas was not capable of meeting forecast demand for GPG, so AEMO issued a notice of a threat to system security in the Victorian gas market to increase gas supplies and enable GPG plants to continue operating to meet electricity demand.

Three gas plants in Victoria were also affected by bushfires on 17 March 2018. However, NEM demand across South Australia and Victoria was low because it was a weekend, and wind generation production was sufficient (600 MW) across both regions, so these gas outages had minimal impact.

Hydro

Water supplies were sufficient for all hydro generation across the NEM to operate under their normal operating and market conditions, and AEMO was not aware of any hydro generator unavailability due to lack of water, before or during summer, which would have restricted their operations during peak demand periods. Hydro generators bid their maximum availability according to the normal process throughout summer.

Coal

All coal generators had sufficient supply during summer. Rebidding from black and brown coal-fired generators related to fuel management, mill limitations, and other supply-related bids accounted for 5% of all rebids in New South Wales and 3% in Queensland and Victoria during the 2017-18 summer.

3.4.3 Lessons for the future

AEMO will continue to work with generators and the AER on improvements to the provision of information on any fuel limitations that may impact capacity or reserves in the NEM. Quality information provided to AEMO is essential for the security and reliability of the grid, and to maximise transparency for AEMO in its decision-making.

---

[22] Including in AEMO's *Energy Supply Outlook* published June 2017 and *Gas Statement of Opportunities* (GSOO) published September 2017, both available at http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities.

3.5 Maximising network availability

Transmission network outages have the potential to impact interconnector capacity and/or generator capacity and therefore reserve conditions, depending on the level of demand and network conditions on any given day. Maximising the availability of the transmission network over summer relied on active co-operation between AEMO and TNSPs to ensure appropriate maintenance before summer and minimal planned outages during summer (especially at high demand times).

3.5.1 Preparing for summer

AEMO and TNSPs began preparing the networks for summer 2017-18 in March 2017. The key focus of this work was to complete bushfire mitigation before summer, undertake as much preventative maintenance that could improve reliability outcomes for the network over the summer period by the end of November 2017, and make sure no planned maintenance was scheduled on high demand days. Broad agreement with TNSPs was reached that only critical outages with no impact on generation or interconnectors would go ahead during summer.

3.5.2 Performance during summer

Planned outages

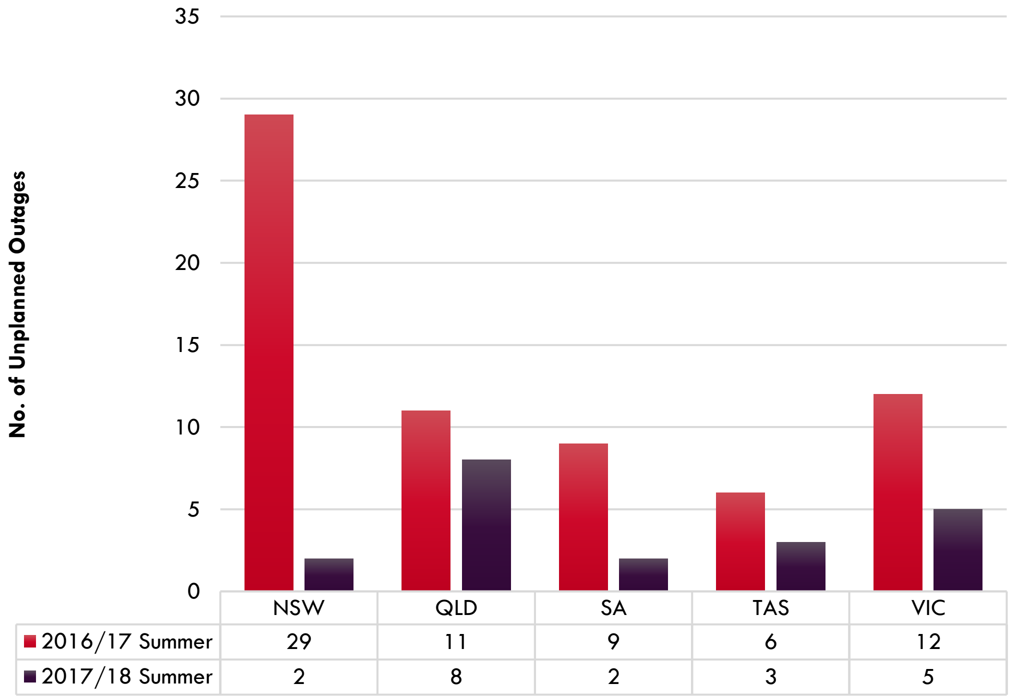
Proactive communication and collaboration with TNSPs ensured maintenance for bushfire risk management was completed before summer, and there were no planned outages at peak times which reduced the maximum available capacity when it was needed.

AEMO also worked with TNSPs to continuously monitor forecasts and recall any planned outages that could coincide with peak demand. Over summer, AEMO allowed 20 planned outages on high temperature days because they would be completed before the peak, sufficient reserves were available to meet demand, or the outages did not affect any generation or interconnector capacity.

Unplanned outages

There were unplanned transmission network outages in all NEM regions (see Figure 11) but none had an impact on system security or reliability. Figure 11 highlights that there was a material reduction in the number of unplanned outages across the NEM compared to summer 2016-17. This outcome was testament to the efforts of the TNSPs in preparing their assets for the summer period.

Figure 11 Number of unplanned transmission outages in NEM regions over summer 2017-18, compared to 2016-17



	NSW	QLD	SA	TAS	VIC
🟥 2016/17 Summer	29	11	9	6	12
■ 2017/18 Summer	2	8	2	3	5

Only one unplanned outage coincided with a day of high forecast demand, in Victoria on 18 January 2018. There was a forecast LOR 1 (later an actual LOR 1 and LOR 2) on this day due to high demand, but the LOR condition was not caused or affected by the transmission outage.

The Basslink high voltage direct current (HVDC) interconnector between Tasmania and Victoria is a key piece of electrical infrastructure which provides a single link between the mainland and Tasmania. During periods of high demand in Victoria, Basslink plays a critical role in the delivery of energy.

Basslink was designed to operate at a continuous rating of 500 MW (up to 630 MW for limited periods). Accounting for losses of energy during the conversion of electricity from alternating current (AC) to direct current (DC) and back again, and transmission across the cable, the continuous rating for electricity flows from Tasmania to Victoria is 478 MW (up to 594 MW for limited periods).

On 20 December 2017, Basslink updated its capacity to reflect that its availability was at the continuous rating reduced to 478 MW into Victoria for the remainder of summer. Basslink's forecast capacity was further reduced on several days (19, 27, and 28 January 2018) due to forecast high temperatures at George Town converter station. While the forecast temperatures in George Town did not materialise, and the capacity of Basslink over the peak periods on these days was rebid to 478 MW, the forecast reduction of capacity had an impact on forecast reserves, forecast LOR conditions, and operational decisions in Victoria on 19 January 2018.

Basslink began a planned outage on 24 March 2018, which was extended to 14 April 2018 and later to 31 May 2018, due to some damage which occurred during the planned outage. Such an outage during peak summer demand would have significant impacts on Victorian reserves.

Voltage control

At times of falling minimum demands, maintaining power system voltages within both operational and system design limits is an emerging challenge. This issue was mainly observed during summer in the Victorian region (particularly in the south-west corridor around Geelong, Portland, and Moorabool) and the South Australian region (around the Davenport area).

Such voltage control issues are becoming, or will become, increasingly evident, not just during summer periods but during other times of the year, and in other NEM regions[23].

AEMO managed this issue during summer according to the standard operating procedures with no breach of operating limits. Further consideration will need to be given to voltage management in low load conditions, and AEMO will continue to work with stakeholders to identify and then pursue more efficient longer-term outcomes to avoid adverse market impacts and reliability and security risks. The potential for participation in the provision of these services DER will also be explored. To address this issue[24]:

- A Regulatory Investment Test for Transmission (RIT-T) process in Victoria for additional reactive power support is currently underway[25].
- AEMO has begun formal discussions with TransGrid, the TNSP in New South Wales, on available options in New South Wales for voltage control during minimum demand periods.
- AEMO looks forward to working with the Energy Security Board (ESB) and AEMC to explore market design changes that incentivise avoidance of minimum load conditions that impose avoidable system costs, such as markets that support load shifting and ramping.

System strength in South Australia

AEMO has published recent studies[26] outlining the minimum number of synchronous machines[27] required to maintain system strength in South Australia. System strength reflects the sensitivity of power system to disturbances, and the stability and dynamics of generating systems and the power system to both:

- Remain stable under normal conditions, and
- Return to steady-state conditions following a disturbance (such as a fault).

---

[23] This will be discussed in AEMO's 2018 *Victorian Annual Planning Report* (VAPR), scheduled to be published in June 2018 and to be available at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Victorian-transmission-network-service-provider-role/Victorian-Annual-Planning-Report.

[24] This report focuses on issues and actions in the NEM, but voltage management in these conditions is also an emerging issue in the Western Australian South West Integrated System (SWIS).

[25] More detail will be in the 2018 VAPR.

[26] See https://www.aemo.com.au/Media-Centre/South-Australia-System-Strength-Assessment.

[27] ElectraNet, the TNSP for South Australia, has been investigating options to address the system strength gap in the region and determined that the installation of synchronous condensers on the network is the most efficient and least-cost option. A synchronous condenser operates with a large rotating shaft connected to and turning synchronously with the frequency of the power system, as large electric motors and synchronous generators do, but the shaft spins freely and can be used to adjust technical conditions on the network. For more information about this project, see https://www.electranet.com.au/what-we-do/projects/power-system-strength/.

Large synchronous machines (hydro, gas, and coal generation, and synchronous condensers) inherently contribute to system strength. Non-synchronous generation (batteries, wind, and solar PV generation) does not presently provide inherent contribution to system strength[28].

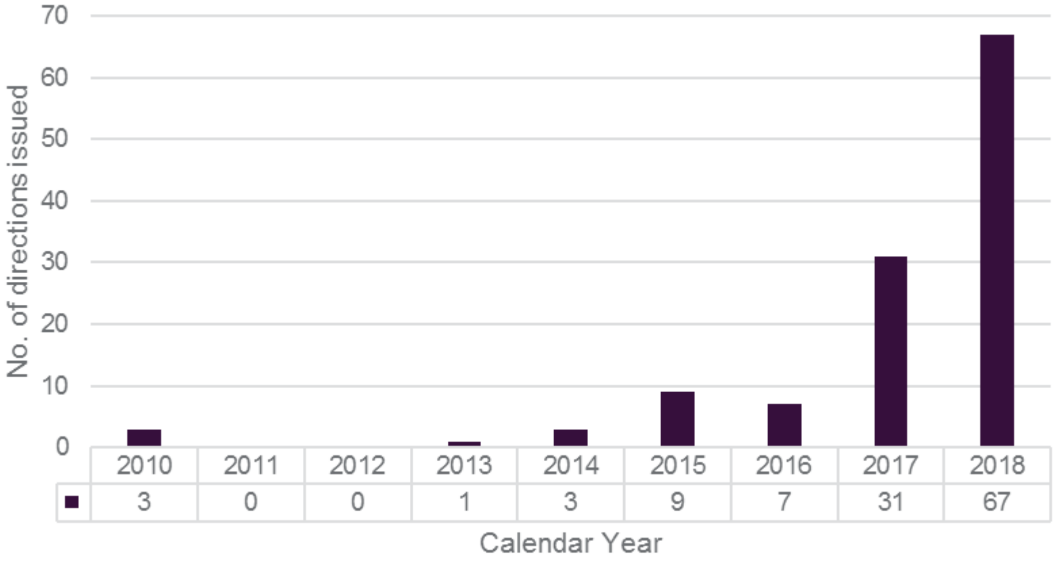
Operating procedures are currently in place to ensure a minimum number of synchronous generating units are in service in South Australia at all times, until a permanent technical solution is commissioned. This solution is expected to be operational by mid-2020.

AEMO's operating procedures identify the conditions and generator dispatch combinations needed to satisfy the system strength requirements. Where natural market outcomes do not deliver the specific needs for system strength, AEMO has powers under the National Electricity Law and National Electricity Rules (NER) to direct the necessary resources into service.

During summer 2017-18, AEMO issued 22 directions to South Australian generators to ensure the correct level of system strength was maintained at all times. These were security directions, for the provision of fault current, not for energy. Where AEMO issues a direction for energy, this is a reliability direction.

Figure 12 compares the number of directions issued in the NEM over the last eight calendar years, as at 20 May 2018.

Figure 12 Number of directions, 2010 to 2018 (year to date)



	2010	2011	2012	2013	2014	2015	2016	2017	2018
■	3	0	0	1	3	9	7	31	67

Note: 2018 is for a partial year, 1 January - 20 May 2018. The majority of Market Notices issued in 2017 and 2018 were due to system strength requirements in South Australia

Reclassifications

AEMO reclassifies non-credible contingency events as credible contingency events[29] if abnormal conditions increase the likelihood of this event occurring (for example, due to severe weather conditions, lightning, and bushfires). The reclassification criteria are set out in section 11 of the Power System Security Guidelines (AEMO procedure SO_OP_3715)[30].

AEMO reclassified 527 events as credible contingencies in summer 2017-18. On nine instances, an actual contingency occurred while it was reclassified as a credible contingency. Of these reclassifications, 500 were due to lightning events, and there were eight instances where the actual contingency occurred (that is, two transmission lines tripped together) while it was reclassified as a credible contingency due to lightning. There was no adverse impact to the power system security or reliability due to these contingency events as action had already been taken to minimise any impacts.

---

[28] For more information, see AEMO, *Power System Requirements*, March 2018, available at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability.

[29] A credible contingency event is defined in the NER as a "contingency event" which AEMO considers to be reasonably possible in the circumstances. Examples could include the unexpected automatic or manual disconnection of one operating generating unit, or the unexpected disconnection of one major item of transmission plant (other than as a result of a three-phase electrical fault anywhere on the power system). A non-credible contingency event is defined in the NER as a "contingency event" other than a "credible contingency event". Examples include three-phase electrical faults on the power system, or simultaneous disruptive events such as multiple generating unit failure or double circuit transmission line failure.

[30] These guidelines are available at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation.

During summer, there were only two instances where AEMO reclassified a non-credible contingency event as credible due to the risk of bushfires. Actual contingencies did not occur during these reclassification events. The number of reclassifications due to bushfires was lower than previous summer periods.

During 25 reclassifications for other reasons (the most common being severe weather), there was one instance where a contingency occurred while it was reclassified as credible contingency. Again, there was no adverse impact to the power system during this event as AEMO has already modified the operation of the power system due to the reclassification process.

3.5.3 Lessons for the future

Compared to summer 2016-17, last summer was notable for reduced forced outage rates on the networks and the negligible transmission contingencies impacting generation and supply during peak periods.

There are, however, consequences that need to be considered when reviewing the approach for future summer preparedness activities, including:

- Moving planned transmission outages to outside peak periods (summer and, in some regions, winter as well) reduces the time available to complete planned maintenance activities, and can push the risk from peak periods into shoulder (autumn and spring) seasons. Although outside the peak, these seasons can have:
  - Very high electricity demand due to late or early summer heat, so transmission is required to support unseasonable peak periods.
  - Severe weather events such as storms, or late or early onset of the bushfire season, which can materially impact transmission availability, and therefore reliability to consumers.
  - Challenges where transmission and or generation outages coincide with other energy industry maintenance activities, such as gas production and pipeline maintenance, which are critical for electricity generation. Electricity transmission capacity and diversity during gas maintenance periods is critical to electricity supply under gas restrictions, or periods of low wind or solar generation.
- It was a challenge to deal with the higher number of planned maintenance outages ahead of summer without accepting some residual risk. AEMO will work with industry and governments to consider any resource and coordination changes needed to prepare for future summers.

Through AEMO's *Integrated System Plan*, due for release in mid-2018, AEMO will identify further opportunities for enhancing voltage control across the NEM, and continue to explore market designs that support resources required for security and reliability as opposed to AEMO directions, which should be a last resort.

4. Reserve adequacy and Reliability and Emergency Reserve Trader (RERT)

All power systems operate with a 'buffer' of reserves to protect reliable supply to consumers in case generation or transmission becomes unavailable unexpectedly. The NER require AEMO to inform the market if these reserves fall below threshold levels by issuing LOR declarations.

Before summer, AEMO indicated a reserve of around 1,000 MW would be required. For summer, AEMO procured 1,141 MW of off-market reserves through existing RERT arrangements in the NER – 867 MW of demand resources and 274 MW of off-market generation – with these resources optimised, based on availability and cost, to manage identified risks.

RERT was activated twice, on 30 November 2017 in Victoria and on 19 January 2018 in Victoria and South Australia.

4.1 Reliability and Emergency Reserve Trader (RERT)

RERT is a function conferred on AEMO in the NER to enter into reserve contracts to ensure reliability of supply meets the reliability standard, and to maintain power system security. RERT is a last resort function, along with directions, to be exercised when there is an expected shortfall in the market. Essentially it is insurance – used judiciously if required to minimise the likelihood of load shedding and impacts to the community which usually arise during periods of high temperature.

There are two stages to RERT:

- **Stage 1 – RERT procurement.**
  - AEMO may procure long notice reserves through an invitation to tender, where we have 10 weeks or longer notice of a projected shortfall (although AEMO cannot contract for reserves more than nine months prior to the date AEMO reasonably expects the reserve may be required).
  - Alternatively, AEMO may maintain a panel of RERT providers which can provide short notice (between three hours and seven days) and medium notice (between ten weeks and seven days) reserve if required, and with which technical details are pre-agreed. Panel members for short notice RERT agree on prices when appointed to the panel, whereas panel members for medium notice RERT do not, and prices are negotiated if and when reserve is required. The RERT panel allows AEMO to run an expedited tender process in short and medium notice situations, as the tendering process is pre-agreed and makes use of pre-determined agreements and standard tender forms. There are no payments for being on the RERT panel.
  - From 1 November 2017, long notice RERT is no longer available under the NER. Long notice contracts entered into before 1 November 2017 remained valid for use over the 2017-18 summer period.
- **Stage 2 – RERT activation.**
  - AEMO continuously assesses whether forecast reliability and security is outside a relevant NEM standard. If AEMO identifies a relevant standard may be breached, and considers the latest time for exercising RERT has arrived, AEMO may choose to activate reserves.

– The trigger for the activation of reserves under RERT depends on the lead time required for activation, and the nature of any identified shortfall. AEMO uses LOR conditions (see Section 2.3.2) and other factors such as environment risk (bushfires, storms) and equipment status information from asset owners to inform this assessment.

There are two principles AEMO must take into consideration when exercising RERT:

1. Actions taken should be those which AEMO reasonably expects to have the least distortionary effect on the operation of the market; and
2. Actions taken should aim to maximise the effectiveness of contracts at the least cost to end use consumers of electricity.

The NER set out other requirements when exercising RERT, including that parties offering into RERT must not be available to the market or subject to any other agreement or arrangement, during the period for which RERT has been contracted.

Under the 2017-18 summer readiness program, these RERT reserves were procured:

- RERT – procurement of RERT by AEMO (long notice, medium notice, and short notice) from generation and demand response for the period 1 November 2017 to 31 March 2018; and
- AEMO/ARENA demand response pilot program – procurement of demand response reserves that would sit within the RERT framework (short notice). The program is for three years and began on 1 December 2017.

4.2 AEMO-ARENA demand response pilot program

This pilot program is a three-year joint initiative between AEMO and ARENA, seeking to enable up to 160 MW of demand response in Victoria, South Australia, and New South Wales.

The program's aim is to trial a strategic reserve model (referencing international market designs) for reliability or emergency demand response, to inform future market design as well as contributing reserves for the 2017-18 and future summers.

Unlike RERT, which is bespoke in nature and relies on the predictability of shortfalls, AEMO and ARENA designed the demand response pilot around defined products (see Figure 13) and availability of reserves when required during the year. The design of these products was based on input from a stakeholder session in May 2017, AEMO control room requirements, and international experiences. The benefits of defining standard products are that it:

- Is more manageable for the AEMO control room to operate (compared to working through bespoke contracts).
- Allows auctions to be run in the future, if a strategic reserve model is pursued. This could lead to better price discovery and competitive price outcomes.

Figure 13 AEMO/ARENA demand response trial product specifications

Feature	Product 1	Product 2
Notification period	60 minutes	10 minutes
Activation duration	4 hours	4 hours
Activation triggers	LOR2, LOR3, System Security	LOR2, LOR3, System Security
Availability	10am to 10pm business days	10am to 10pm business days
Activation frequency	10 per year (ie. 40 hours)	10 per year (ie. 40 hours)

ARENA will provide, over a period of three years, up to $22.5 million of funding for projects outside New South Wales, and ARENA together with the New South Wales Government (on 50-50 basis) will provide up to $15 million of funding for New South Wales projects.

Successful awardees receive ARENA capital funding grant in the form of availability payments over three years, and were required to sign onto the AEMO short notice RERT Panel and offer and be available for short notice RERT if requested. If this RERT is activated, awardees receive usage payments capped at $1,000 a megawatt hour (MWh), and Market Customers pay for the activation charges in accordance with the current cost recovery mechanism for RERT under the NER.

This program has delivered 141 MW in year 1, and will deliver 190 MW in year 2 and 202 MW in year 3, across New South Wales, Victoria, and South Australia.

4.3 Total RERT resources

AEMO expected to have a total of 1,054 MW of off-market reserves available over summer when we published the *Summer Operations 2017-18* report in November 2017. This total included 96 MW of emergency diesel generation offered in Victoria, which was subject to approvals at the time the report was published, so was noted but not included in tables and charts.

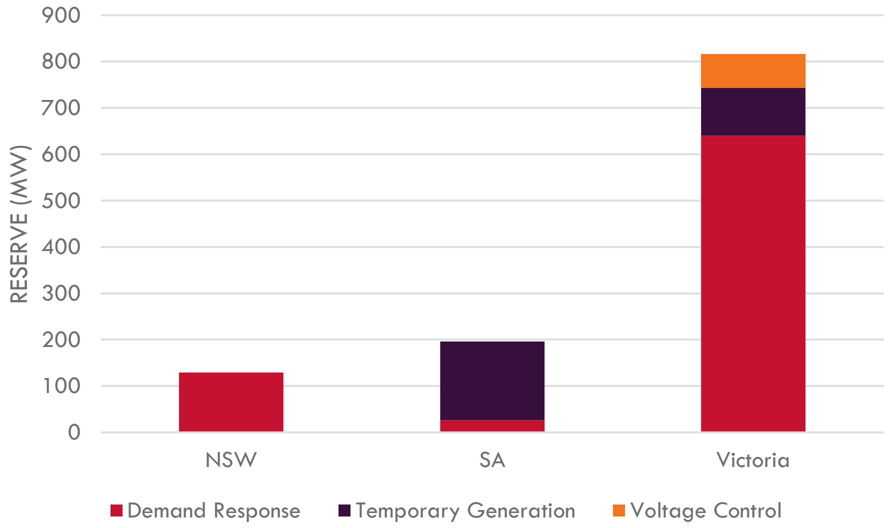
Table 6 and 0 below show the 1,141 MW of RERT resources that were ultimately available for summer operations (all or part of summer). This includes the diesel generation offered in Victoria (ultimately 104 MW was made available).

It should be noted that, while AEMO procured more than the 1,000 MW indicated in published modelling in 2017, not all resources are available at any given point in time. In reality, limitations on run times, and availability of the resources at only certain times throughout the day or on certain days, reduce the total available at any given time. AEMO optimises the resources based on availability and cost to manage any identified risk.

Table 6 RERT resources available in summer 2017-18

	Source	Capacity	Comparison to plan
RERT demand	AEMO/ARENA trial	141 MW	- 2 MW
RERT demand	Other tendered demand resources	726 MW	-15 MW
	Total RERT demand resources	867 MW	-17 MW
RERT generation	South Australia diesel generators	170 MW	Same (nominal capacity was 277 MW)
	Victoria diesel generators	104 MW	+ 8 MW (confirmed and increased after report publication)
	Total RERT generation resources	274 MW	+ 8 MW
	Total RERT (off-market) reserves	1,141 MW	+ 87 MW

Figure 14 RERT available by generation/demand



In the November report, RERT demand response was not split but was shown as a single total. Here, 60 MW available to help control voltage in Victoria is highlighted separately.

Before summer, AEMO estimated the total cost of these resources may be up to $67 million. AEMO's review of summer 2017-18 found the total cost to have the reserves on call and to activate RERT twice was $51.26 million. We have estimated this equates to an annual average of less than $6.00 (about 0.3% of an average household bill) per household bill. Table 7 below summarises the total cost of RERT to date in the financial year 2017-18[31].

---

[31] If necessary, these figures will be updated after the end of the financial year in accordance with NER 3.20.6(c)(3).

Table 7 RERT costs associated with 2017-18 financial year ($ million)

	Availability payments	Pre-activation costs	Activation costs	Other costs [A]	Total costs [B]
RERT costs in financial year 2017-18	$26.29	$21.56	$3.23	$0.17	$51.26

A. "Other costs" represent compensation paid to Market Participants due to the intervention event (for example, to compensate for energy generation which is displaced by RERT capacity), and to Eligible Persons due to changes in interconnector flows, and therefore changes in the value of Settlement Residues.
B. Costs are passed through to Market Customers in the relevant region in accordance with the NER.

4.4 Activation of RERT under LOR conditions

The trigger for the activation of reserve contracts depends on the lead time required to activate the reserve and the nature of the reserve shortfall:

- Some RERT resources may be activated before any contingency occurs on the power system, because they have very long lead times for activations (several hours).
- Other RERT resources may be activated after a contingency occurs, because they have very rapid response times (minutes).
- After a contingency occurs, AEMO has at most 30 minutes to secure the power system, so we will optimise the resources based on their availability to manage the identified risk.
- Some RERT resources may be activated only when the system is in actual LOR 3, as they have very short lead times to activate (minutes) and may only be able to run for short periods (one hour). Generally, these reserves need to be paid for (regardless of whether they are dispatched) to be available for activation if an LOR 3 condition materialises, which it may not.

AEMO is required to minimise the market impact of the RERT services, and to obtain the services at least cost. To meet these requirements, AEMO optimises the selection of the RERT services based on the characteristics of the service:

- Cost.
- Ability to meet the requirement.
- Size of reserve blocks (meaning the amount of MW available in each contract).
- Length of dispatch/activation times.
- Dispatch/activation constraints (for example, maximum number of days or consecutive days per week of dispatch/activation, maximum and/or minimum periods of dispatch/activation, or times of the day reserve is available).
- Shutdown periods when the reserve blocks are not available.

RERT is activated under LOR 2 or LOR 3 conditions, where there is an insufficient market response to manage the identified risk. When required, RERT is activated using the following process:

- Declare a reserve condition and seek a market response.
- If an inadequate market response is received, confirm availability of RERT providers (LOR 2 and 3 conditions only).
- If the reserve condition still exists when the latest time to intervene is reached, exercise the RERT process – taking into account pre-activation and activation times.
- If the reserve condition still exists after exercising the RERT process, issue Directions or NER clause 4.8.9 Instructions to Market Participants to provide additional capacity, if available.
- If, after exhausting all these options, the demand cannot be met, shed load to return the power system to a secure state and to avoid damage to equipment, or any cascading failures.

A reserve shortfall in a NEM region may be able to be satisfied, in whole or part, using RERT from an adjoining region. However, AEMO must consider likely interconnector flows during the reserve shortfall timeframe, to ensure there will be sufficient headroom to allow transfer of the RERT.

AEMO exercises RERT in preference to issuing Directions to market participants to support reliability under conditions of supply scarcity, that is, under reserve shortfalls.

Similarly, for power system security-related issues, RERT should be used in preference to issuing Directions.

There may be situations where both RERT and Directions may have to be used to resolve a reserve shortfall. There may also be situations where Directions are the only suitable option.

4.5 Review of activation of RERT during summer 2017-18

AEMO activated RERT twice in summer 2017-18, on 30 November 2017 (in Victoria) and on 19 January 2018 (in Victoria and South Australia) when consumer supply was at risk due to severe weather conditions. Reports on both events are published as Annexures to this report.

In summary, AEMO's review of summer operations has concluded, in relation to RERT, that:

- RERT was an effective tool at improving reserves across a range of time horizons.
- RERT providers were highly engaged, and communication between them and AEMO was efficient, which enabled sound decision-making in determining the requirement for, activation of, and subsequent deactivation of reserves.
- Training and onboarding processes for providers became smoother over time.
- Demand response resources trialled through the AEMO/ARENA pilot were effective, and performed to expectations. Ongoing assessment of these resources and their adequacy will continue over the next two summers.
- Using AEMO's deterministic approach to managing reserves, which was in place at the time of activation of RERT on 30 November 2017 and 19 January 2018, there were sufficient levels of RERT available to mitigate the risk of load shedding against the single largest credible risk determined at the time of peak demand.

AEMO also conducted a backcast of reserve requirements, to determine if the level of RERT dispatched on 30 November 2017 and 19 January 2018 would have increased or decreased if the probabilistic approach to managing reserves, introduced from 15 February 2018, had been in operation. The updated approach takes into account uncertainties including weather, demand, and generation availability (see Section 2.3.2). In addition, AEMO backcast reserve requirements for the heat event in Queensland which occurred in early February.

The backcast identified that the LOR 2 level, the key trigger for activation of RERT, would have increased, due to the uncertainty related to extreme heat events on all three occasions:

- On 30 November 2017 in Victoria, the LOR 2 level would have been increased from 594 MW to approximately 1,094 MW and additional RERT would have been dispatched.
- On 19 January 2018, the LOR 2 level would have been increased from 560 MW to 1,099 MW in Victoria, and from 350 MW to 501 MW in South Australia. Additional RERT would have been dispatched in both regions.
- On 14 February 2018 in Queensland, the peak demand day for the summer, the LOR 2 level would have been increased from 750 MW to 859 MW. No RERT was procured in Queensland and there were sufficient market reserves to meet this requirement.

Further, AEMO also conducted a more detailed backcast and system adequacy assessment of the heat event that occurred in Victoria on Sunday 28 January 2018, when temperatures of 38.1 °C were recorded at Melbourne Olympic Park weather station. Although this was a holiday weekend, demand on the day reached 9,144 MW. This level of electricity demand exceeded all previous weekend records in Victoria, due to an estimated 1-in-35-year event of very high temperature combined with very high humidity.

AEMO 'replayed' the weather for 28 January 2018 through our forecasting models and determined that if the heat event had occurred on a weekday in February (when industry and schools had returned from summer break), then a demand of 10,202 MW was feasible. AEMO then assessed the adequacy of generation and transmission to meet this level of forecast demand, assuming all plant was available at rated capacity, all transmission assets were available, there were no system constraints, and reserves were managed in the same manner.

The scenario determined that reserves (against this level of demand) would have fallen to 71 MW without the activation of RERT. With a LOR 2 level of 560 MW, at least 500 MW of RERT would have been initiated over a two-hour period to bring reserves back to a level sufficient to mitigate the risk of load shedding. However, using the now current reserve methodology as outlined in section 2.3.2 of this report, it is likely that 824 MW of reserve would have been activated had the scenario eventuated. This clearly demonstrates that RERT is an invaluable 'insurance policy' against credible weather and demand scenarios.

Last summer was the first time procured RERT had been activated, and the first time more than one contract at a time had been entered into. AEMO will work to improve communications around activation of reserves and verification of quantities of demand response. The Annexures identify improvements AEMO will undertake before summer 2018-19.

5. Operational improvements

AEMO worked with generators to improve the understanding of the likely performance of assets under severe operating conditions, updated our forecasting tools to improve the visibility of risks to the power system to enable more informed operational decisions, and implemented a range of additional training for our control room and support staff. More operational improvements from our report into the 2016 South Australian black system were also implemented.

5.1 Operator training

5.1.1 Preparing for summer

Ahead of summer 2017-18, AEMO provided a range of additional training for NEM operations staff. This training focused on new and updated processes, systems and procedures, managing uncertainty and high-risk events such as bushfires, severe storms, and heatwave conditions. The training also covered improvements in communication with Market Participants and governments.

This summer training used AEMO's NEM Simulator, providing real-life examples of the processes and systems to be used through the summer period. A range of online learning courses were also developed in-house for both control room and support staff, providing an effective and efficient method for delivery.

The training provided was in addition to normal annual training activities that focus on system restarts, managing complex environmental impacts on the power system, contingency and reserves management, and undertaking directions.

5.1.2 Performance during summer

The additional training provided to NEM operators ahead of summer was found to be valuable preparation for the peak period. Through use of the NEM Simulator, operations staff were able to refine their skills and responses to simulated scenarios in a safe environment. This led to an increase in situational awareness, and feedback from control room staff and observations indicate faster response times to events.

5.1.3 Lessons for the future

AEMO is in the process of increasing the provision of offline training for operators, from 40 hours per year to 120 hours. Benefits of this commitment are expected to continue to be realised in the coming summers.

AEMO will continue to monitor changes to Rules, processes, and procedures and deliver training to NEM operators and control room staff so they are up to date and can work efficiently with participants. Additional tools that simplify decision-making, particularly around the activation of RERT contracts, will be given a high priority for next summer.

5.2 Other

In November 2017, AEMO reported on a range of actions that were underway arising from the South Australia black system which occurred in September 2016. A key focus of this work was to avoid a cascading failure of the South Australian power system in the event of an unexpected loss of the Heywood Interconnector, which connects South Australia to Victoria, using a control system called a System Integrity Protection Scheme (SIPS).

On 21 December 2017, ElectraNet (the TNSP for South Australia) successfully completed the commissioning, and therefore armed, the automatic load shedding component of the South Australian SIPS. This materially reduces the risk of a black system in the event of the loss of the Heywood Interconnector. The basis of ElectraNet's design was the detailed power system analysis undertaken by AEMO.

ElectraNet and AEMO will do more work in 2018 to further enhance the SIPS, and explore opportunities for other technologies to participate in system security services in South Australia.

6. Collaboration and communication

The energy transition is increasing opportunities for collaboration to make the power system more innovative, competitive, and efficient for consumers. However, this must be integrated across the energy system, from consumer to supply, and coordinated in an optimal way across the NEM. With this in mind, AEMO sought greater open and transparent communication before and throughout summer, not just with industry and government stakeholders, but also more broadly with the community. AEMO's approach to summer communications was to make every effort to share:

- Information about actions being taken leading up to, during, and after any event that should occur on the power system during summer.
- A clear understanding that AEMO, industry, and governments had planned and would implement all actions possible over summer to support the ongoing secure and reliable supply of energy to Australian consumers.

AEMO co-ordinated multiple industry and government briefing and training sessions before summer 2017-18, with a key focus on improving operational and emergency communications and information sharing. During summer, AEMO convened weekly outlook teleconferences with all NEM jurisdictions and industry representatives to provide an outlook on forecast weather, supply, and demand conditions. This group was often the first point of call during operational challenges and ahead of forecast heatwaves.

AEMO also took a more proactive and wider approach to communicating with the public, directly and through the media, about summer operations and activity, explaining how the energy sector prepared for both severe conditions and unforeseeable events. AEMO's new web portal, Energy Live, was launched on 1 December 2017 and was a key channel to share information online and on social media with the public and media.

6.1 Operational communications

6.1.1 Market Notices

AEMO issued Market Notices (MNs) to inform market participants about prevailing market and/or system conditions, according to existing AEMO operational procedures[32]. AEMO issued MNs in these key operational categories:

- Reserve Market Notices – AEMO issued reserve-related MNs for both actual and forecast LOR conditions.
- RERT Market Notices – when AEMO activated RERT services, we informed market participants including relevant contracted RERT service providers, at appropriate times as required by internal procedures and contract terms.
- Reclassification Market Notices – AEMO issued these MNs whenever we reclassified a non-credible contingency as credible contingency (see Section 3.5.2), so the prevailing system risk could be managed effectively.
- Extreme Temperature Market Notices – AEMO issued MNs proactively to market participants when forecast temperatures in metropolitan cities were equal to or greater than the generation capacity reference

---

[32] AEMO publishes Market Notices at http://www.aemo.com.au/Market-Notices.

temperatures[33], asking participants to review their generating plant bids considering the local temperature and revise availability as necessary.

- Directions – AEMO issued directions to generating plant to maintain system security or reliability. In these cases, AEMO issues MNs to all Market Participants informing them of either the requirement to direct, or that a direction had occurred. Individual MNs are also issued to the relevant Market Participant, with specific instructions AEMO requires the Market Participant to take to keep the system secure or reliable.

6.1.2 Industry engagement

AEMO continued to engage closely with generators, Market Network Service Providers, and TNSPs and Distribution Network Service Providers (DNSPs) throughout the year about operational matters. AEMO proactively communicates with these participants about their plant availability and/or any issues regarding their operation.

Throughout summer, AEMO maintained proactive dialogue with generators whenever high temperatures and demand was forecast in any region.

AEMO also developed a new procedure and modified our systems this summer for generators to submit additional information regarding the availability of their assets, known as recall information. This avoided any uncertainty between AEMO and the asset owner about the time it may take to bring a specific generator into service. When there are foreseeable circumstances which may require direction/intervention in the NEM, AEMO may initiate contact with scheduled generators to seek additional information on any capacity that can be recalled, and the associated recall time according to this new procedure.

It is common operational practice to communicate with TNSPs regarding their planned network outages via the Network Outage Scheduler (NOS) tool. This tool identifies specific network elements which may be removed from service for maintenance, the times when the outages will occur, and the physical constraints on the network. This information is visible to the market and updated every 30 minutes. During summer 2017-18, when AEMO identified any planned outages likely to impact the supply or reserve conditions significantly, AEMO initiated a review of the outages with TNSPs well in advance to assess the risk to the power system. Where necessary, planned outages were rescheduled.

6.2 Government communications

6.2.1 Weekly Responsible Officer (RO) conferences

Under AEMO's Power System Emergency Management Plan (PSEMP), weekly "7-Day Summer Readiness Outlook" meetings were held throughout summer to provide information about NEM supply-demand and weather forecasts for the coming week to jurisdictions (the governments of the Australian Capital Territory, New South Wales, Queensland, South Australia, Tasmania, and Victoria, and the Commonwealth Government). Some industry representatives, who had specific emergency management responsibilities in their states, also attended the meetings.

Information on the gas system, including current incidents, supply demand forecasts, plant and network equipment outages, and maintenance, was also discussed, to support fuel availability for GPG. The introduction of this information into these discussions was a key learning from the inaugural gas and electricity emergency exercise held before summer.

Jurisdictions were represented at these meetings by Responsible Officers (ROs), Jurisdictional System Security Coordinators (JSSCs), Jurisdictional Designated Officers (JDOs), and Jurisdictional Contact Officers, who are appointed in each state as a key point of contact for power system emergency events. Information from these meetings was then used to brief Ministers and senior government officials on power system conditions and the forecast outlook.

6.3 Media and consumer communications

AEMO's new web portal, *Energy Live*, is designed to be an independent, consumer-friendly source of information and news, to encourage everyone to have informed energy conversations. It recorded between 4,000 and 7,500 monthly users over summer, with feature article *Energy Facts and Safety Tips* generating more than 2,000 unique page views.

The site acted as a valuable go-to source of information, where AEMO could share simple information with consumers and increase energy literacy by using fact sheets, podcasts, videos, and infographics.

AEMO also used social media to reach the public, with some summer posts reaching more than 30,000 users.

---

[33] The generation capacity reference temperatures, and effects of temperature on generation, are explained under the "background information" tab in each regional spreadsheet on AEMO's Generation Information webpage, at http://www.aemo.com.au/Electricity/Planning/Related-Information/Generation-Information.