



ADVICE TO COMMONWEALTH
GOVERNMENT ON
DISPATCHABLE CAPABILITY

Published: **September 2017**



IMPORTANT NOTICE

Purpose

AEMO has prepared this document to provide advice to the Commonwealth Government on matters relating to dispatchable capability in the National Electricity Market (NEM), as requested by the Hon Josh Frydenberg, Minister for the Environment and Energy.

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 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.

© 2017 Australian Energy Market Operator Limited. The material in this publication may be used in accordance with the [copyright permissions on AEMO's website](#).



EXECUTIVE SUMMARY

This report responds to the Commonwealth Government's request for advice on the level of dispatchable resources required to maintain the reliability of the electricity supply system underpinning the National Electricity Market (NEM). AEMO's advice and recommendations set out herein reflect analyses undertaken both as part of its responsibilities under the National Electricity Rules and in consideration of the specific questions raised by the Commonwealth.

AEMO's advice:

The NEM is not delivering enough investment in flexible dispatchable resources to maintain the defined target level of supply reliability, as the transition from traditional generation to variable energy resources proceeds. This was vividly illustrated by the load-shedding events of February 2017 and by the Finkel Review analysis. Most stakeholders see changes to market rules as the most economically efficient way to remedy this deficiency. AEMO forecasts of NEM demand and published investment plans confirm the urgency of this task and short-term measures will be necessary until a long-term solution is agreed and becomes fully effective.

AEMO's recommendations:

- **Prior to summer 2017-18:** A strategic reserve of around 1,000 megawatts (MW) of flexible dispatchable energy resources is required to maintain supply reliability in South Australia and Victoria over next summer. AEMO is already acting to deliver this under our summer readiness plan.
- **Up to 2021-22:** Progressively decreasing levels of strategic reserve will be required over the next four summers, provided there is no unforeseen major loss of existing resources. New mechanisms to deliver these reserves must be identified and in place in time for 2018-19.
- **Liddell Power Station retirement:** Prior to the retirement of Liddell (announced by AGL to occur in 2022), around 1,000 MW of new investment is expected to be required to preserve reliability of supply in New South Wales (NSW) and Victoria at the NEM standard. Mechanisms should be established in the NEM design to address this, and similar requirements, for the long term.
- **Stakeholder consultation:** Action on each of the above should include much broader and deeper stakeholder consultation than has been possible in the preparation of this initial advice.

AEMO caveats on this advice:

- Uncertainty in all NEM forecasts remains extremely high, so all estimates of dispatchability must be regarded as subject to progressive refinement.
- AEMO, like every system operator in the world, targets a defined market reliability standard (NEM: 99.998%) and cannot promise or deliver 100% supply reliability. There are a number of variable factors that can, at one time or simultaneously, have an adverse impact on the power system and are outside AEMO's control, such as major environmental events, bushfires or floods, and/or unplanned asset faults and failures.

AEMO's focus is to supply economically efficient, secure and reliable electricity to all consumers in the NEM and in Western Australia's Wholesale Electricity Market. AEMO's operators continuously select resources to achieve security-constrained economic dispatch. This means that at all times, AEMO operates the system to balance supply and demand for power using the most economic resources available, consistent with maintaining a secure and reliable system. While AEMO applies economic principles to do this, power systems must operate in accordance with the laws of physics. This means



that to achieve economically optimal outcomes, the NEM must have both the volume and type (i.e. flexibility, dispatchability).

Balanced, secure grid operation can be achieved with a varied portfolio of resources. These can include traditional and new types of generation on the grid, storage facilities such as batteries and pumped hydro, demand resources located behind the meter or flexible demand, or network capability. As the independent operator, AEMO remains indifferent to the fuel used by a resource or its ownership. Its primary concerns are the flexibility, dispatchability, regional location and visibility (and predictability) of resources. AEMO's objective is to evaluate current and emerging system needs and to evaluate whether the market is adequately supporting retention of existing resources and investment in new resources required to balance the system and deliver optimal economic outcomes for consumers. AEMO welcomes the expanded national planning role contemplated in the Finkel review as an extremely helpful tool to achieve that objective.

As numerous reports have pointed out, the NEM is rapidly transforming from a system that was dominated by more traditional large-scale thermal and hydro resources, to one that now accommodates significant and growing numbers of variable renewable distributed energy resources, both on the grid and behind the meter.

In earlier studies, AEMO identified that while renewable resources like wind and solar can provide low cost energy to the grid and help meet environmental goals, they do not currently supply the type of essential frequency control, system strength and inertia services necessary to keep the system secure.

In response to this concern, AEMO initiated the Future Power System Security (FPSS) program, to examine the key security needs for the evolving system. This work, together with additional reviews completed by the Australian Energy Market Commission (AEMC), and the Finkel review¹, led to a number of recommendations to develop specific mechanisms to require networks to install the capabilities to ensure secure operations.

The Commonwealth's inquiry follows a similar path. To estimate both the level of need for flexible dispatchable resources and the timing of this need, AEMO took a multi-faceted approach. Our analysis considered the forecast needs of the system, market changes, and investment trends. AEMO also spoke with market participants (including representatives of major consumers, suppliers, networks, and investors) and the AEMC, and engaged the Brattle Group, an internationally recognised energy economics consultancy, to review how other markets around the world are addressing this issue.

In order to maintain a reliable system, AEMO must have the ability to direct resources on and off the system to meet changing system balance requirements. As more renewable resources and rooftop solar have entered the grid, the system has become more variable and economically challenging for traditional supply investments. Since by their nature, renewable resources like wind and solar are not controllable by operators to the same extent as traditional generators, AEMO's analysis identifies and begins to address a growing concern that the market today does not provide sufficient incentive to owners of flexible and dispatchable resources to either increase their capability or invest in new resources. We note that absent to changes, we face an increasing and unacceptable risk that there will be insufficient capability in the system to meet NEM reliability standards. In turn, this exposes consumers to a heightened risk of involuntary and unacceptable load shedding.

AEMO notes that the Finkel review also explored this issue and recommended that additional mechanisms, specifically the need for a security reserve should be assessed and a Generator Reliability Obligation should be developed. Consequently, in many respects the analysis reported here amplifies the concerns expressed in the Finkel review, and also provides additional information to support the relative urgency of implementation of these approaches and recommended considerations.

Finally, AEMO observes that while it consulted with market participants and the AEMC, its ability to consult in depth was constrained by the time allotted to prepare the report. Consequently, AEMO's

¹ *Independent Review into the Future Security of the National Electricity Market*



recommended approaches to maintain reliability in the NEM also specify the need for broader consultation to design the approaches required to achieve this goal in the necessary timeframe.

Key findings

This report outlines the following findings from our analysis:

1. Declining demand from the grid due to growth in rooftop PV and energy efficiency improvements, coupled with the growth of more variable demand and low operating cost variable renewable resources, is eroding the business viability of traditional baseload generation and increasing the need for dispatchable resources that can operate more flexibly than traditional baseload supply.
2. AEMO's 2017 *Electricity Statement of Opportunities* (ESOO) shows that targeted actions already underway to provide additional reserves² are necessary to reduce heightened risks of unserved energy (USE³) and a concomitant increased potential that Victoria and South Australia could not meet the NEM reliability standard in 2017–18. To mitigate this risk, AEMO is pursuing around 1,000 MW of strategic reserves in its summer readiness plan.
3. The 2017 ESOO also shows that, given the limited reserves in the south-east of the NEM, risks of USE will continue beyond this summer over a 10-year horizon in Victoria, South Australia, and NSW. Factors in this extended period of risk include:
 - Following the AEMC's June 2016 rule change modifying the Reliability and Emergency Reserve Trader (RERT) mechanism, long notice RERT contracts such as those currently being established by AEMO for this summer cannot be established beyond November 2017, so new Rules mechanisms will be required for future periods of tight supply.
 - Almost all projected generation investment in the NEM over coming years is renewable resources of limited dispatchability.
4. AEMO's analysis indicates a strategic reserve will continue to be required in summers beyond 2017–18. However, the amount of required reserve will progressively reduce over the four summers to 2021–22, as peak demand continues to be moderated by additional rooftop PV, new large-scale renewable generation, and ongoing energy efficiency improvements. It will then increase again in NSW and Victoria after Liddell Power Station closes (announced for 2022).
5. AEMO's initial analysis indicates the NEM will need as much as 1,000 megawatts (or one gigawatt GW) of additional new flexible and dispatchable resources to replace the contribution of Liddell. Further analysis is warranted to confirm this preliminary estimate. However, the reserve requirement would increase if either projected new resources do not come online as currently forecast, more generation is retired, or any existing generators were to suffer catastrophic failure.
6. The proposed strategic reserve of flexible dispatchable capability in this, and coming summers, will enable AEMO to respond in emergency periods to reduce the risk of disruption of supply to business and household consumers. USE risks could be higher if:
 - As occurred in February 2017, temperatures were hotter than average (driving increased demand), especially if this were to occur simultaneously across multiple regions; or
 - Existing generation output was lower (due for example to equipment failure, fuel constraints, or earlier retirement than currently anticipated), or
 - Investment in new renewable generation was delayed or had reduced output at times of peak demand.

Similarly, if these factors were to vary in the opposite direction, USE risk would fall.

² Such as the South Australian Energy Plan and AEMO's summer readiness plan, including use of the Reliability and Emergency Reserve Trader (RERT) mechanism and its demand response program with the Australian Renewable Energy Agency (ARENA).

³ USE is the term used in the National Electricity Rules to quantify requirements for load shedding as a last resort to balance supply and demand.



7. From its analysis, AEMO has concluded that the current market design is unlikely to provide adequate and sustained signals to the market to incentivise development of new flexible dispatchable resources at the level required to maintain system reliability over the medium and long-term.
8. AEMO has also concluded that given the short time available to bring new resources online, the value of avoiding unnecessary investment in new power plants with uncertain long-term business viability, and the value of maintaining fuel diversity to manage price risk, consideration should also be given to the possible extension of the capability of some existing resources to support the energy transition now underway. This could take the form of life-extension or investment to increase the flexibility of current dispatchable resources, and thereby improving their business viability and extending their life in the market.
9. The Brattle Group's report sets out how the issue of reliability has been addressed in various international electricity markets using different mechanisms. Some energy-only markets like the NEM have adopted strategic reserves to provide the system operator with operational reserves to be used during events of severe system stress. It indicates that strategic reserves are potentially compatible with the NEM market design, in that they can be designed to not interfere with market competition and investment signals.

Recommendations

AEMO makes the following recommendations to ensure there is sufficient flexible dispatchable generation in the NEM to preserve supply reliability through the next decade of transition:

1. AEMO, in consultation with the AEMC, its Expert Panel and stakeholders should immediately develop a strategic reserve mechanism to mitigate the near-term risks of USE in the power system and avoid disruption of supply to consumers. This mechanism should then be considered for recommendation by the Energy Security Board (ESB). AEMO recommends the development of a strategic reserve option for use from summer 2018–19 to summer 2020–21.
2. AEMO should consult with industry and consumers through its Expert Panel and working groups, the academic community, and the AEMC, to immediately begin development of a longer-term approach to retain existing investment and incentivise new investment in flexible dispatchable capability in the NEM. The aim would be to complement the development of the strategic reserve mechanism outlined above. This mechanism should then be considered for recommendation by the ESB, with the approach to be in place before 2021–22 in readiness for Liddell's retirement.

Consistent with the Energy Council's adoption of the Finkel review recommendations and its report to COAG on implementation, this work should be completed for consideration by the COAG Energy Council by mid-2018.



CONTENTS

1. INTRODUCTION	6
1.1. AEMO's role – balance the system	6
1.2. The short-term and longer-term risk	6
2. THE CURRENT ENVIRONMENT AND TRANSFORMATION CHALLENGE	7
2.1. Changing generation mix	7
2.2. Changing investment trends	7
2.3. Electricity Statement of Opportunities (ESOO) analysis	10
2.4. Operational challenges	13
2.5. System security considerations	15
3. STAKEHOLDER CONSULTATIONS	17
4. RECOMMENDATIONS	18
4.1. Short-term – strategic reserve mechanism	18
4.2. Longer term – extended market design	19



1. INTRODUCTION

1.1. AEMO's role – balance the system

As the operator of the National Electricity Market (NEM) power system and wholesale power markets, AEMO's principal concern is to identify whether the system has sufficient levels and types of investments in the resources necessary to operate an efficient, secure, and reliable power system. AEMO applies what is known as security-constrained economic dispatch, so at all times it is dispatching the most economic resource necessary to maintain the system balance.

To maintain a secure and reliable power system, AEMO requires a reliable portfolio of dispatchable energy resources that are capable of responding quickly and effectively to the dynamic needs of the system on a locational and NEM-wide basis. The physics of the power system define the requirements for balance.

AEMO's goal is to provide clear advice on the system needs and maintain an informed view of appropriate mechanisms to meet those needs from the market, whether supply based, demand based, storage or network investments, or a combination of these.

Based on the changes in the system, combined with AEMO's observations and stakeholder feedback, AEMO is concerned that the current energy-only market design does not sufficiently value resource flexibility and dispatchability, and that, in the absence of a market design change, it is unlikely sufficient investments in new resources or existing resources that provide dispatchable capability will occur.

These observations are consistent with similar findings in the Finkel review.

1.2. The short-term and longer-term risk

AEMO's 2017 ESOO modelling shows reserves have reduced to the extent that there is a heightened risk of significant unserved energy (USE) over the next 10 years, compared with recent levels. This analysis also shows the current reliability standard (0.002% of USE) may not be met under some plausible contingency events, such as higher demand or the extended unavailability (or early retirement) of existing generation.

In this report, AEMO recommends actions to mitigate the risk in both the short and longer-term:

- The highest forecast risk is in 2017–18, with the likelihood of a shortfall and load shedding being between 39% and 43% in Victoria and between 26% and 33% in South Australia. Targeted actions are underway to secure additional reserves and reduce these risks, including the RERT, the AEMO/Australian Renewable Energy Agency (ARENA) demand response program, and the South Australian Energy Plan.
- After the coming summer, forecast USE risks continue, but at a lower level, as demand moderates due to efficiency gains and rooftop photovoltaic (PV) penetration, and increased variable generation is commissioned. The risks would be much higher if demand was higher, any generation was unavailable for an extended period, or generation was withdrawn from the market. As a result of recent NEM rule changes, AEMO is unable to procure new long notice RERT after November 2017, so other strategic reserve mechanisms are required to mitigate these risks.
- The announced 2022 retirement of the Liddell Power Station results in heightened USE risks in NSW and Victoria. These risks become even more substantial if more generation plant retires (probable given increasing variable generation undercuts high capacity dispatchable generation energy provision) or catastrophically fails (possible given the age of some plant), or there are fuel shortages. In this longer-term timeframe, a more considered, alternative mechanism for retaining existing and inventing new dispatchable/flexible resources will need to be developed to mitigate these USE risks.



2. THE CURRENT ENVIRONMENT AND TRANSFORMATION CHALLENGE

2.1. Changing generation mix

Like other energy systems around the world, the NEM is undergoing unprecedented transformation, with radical changes to the dynamics of the power system, including:

- Progressive retirement of an aging traditional power generation fleet.
- Flattening grid demand growth.
- Increased efficiencies in gas-powered generation (GPG).
- Rapid growth of large-scale variable renewable energy resources.
- Increasing penetration of rooftop PV.
- Advances in storage capability.
- The ability to access and exploit increasingly large amounts of data.

Older baseload units are finding it increasingly difficult to compete in this environment. These units have historically relied on relatively constant high production levels and stable revenues. In general, they are not well suited to quickly responding to rapidly varying energy system needs. Their business model will be further challenged by the increasing variability in the system and falling costs of competitive sources of energy.

Evidence of these radical transformations can be seen in the portfolio of resources supplying the grid in the NEM. Over the past decade, 5,199 megawatts (MW) of baseload generation has retired, and has been replaced by 2,895 MW of GPG, 273 MW of hydro, 91 MW of liquid fuel, 2,965 MW of wind, 265 MW of large-scale solar, 240 MW of coal plant expansion, and 186 MW of other sources of generation, such as biomass.

This change in the generation mix has recently become faster, with new supply resources since 2014 being predominantly made up of renewables. At 1 July 2017, there were 21,721 MW of connection requests in train in the NEM, comprising 10,678 MW for large-scale wind and 11,043 MW for large-scale solar.

In addition, the NEM has witnessed unprecedented growth of rooftop PV units – from 14,064 units in 2008 to 1,691,840 units (with an estimated output of 4,917 MW) in 2017.

2.2. Changing investment trends

The design of the NEM is such that high current and forward wholesale prices should provide a signal for investment in new dispatchable generation to mitigate the risk of a supply shortfall.

Currently, AEMO would expect to see a pipeline of connection proposals for new dispatchable generation, however, this is not the case.

Feedback from market participants and investors is that it is more financially secure to invest in renewable resources and that they are seeking greater market and policy certainty to be able to make investments in new dispatchable generation.

In the absence of such certainty, investors will increase risk premiums in their financial models (which, in turn, will make investments seem less attractive), and they will continue to evaluate other options and defer making decisions.

The design of the NEM requires an active derivative market to allow participants to hedge their risks. This is achieved through a bilateral over the counter (OTC) contract market and an exchange-based futures market operated by the Australian Stock Exchange (ASX).



With the retirement of baseload generation, there is evidence of a reduction in liquidity in the derivative market, and this would seem to be at least partially responsible for the recent increase in wholesale prices. However, while general liquidity might have declined, there are specific areas where a lack of liquidity has long been a problem, such as in South Australia, where traded volumes are significantly less than in the other states.

For investors considering investing in new dispatchable generation, there is little certainty to be derived from the forward market. Most of the trading only covers the next two years, with very little in the way of price signals beyond this.

For a potential GPG investment or investment to increase the capability of an existing generation or network resource, the problem is compounded by the absence of a robust forward market and a contract market that is opaque and illiquid. This means the key revenue and cost items in the investment case can be hard to substantiate.

The changes occurring in the generation and demand sectors inevitably flow through to the wholesale market, and impact price and liquidity. For example, a reduction in baseload generation is likely to lead to a reduction in the volume of swaps being offered to the wholesale market, and an increase in their price. Conversely, changes in load shape are likely to lead to a reduction in demand for swaps, but may increase demand for caps.

All these changes are set against a background of a changing market structure. Vertically integrated players can hedge all, or some, of their load internally, and may only need to use the wholesale market for balancing their position. New entrant retailers usually do not have their own generation, so rely on the wholesale market and derivative market to manage their risk.

The concepts outlined in this section and the previous section are illustrated in the following two charts, which show the changing generation mix in the NEM over the last 10 years, and what is forecast over the next 10 years compared with forecast demand.

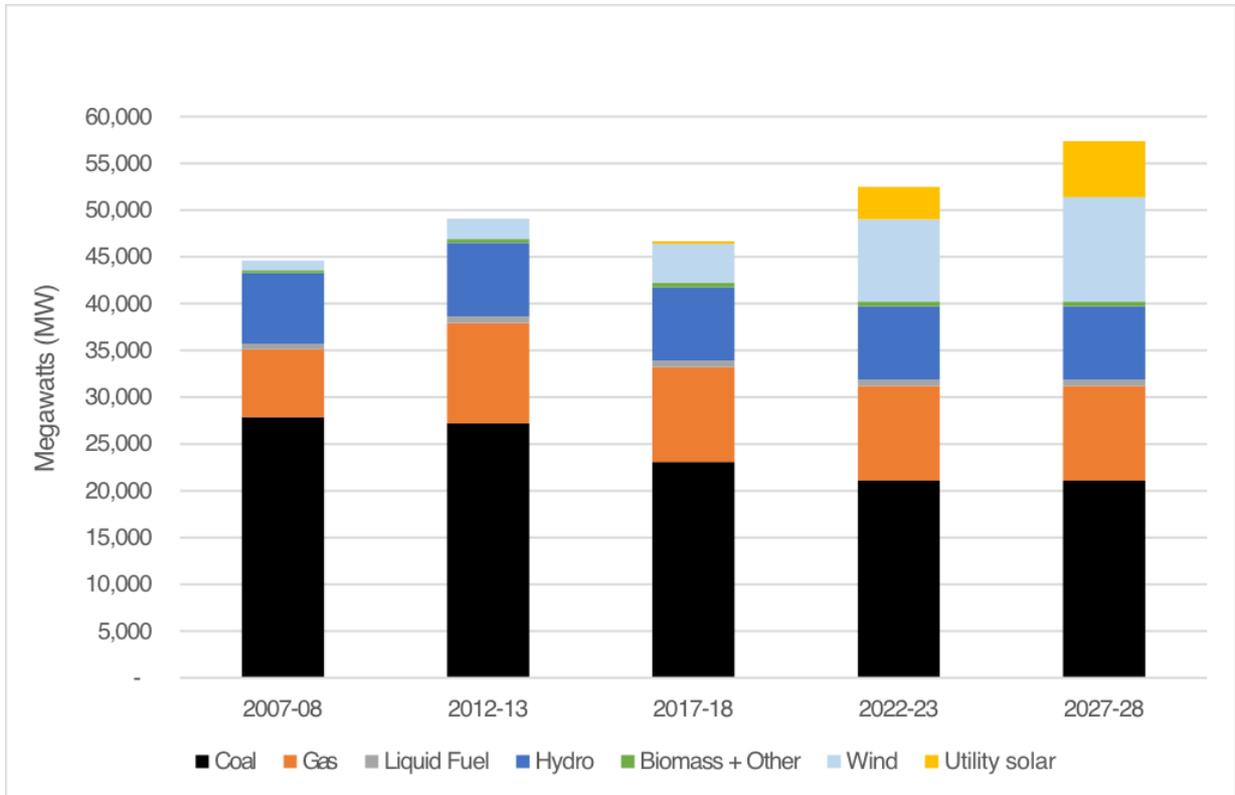
Figure 1 shows the actual or expected installed generation capacity in the NEM from 2007–08 to 2027–28. Figure 2 shows an indicative likely generation capacity forecast to be available during peak conditions over the same 20-year period. For example, dispatchable generation is 95% of installed capacity to allow for outages and lower ratings, and renewable generation is 5% of installed capacity.

For simplicity, demand response is not included here, as historically it has been a relatively small component. The illustrative peak NEM demand is a 10% Probability of Exceedance (POE)⁴ forecast, using average five-year diversity between regional peaks.

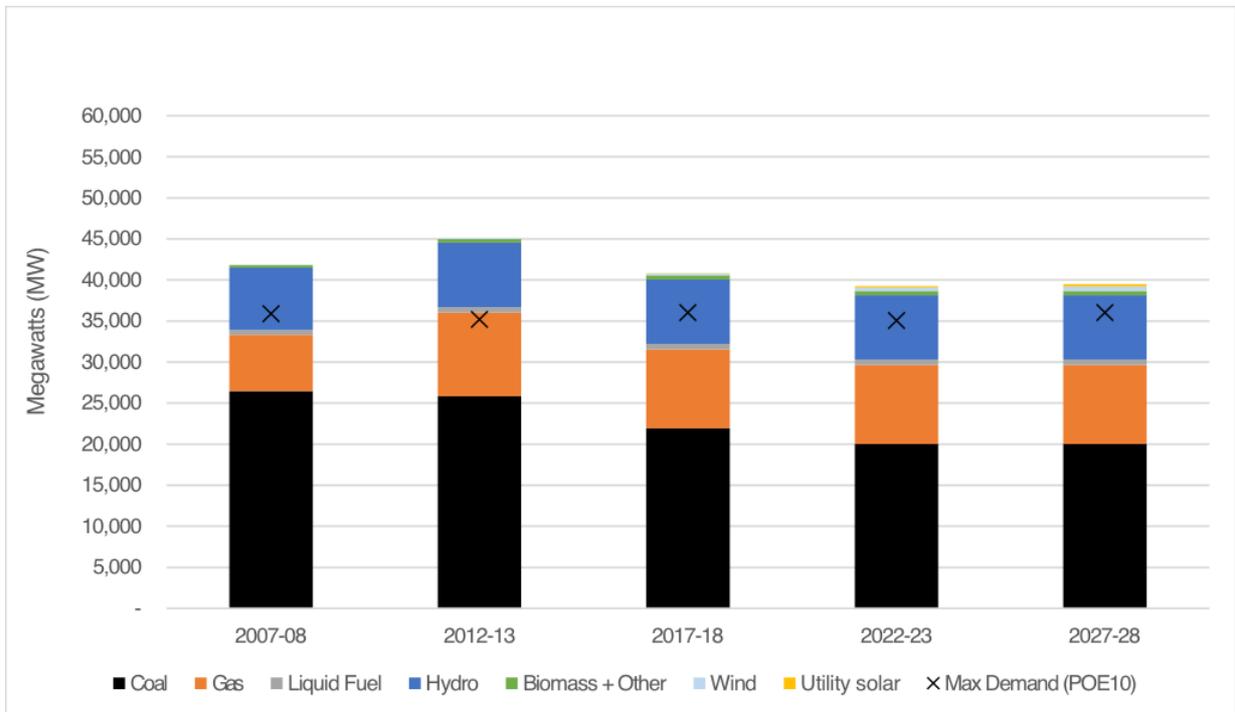
⁴ POE, or probability of exceedance, refers to the likelihood a demand forecast will be met or exceeded. A 10% POE forecast is expected, on average, to be exceeded once every 10 years, and indicates demand under more extreme weather conditions.



1. NEM installed generation capacity by type, 2007–08 to 2027–28



2. NEM available capacity at time of 10% POE forecast demand, 2007–08 to 2027–28





The key points highlighted by these two charts are:

- In 2007–08, forecast reserves (available capacity above forecast peak demand) were around 13%. During the second half of the 2000s, the NEM experienced a number of load shedding events.⁵ This shortfall in reserves was due to higher than expected demand growth, largely driven by air-conditioning load and positive economic conditions.
- In the five years after 2007–08, an additional 5 GW (net) generation was installed in the NEM, due to forecasts of annual maximum demand growth continuing at high levels. However, changing economic conditions, coupled with reduced demand through increased energy efficiency (including installation of rooftop PV) resulted in a flattening of peak demand forecasts, which resulted in higher reserve margins by 2012–13.
- Over the five years from 2012–13 to 2017–18, there was a significant reduction in dispatchable generation (coal, gas, liquid fuel, hydro, biomass), and a rapid increase in variable generation (primarily wind). This results in a forecast reserve margin in 2017–18 of around 12%, slightly less than that in 2007–08.
- For the next 10 years from now to 2027–28, reserve margins are forecast to continue to decrease, as dispatchable generation retires and predominantly variable generation is installed. Based on current projections, the reserve margin will reach less than 10% from 2022–23.
- Based on the load shedding events of the second half of the 2000s, which occurred when reserve margins were similar to today, the above charts reinforce the heightened risks of load shedding in 2017–18, and confirm that these risks will continue to remain high if only variable generation continues to be installed in the NEM without any firming capacity from generation or demand response.

2.3. Electricity Statement of Opportunities (ESOO) analysis

The reliability standard

The 2017 ES00 assessed supply adequacy across the NEM to 2026–27 with reference to the current NEM reliability standard, which specifies that the level of expected USE should not exceed 0.002% of consumption per region, in any financial year. The current NEM reliability standard is at the lower end of international standards, and considerably lower than in some OECD countries.

The reliability standard is a planning standard that was designed to deliver an economically efficient outcome for the market (in other words, where the cost of additional capacity was equivalent to the avoided cost of load shedding). It has an implicit acceptance of load shedding (for example, the 0.002% standard allows up to 1,320 megawatt hours (MWh) of load shedding in NSW over the course of the 2017 calendar year).

Until recent years, the forecast USE risk has been low. Since the retirement of Hazelwood Power Station was announced in 2016, the risk of USE approaching the standard has been an identified risk. This trend highlights an increased likelihood of load shedding events in the NEM due to the reduction in firm supply capacity over recent years as dispatchable generators have retired.

The 2017 ES00 analysis shows that a number of regions in the NEM (Victoria, South Australia, and NSW) are forecast to approach the 0.002% reliability standard under the base case conditions in the 10-year outlook period, if targeted actions are not taken to secure additional reserves.

Moreover, under a set of plausible scenarios, such as higher demand conditions or the loss of a large generator over summer, the ES00 forecasts the reliability standard would not be met in the most at-

⁵ These events were due to demand being higher than the available supply or due to pre-emptive or automatic tripping of load due to risks to the transmission system or actual transmission faults. Having additional reserves across the NEM would have reduced the extent of load shedding, however these events are by their nature more locational, particularly the transmission related events.



risk regions, namely South Australia, Victoria, and NSW. Targeted action is recommended for subsequent summers to provide additional reserves to reduce these heightened risks of load shedding.

Short-term risks being mitigated

Summer 2017–18

The ESOO modelling for summer 2017–18 shows a significant forecast USE range of 0.0015% to 0.0025% in South Australia and 0.0017% to 0.0023% in Victoria, if the actions planned through the South Australia Energy Plan, RERT, and the joint AEMO/ARENA demand response program were not implemented.

ESOO analysis indicates that, without these actions, South Australia has a 26% to 33% risk of some load shedding in summer 2017–18 with an average magnitude of 81–97 MW (~3% of forecast 2017 peak demand), but could reach 243 MW. If USE occurs it is likely to last for two to four hours. Victoria has a 39% to 43% risk of some load shedding in summer 2017–18 with an average magnitude of 218–229 MW, but could reach 760 MW. If USE occurs it is likely to last for four to five hours.

The actions to secure a reserve have been taken because this level of risk is likely to be unacceptable for households and businesses which are now more dependent on technology and have grown used to receiving a much more reliable supply over the past decade than the standard requires. The amount of concern raised following the February 2017 directed customer load shedding in South Australia and NSW suggests limited tolerance to loss of supply events, especially during heatwave conditions.

While ESOO analysis is based on multiple statistical simulations that produce a probability distribution function for USE, the results are backed up by AEMO's MT PASA⁶ outlook, which indicates the risk of Loss of Reserve (LOR) conditions for this summer. Although the purposes of the ESOO and MT PASA are different (MT PASA is used for near-term operations and assessment of generator preventative maintenance planning, while the ESOO compares medium-term supply adequacy against a planning standard), as are the inputs (MT PASA uses more granular, short-term generator availability information, while the ESOO uses longer-term advice provided by generators), they are both showing a reduction in reserves, further reinforcing the necessity of actions to secure a reserve.

The system is finely balanced, and, with reduced reserves, probable events such as heatwaves, low renewable generation and/or plant or transmission outages result in disproportionate increase in USE risk. The 2017 ESOO modelling shows that, absent the number of actions that have been undertaken to increase available resources, the risks of USE and of not meeting the reliability standard would be much higher if (as happened in February 2017) temperatures were hotter than average (thus increasing electricity demand especially simultaneously over multiple regions), existing generation output was lower (such as generator failure, generator reduced capacity at high ambient temperatures, fuel constraints, earlier retirement), or new renewable generation was delayed. Explicitly, if a large thermal unit in either South Australia or Victoria was not available over summer, expected USE would be above the reliability standard in both regions.

Summer 2018–19 to summer 2021–22

Beyond summer 2017–18, the forecast risk of USE reduces in South Australian and Victoria, due to increasing renewable generation and reductions in operational demand driven by energy efficiency and continued uptake of rooftop PV. However, these USE levels are still significant, particularly when compared with recent performance prior to summer 2016–17.

⁶ MT PASA, or Medium Term Projected Assessment of Supply Adequacy, which is updated routinely by AEMO to provide information to the market. See: <http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Market-Management-System-MMS/Projected-Assessment-of-System-Adequacy>.



Moreover, if the reduction in operational demand does not occur, or if there is a major loss of a thermal generation unit, there will continue to be an elevated risk of USE at similar levels to that expected for the 2017–18 summer.

As well as highlighting that ongoing USE risks exist beyond the 2017–18 summer, this discussion highlights that strategic reserve requirements depend on a number of factors. Requirements need to be assessed on at least an annual basis, and the requirement may go up and down each year.

Reducing the short-term risk – strategic reserve requirements

Action has been taken to secure a strategic reserve for the 2017–18 summer through the RERT provisions and joint AEMO/ARENA demand resource program.

The strategic reserve of around 900–1,000 MW that AEMO is pursuing is warranted for the coming summer, on the basis of:

- An additional 970 MW additional capacity across South Australia (250 MW) and Victoria (720 MW) will lower the likelihood of USE to one in 10 years.
- As outlined in the following table, if there is a coincident extreme peak in South Australia and Victoria, with renewable generation operating at 5% of its maximum output, there would be a shortfall of 926 MW this summer, even with all other generation at full capacity and all transmission in service, and no allowance for pre-contingency system operational conditions.
- A strategic reserve option for use from summer 2018–19 to summer 2020–21 is recommended to mitigate the near-term risks of USE in the power system and disruption of supply to consumers.

1. Victoria and South Australia supply-demand balance at extreme conditions

	2017–18 (MW)	2018–19 (MW)
Firm generation capacity available across Victoria and South Australia*	11,646	11,846
Capacity of intermittent generation available under severe conditions (5% contribution)	156	172
Total capacity across both regions	11,802	12,018
Victoria and South Australia peak demand (10% POE with coincident peak)	13,518	13,255
Capacity deficiency across Victoria and South Australia	-1,716	-1,237
Maximum available interconnector capacity Into Victoria from New South Wales and Tasmania)**	790	790
Supply shortfall across Victoria and South Australia	-926	-447

* Firm generation capacity reflects the summer temperature de-rated capacity, which reflects high temperatures at the time of peak demands.

** Allows for voltage instability and likely generation dispatch that reduces interconnector capability.

The above table highlights the impacts of the uncertainty associated with variable generation and its ability to provide supply during coincident peak demand conditions. AEMO's records show that wind generation output within a region during peak conditions can fall to as low as 2% of installed capacity, however, given the scale of the NEM, geographic diversity tends to increase the average output of variable generation, and 5% of capacity has been allowed for in the above case study. The ability to achieve this geographic diversity can, however, be limited by the interconnectedness of the transmission system.



More extreme conditions would place increased strain on the supply and demand balance. Indicatively⁷, every 1 °C increase in temperature results in a 1–2% increase in demand, and also reduces the capability of transmission and generation.

Looking beyond the coming summer, Table 1 shows a continuing need for a strategic reserve, but at a lower level than this summer. While RERT provisions will be used in summer 2017–18, AEMO considers that the RERT was designed to be a source of emergency capacity which would only be required in rare circumstances, and recent NEM rule changes have ended AEMO's ability to procure new long notice RERT after November 2017.

Given the current outlook for the NEM, the RERT should be replaced with a strategic reserve that provides a level of assurance for the increased uncertainty in the power system, at least until a more wide-ranging and considered solution can be designed and implemented.

Longer-term risk

In the medium term, the retirement of Liddell Power Station in 2022 will increase the risk of USE in NSW to 0.0015% in 2024–25. The likelihood is between 29% and 46% that USE will eventuate in NSW in 2024–25, averaging from 224–290 MW lasting from two to six hours (depending on supply and demand variations).

The risk of USE also increases in Victoria after the closure of Liddell Power Station, reaching up to 0.0010% USE by 2026–27. To reduce the risk of USE to a one in 10 year likelihood after the closure of Liddell would require in the order of 1,010 MW (across NSW and Victoria) of additional dispatchable resources in 2024–25. However, given the uncertainties in the NEM noted above, there are significant risks that this requirement could be higher in the outlook period.

Longer-term in the NEM, any number of events could eventuate, including increased demand, additional generation plant retirements (probable given increasing variable generation undercuts high capacity dispatchable generation energy provision), or catastrophic failures of generation plant (possible given the age of some plant), or fuel shortages (such as the Mt Piper coal mine). For example, the retirement of an additional coal plant (modelled as 1,320 MW) in NSW from 2023 could, without replacement, increase expected USE in NSW to 0.0054%, which would significantly exceed the current reliability standard.

2.4. Operational challenges

Recent events in South Australia and NSW, combined with continuing retirements of aging plant, have highlighted the growing challenges of operating the power system with increasing levels of variable resources, and reinforced the requirement for sufficient dispatchable reserves.

Weather now plays a much greater role, impacting both supply and demand. Temperature, humidity, wind speed, and cloud conditions all need to be factored into forecasting demand and the requirement for dispatchable generation.

The hot weather and variable wind conditions in Australia in February 2017 led to load shedding in South Australia on 8 February and in NSW on 10 February.

Figure 3 shows that South Australian non-dispatchable generation (rooftop PV and wind) varied significantly throughout the week, ranging from as little as 3% of effective demand on 8 February to almost 100% on 12 February.

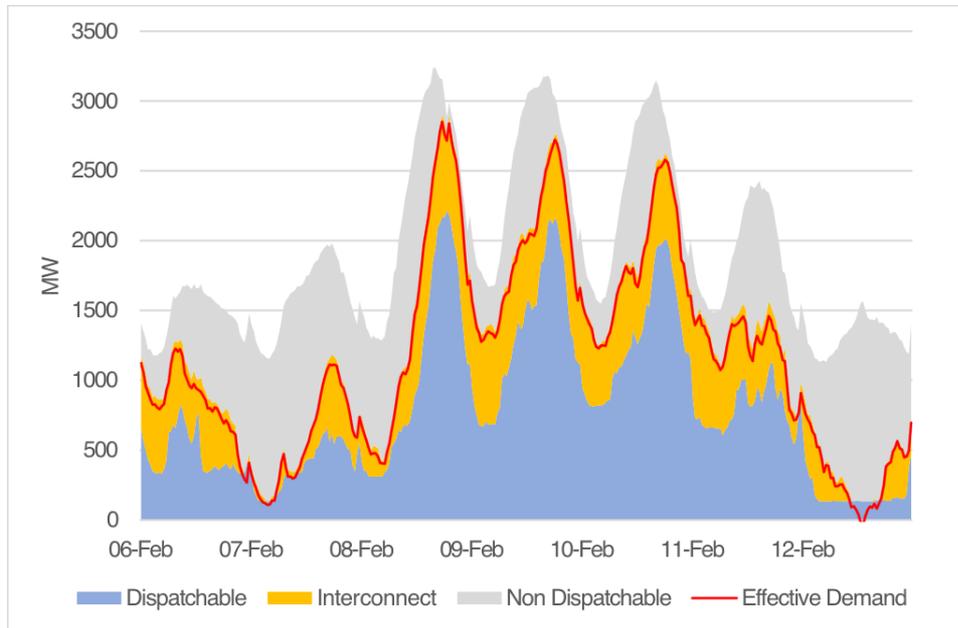
NSW (see Figure 4) experienced high heat on 10 February, with temperatures reaching 45°C in western Sydney. Voluntary load restrictions helped reduce the expected demand, but at around 16:30 EST Tallawarra tripped, which coincided with Colongra having issues starting due to low gas pressure. This

⁷ The extent of this impact is dependant on a variety of factor such as temperature verse non-temperature dependent loads, number of preceding peak temperature days, NEM region and humidity levels.

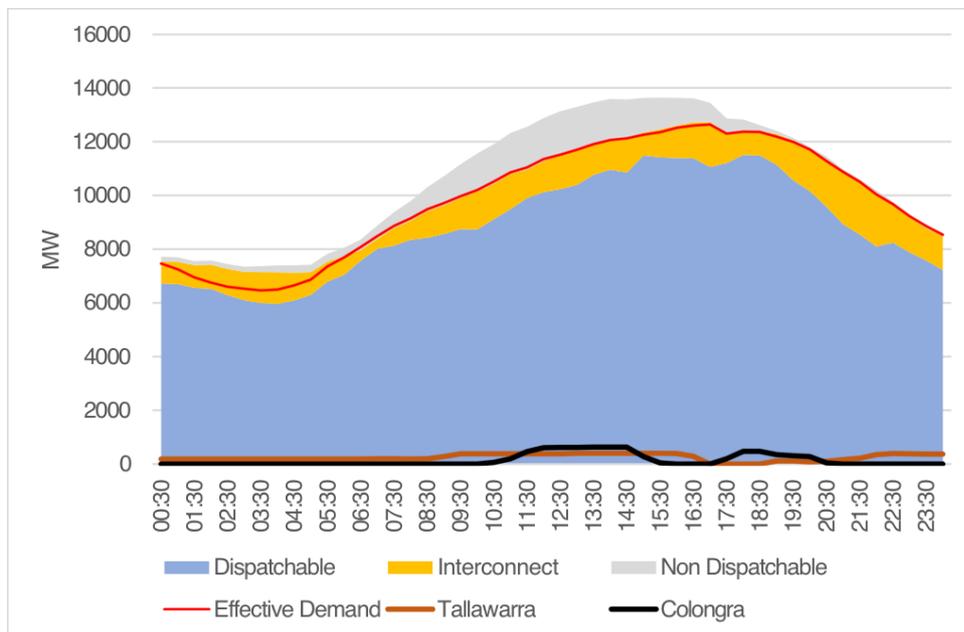


loss of dispatchable generation required AEMO to direct TransGrid to shed one Tomago plotline to restore power system security.

3. South Australia supply and demand in February 2017



4. New South Wales supply and demand on 10 February 2017



The events of the second week of February 2017 illustrate some of the challenges of managing a power system in transition. These issues are compounded by an aging generation fleet and increased complexity for generators in managing their fuel supplies due to tighter gas markets, coal quality issues, and water management strategies. The above examples also show the increasing variability on the



power system. This highlights that dispatchable resources that are more flexible in capability, such as quick starting or fast ramping up and down quickly, will provide additional benefits.

In light of these changing dynamics, it also is important to consider whether traditional measures of reliability and USE are still appropriate. AEMO notes that the AEMC is undertaking this review.

It is the combination of these operational factors, tightening reserve levels with continued and increasing risk to load shedding, and the lack of investment in the appropriate mix of resources that leads AEMO to recommend, not only short-term measures to mitigate these risks, but also a longer-term solution that will attract investment in resources which can be turned on and off by AEMO to ensure security and reliability are maintained across the system.

2.5. System security considerations

AEMO's work on the Future Power System Security (FPSS) program has identified an increasing need for a range of new or expanded services to maintain power system security with a changing generation mix. The need for investment to maintain security has been considered, and there are implications for the current market design, where these services have yet to be fully defined and valued.

Dispatchable resources can assist with resolving a number of system security issues, particularly if they are also flexible in terms of capabilities such as fast start/stop and quick ramp rates, although the type of generation (synchronous versus non-synchronous) is also a key consideration. For at least the foreseeable future, a minimum but adaptable level of existing (or new) synchronous plant that can be dispatched onto the system is critical for system security. Further analysis is required to determine the optimum means to define these system security requirements and incentivise their provision.

Synchronous versus non-synchronous

As thermal generation is displaced by variable renewable energy, such as wind and solar, it is necessary to change the way the power system is managed. For the purposes of system security, the key distinction is whether the generation is synchronous or non-synchronous rather than dispatchable, although dispatchable means it has the flexibility of being brought on or off the system, and being available when required. Coal, gas, and hydro generation are (generally) synchronous, whereas wind and solar are (generally) non-synchronous.

Synchronous generation has a range of physical attributes that have, to date, been relied on in the fundamental design and operation of the power system.

For example, inertia is provided by the large rotating masses of the generator and turbines. These rotate with the system frequency, and their mass resists changes to frequency almost instantaneously. Although some non-synchronous generation, like wind, also has rotating turbines, these technologies are partially or fully connected to the power system via power electronic interfaced equipment (inverters), which decouples their mechanical movement from the power system, thus making them ineffective in providing inertia.

While dispatchable generation is usually synchronous, it does not follow that dispatchable generation is the only source of system security services. There are other options, such as synchronous condensers which can provide inertia.

Security impact of non-synchronous generation depends on many factors

AEMO, and other international power system operators, are examining a range of options for managing power system security given the changing generation mix. The solutions adopted will determine the future need for synchronous capacity to manage power system security.

Given the range of potential solutions, it is not possible to define a single fixed minimum level of synchronous generation that is required to maintain system security.



The amount of non-synchronous generation that can be securely incorporated into the power system varies, depending on the system security frameworks put in place. As the level of dispatchable generation in the power system decreases, a point will be reached where power system reliability may fall below required levels, as there simply may not be enough generators with firm capacity to provide sufficient output during peak demand periods.

In South Australia, it is already necessary to run a hybrid system that is able to shift from being mainly synchronous to mainly non-synchronous in the space of a few hours. AEMO currently manages power system security in this environment by:

- Invoking operational constraints to limit transfers over the Heywood Interconnector.
- Limiting the output of non-synchronous generation depending on the level of synchronous units online.
- Requiring a minimum amount of synchronous generation to be online at all times.

While these are effective operational measures, there are cost impacts associated with dispatching plant out of merit order which are ultimately borne by consumers. Transmission networks play an important role in maintaining system security. There is scope for network infrastructure, such as synchronous condensers, to provide some of the system security services historically provided by synchronous generators. Additional transmission lines may also enable increased ability to import system security services.

The AEMC is currently considering the market frameworks required to ensure sufficient inertia and system strength to maintain power system security.⁸ Under the AEMC's draft determination, responsibility for procuring these services lies with transmission networks, not generators, on the grounds that this approach will result in a more efficient outcome for consumers in the long term. While AEMO agrees this is the best solution in the short term, it should only be an interim arrangement until a more holistic review of system security requirements can be undertaken, to determine if there are other measures that would result in lower costs to consumers.

It should also be recognised that current NEM market structures do not fully reward all the essential system security services provided by synchronous generators. Historically, AEMO has been able to obtain adequate levels of inertia, system strength, and primary frequency control as a by-product of synchronous generation. This approach is no longer sufficient to ensure that system security is maintained, and new market services may be required to incentivise provision of these services.

Technological developments mean that non-synchronous generators will be increasingly able to provide system security services. AEMO has developed a set of revised technical standards that are proposed to apply to all new generators connecting to the NEM, which have been lodged as a Rule change proposal.

Management of system security is becoming increasingly complex, with multiple options to resolve the challenges. The issue for system security, at least in the short term, is ensuring there is enough synchronous generation (or condensers) connected to the system to provide the required services. Beyond this immediate need, the focus should be on establishing the incentives and market mechanisms to provide the range of services currently delivered by synchronous generation in the most efficient way possible. Irrespective, as the requirements to meet system security will vary depending on a variety of factors such as generation mix and demand, it will be critical that the plant providing these services is dispatchable.

⁸ Available at: <http://www.aemc.gov.au/Rule-Changes/Managing-the-rate-of-change-of-power-system-freque>; <http://www.aemc.gov.au/Rule-Changes/Managing-power-system-fault-levels>.



3. STAKEHOLDER CONSULTATIONS

AEMO engaged with a wide range of stakeholders, primarily through representative organisations to facilitate engagement in the limited time available, and included the issues and concerns raised in its considerations. However, AEMO has not had the opportunity to consult with stakeholders at this stage on its specific recommendations.

Consultation included meetings with the Australian Aluminium Council, the Australian Petroleum Production and Exploration Association, the Energy Council of Australia, Energy Users Association of Australia (EUAA), Energy Consumers Australia (ECA), Energy Networks Association (ENA), the Minerals Council, the Reliability Panel, and a group of financiers and bankers.

A key theme in discussions with stakeholders was a desire for a market-based approach to resolving issues around reliability and security that is resource-neutral. Some stakeholders noted the links between market mechanisms relating to reliability and broader components of the market design features, highlighting the importance of a coordinated and holistic approach to considering these matters, and the importance of implementing all of the Finkel review recommendations.

Particular stakeholders identified the value of examining the existing market framework in light of the broader changes occurring in the industry, including the need for a strategic reserve (emanating from the AEMO/ARENA work), and a capacity market (drawing on learnings from Western Australia and international markets).

Reliability, security, and price were key factors. Stakeholders noted that a significant amount of baseload coal generation is expected to exit the market by 2032, highlighting the need for appropriate mechanisms to support the market's transition, including the need for dispatchable resources.

Other matters discussed were:

- Private investor confidence – stakeholders noted the need for private investor confidence and were concerned about government intervention in energy markets, particularly in an environment where investors are considering 40–50 year life assets. Stakeholders also noted the need for a government decision on climate change policy to provide the necessary certainty for investment decisions.
- Energy prices – a key issue for energy users was affordability, and discussion focused around drivers, including gas prices and structural issues, and noted difficulty in contracting. From a smelter perspective, it was noted that, within 12 months prices have increased substantially and will have significant impacts on their business and ability to continue operations in Australia.
- Market structure and contract market liquidity – some stakeholders, particularly users, raised concerns about structural issues prevalent in the existing market, particularly since the exit of Hazelwood. Stakeholders recognised the greater consolidation of industry players was negatively affecting the liquidity of the contract market.
- Role of demand side – a number of stakeholders recognised the important role that demand side, including the industrial sector, can play in the market, and noted the market needs to better incentivise demand to participate. They noted the work being done by AEMO and ARENA on the demand side could support demand side development.
- The need to consider all resources – the market needs to address security and reliability issues from a whole of resource perspective, including generation (coal, gas, pump storage, wind, battery and solar), demand, and network. In some discussions, stakeholders noted the important role the network and interconnection can play in the energy markets – supporting the backbone of the system, transporting energy between regions, and valuing and utilising resource-rich zones – and said network resources can support reliability and security issues. Some discussions noted the importance of an integrated view of the energy system, which would allow the co-optimisation of generation and transmission investments, and identifying resource zones.



4. RECOMMENDATIONS

The key finding of this report is that there is a need to retain and incentivise resources that can be dispatched as required to reduce power system risks. These resources could consist of generation on the grid, storage, demand resources behind the meter, flexible demand, or flexible network capability. However, given the increasing variability on the power system, dispatchable resources that are more flexible in capability, such as starting and stopping, or ramping up and down quickly, will provide additional benefits.

AEMO has investigated a range of approaches the Commonwealth government could undertake to address reliability or affordability needs in the NEM.

To support this work, AEMO engaged the Brattle Group to provide advice on international market experiences and drivers of reform in those markets. A copy of the report is enclosed with this advice.

The following recommendations on approaches to maintain reliability in the NEM provide for broader consultation in the development process, noting that stakeholder consultation in preparing this report did not include discussion of specific recommendations.

Timely implementation will be essential, and AEMO has also recommended target timeframes for developing proposed approaches and delivering them to the COAG Energy Council.

4.1. Short-term – strategic reserve mechanism

To address brief, but extreme periods in the NEM, AEMO proposes the development of a strategic reserve, similar to the existing RERT and AEMO/ARENA demand response procurement mechanisms.

Demand response and peaking generation (such as diesel generators) would be procured ahead of time and used to avoid load shedding, but would only be enabled during periods of scarcity pricing.

Strategic reserves provide a fairly simple and complementary addition to enhance reliability, and are used only as a last resort to avoid shedding load. This would allow AEMO to identify opportunities that might not be economical in the energy market, but would still be preferred by consumers as alternatives to load shedding.

Since strategic reserves are procured outside of the market and are not activated outside of a shortage event, they do not distort private investment signals from existing energy markets, and are compatible with a broad range of future energy or capacity market designs.

Internationally, strategic reserves are used in several energy-only markets like the NEM. Examples include Belgium, where the system operator procures a resource-neutral strategic reserves on a 1-year forward basis, and Texas, which uses a demand response program called the Emergency Response Service (ERS).

Strategic reserves are recommended because they are compatible with the NEM market design, can leverage the current efforts of ARENA, and can be implemented to secure sufficient resources by summer 2018-19.

Fixed capacity or fixed budget

Two broad approaches can be undertaken for procuring strategic reserves:

- One option is to procure a fixed quantity of strategic reserves, based on an assessment of potential shortfalls in demand in the market. This has been AEMO's approach to date in procuring RERT to meet the current NEM reliability standard. However, to go further than the current NEM reliability standard, a new standard could be created to determine the level of additional reserves to be procured.



- Alternatively, a fixed budget could be allocated to the scheme, with the maximum possible quantity of reserves to be purchased within that budget. The Texas market (ERCOT) takes this approach, allocating the budget across several distinct services and co-optimising between them.

The budget allocated to strategic reserves should reflect the additional cost to consumers that any future load shedding would impose. It could either be determined at a strategic level (for example, ERCOT allocates US\$50m/year to the scheme, a small fraction of overall energy costs), or be derived based on the expected level of future USE.

For example, if long-term market analysis indicated a potential USE of 0.0005% (approximately 1,000 MWh per annum), AEMO's survey of Value of Customer Reliability (VCR)⁹ indicate customers would be willing to pay an additional \$25m to \$50m per annum to avoid this load shedding.

A well-designed strategic reserve scheme would allow peaking resources or voluntary demand response to meet this response instead, while acknowledging that not all load shedding could be avoided. The appropriate pathway will need to be explored as part of a future detailed design stage.

AEMO's recommendation

That AEMO, in consultation with stakeholders and its Expert Panel, immediately develop a strategic reserve mechanism to mitigate the near-term risks of USE in the power system and disruption of supply to consumers. AEMO recommends the development of a strategic reserve option for use from summer 2018–19 to summer 2020–21.

AEMO is pursuing 1,000 MW of strategic reserve for summer 2017-18 as an immediate measure using:

- RERT, which allows AEMO to procure emergency reserves to meet an identified shortfall. From 1 November 2017, this framework only allows resources to be procured 10 weeks ahead of any identified need.
- The partnership between AEMO and ARENA, procuring emergency demand response for up to three years, commencing 1 December 2017.

A new strategic reserves framework could replace these services, incorporating existing contracts and providing the basis for more comprehensive, longer-term resources. This could build on the ARENA tender process, but with eligibility expanded to include all potential providers, not just demand response (as in the Belgium model). This could help support reliability while transitioning the generation fleet, and could align with the three-year notice period before closure recommended in the Finkel review.

4.2. Longer term – extended market design

AEMO also evaluated the potential risk that, absent to further change, the NEM would continue to lose dispatchable energy capability and not have sufficient investment in appropriate new capability.

This analysis led AEMO to conclude that, without extensions to the current market design, it cannot provide adequate and sustainable price signals to either maintain dispatchable capability or incentivise new development at the level necessary to maintain system reliability.

AEMO is particularly concerned that the system will need such capability to preserve reliability through the retirement of Liddell Power Station (announced to be in 2022). Time is of the essence to obtain the appropriate level of resources to support overall system reliability.

Indeed, AEMO's initial analysis indicates the market will need incremental new dispatchable resources to replace Liddell Power Station when it closes. Initial analysis shows that the amount required may be

⁹ VCR measures, in dollars per kilowatt-hour, the value different types of customers place on having reliable electricity supplies under different conditions. This figure is based on a VCR of \$24.76/kWh (residential consumers) to \$47.67/kWh (business customers). For more information see: https://www.aemo.com.au/-/media/Files/PDF/AEMO_FactSheet_ValueOfCustomerReliability_2015.pdf.



as much as 1 GW. Further analysis is warranted, however this amount would be larger if either projected new resources do not come online, or additional generation retired in the interim.

For this reason, AEMO proposes immediate development of an approach to retaining and incentivising investment in dispatchable capability in the NEM to complement the development of the strategic reserve mechanism outlined above.

AEMO is indifferent on what technology or types of resources are used. Rather, as the independent operator, AEMO's primary role is to ensure the resource is able to meet the demands of the system at a time and at a location where it is necessary (that is, the resource is dispatchable). Maintaining an adequate portfolio of diverse resources also assists in managing price risk, and such resources could be made up from generation, pumped storage, behind the meter, flexible demand resources, or flexible network capability.

AEMO's recommendation

That AEMO, working with industry and consumers through its Expert Panel and working groups, the academic community, and the AEMC, immediately begin development of a longer-term approach to retain and incentivise investment in dispatchable capability in the NEM, to complement the development of the strategic reserve mechanism, with the approach to be in place before 2021–22 (in readiness for the impact of Liddell's retirement). Consistent with the Energy Council's adoption of the Finkel review recommendations and its report to COAG on the Finkel review, this work should be completed for consideration by the COAG Energy Council by mid-2018.

Further analysis and advice will cover:

- Consideration and recommendation of the appropriate level of dispatch flexibility that should be maintained in the NEM by region, and for the wider system. The COAG Energy Council has already agreed that AEMO should conduct this analysis.
- Evaluation of current resources in the NEM, their vulnerability to retirement, and capability to meet system requirements with existing or new capital investments. As required by the COAG Energy Council, AEMO will develop a register of expected retirements. AEMO recommends a review of existing resources, and determination of whether there are opportunities for cost-effective investment under the right type of market mechanisms.
- Consideration and development of appropriate approaches to compensate for dispatch flexibility, to ensure optimal retention and investments in flexible resources that assist in physically balancing the system. This last part of the evaluation will consider the appropriate market mechanisms long-term, and any mid-term actions that can, and should, be immediately undertaken. This analysis will necessarily include consideration of the market changes articulated in the Finkel review recommendations, including the consideration of demand side markets, the development of mandatory day ahead commitments, the articulation of a Generator Reliability Obligation, and the development of further approaches to gain investment in flexible capability.
- For this aspect of its analysis, AEMO will consult with industry and consumers through its Expert Panel and working groups, the academic community, and the AEMC (which, subsequent to the Finkel review, announced it was undertaking a similar study).