NSW GOVERNMENT | Chief Scientist & Engineer

Assessment of Summer Preparedness of the NSW Energy Market: 2020/21

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NSW GOVERNMENT | Chief Scientist & Engineer

The Hon Matthew Kean MP
Minister for Energy and Environment
52 Martin Place
SYDNEY NSW 2000

Dear Minister

Assessment of summer preparedness for the NSW energy market: 2020/21

In September 2019, you requested that I provide advice on the risks within the national electricity market, especially in relation to summer.

This report is submitted in fulfilment of Term of Reference 2, to provide a yearly assessment of the summer preparedness of the NSW Energy Market. The assessment was undertaken by an expert panel chaired by myself, with Dr Chris Armstrong, Deputy Chief Scientist & Engineer (deputy chair), Mr Neville Henderson (former commissioner of the Australian Energy Market Commission) and Professor David Hill (Professor Emeritus, The University of Sydney). Secretariat support was provided by the Office of the Chief Scientist & Engineer.

The Panel and secretariat consulted with the Australian Bureau of Meteorology (BOM), the Australian Energy Market Operator (AEMO), the Australian Energy Market Commission (AEMC), Australian Energy Regulator (AER), Energy Security Board (ESB), NSW, Queensland and Victorian government agencies, network operators and generators.

The Panel examined issues including:

- summer 2019/20, including the impact of the bushfires and storms;
- risks and impact of the COVID-19 pandemic;
- NSW Government and the electricity sector preparedness for the upcoming summer and potential risks identified; and,
- future planning and emerging risks for electricity systems and markets.

The Panel have concluded that the NSW Government is well prepared for the coming summer in regards to the supply of electricity, however there are a number of risks to the system due to the impacts of extreme weather and the COVID-19 pandemic that could affect the security and reliability of electricity supply. The report also considers future risks and opportunities.

Yours sincerely,

H. Durrant-Whyte.

Hugh Durrant-Whyte
Chief Scientist & Engineer
30 October 2020

Findings & Recommendations

Review of summer 2019/20 and preparedness for summer 2020/21

Table 1 sets out the Panel's findings on the risks to the NSW electricity system, including how the NSW electricity system performed over the 2019/20 summer, how risks have changed since last summer and preparedness for the 2020/21 summer.

Table 1: Panel summary of the 2019/20 review and 2020/21 summer preparedness risk assessment

Category	2019/20 review	2020/21 summer risk comparison to summer 2019/20	NSW 2020/21 summer preparedness
Generation capacity in meeting demand	Market responded to LOR situations, with no load shedding	Improved	Well prepared
System reliability, strength and security	System showed resilience	Improved	Well prepared
Extreme weather	Disruptions and signficant damage but no major impacts on supply	Bushfires less likely Flood and storm risk higher	Well prepared, but uncertainty on the severity of flood and storms
COVID-19	N/A	Increasing risk and uncertainty	Well prepared, but great uncertainty
Future market design, planning & policy	Some development	Improvement	Unlikely to have material impacts in short term
Overall	In the face of significant bushfires, the system showed great resilience	Improved	Well prepared, noting uncertainty associated with extreme weather and COVID-19

Risk level	High	Medium	Low

Summer 2019/20

- The climate and bushfire outlooks for summer 2019/20 anticipated a difficult fire season, however the immense scale of the disaster was unforeseen. Significant damage to assets and infrastructure was sustained by the transmission, distribution and telecommunication networks with substantial mobilisation of resources required to reduce customer disruptions (~250,000 electricity customers with bushfire related disruptions) and restore operations to both the electricity and telecommunications networks.
- Extreme weather continued through the summer, with a series of severe storms in February 2020 extinguishing some major fires but also causing widespread flooding and destruction (with more than 200,000 customers disconnected from power).
- Preparations undertaken by Australian Energy Market Operator (AEMO), the electricity industry and NSW government for the 2019/20 summer were effective and helped to mitigate the potential for widespread impacts caused by the unprecedented bushfire and storm activity. However, the bushfires highlighted vulnerabilities in the transmission and distribution networks which will need to be addressed through improved design and construction to mitigate future risks. Some Distribution Network Service Providers (DNSPs) have begun to implement risk-based priority assessments for infrastructure upgrades in regions with high fire danger.
- Some delays were experienced with unplanned generator outages at Mortlake (Origin Energy) and Loy Yang A (AGL) power stations in Victoria, however steps were taken by AEMO to reduce the impact of the outages and there were no material impacts on reliability of supply as a result.
- AEMO reported that forecasting performance for summer 2019/20 was good, however solar forecasts were impacted by smoke haze, and unpredicted widespread cut-out of wind generation was triggered by extreme ambient temperature conditions (above 40°C) which are typically underestimated by conventional forecasting methodology.
- Record high demand of 36,711 MW and 38,055 MW aggregate estimated underlying demand in the National Electricity Market (NEM) were achieved on 30 and 31 January 2020 respectively. Conversely, minimum operational demand levels also reached record low levels in regions of the NEM (458 MW in South Australia on 10 November 2019), driven by increased rooftop photovoltaic (PV) generation.
- NSW experienced nine actual Lack of Reserve (LOR) conditions (5 LOR1 and 4 LOR2). Regional separation events in the NEM led to two out of the four actual LOR2. The Reliability and Emergency Reserve Trader (RERT) was activated on three occasions in NSW.
- The Panel notes that EUSFA in previous years had undertaken a number of exercises with the various market participants, and that these exercises built upon previous years exercises and procedures. The Panel notes that Recommendation 4 from the 2019/20 Assessment to conduct an end-to-end was not actioned. There are many issues with undertaking an exercise of this scale, not the least of which is working within the COVID-19 environment.

  Recommendation 1

  That the NSW Government continue to engage with the NSW electricity market participants to undertake an end-to-end exercise. This test would be more robust if it integrates the restrictions that have been in place at times during the COVID-19 pandemic.

- As noted in the NSW Bushfire Inquiry, the Royal Commission into Natural Disaster Arrangements and by stakeholders consulted as part of this assessment, there is work to

be done with telecommunication companies, government (Commonwealth and state) and the electricity sector to ensure critical telecommunication infrastructure is identified (and reflected in, for example, the NSW Digital Twin) and proactively supported (via backup fuel, and emergency or replacement generators). This is a key component of emergency management and communication of information to the community during emergency situations.

- Non-standardised terminology for assets and infrastructure can slow down communication between electricity businesses and emergency agencies.
- Furthermore, the electricity and telecommunications systems are interdependent, they rely on each other operationally, so close knowledge sharing and involvement of telecommunications organisations in electricity emergency response and exercises are important.
- Stand Alone Power Systems (SAPS) are being recognised as a valuable solution for both emergency restoration and cost-effective long-term provision of supply in remote communities and applications such as isolated telecommunications equipment. Although some SAPS were provided during the bushfire emergency situation, there are regulatory barriers that need to be re-examined to enable the full potential of SAPS for long-term supply and this is currently being considered by market bodies and governments.

Summer 2020/21 Assessment and Preparedness

- The outbreak of the COVID-19 pandemic and associated community and movement restrictions has impacted the use and the management of electricity. This gives a level of uncertainty for forecasting electricity demand, ability to manage planned and unplanned outages and how we deal with emergency situations. For example, COVID-19 restrictions have the possibility to impact the length of unplanned outages with issues around supply chains for importation of infrastructure components and access to personnel both within and outside Australia.
- Generators and the network operators have all indicated that they are on track with their summer preparedness programs and have the required COVID-19 protocols in place. The Panel notes that where practical generators and networks should run through COVID-19 related exercises or scenarios that may highlight any improvements to their protocols.
- The Panel does note that some larger scale maintenance or upgrade activities that had been planned for Spring 2020 had to be delayed until the first half of 2021 due to COVID-19 conditions, however smaller scale maintenance work did occur.
- The reliability forecast for 2020/21 summer has improved compared to last summer with expected Unserved Energy (USE) remaining below the new Interim Reliability Measure (IRM) for all NEM regions. This is a combined result of reduced demand (COVID-19 driven) and increased generation capacity from new investment, and thermal plant return from outages. AEMO is monitoring COVID-19's impacts on the electricity system and will provide updated information (such as through the Electricity Statement of Opportunities (ESOO) report) should the situation change.
- The Bureau of Meteorology (BOM) has declared La Niña conditions which will increase the probability of rain and associated storms and floods. This poses risks for the electricity system.
- The previous summer highlighted the need for the electricity sector and emergency managers to have better access to information to improve management of emergency events and support faster recovery efforts. This includes access to information on the locations of telecommunication network infrastructure.
- COVID-19 may have exacerbated fatigue levels of staff that are still recovering from the bushfire season, with limited respite between the two events. EUSFAC has taken proactive measures to prepare for future events including the increase in capability of 'surge staffing',

where EUSFA can draw on other parts of NSW Government to increase staffing levels to deal with emergency responses and plans for fatigue management.

- It was noted that the strong communication channels were established between jurisdictions last summer during the emergency period in regard to both electricity and bushfire emergency management. Regular communication between the operational groups in the different jurisdictions should be maintained throughout the year to allow for efficient and effective information sharing and relationship development.
- If a COVID-19 hot-spot is declared in a region in NSW and an electricity supply event occurs in that region it is likely to take longer to re-establish supply. This may be due to local public health and border restrictions limiting the movement of people and equipment supply chain issues. EUSFA is involved in expediting and approving Critical Worker Permits for the electricity sector. The Panel notes that there is a risk in electricity emergency situations for the cross-border movement of staff without permits or where there is a level of urgency and not time enough to process a Critical Worker Permit. This is been explored by the NSW Government (EUSFAC and Deputy SEOCON).
- The Panel notes the network businesses, based on experience from last summer, are undertaking expenditure to bolster their holdings of spare equipment (where possible).

Recommendation 2

The NSW Government should explore with the electricity transmission and distribution businesses and with revenue regulators whether sufficient contingency allowances have been provided to cover the holding of sufficient spare equipment (e.g. poles, transformers etc. wires, spare parts, etc) in extreme events that impact electricity supply or disrupt supply chains.

- The NSW Bushfire Inquiry provided a number of recommendations that could have implications for the electricity sector and associated emergency management. The NSW Government has accepted all recommendations in principle. NSW electricity market utilities have indicated to the Panel that they are responding to or applying the recommendations where relevant.
- It was also noted by the Panel in discussions with stakeholders that there was work needed to coordinate actions between the electricity and telecommunications sectors in emergency situations. This was highlighted in the NSW Bushfire Inquiry and the Commonwealth's Royal Commission into National Natural Disaster and their associated recommendations.
- As a result of issues related to the management of the electricity system during the bushfire and COVID-19 emergencies the Australian Competition and Consumer Commission (ACCC) has allowed the generators to share information to ensure stability of electricity supply across the NEM.
- AEMO has observed a decline in thermal generation reliability which increases uncertainty of plant availability when it is most needed. Planned outages are typically undertaken during the shoulder months (during spring and autumn) when demand was lower. These shoulder periods have become warmer and drier over recent years leaving less time for maintenance and placing a greater strain on generation plant and infrastructure. COVID-19 has added another layer of complexity to shoulder period maintenance due to various restrictions in accessing people and equipment. This could result in longer forced and planned outages.
- In NSW the minimum daily demand has historically occurred overnight. However, with greater levels of solar generation coming on-line, minimum daily loads on the grid are occurring around midday. This has implications for thermal generators as it means they are ramping up and down more often, leading to increased wear and tear on the plants, which over the longer term can lead to reduced energy reliability.

- As noted in previous summer preparedness assessments there is a major risk to the system with concurrent and/or multijurisdictional events. This is made more complex this year with the overlay of the COVID-19 pandemic.
- The Panel found that the NSW Government is well prepared for emergency situations that may occur in upcoming summer, and it has implemented or progressing the recommendations from the 2019/20 Assessment Report.
- As recommended in the 2019/20 Assessment, the NSW Government has improved and maintained its communication with generators. For example, it is understood that the issues around coal supply for Mt Piper Power Station (EnergyAustralia) have improved for this summer, noting that there are still efforts underway to secure coal supply for future years.

Challenges and opportunities for future summers

- The NEM, like many power systems worldwide, is undergoing the transition from a system dominated by large thermal power stations, to a more complex system comprising a multitude of power generation resources, and with an increasing concentration of generators that are more intermittent. This transition imposes challenges to maintain electricity reliability and security but also presents opportunities to supply low-cost, low-emissions electricity with new and emerging technologies and services.
- Table 2 summarises the assessments of NSW's system reliability, security, operability and flexibility in the medium to longer term based on AEMO's modelling work, matched to the risk (as assessed by the Panel), noting that some issues are NEM-wide and would require a holistic approach for the future market planning and design.
- The design and planning of the future electricity system is underway led by the post-2025 market design by the Energy Security Board (ESB); AEMO's Integrated System Plan (ISP); and AEMC work on a wholesale market response mechanism.
- Some stakeholders raised concerns around government directly investing in new generation capacity as this could discourage private investment. The Panel's view is that government should support the operation of the market including addressing market failures where investment is not forthcoming in a timely manner with respect to anticipated reliability criteria. The NSW Government has a range of announced and existing strategies, policies and programs to ensure a stable and secure electricity supply in the short term but also support the future electricity system design in the longer term.
- As the system is digitised, data sharing between market participants and relevant industries (e.g. telecommunication) in a communicable format will be critical to provide real time information in emergency situations. Cybersecurity will become increasingly important for the safe and secure operation of the electricity system.
- There is critical, cross-sectorial (electricity, telecommunications, emergency services) information that is readily available and accessible that could improve the resilience and reliability of the electricity system, particularly in emergency situations to balance supply (including from an increased penetration of DER) and demand.

Recommendation 3

The NSW Government engage with stakeholders to understand the data that does or could exist (i.e. with future technologies and systems, such as the Internet of Things) and how this could be incorporated into system and emergency management. In understanding the data that exists, this could also identify any barrier (regulatory, etc.) that would prevent the sharing and utilisation of the data. The Panel also recognises and supports the concept of the NSW Digital Twin as one way to provide information in an open format.

Table 2: Summary of future challenges and opportunities in the NSW Electricity Market

System	Requirements	NSW assessment	Risk level (indication only)
Reliability	Reliability and meeting max demand	• NSW exceeds IRM in 2023/24 and approaches reliability standard in 2028/29 based on AEMO 2020 ESOO forecasting • Pipeline of projects in response to market investment signals to fill in the shortfall	
	Minimum demand	• NSW minimum demand declines but less aggressive compared to other states • Risks of widespread, unintended rooftop PV disconnection affecting system security • Longer term: increased visibility and active management of DER, such as rooftop PV interventions to maintain system security	
	Reserve capacity	• NEM has no reserve markets and is reliant on RERT for response to LOR conditions • Market options considered by market bodies (i.e. ESB, AEMO, AEMC)	
	Interconnection reliance	• NSW has strong connections with neighbouring states but is heavily reliant on imports • Extensive augmentation of transmission network and interconnectors	
Security	Frequency management	• Adequate inertia and low probability to have island events for NSW • Adequate frequency control services but requirements will likely increase	
	Voltage management	• System strength gap in 2035 after coal retirements based on AEMO ISP modelling • No voltage management gap to 2025 based on AEMO ISP modelling	
	System restoration	• Existing service market for NEM and procurement services to meet NSW regional requirements	
Operability and Flexibility	Coal generation	• NSW coal generation reliability and availability declines • Risks around early retirement and unplanned outages that aren't rectified	
	Renewable and distributed energy	• Large scale renewable development and network development • DER aggregation and interoperability issues for NEM	
	Dispatchable capacity	• New capacity being developed by industry and with government support	

Risk level	High	Medium	Low

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1 Introduction

In 2017 the (then) Minister for Energy Utilities established the NSW Energy Security Taskforce, chaired by the (then) NSW Chief Scientist & Engineer (CSE) to examine how NSW manages energy security and resilience, including readiness, planning preparation and response capability to extreme events such as weather. The Taskforce's reports found that NSW is reasonably well placed to deal with risks under normal conditions, but large spikes in demand due to extreme events such as heatwaves pose challenges for the electricity systems. The reports also examined longer-term issues to strengthen resilience of the NSW electricity system.

In 2018 the (then) Minister for Energy and Utilities requested the CSE chair a panel to assess the adequacy of the state's preparedness in relation to the energy market and associated departmental emergency management for summer 2018/19 (2018/19 Assessment).

In September 2019, the Minister for Energy and Environment requested that the CSE provide expert advice on the risks within the National Electricity Market (NEM) in relation to summer. This advice would build on the work of national bodies and to focus on opportunities for the NSW Government to take further action to maintain the reliability of electricity supply in the State. A report was requested to provide an assessment for the 2019/20 summer (2019/20 Assessment) with updates to be provided upon request yearly thereafter to 2023. The full Terms of Reference are at Appendix 1. The 2019/20 Assessment report[1] was submitted to government in October 2019.

This 2020/21 assessment of summer preparedness for the NSW energy market report (2020/21 Assessment) was requested as per Term of Reference 2. This report updates the 2019/20 Assessment, accounts for market developments, ongoing monitoring and work from national bodies, provides an ongoing assessment of summer preparedness and identifies any emerging risks for NSW and makes recommendations on actions to address any vulnerability identified for summer 2020/21. This report also considers the impact of the natural disasters that impacted NSW over the previous summer, with a focus on the significant bushfire season but also examining storms and flooding, as well as the impact of the current COVID-19 pandemic.

A background on the NEM and the roles and responsibilities of market bodies, network service providers, response to supply and demand events, and the core roles in energy emergency response is described in the 2019/20 Assessment[2].

1.1 Process for the Panel

To undertake the 2020/21 Assessment an Expert Panel (the Panel) was established. The Panel was chaired by Professor Hugh Durrant-Whyte (NSW CSE), with membership including Dr Chris Armstrong PSM (Deputy NSW CSE and Deputy Chair), Mr Neville Henderson (former commissioner of the Australian Energy Market Commission [AEMC] and member of the 2019/20 Assessment Expert Panel) and Professor David Hill (Professor Emeritus, The University of Sydney, Professor in the School of Electrical Engineering and Telecommunications at the University of NSW and Chair Professor of Electrical Engineering at the University of Hong Kong). Secretariat support was provided by the Office of the NSW Chief Scientist & Engineer (OCSE).

In undertaking the work, the Panel received briefings and presentations from national energy market bodies including Australian Energy Market Operator (AEMO), AEMC, Australian Energy Regulator (AER) and the Energy Security Board (ESB), State government agencies (NSW, Queensland and Victoria), the Bureau of Meteorology (BOM), network utilities, and major

[1] CSE (2018), *Assessment of summer preparedness for the NSW energy market*.
[2] CSE (2019), *Assessment of summer preparedness for the NSW energy market: 2019/20*.

generators in NSW on their preparedness for the coming summer, reflections on last summer and current COVID-19 preparations. A full list of stakeholders consulted is at Appendix 2.

The Panel drew upon a range of reports prepared by AEMO including:

- 2019-20 NEM Summer Operations Review Report
- 2020 NEM Electricity Statement of Opportunities (ESOO)
- 2020 Integrated System Plan (ISP) Final Report and Appendixes
- 2020 Power System Requirements
- NEM Lack of Reserve Framework Report
    - Reporting period 1 October 2019 to 31 December 2019
    - Reporting period 1 January 2020 to 31 March 2020
- Reliability and Emergency Reserve Trader (RERT) End of Financial Year 2019-20 Report
- Preliminary and Final Reports – New South Wales and Victoria Separation Event on 4 January 2020
- Preliminary Report – Victoria and South Australia Separation Event, 31 January 2020
- Quarterly Energy Dynamics Q2 2020
- Quarterly Energy Dynamics Q3 2020

The Panel also examined and relied upon the information from:

- NSW Bushfire Inquiry Final Report (2020)
- Royal Commission into National Natural Disaster Arrangements Report (2020)

The Panel acknowledges that there are reports and activities relevant to the TOR that were still in development and should be considered when released. These include, but are not limited to:

- AEMO Summer 2020-21 Readiness Plan
- AEMO 2020 System Strength and Inertia Report
- AEMO Final report - Victoria and South Australia Separation Event, 31 January 2020
- AEMO 2020 Forecasting Accuracy Report
- AER Electricity Network Performance Report 2021

1.2 Structure of this report

- Chapter 2 – provides 2019/20 summer electricity reliability forecasting accuracy analysis, post-summer operation review, outcomes and learnings from last summer
- Chapter 3 – provides 2020/21 summer electricity reliability forecasting, pre-summer risks assessment, preparedness plans and actions by AEMO, NSW Governments and electricity industry, and the impact of the COVID-19 pandemic
- Chapter 4 – provides a discussion of issues and opportunities for NSW to be better prepared for future summers

2 Summer 2019/20 Review

The NSW 2019/20 Assessment[3] found that:

- AEMO's supply and demand forecasting for summer 2018/19 ESOO was accurate, leading to a good summer reliability outcome without load shedding in NSW.
- The NSW Government had improved its response to electricity emergencies with information protocols and levers.
- NSW was well placed for summer 2019/20, with the overall risk of Unserved Energy (USE) well below the standard. AEMO, energy generators and network service providers had undertaken a significant amount of work for summer preparedness. The Panel highlighted a number of system and climate risks that could impact the security and reliability of electricity supply in NSW.
- Beyond summer 2019/20, the level of USE was forecasted to rise with the retirement of Liddell Power Station (AGL), potentially leading to a future tightening of supply in NSW. AEMO highlighted that the reliability standard may no longer be fit-for-purpose. The Panel noted that the shoulder period is becoming more critical and situational preparedness requires attention all year round.

The Panel made several recommendations based on the findings of 2019/20 Assessment with different implementation timeframes. The Panel received a progress update from NSW Government Energy and Utility Services Functional Area (EUSFA) Team in August 2020 confirming that most recommendations have been addressed or are being progressed through further action. However, the end-to-end exercise (Recommendation 4) has not been actioned, this is due to factors such as the size of the exercise and considerable disruptions due to bushfires and the COVID-19 pandemic.[4]

2.1 Climate and extreme weather

The summer of 2019/20 and the preceding shoulder season were characterised by extreme conditions and unprecedented bushfire conditions in NSW and the wider east coast of Australia, which were a major external source of pressure on the electricity system. Extreme temperature days created high demand for electricity and the physical impact of fires and storms on critical infrastructure was felt throughout the electricity network.

2.1.1 Forecasting accuracy

The summer climate outlook created the expectation of a dry and hot summer conducive to fire activity, exacerbated by prolonged drought conditions throughout NSW. Outlooks provided by the BOM, Bushfire and Natural Hazards CRC (BNHCRC), together with warnings from experts and leaders in fire management agencies signalled that the prevailing conditions of 2019/20 created the potential for a destructive fire season. The season that eventuated exceeded expectations.

The BOM forecasted that warmer than average daytime temperatures would be very likely across almost all of Australia from October 2019 to January 2020.[5] There was also a greater than 80% chance that the eastern two-thirds of Australia would be drier than average. Two major climate drivers influencing the dry weather forecasts across eastern Australia were a positive Indian Ocean

[3] CSE (2019), *Assessment of summer preparedness for the NSW energy market: 2019/20.*
[4] NSW Government (EUSFAC), personal communication, 27 August 2020.
[5] BOM (2019), *Climate outlook for October to January,* 26 September 2019, accessed 24 September 2020.

Dipole[6] (IOD) and a prolonged negative Southern Annular Mode[7] (SAM). By early 2020, these two major influences returned to neutral phases bringing roughly equal chances of a wetter or drier than average February to April 2020 for most of Australia.[8]

In line with forecasts of a warmer than average summer, December 2019 turned out to be the hottest December on record in NSW. Many sites recorded all-time maximum temperatures during the summer months. The mean maximum temperature for summer was 2.39°C above average (sixth-highest on record) and the mean minimum temperature was 2.28°C above average (fourth-highest on record).[9] A maximum temperature of 48.9°C was recorded at Penrith Lakes on 4 January 2020, currently the highest recorded temperature on record for the Sydney basin.

December 2019 was the second-driest December on record for NSW. Heavy rainfall in February 2020 meant that many coastal regions experienced above average summer rainfall. A succession of low-pressure systems in early February 2020 led to many east coast sites experiencing the wettest four-day period on record. A number of sites recorded the highest summer daily rainfall ever on 10 February 2020. By contrast, the western part of the state was dry, generally experiencing less than 50 mm of rainfall for the whole summer. Overall, summer rainfall for NSW was 10% below average.

The spring months leading up to summer were also characterised by warm, dry and gusty conditions. On 5-6 September 2019, some sites in northeast NSW experienced maximum temperatures that were 10°C above average.[10] The weather conditions from spring to early summer contributed to dangerous fire conditions and exacerbated an already heightened risk due to prolonged low rainfall levels in most areas of NSW meaning that available fuel loads were extremely dry. For some areas, the January to August period was the driest on record since (at least) 1900. Some areas were also affected by low rainfall in 2017 and 2018, leading to large multi-year rainfall deficits. Long-term lack of rainfall (meteorological drought) also led to depleted surface and groundwater storages (hydrological drought).

All available indicators pointed towards a high risk of bushfire for the 2019/20 season. Accumulated Forest Fire Danger Index[11] (FFDI) values for spring 2019 were the highest on record for Australia as a whole. For NSW, the area-averaged FFDI in December 2019 was highest on record. A seasonal outlook produced by the BNHCRC in August 2019 showed above normal fire potential[12] for the entire east of coast of NSW (Figure 1).

While the statutory Bush Fire Danger Period (BFDP) runs from 1 October to 31 March, the NSW Rural Fire Service (RFS) declared an early start to the BFDP on 1 August 2019 for 12 Local

[6] The Indian Ocean Dipole (IOD) is defined as *"sustained changes in the difference between seas surface temperatures of the tropical western and eastern Indian Ocean"*. The IOD has 3 phases: neutral, positive and negative. A positive IOD generally *"means there is less moisture than normal in the atmosphere to the northwest of Australia. This changes the path of weather systems coming from Australia's west, often resulting in less rainfall and higher than normal temperatures over parts of Australia during winter and spring."* BOM, *Indian Ocean influences on Australian Climate*, accessed 12 October 2020.

[7] The Southern Annular Mode (SAM) *"describes the north-south movement of the movement of the westerly wind belt that circles Antarctica, dominating the middle to higher latitudes of the southern hemisphere"*. A negative SAM leads to less rainfall in the southeast and east and a greater chance of spring heatwaves in southern Australia. BOM, *Southern Annular Mode and the Australian climate*, accessed 12 October 2020.

[8] BOM (2020), *Climate outlook for February to May*, 9 January 2020, accessed 24 September 2020.

[9] BOM (2020), *New South Wales in summer 2019-20: wet in the east, very hot at times*, 2 March 2020, accessed 24 September 2020.

[10] BOM (2019), *Special Climate Statement 71 – severe fire weather southeast Queensland and northeast New South Wales in September 2019*.

[11] The McArthur Forest Fire Danger Index (FFDI) is a tool for assessment of forest fire danger in Australia. It combines information about temperature, wind speed, relative humidity and a representation of fuel availability called the Drought Factor. The BOM calculates the Drought Factor Value based on either the Keetch Byram Drought Index or the Mount Soil Dryness Index.
Dowdy, A., Mills, G., Finkele, K. and de Groot, W. (2009), *CAWCR Technical Report No. 10: Australian fire weather as represented by the McArthur Forest Fire Danger Index and the Canadian Forest Fire Weather Index*.

[12] In considering the potential ability of a large fire to take hold, this assessment methodology incorporates recent and predicted weather, dryness of the land and forests, recent fire history and local firefighting resources.
Bushfire and Natural Hazards CRC (2019), *Hazard Note: Australian Seasonal Bushfire Outlook: August 2019,* Issue 63, accessed 28 September 2020.

Government Areas, taking into consideration several factors including local fuel availability.[13] A high level of fire activity had been observed over winter, with more than 1000 fires a month.[14] On 16 October 2019, the NSW RFS reported that the fire season had already seen more than 5,000 bush and grass fires burn in excess of one million hectares, with RFS Commissioner Shane Fitzsimmons warning people not to think *"this is just another year"*.[15] Two catastrophic fire danger ratings were issued during the season (12 November[16] and 21 December 2019[17]), the first time the highest rating had been used since introduction of a new system in 2009.[18]

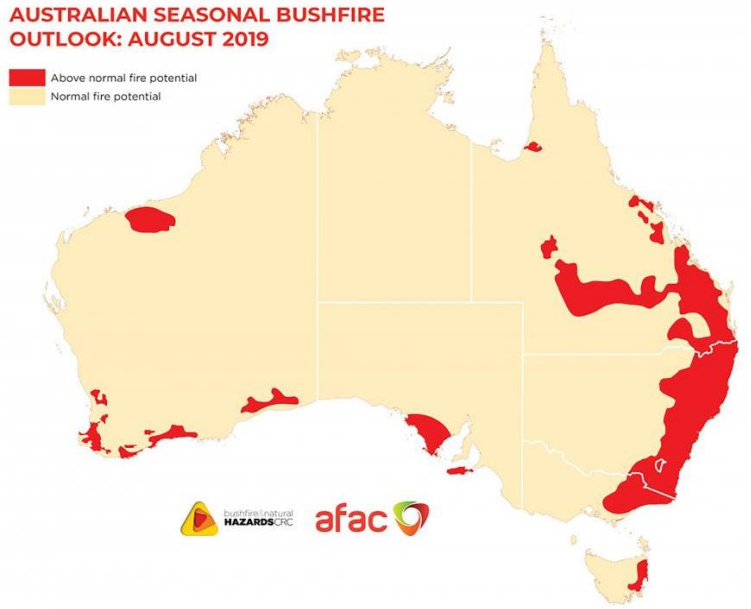

Figure 1: Fire potential outlook for the summer 2019/20 summer period
Source: Bushfire and Natural Hazards CRC[19]

The NSW Bushfire Inquiry (the Inquiry) reported that the bushfire season ran from 1 July 2019 to 31 March 2020, a total of eight months. While an average fire season in NSW would see approximately 300,000 hectares burnt,[20] the 2019/20 fires burned through more than 5.52 million hectares. Figure 2 depicts the extensive nature of the 2019/20 fire grounds (both burnt and unburnt areas) mapped by the NSW RFS. As described above, prevailing hot, dry and gusty weather on the back of prolonged drought across the state were factors that exacerbated an already heightened risk. The Inquiry report describes that extended drought conditions in NSW had led to available fuel being extremely dry, and that fuel was distributed in large contiguous areas through forested regions along the east coast. Combined with the fact that many naturally occurring firebreaks were also dry as a result of severe drought, these factors increased the likelihood of mega forest fires.[21]

[13] NSW RFS, *"NSW RFS declares start of Bush Fire Danger Period",* 1 August 2019, accessed 14 October 2020.
[14] Clifford, J. and Henderson, A., *"Bushfire royal commission hears former fire chief's October 2019 warning of catastrophic fire conditions"*, ABC News, 4 August 2020, accessed 14 October 2020.
[15] NSW RFS, *"Update on Northern NSW bush fires",* 16 October 2019, accessed 14 October 2020.
[16] NSW RFS, "*Dangerous fire conditions forecast for Tuesday 12 November",* 10 November 2019, accessed 25 September 2020.
[17] NSW RFS, *"Catastrophic fire danger forecast for Blue Mountains Saturday 21st December 2019"*, 20 December 2019, accessed 25 September 2020.
[18] Thomas, S. and Cockburn, P., *"School closures and evacuations* (sic) *warnings as NSW catastrophic fires loom for Sydney"*, ABC News, 11 November 2019, accessed 25 September 2020.
[19] Bushfire and Natural Hazards CRC (2019), *Hazard Note: Australian Seasonal Bushfire Outlook: August 2019,* Issue 63, August 2019. Accessed 28 September 2020.
[20] Owens, D. and O'Kane, M. (2020) (2020), *Final report of the NSW Bushfire Inquiry 2020.*
[21] Owens, D. and O'Kane, M. (2020) (2020), *Final report of the NSW Bushfire Inquiry 2020.*

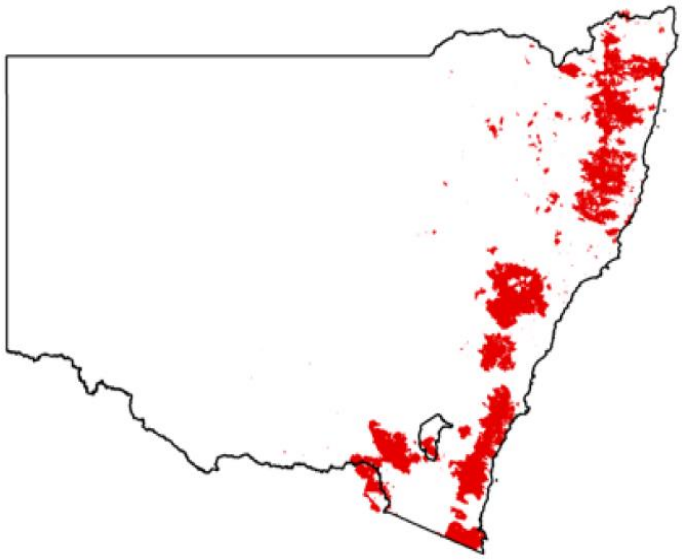

Figure 2: RFS Fire Ground Map for the 2019/20 bushfire season (as at 3 February 2020)
Source: Department of Planning, Industry and Environment[22]

The Inquiry also noted that a substantial increase in fire-generated thunderstorms (pyrocumulonimbus) was observed compared to previous years (an almost 50% increase on 2018/19).[23] These fire-generated thunderstorms created extreme wind, spread embers many kilometres ahead of main fire fronts and generated new ignition points through dry lighting. This created challenges for containment and increased dangers for emergency personnel.[24]

2.1.2 Impact of Bushfires and Emergency Management

In relation to the impact of the bushfires on critical infrastructure, the Inquiry found that electricity networks were extensively affected by fires, with power outages experienced by hundreds of thousands of customers. Loss of power cascaded into loss of communications systems, with lack of appropriate backup systems impacting the ability of emergency organisations to send critical warnings, leading to increased community distress. Limited access to real time information also made it difficult to assess the location and status of critical electricity and communications infrastructure.[25] The telecommunications system was dependent on electricity supply, and vice versa.

The Energy and Utility Services Functional Area Coordinator (EUSFAC) and EUSFA team played a key role as a liaison between electricity industry organisations and emergency agencies during the bushfires. While deployed, the EUSFA team provided an operational 'translation' between RFS and the Network Service Providers (NPS's) along with other activities. It was noted by the EUSFA that improved integration of mapping tools and standardisation of terminology for infrastructure and assets would increase the efficiency of emergency response.[26] The extent of simultaneous active fires increased challenges for the EUSFA team, and the prolonged nature of the season meant that surge staff quality and capability was of increased importance to enable fatigue management for the team. The Panel understands that work is being undertaken to further strengthen resourcing capacity.

The Telecommunications Services Functional Area Coordinator (TELCOFAC), through the Telecommunications Emergency Management Unit (TEMU) of the NSW Telco Authority, performs a similar coordination role as the EUSFAC for the NSW telecommunications industry during

[22] Department of Planning, Industry and Environment (2020), *NSW Fire and the Environment 2019-20 Summary.*
[23] NSW Government (2020), *Final report of the NSW Bushfire Inquiry 2020.*
[24] BOM, *"When bushfires make their own weather",* 8 January 2018, accessed 25 September 2020.
[25] Owens, D. and O'Kane, M. (2020) (2020), *Final report of the NSW Bushfire Inquiry 2020.*
[26] NSW Government (EUSFA Team), personal communication, 27 August 2020.

emergency. During the bushfire season, TEMU facilitated access and escorts into hazardous areas for emergency, preventative and restoration work on assets. They also assisted in facilitating access for the deployment and refuelling of generators. They found that telecommunications operators were not always able to provide timely information on the location and status of their assets during bushfire emergencies. In some instances, slow response times and lack of information led to preventable losses of infrastructure.[27] The Royal Commission into Natural Disaster Arrangements indicated that the TEMU-model of facilitating government-to-service provider coordination was valued by both sectors, particularly given that TEMU provided a presence in emergency operations centres, and that this model should be expanded to other states and territories[28]. However, it also noted that the information provision was, at times, unidirectional and there would be scope for improving information sharing between governments and the telecommunication and energy sectors.

Telecommunications are of heightened importance during emergency situations, such as bushfires, to enhance and coordinate the emergency response, and to provide access to critical information for the community (including communication of evacuations and provision of appropriate support to vulnerable community members). Telecommunications assets are highly dependent on electricity infrastructure to remain operational. A review conducted by the Australian Communications and Media Authority found that more than 90% of communications outages during the bushfire season were related to power outages rather than direct fire damage, highlighting the risks associated with this dependency.[29] In relation to the emergency coordination efforts, several electricity industry stakeholders commented on the lack of telecommunication industry representation in state and local operation command centres during the emergency response.

Distribution network service providers (DNSPs) experienced heavy bushfire impacts on their assets. A significant proportion (45%) of the franchise area managed by Endeavour Energy was burned, with 1,000 poles having to be replaced and a total of 54,000 customers services being impacted.[30] Essential Energy had to replace in excess of 3,000 poles, more than 4,000 cross-arms, and had 190,000 bushfire-related customer supply disruptions over the season.[31] However, despite the immense challenges faced, all organisations reported a high level of morale amongst their workforces and good inter-organisation relationships in restoration efforts. Cooperative sharing of pole stock and resources enabled more efficient restoration of services for customers.

The value of Stand-Alone Power Systems (SAPS) for emergency response and restoration works is also being realised. In some situations, electricity can be provided in a manner that is more reliable and cost-effective than by grid connection. Installation of SAPS for remote communities also enables the removal of distribution infrastructure in high risk fire areas thereby reducing risk for network-induced fires and interruption of supply due to line damage. During the 2019/20 bushfire season, several SAPS were deployed by the DNSPs for restoration of community power and for backup generation on key assets such as water pumping facilities and telecommunications towers. For example, Endeavour Energy implemented its first SAPS, seeking a waiver from the AER to allow this to occur. Stakeholders indicated that they are reviewing potential alternate sites for SAPS, noting that there remain some regulatory barriers to be addressed in order to enable the full potential of SAPS for long-term supply arrangements by distribution networks. The Panel acknowledges that the AEMC released its final report[32] on updating the regulatory frameworks for SAPS in May 2020 and that there is work underway to implement changes.

There was also an expectation, from the government and communities, that DNSPs would play an active role in immediate, on-the-ground response to bushfires, providing back-up generation and

[27] NSW Government (NSW Telecommunications Authority), personal communication, 25 September 2020.
[28] Commonwealth Government (2020) Royal Commission into National Disaster Arrangements Report
[29] Australian Communications and Media Authority (2020), *Impacts of the 2019-20 bushfires on the telecommunications network.*
[30] Endeavour Energy, personal communication, 4 September 2020.
[31] Essential Energy, personal communication, 10 September 2020.
[32] AEMC (2020), *Updating the regulatory frameworks for distributor-led stand-alone power systems*.

door-to-door assessments of power connections. This has not traditionally been part of the remit of DNSPs, and while preparations for the upcoming bushfire season have seen some targeted investment in backup generation and communication assets, this kind of investment is not currently supported by the regulatory framework governing networks. The Panel noted from discussions with the DNSPs that if distribution networks are to increase the resilience of their infrastructure to bushfires and continue to provide the level of response services expected recently, regulatory changes will be required. It was also noted in discussions with stakeholders that there are some issues in relation to determining the status of the network, with current arrangements preventing the sharing of smart meter data from retailers to DNSPs regarding the connection status of electricity to a property. Improved access for DNSPs to real time data would assist the efficiency of restoration efforts. Approaches to data sharing and security for a future grid that is increasingly digital are discussed further in Chapter 4.

TransGrid was pleased with the resilience of their network, given the extensive nature of the bushfire season. A significant amount of funds have been spent on replacement of fire-damaged assets, with more work planned to improve the lifespan and resilience of transmission infrastructure across the network. As part of a preventative approach, decisions were made to switch out assets on several occasions during the season in order to mitigate fire risks. Processes for de-energisation of transmission lines were enacted in cooperation with EUSFAC to enable NSW RFS access to easements for necessary backburning procedures.

NSW thermal generators experienced a range of impacts. Most generators were largely unaffected by direct fire threats, some had fires come up to their fence line and some were in areas where fire disrupted transmission lines. All generators reported that their fire preparedness plans were effective with no major impacts on their generation capability. One site was able to provide refuge and water refilling stations for emergency crews operating in their area.

Many of the electricity industry stakeholders also provided evidence to the NSW Bushfire Inquiry. The findings and recommendations with regard to critical infrastructure are discussed further in Chapter 3.

2.1.3 Impact of Storms

In addition to being fire season, the period from October to March is ‘Severe Thunderstorm Season’ in NSW, with a higher likelihood of increased storm frequency caused by warmer weather and spring/summer weather patterns.[33] Severe thunderstorms are associated with damaging winds, tornadoes, very heavy rainfall that can lead to flash flooding, and hail.[34] Such weather poses threats for security of the electricity system through tree and pole collapse. Several notable storms occurred in the 2019/20 season and are highlighted here.

2.1.3.1 26 November 2019

Severe thunderstorms on 26 November 2019 caused damage to a large section of the electricity distribution network in Sydney’s northern suburbs. The storm brought wind gusts of more than 100 km/h and more than 10,000 lightning strikes. A tree fell on rail tracks between Gordon and Lindfield stations, blocking trains on the North Shore and Western lines.[35] The NSW State Emergency Service (SES) received more than 2,000 calls for assistance during this event.[36] Ausgrid reported that 110 power poles had been destroyed in the storm, with 1,900 hazards

[33] NSW SES, *Storm Types*, accessed 28 September 2020.
[34] BOM, *Severe Thunderstorms*, accessed 28 September 2020.
[35] Cormack, L., “Almost 30,000 homes and businesses still without power, school closed after storm”, The Sydney Morning Herald, 27 November 2019, accessed 25 September 2020.
[36] NSW SES, *“Don’t let your trampoline become a kite”*, 28 November 2019, accessed 28 September 2020.

reported. About 52,000 customers lost power and it took about a week for a team of more than 700 workers to restore the network completely.[37]

2.1.3.2 20 January 2020

Widespread hail was reported in Greater Sydney during a severe thunderstorm on 20 January 2020, with hail of up to 6 cm in diameter reported in the southwest and two people struck by lightning in the Blue Mountains.[38] More than 13,000 homes in the Sutherland Shire lost power and the Insurance Council of Australia estimated a damage bill of $32 million.[39,40]

2.1.3.3 February 2020

During early February 2020, a coastal trough parallel to the east coast[41] brought torrential rainfall to the Sydney basin ending several major fires including the Currowan, Gospers Mountain and Green Wattle Creek fires. However, the severe storms also caused widespread damage and flooding in many areas of Sydney. Large impacts were felt across the electricity distribution system.

Major flooding occurred in the Hawkesbury-Nepean and Georges Rivers following heavy rainfall from 7 to 10 February. Local flooding events were observed across parts of Greater Sydney, and there was also coastal erosion on some beaches.[42] The NSW SES issued evacuation orders for Narrabeen Lagoon, the Hawkesbury River (at North Richmond Lowlands and Windsor) and the Georges River (at Moorebank, Chipping Norton and Milperra). Several flood rescues were performed.[43]

Distribution networks were heavily impacted by this event. In relation to storms on 8-9 February, Ausgrid reported that 140,000 customers lost power, with 180 poles having to be replaced and 250 km of powerlines restrung. It was the worst impact to their network in 30 years.[44] Endeavour Energy reported 93,000 homes and businesses impacted by storms on 9 February and more than 1,000 electrical hazards requiring repair.[45]

A separate severe thunderstorm event on 18 February left 80,000 Ausgrid and 21,000 Endeavour Energy customers without power.[46,47] On 26 February 2020, a severe thunderstorm left 26,000 customers without power across the Hunter and Lake Macquarie regions. In these events, while most customers experienced restoration times of less than 24 hours, some had to wait several days for reconnection to the grid.

[37] Ausgrid, *"Power restored to Sydney's north after cyclone-like storm*, 3 December 2019, accessed 28 September 2020.
[38] BOM, *"Greater Sydney in January 2020: record heat, severe storms, smoke and dust"*, 3 February 2020, accessed 28 September 2020.
[39] Ausgrid (2020, January 20), Crews are working to safely restore power to about 14,000 homes & businesses after severe storms brought strong winds, lightning & hail across the Sutherland Shire & northern beaches [Tweet].
[40] Porter, M. and Trembath, M., *"All 783 jobs completed by 36 SES units after shire supercell storm*", St George and Sutherland Shire Leader, 26 January 2020, accessed 28 September 2020.
[41] BOM, *"Weekly Rainfall Update for 7 days to 9 am 11 February 2020",* 11 February 2020, accessed 30 September 2020.
[42] BOM, *"Greater Sydney in February 2020: wet with warm nights",* 2 March 2020, accessed 28 September 2020.
[43] NSW SES, *"NSW Coast Receives Persistent Heavy Rainfall"*, 8 February 2020, accessed 28 September 2020.
[44] Ausgrid, *"February Storm Update: Thankyou to our customers"*, accessed 28 September 2020.
[45] Endeavour Energy (2020, February 10), Work is continuing to restore power to 16,500 customers. Yesterday's storm interrupted power to 93,000 homes & businesses. While 76,500 customers are back on, there is many hours of work still needed to repair the 1,150 electrical hazards on the network. Please #StaySafe [Tweet].
[46] Ausgrid, *"February Storm Update: Thankyou to our customers"*, accessed 28 September 2020.
[47] Endeavour Energy (2020, February 18), Severe lightning and 100km plus windstorm swept across Western Sydney and the South Coast tonight. Crews working to restore power to 21,000 customers. Please stay 8 metres back from fallen power lines. #SydneyStorm [Tweet].

2.2 National Electricity Market (NEM) Operational Review

2.2.1 Overview for the NEM

AEMO concluded in its 2019/20 NEM Summer Operations Review[48] that work undertaken to prepare the power system for the 2019/20 summer was effective in mitigating the potential impacts of a range of unprecedented extremes in temperature, fire danger, smoke, dust and storm activity but recognised there are both continuing and emerging challenges for maintaining security of the NEM into the future. Some highlights from the report are summarised below.

Demand - Record high demand of 36,711 MW and 38,055 MW aggregate estimated underlying demand[49,50] in the NEM were achieved on 30 and 31 January 2020 respectively, tied to extreme temperatures experienced over these days. Minimum operational demand levels also reached record low levels in regions of the NEM (458 MW in South Australia on 10 November 2019), driven by increased rooftop photovoltaic (PV) generation. The network challenges created by low minimum demand are discussed further in Chapter 4.

Generation capacity - Plant availability generally reflected pre-summer forecasts, including an assumed delay in the return to service of generating units at Mortlake (Origin Energy) and Loy Yang A (AGL) power stations. A substantial amount of new capacity (approximately 3,700 MW) entered the NEM ahead of summer 2019/20 (mostly solar and wind) which assisted with management of reserves during periods of high demand. However, unplanned generator outages in NSW on 23 January and 1 February 2020 contributed to actual Lack of Reserve[51] (LOR) 2 conditions being declared. Bushfire smoke and dust had material impacts on solar generation throughout summer and created challenges for forecasting.

Wind generation capacity - AEMO observed that wind generation was significantly de-rated on a large-scale during summer 2019/20 and that improvements are required to forecast and manage events such as these in the future. While NSW does not yet have as high a volume of wind generation as other NEM jurisdictions, these issues should be noted as the generation mix continues to change. Two notable events occurred across South Australia and Victoria:

- *20 December 2019*: Extreme ambient temperatures (>40°C) led to wide-scale cut-out of wind turbine operation triggering a non-forecast LOR2 condition.
- *31 January 2020*: Wind farms were impacted by a variety of conditions on this day including de-rating due to high temperature and high winds, drop-outs due to low wind, and network outages. The variability of output has implications for output forecasting and the assessment of reserves.

Transmission performance - There was an observed increase in the number of unplanned transmission network outages in all NEM regions compared to the previous summer. The largest increase was in NSW, mainly due to the impact of bushfires. Significant regional separation events over summer 2019/20 were associated with unplanned transmission outages caused by fire impacts and extreme weather events.

[48] AEMO (2020), *2019-20 NEM Summer Operations Review Report (June 2020)*.
[49] Underlying demand is operational demand (from the grid, unadjusted for RERT or load shedding) plus estimated rooftop PV generation. AEMO (2020), *2019-20 NEM Summer Operations Review Report (June 2020)*.
[50] AEMO (2020), *2019-20 NEM Summer Operations Review Report (June 2020)*.
[51] 'Lack of Reserve' (LOR) conditions are market notices issued by AEMO designed to elicit a market response to provide more capacity or demand response, and are designated LOR1 (market signal for more generation, with no impact to power system security or reliability, but there may not be enough reserve capacity to restore contingency capacity), LOR2 (AEMO activates additional resources, including demand response or support generation, whilst there is still not impact to power system security, but it is unlikely the amount of capacity in reserve would be enough to cover involuntary load shedding) and LOR3 (deficit in the supply/demand balance, with involuntary load shedding occurring or about to commence).

Reserves – In response to potential risk of USE being exceeded for Victoria identified in the 2019 ESOO[52], AEMO contracted additional reserves to mitigate a situation where insufficient supply might lead to load shedding. This risk was identified in relation to potential for the unplanned outages at Loy Yang A and Mortlake power stations to overrun into the summer period. Several contracts were secured under Long Notice Reserves and medium and short notice panels for Reliability and Emergency Reserve Trader[53] (RERT). AEMO declared a total of 33 LOR conditions in the NEM over the shoulder and summer 2019/20 period: 17 actual and 16 forecast.

Directions - AEMO noted that more directions were issued in 2019/20 than in any other year, with most of these being issued in order to maintain system strength in relation to the Victoria-South Australia separation event on 31 January 2020 (see Section 2.3.3.2). Several stakeholders consulted for this review highlighted the general need for greater grid flexibility as a growing area of concern for the NEM as Variable Renewable Energy (VRE)[54] penetration increases, and thermal generation is retired (see Chapter 4).

Staff Expertise – AEMO implemented additional training measures for NEM operations staff ahead of summer 2019/20. Courses and exercises were conducted using the NEM Simulator[55] with a focus on uncertainty management and high-risk events including bushfires, severe storms and heatwave conditions. RERT and load shedding exercises were also included in the training. These were identified by AEMO as valuable in preparing staff to handle the range of emergency scenarios that eventuated during summer 2019/20.

2.2.1.1 Learnings from summer 2019/20

AEMO's key observations from 2019/20 about the challenges of summer electricity operations include:

1) Increasing impacts of extreme heat and bushfire on electricity generation including:
   - increasing generation demand (for cooling)
   - degraded output capacity of generators (both conventional and renewable)
   - solar forecasting ability impacted by bushfire smoke haze
   - thermal generation constraints due to environmental limits and temperature tolerances
   - sudden cut-out of wind generation at high temperatures
   - maintaining gas infrastructure under tolerance limits during prolonged extreme heat
   - management of multi-region heatwaves.
2) A need to strengthen the transmission and distribution networks against impacts of fire by improving thermal tolerance, using fire-resistant material and strengthening interconnection between major load centres.

Preparedness of the electricity system for the upcoming summer and into the future is discussed in the following Chapters.

2.2.1.2 Other market bodies

The AER noted to the Panel that reporting around major events and outages has been satisfactory. They observed that summer readiness programs implemented by industry have improved cooperation between the operators through the summer period. Analysis of the 2019/20 financial

[52] AEMO (2019), *2019 Electricity Statement of Opportunities.*
[53] The RERT is a function conferred on AEMO under the *National Electricity Rules* to maintain power system reliability and security using reserve contracts. Reserve contracts can be procured under long notice (at least 10 weeks), medium notice (seven days to ten weeks) and short notice (three hours to seven days).
[54] VRE in this report is defined by AEMO as renewable energy that fluctuates in its output, such as wind or solar
[55] The NEM Simulator is a model that mirrors the architecture and systems of the NEM, which enables operators to practice the processes required for management and handling of various scenarios that might occur in the NEM.

year will be available in mid-2021. It is expected that this will show the impact of the 2019/20 bushfires on reliability.[56]

The AEMC reflected that there had been concerns around system reliability heading into the 2019/20 summer period, even discounting major bushfire events, due to extended outages at large generators. Given the severity of events, the electricity system was somewhat resilient, and bolstered by preparations made by industry in the lead up to the summer.[57]

2.2.2 Forecasting Accuracy

AEMO reports on forecasting accuracy annually. The AEMO 2020 Forecast Accuracy Report reviewing 2019 demand, supply and reliability forecasts is expected to be delivered by the end of 2020. The following observations are highlights from the AEMO *2019-20 NEM Summer Operations Review*.[58]

2.2.2.1 Demand

AEMO reports that key performance indicators for load forecasting were met for the summer 2019/20 period, with strong improvement observed in day-ahead forecasting performance for NSW. AEMO acknowledged the continuing challenges for forecasting high temperatures in major city centres, which impacts the ability to provide accurate assessment and forecasts of generation reserve on peak demand days. Additionally, a range of market and weather-related factors can rapidly impact load volumes during extreme conditions causing deviation from forecasts.

The Medium Term Projected Assessment of System Adequacy (MT-PASA) forecast for NSW over summer 2019/20 generally overestimated demand, with actual daily operational demand peaks remaining well below the 10% and 50% Probability of Exceedance (POE)[59] levels (Figure 3). Demand peak forecasts for the shoulder periods were also higher than the actual demand levels that eventuated.

[56] Australian Energy Regulator, personal communication, 17 September 2020.
[57] Australian Energy Market Commission, personal communication, 4 September 2020.
[58] AEMO (2020), *2019-20 NEM Summer Operations Review Report (June 2020)*
[59] Probability of exceedance is the probability that the forecast electricity demand would be met or exceeded. A 50% POE demand represents a 50% probability of the forecast being met or exceeded. AEMO (2020), *Generation and Load*, accessed 1 October

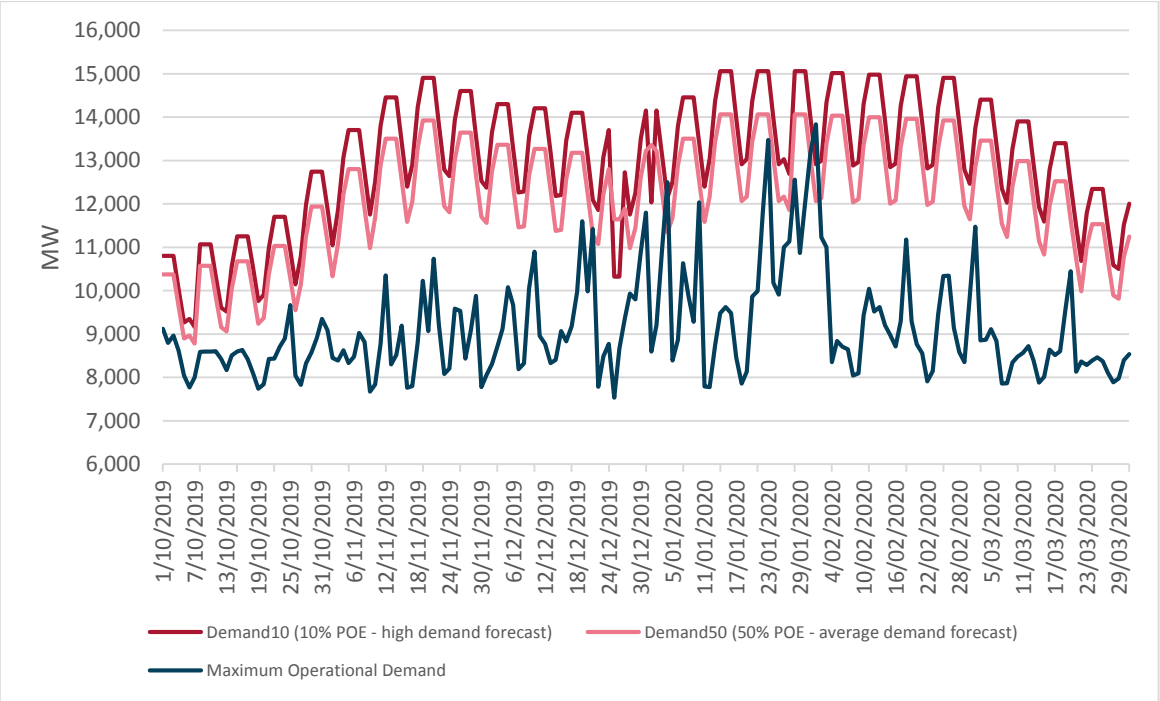

Figure 3: Comparison of 10% and 50% POE MT-PASA demand forecasts for NSW with actual maximum operational demand
Source: AEMO MT-PASA[60] and AEMO Operational Demand – Actual Daily[61]

2.2.2.2 Supply

Deviations from the forecasts for scheduled generation availability were caused by severe weather conditions, which caused an increase in unplanned transmission outages and led indirectly to loss of generation. Overall, a decrease in unplanned generation outages was observed.

Bushfire smoke and raised dust levels affected the Sydney basin for much of December 2019 and January 2020 impacting forecasts for large-scale and roof-top solar generation. AEMO modelling suggests that smoke plumes caused a decrease in solar output of approximately 6 to 13% throughout the summer.[62] Monitoring data from rooftop solar in Sydney and Canberra found reductions of 15 to 45% on days of heavy smoke haze.[63]

As described in Section 2.2.1, high-temperature wind power generation de-rating was observed on a wide scale for the first time in South Australia and Victoria, causing wind power generation availability to be over-forecast. AEMO is currently investigating how events such as these can be better anticipated and managed by wind generators and the forecasting system.

Apart from the issues due to smoke, dust and high temperatures, forecast deviations for intermittent generation were relatively low. In NSW, for the 4-hour ahead horizon, average forecasting error was decreased for both semi-scheduled and rooftop solar generation compared to 2018/19. However, an increase in average error was observed for semi-scheduled solar generation at the day ahead horizon. Measures are being developed to address known biases caused by weather forecasting methodologies that result in over-forecasts for semi-scheduled solar and roof-top solar and under-forecasts for semi-scheduled wind-generation.

[60] AEMO (2019), *Market data – NEMWEB. Medium Term PASA 27 September 2019 (13:00)*, accessed 24 September 2020.
[61] AEMO (2019, 2020), *Market data – NEMWEB. Operational Demand – Actual Daily (Archive)*, accessed 24 September 2020.
[62] AEMO (2020), *2019-20 NEM Summer Operations Review Report (June 2020)*.
[63] Potter, A. (2020), "*How much does smoke haze affect rooftop solar production?*", Solar Analytics Blog, 13 January 2020, accessed 13 October.

2.2.2.3 Reserves

AEMO produces forecasts that project supply and demand on a range of timescales in order to identify when additional reserves may be required. These forecasts were assessed and updated with improved levels of information to support sufficient provision of reserves during 2019/20. AEMO also integrated the forecasting of RERT activation into its demand forecasting system ahead of summer 2019/20 and reports that this enhanced the ability of control room staff to manage the RERT process.

2.2.2.4 Forecast Uncertainty Measure Values

In December 2018, AEMO implemented changes to the Reserve Level Declaration Guidelines. These changes were introduced following consultation with stakeholders around a number of factors that improved information about plant capacity modelling, interconnector support, network limitations (inter- and intra-regional), and changes to the confidence level. A noticeable reduction in the maximum Forecast Uncertainty Measure (FUM) values was noticed across all jurisdictions and forecast horizons for summer 2019/20 compared to 2018/19 (see Figure 4 for NSW region). FUM values are an estimate for the uncertainty associated with forecasting reserve levels and are incorporated into assessment of LOR forecast declarations. Decreased FUM values represent decreased forecast uncertainty and can lead to potential reductions in LOR declarations, thereby lowering the required reserve amounts that need to be contracted by AEMO.

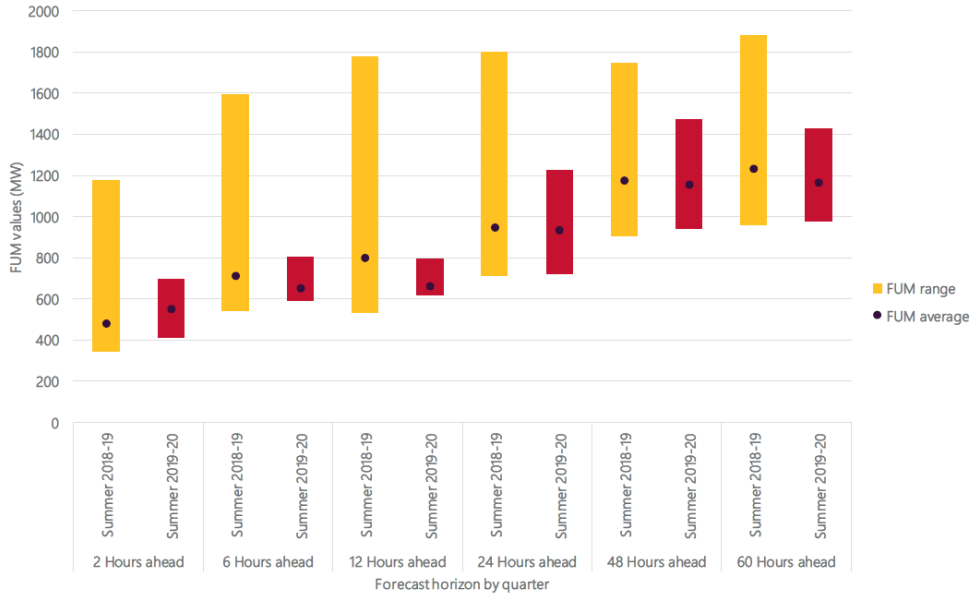

Figure 4: Reduction in maximum and range of FUM values for summer 2019/20 (red) compared to summer 2018/19 (yellow)
Source: AEMO[64]

[64] AEMO (2020), *2019-20 NEM Summer Operations Review Report (June 2020)*

2.3 NSW Operational Review

2.3.1 NSW electricity businesses

NSW electricity businesses reported that summer preparedness plans had been effective and that they were satisfied with the way their systems and workforces handled the extraordinary stresses of summer 2019/20. Many businesses conducted their own reviews (including independent audits) following the bushfire season and have begun to implement actions that were advised as a result, including improvement of back-up power supply for internal communication systems, extra fire protection, and increased security of water sources and supplies.[65]

In NSW, generator capacity was in line with pre-summer forecasts.[66] However, a few generator outages late in the summer peak directly reduced scheduled generation availability.[67,68] Fortunately, mild temperature conditions in that late summer period minimised the impact on reserves. AEMO also reported that all regions of the NEM were impacted by indirect loss of generation due to unplanned transmission outages.

Preparations undertaken by AEMO and TransGrid for summer 2019/20 included bushfire mitigation activities, undertaking preventative maintenance and scheduling planned maintenance outside of high demand periods. NSW had a reduced number of planned transmission outages compared to 2018/19. However, as a result of bushfires, NSW had the largest number of unplanned transmission outages of all the regions and this was also a significant increase on summer 2018/19 (58 versus 10 outages).[69] Bushfire-related transmission outages led to a regional separation event between Victoria and NSW on 4 January 2020, this led to an actual LOR2 declaration for NSW (described in Section 2.3.3.1).

2.3.2 LOR and RERT events in NSW

Similar to the previous summer (2018/19), no LOR3 declarations occurred in the NSW region. However, nine actual LOR conditions were declared in NSW (five actual LOR1, four actual LOR2), and the RERT scheme was activated on three occasions in NSW in response to actual LOR2 declarations.[70,71,72] Half of the actual LOR2 conditions declared for the NEM were in the NSW region. Compared to the previous season and other jurisdictions, the NSW region experienced a substantial increase in actual LOR declarations during the 2019/20 shoulder and summer period compared to 2018/19, reflective of high demand and constraints imposed by extreme conditions and bushfire events (Figure 5).

[65] AEMO and DNSPs, personal communications, August to September 2020.
[66] AEMO (2020), *2019-20 NEM Summer Operations Review Report (June 2020)*
[67] Generation units at Bayswater (Unit 4, 660 MW) and Mt Piper (Unit 1, 700 MW) had availability issues on 23 January 2020. McArdle, P. *"Factors contributing to events in NSW on Thursday 23rd January 2020 – taking a closer look…"*, WattClarity, 25 January 2020, accessed 26 October 2020.
[68] Generation capacity at Colongara Gas Turbines (approximately 650 MW) was temporarily unavailable on 1 February 2020. McArdle, P., *"Out of the blue, another LOR2 – NSW region on Saturday 1st February 2020"*, WattClarity, 2 February 2020, accessed 26 October 2020.
[69] AEMO (2020), *2019-20 NEM Summer Operations Review Report (June 2020)*
[70] AEMO (2020), *NEM Lack of Reserve Framework Report, Reporting period 1 October 2019 to 31 December 2019.*
[71] AEMO (2020), *NEM Lack of Reserve Framework Report, Reporting period 1 January 2020 to 31 March 2020.*
[72] AEMO (2020), *Reliability and Emergency Reserve Trader (RERT) End of Financial Year 2019-20 Report*.

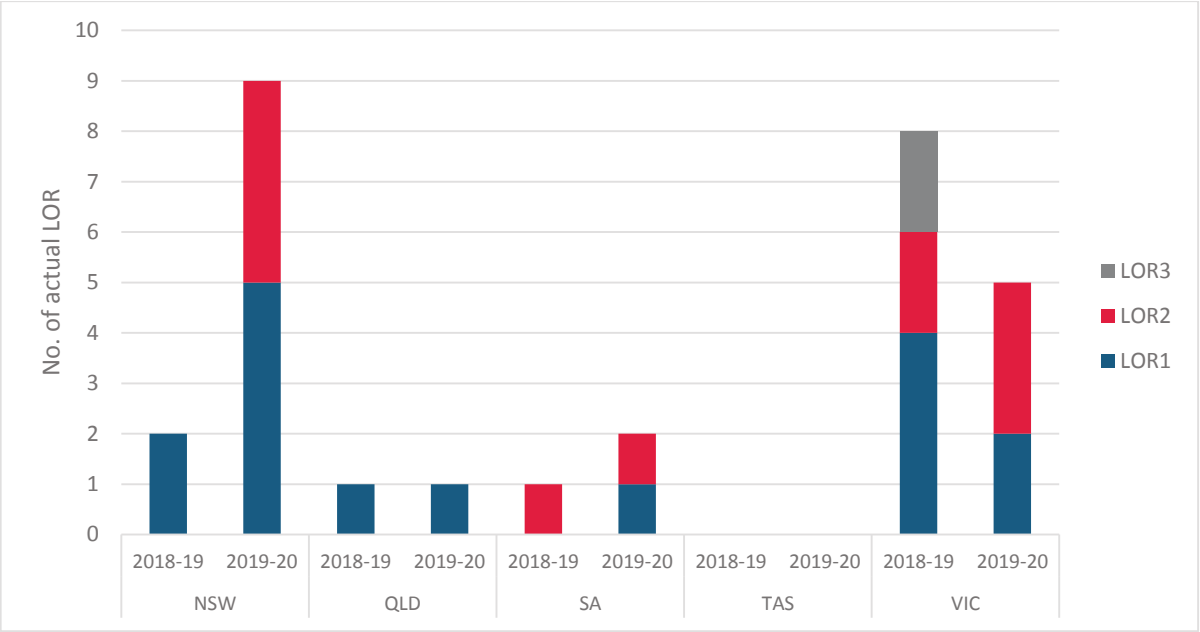

Figure 5: Comparison of actual LOR declarations for the shoulder and summer season (October through March) for the years 2018-19 and 2019-20.
Source: AEMO[73,74]

Each of the actual LOR2 declarations were experienced on days that were in the top 5 for total operational and peak demand from the grid over the period 1 October 2019 to 31 March 2020.[75] Two of the actual LOR2 were also related to extreme weather events (bushfire and storm impacts). This highlights the potential risks to electricity supply when contingent events occur on days of high demand, which are expected to occur more frequently due to changing climate.

The resolution of LOR conditions generally involves increased generation availability through market response, reduced demand forecast or increased reserve availability through activation of the RERT mechanism by AEMO. Table 3 provides a summary of the four actual LOR2 events and related RERT activations that occurred for the NSW region during the season. Detailed reports on LOR declarations are released quarterly by AEMO.[76]

[73] AEMO (2020), *NEM Lack of Reserve Framework Report, Reporting period 1 October 2019 to 31 December 2019.*
[74] AEMO (2020), *NEM Lack of Reserve Framework Report, Reporting period 1 January 2020 to 31 March 2020.*
[75] OCSE analysis and AEMO (2019, 2020), *Market data – NEMWEB. Operational Demand – Actual Daily (Archive)*, accessed 24 September 2020.
[76] AEMO, *NEM Lack of Reserve Framework Quarterly Reports*, accessed 20 October 2020.

Table 3: Actual LOR2 conditions and RERT activations in NSW over shoulder and summer 2019/20

Date	RERT contracted[77]	RERT activated[78]	Description[79]
4/1/2020	368 MW for a shortfall of 257 MW	68 MW Total cost $8.36m	• Multiple transmission lines tripped in southern NSW, separating the NEM north and south of the area, with reduction in available generation. • Major bushfires in the area were found to have a significant role in this event
23/1/2020	520 MW for a shortfall of 258 MW	152 MW Total cost $7.54m	• Fluctuations in demand forecasts and generator ability led to several revisions of the LOR forecasts from LOR1 to LOR2. • An actual LOR2 was declared due to significant and rapid decrease in generation availability.
31/1/2020	478 MW for a shortfall of 275 MW	134 MW Total cost $11.15m	• Towers supporting major transmission lines in western Victoria were damaged in a storm causing separation of Mortlake Power Station, two Victorian wind farms, the APD aluminium smelter and South Australia from the NEM. • The NSW-Vic Interconnector was constrained down due to the separation event, and the forecast demand rose in NSW leading to an LOR2 condition.
1/2/2020	N/A	N/A	• During actual LOR1 conditions, generation availability suddenly decreased resulting in reduction of available reserve causing an actual LOR2. RERT was not activated.

2.3.2.1 Large demand-side response

The Tomago Aluminium Smelter (Tomago) is a large electricity customer in NSW, with three pot lines at ~300 MW of demand each. Turning off one of the potlines reduces the grid demand to the equivalent of more than 100,000 homes and provides a valuable demand side service to protect the system by preventing load shedding under conditions where there is a lack of reserve. For example, Tomago was contracted by AEMO to provide reserve electricity through the RERT process during LOR2 events in NSW on 4 January, 23 January and 31 January 2020[80], with this causing a significant amount of disruption to their typical operations. A typical year would see three to four hours of disruption, however a total of 10.5 hours was experienced in January 2020 alone.[81]

Tomago can take a large amount of demand out of the grid at very short notice (seconds to minutes) when directed by the TNSP (at the instruction of AEMO for involuntary load shedding). However, the smelter has physical constraints on the pot lines which limit both duration and frequency of shutdowns.

2.3.3 Separation events that impacted NSW

AEMO has released analysis of the regional separation events of 4 January 2020 (NSW-VIC) [82,83] and 31 January 2020 (VIC-SA) [84]. Both events resulted in the declaration of actual LOR2

[77] AEMO (2020), *Reliability and Emergency Reserve Trader (RERT) End of Financial Year 2019-20 Report*.
[78] AEMO (2020), *Reliability and Emergency Reserve Trader (RERT) End of Financial Year 2019-20 Report*.
[79] AEMO (2020), *2019-20 NEM Summer Operations Review Report (June 2020)*.
[80] AEMO (2020), *Reliability and Emergency Reserve Trader (RERT) Quarterly Report Q1 2020*.
[81] Tomago Aluminium Smelter, personal communication, 10 September 2020.
[82] AEMO (2020), *Preliminary Report – New South Wales and Victoria Separation Event on 4 January 2020.*
[83] AEMO (2020), *Final Report – New South Wales and Victoria Separation Event on 4 January 2020.*
[84] AEMO (2020), *Preliminary Report – Victoria and South Australia Separation Event, 31 January 2020*.

conditions for NSW as detailed above in Table 3. Further details on these two major events are described in this section.

2.3.3.1 4 January 2020 - Separation of NSW and Victoria

On 4 January 2020, AEMO released market notices advising the elevated likelihood of a non-credible contingency event due to possible impacts of extreme and severe fire conditions on transmission elements in both the NSW and Victoria regions. Total operational demand across NSW on this day was the fifth highest for the 2019/20 summer.[85] This was reflective of extreme conditions with several Sydney sites recording their highest maximum January temperatures, including Penrith Lakes which recorded a maximum temperature of 48.9 °C. Sites at Badgerys Creek, Richmond RAAF, Bankstown Airport, Parramatta North and Horsley Park all experienced record maximum temperatures of 47 °C or above.[86]

At 4:10 PM AEDT[87], bushfires in the Snowy Mountains area caused several major transmission lines to trip, disrupting the Victoria-NSW Interconnector and separating the NEM into north-south islands. The main part of NSW remained connected to Queensland while southwest NSW remained connected to the southern island with Victoria, South Australia and Tasmania. Generation availability rapidly declined through loss of imports from Victoria, loss of connections to Tumut (Snowy Hydro), and constraints introduced by AEMO to maintain power system security. This triggered actual LOR2 conditions for the main NSW region at 5:34 PM, which remained in place until 10:00 PM.

In the 40 minutes preceding the separation event, a significant number of unplanned transmission outages had occurred due to bushfire activity. This meant that generation at Tumut 1 and 2 was disconnected from the network, and that Victoria and NSW had been connected via an unusual combination of lines at the time of separation. In response to the separation, AEMO activated RERT based on manual calculations for NSW reserve. Reserve had to be calculated manually due to the unusual system configuration in place at the time (southwest NSW being connected to Victoria) making the PASA calculation of reserve unreliable. AEMO activated 68 MW of RERT and pre-activated a further 300 MW in case of a subsequent contingency event. This included all RERT services available to NSW at the time.

Spot prices rose significantly following the separation event, with a price of $14,700/MWh[88] being reached during the 6:00 PM and 6:30 PM trading intervals (5:00 PM and 5:30 PM [NEM time/AEST]).[89] This resulted in a substantial amount of demand side response, including reduction of demand from Tomago Aluminium Smelter. Together with RERT capacity, this helped improve the reserve levels such that the LOR condition was removed by 10:00 PM.

Reconnection between Victoria and NSW was established at 10:56 PM and the Automatic Generation Control[90] system was returned to normal configuration at 10:59 PM. Most of the major transmission lines were returned to service by the end of the night with the exception of one line which remained out of service until 26 January.

In their final event report, AEMO found several issues with Frequency Control Ancillary Services (FCAS) and frequency deviation during this event and have indicated that actions are being taken

[85] OCSE analysis. AEMO (2019, 2020), *Market data – NEMWEB. Operational Demand – Actual Daily (Archive)*, accessed 24 September 2020.
[86] BOM, *Greater Sydney in January 2020: record heat, severe storms, smoke and dust*, 3 February 2020, accessed 15 October 2020.
[87] All times for this section are reported in Australian Eastern Daylight Savings Time [AEDT].
[88] AER (2020), *Electricity spot prices above $5000/MWh: New South Wales, 4 January 2020*.
[89] For comparison, the NEM-average wholesale price for Q1 2020 was $66/MWh. AEMO (2020), *Quarterly Energy Dynamics Q1 2020.*
[90] The Automatic Generation Control (AGC) system is a system which governs energy market dispatch of generating units which are on remote control and the regulation of frequency control ancillary services (FCAS) dispatch. The AGC is the secondary layer of control for frequency. It normally operates on a single frequency for mainland Australia but in separation events the separated regions need to be managed independently. AEMO (2019), *System Operating Procedure: Dispatch*, version 86. Accessed 15 October 2020.

to address these.[91] A review of PASA tools by AEMO is also being conducted in order to improve ability to accurately calculate reserve levels in response to changes in region boundaries. During the event it was also found that a large proportion (40-50%) of rooftop photovoltaic (PV) systems exhibited behaviours that were inconsistent with the relevant standard (AS/NZS4777.2:2015) in terms of required disturbance ride-through capability resulting in a sudden drop in generation output due to disconnections. Actions by AEMO are being progressed to understand and improve the response of distributed PV during system disturbances which will be increasingly important as solar penetration continues to increase in the NEM (see Chapter 4).

2.3.3.2 31 January 2020 - Separation of Victoria and South Australia

Severe storm activity brought down several steel transmission towers carrying the Moorabool - Mortlake and Moorabool - Haunted Gully 500 kV lines, causing separation of South Australia from Victoria at about 2:26 PM on 31 January 2020. At the same time, the Haunted Gully - Tarrone 500 kV line also tripped. Both potlines at the Alcoa Portland aluminium smelter also tripped, disconnecting a load of approximately 450 MW. The reasons for these two coincident events are subject to ongoing investigation by AEMO.

Immediately, flows of 500 MW into Victoria on the Victoria-South Australia interconnector reversed direction into South Australia. This happened as a result of the tripped potlines at the smelter and the generation at Mortlake Power Station and the Macarthur and Portland windfarms remaining online and connected to the South Australia region.

AEMO declared actual LOR2 conditions for both Victoria and NSW regions in response to the event. Victorian reserve levels fell due to loss of imports from South Australia and disconnection of generation at Mortlake Power Station, Macarthur and Portland Wind Farms. NSW reserve levels fell as the Victoria-NSW Interconnector was constrained down. AEMO noted that higher flows into NSW were observed on the Queensland-NSW Interconnector following the event, and the reasons for this will be examined further in their final event report.

The separation event also caused frequency issues for the South Australian region, with an elevated frequency of 51.11 Hertz (Hz)[92] immediately post-separation. This activated an Emergency Frequency Control Scheme [93] causing some generation units and batteries to trip or reduce output in order to preserve the system. An increase in scheduled generation was also observed, and AEMO reports that this was likely a result of decreased (behind the metre) rooftop solar and other non-scheduled output in the region in response to the high frequency. This highlights a need for greater understanding of the interactions that increasing levels of VRE generation will have with the grid under emergency situations.

The final report for the event will soon be available from AEMO.[94] The event highlights the interdependent nature of the NEM regions, where a major event in Victoria and South Australia has flow on impacts to NSW, and the potential impact of coincident or cross-jurisdictional events (as noted in previous Panel Assessments).

[91] These include corrective action for generating units which did not deliver their enabled FCAS requirements, a review of frequency constraint formulation by AEMO, and further investigation into unexpected frequency deviation during the Victoria/South Australia area shortly after the event.
[92] The normal operating frequency band for the NEM mainland is 50 ± 0.15 Hz, with 51 Hz being the upper limit of the operational frequency tolerance band. AEMC (2017), *The Frequency operating standard.*
[93] An Emergency Frequency Control Scheme was implemented in South Australia following recommendations by AEMO in response to the System Black event of 2016. As part of this scheme, Over-Frequency Generation Shedding (OFGS) controls staged shedding of generation in a pre-determined sequence when the network is operating at frequencies between 51 and 52 Hz. The aim of OFGS is to protect the system by limiting frequency excursions to a maximum of 52 Hz. AEMO (2018), *Power System Frequency Risk Review Report 2018.*
[94] AEMO reports on power system operating incidents are uploaded to their website as they become available.

3 Summer 2020/21 Forecasts, Risks Assessment and Preparedness

This chapter provides an overview of reliability and demand forecasts, the status and risks to generation, transmission and distribution infrastructure and the expected climatic conditions for summer 2020/21.

An important factor going into summer 2020/21 is the Coronavirus (COVID-19) pandemic and the impact it could have on many aspects of summer supply and demand. COVID-19 represents a great uncertainty for all aspects of the energy sector, in that it has, and can have, an impact on supply chains (component manufacture and transport) and personnel (national and international border restrictions), thereby having an impact on maintenance, outages (planned or unplanned), projects (future delays in commissioning), operational procedures (split worker shifts, duplicated control rooms) and emergency management situations. COVID-19 has also altered consumer behaviour, with working from home arrangements changing the magnitude and occurrence of peak demands. All of the above are further compounded by uncertainty around COVID-19 related restrictions, with different implications for the electricity sector if current arrangements persist, or the situation improves or deteriorates. The following chapter makes commentary on the impact of COVID-19, which is explored more thoroughly in Section 3.4.3.

3.1 Reliability and demand forecasts

AEMO has forecasted that for summer 2020/21 all jurisdictions will meet the reliability standard (USE <0.002%). The forecast is an improvement compared to last year and the result of factors including[95]:

- *Reduction in forecast demand* - AEMO concludes that demand growth is unlikely to cause supply scarcity risk in the short term. AEMO runs sensitivities with varying economic and behavioural assumptions to understand consumption, large loads and Distributed Electricity Resources (DER)[96] forecasts. All analysis suggests a reduced peak demand and electricity consumption in 2020/21 summer.
- *New generation capacity* - An additional 4,300 MW new VRE capacity forecast to be operational in 2020/21 summer compared to last summer in the NEM. In NSW, since the 2019 ESOO, there is an additional committed 1,676 MW VRE projects, 240 MW of pumped hydro and 105 MW of thermal generator upgrades over the next 10 years. In South Australia, there will be an increase in scheduled capacity from generator updates, battery expansions and gas generation[97].
- *Full return to service of units from prolonged outages* - Unlike 2019/20 summer, there are currently no generators on extended forced outages that the Panel is aware of thus not presenting a risk of extending the outages into the critical summer period. However logistical challenges due to COVID-19 may extend service time for planed or unplanned outages.

Since the 2019/20 Assessment, the ESB published a set of changes to the National Electricity Rules to establish an out-of-market capacity reserve called the Interim Reliability Measure (IRM). These rules, designed to reduce the risk of load shedding, were proposed by the ESB as a change to the National Electricity Rules. The change was recommended and approved by the Energy Ministers in August 2020 following consultation undertaken through the COAG Energy Council in

[95] AEMO (2020), *2020 Electricity Statement of Opportunities*.
[96] Distributed energy resources (DER) are generally smaller generation units (such as rooftop PV, etc.) or demand management devices (such as batteries) at the distribution level (AEMO).
[97] The South Australia Government has leased diesel generators to Infigen Energy to relocate and convert them into gas generators with a 25-year contract. Harmsen, N., *"Back-up power stations to prevent SA blackouts privatised but will contribute more to grid"*, ABC News, 28 August 2019, accessed 4 September 2020.

March 2020 and was published as the National Electricity Amendment (Interim Reliability Measure) Rule 2020 in August 2020. This amendment added the new Clause 3.9.3C(a1):

> *The interim reliability measure for generation and interregional transmission elements in the national electricity market is a maximum expected unserved energy in a region of 0.0006% of the total energy demanded in that region for a given financial year.*

The 2020 ESOO also indicates that USE is not expected to exceed the IRM of 0.0006%. AEMO also notes that there is a proposed Retailer Reliability Obligation (RRO) amendment that, as drafted for consultation (soon to be released), will measure AEMO's reliability forecast against the IRM of 0.0006% in order to determine a forecast reliability gap.

The Panel also noted that a review is currently being undertaken by the Independent Pricing and Regulatory Tribunal (IPART) to examine Distribution Reliability Standards and the inclusion (or exclusion) of events in reliability standard measures.

AEMO has forecasted a maximum operational demand of 13,786 MW and 12,711 MW for 10% POE and 50% POE respectively in NSW for 2020/21. This is lower than for 2019/20, this decline is attributed to the impact of COVID-19. However, with more people at home the forecast residential consumption has increased. The operational maximum demand is forecasted to occur in NSW between 16:00 and 19:00 (this is forecast to continue until the mid- to late-2030's).

In Victoria, the expected USE has declined since the 2019 ESOO[98], however the risk of load shedding remains in conditions where peak demand at 10% POE level coincides with low renewable generation, and/or when prolonged generation or transmission outages occur.

The forecast maximum demand over the summer (average and high demand scenarios) compared with forecasted supply (medium-term horizon) for the NSW region is at Figure 6. The figure shows a tightness in supply and demand from late-October to mid-December. This coincides with planned outages at Mt Piper Power Station (EnergyAustralia) and on Victorian transmission links (including a single line through the Heywood interconnector in October/November which has implications for both Victoria and South Australia). The unit upgrade being undertaken at Mt Piper Power Station is due to come online in late December 2020[99]. Unlike last year, there are currently no generators on extended forced outages with a risk of their return to service pushing into the critical summer months.

The 2020 ESOO discusses that COVID-19 has led to changes in electricity use patterns *"as a result of disrupted economic and social activities and changing work arrangements, and the short to medium-term impact on electricity consumption is highly uncertain, despite the net impact on total consumption to date being relatively modest".* It was noted by the Panel in consultations with the NSW electricity market participants that the effect (so far) of COVID-19 on the network and aggregated demand has being relatively 'benign' when compared to international and other national jurisdictions, but in noting that there is still uncertainty in regards to this coming into summer (see Section 3.4.3).

[98] AEMO (2019), *2019 Electricity Statement of Opportunities.*
[99] The unit upgrade is to increase the two 700 MW turbines by 30 MW each (one in October 2020, one October 2021) EnergyAustralia (2019)

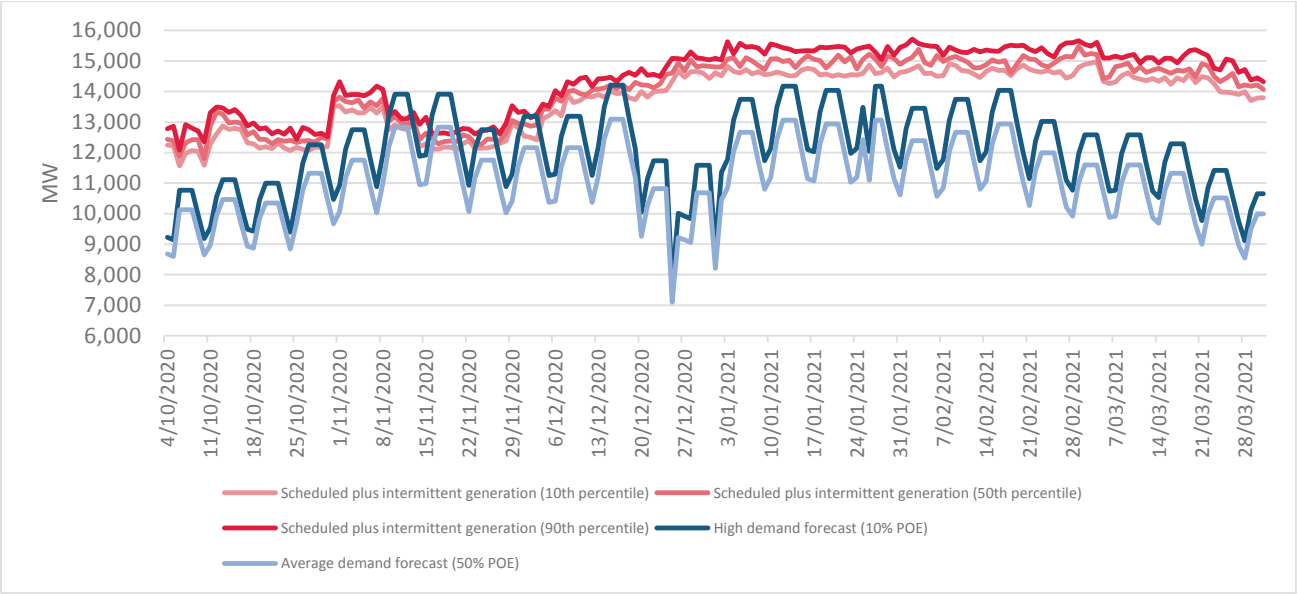

Figure 6: Comparison of NSW demand forecasts (10% and 50% POE) with scheduled and intermittent generation (at 10%, 50% and 90% intermittent)

Source: AEMO[100,101]

3.2 Generation and transmission infrastructure status

For the upcoming summer, coal-fired and gas generators, transmission and distribution network operators informed the Panel of their preparations and status.

3.2.1 Outages

Planned and unplanned outages from generators, Transmission Network Service Providers (TNSPs) and DNSPs have the potential to impact the reliability of electricity supply. Major maintenance and upgrades are generally not conducted over the summer period. As discussed in the 2019/20 Assessment most outages for maintenance and upgrades occur in the 'shoulder period', but with the impacts of climate change (for example, the extension of summer conditions with warmer spring and autumn temperatures) these shoulder periods are becoming shorter. This poses risks with concurrent events, such as unplanned outages or major weather events, during those periods. Over 2020/21 there is clustering of outages, such as in October/November in Victoria, with other regions having planned outages in April/May.

In the 2020 ESOO, AEMO has modelled increased forced outage rates and, for the first time, forward-looking forced outage rates to estimate the impact of maintenance programs and deteriorating generator performance as parts of the fleet approach retirement. Within this assessment, they have also applied the concept of high impact low probability (HILP) to distinguish outages of duration of five months or more. Further, the 2020 ESOO has examined a two-tiered generator rating assessment: one during near-maximum demand periods (associated with 10% POE ambient conditions) and one for average summer conditions.

As part of their other surveying processes, AEMO collects unplanned forced outage generation data (e.g. timing, duration, severity). The data indicates that there are some categories of thermal generation that have experienced recent deterioration compared to their longer-term historical performance. However, it was also noted that HILP generator outage can have a significant impact on this trend (with a 0.84% HILP forced outage assumption, in conjunction with the ~16% forced

[100] AEMO (2020), *Market data – NEMWEB. Medium Term PASA*, 29 September 2020, accessed 1 October 2020.
[101] AEMO (2020), *Market data – NEMWEB. Medium Term PASA Regional Availability*, 1 October 2020 (9:33AM), accessed 1 October 2020.

outage for 2019/20 rate, for NSW black coal). Noting this, AEMO have forecasted an approximate 13.5-14% full forced outage rate for NSW black coal generators for summer 2020/21 (Figure 7).

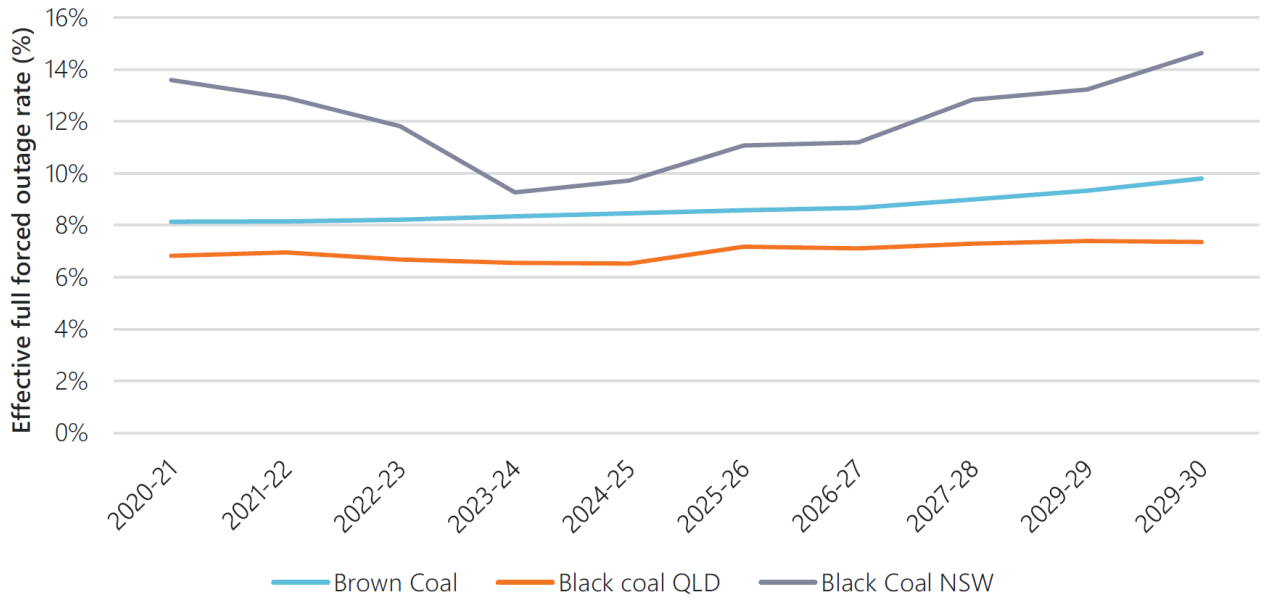

Figure 7: Effective full forced outage rate projections for coal-fired generation technologies

Source: AEMO[102]

In discussions with the Panel, a number of stakeholders raised concerns about the potential impact of increased ramping of the older generation units (i.e. ramping up and down of the units in response to varying demand) on plant longevity and associated maintenance requirements such as frequency and duration. This issue is further discussed in Chapter 4 and it has future implications beyond this summer.

Impacts of COVID-19 have meant that generators have found it more difficult to complete scheduled maintenance and outages resulting in outage extensions, changes to scope of planned works, and planning for shorter outages ahead of the summer period with major maintenance-related outages pushed to post-summer periods. For example, the Mt Piper Power Station (Unit 1) has a major planned outage from late September to late December that is on track, but with the various restrictions related to COVID-19 has the potential to overrun.

3.2.1.1 Coal supply

The 2019/20 Assessment discussed issues around the supply of coal to the Mt Piper Power Station due to geological issues at Centennial Coal's Springvale Coal Mine. In discussions with the Panel for the 2020/21 assessment, EnergyAustralia noted that there is the ongoing issue with the quality of coal produced from the mines, in that the 'stickiness' of the coal impacts the efficacy of the coal milling process that provides pulverised fuel to the boiler furnace. In noting this, the situation has improved since last year, as they have sourced additional coal (of an improved quality), and the Panel does not see this as a risk for summer 2020/21. However, as per the recommendation from the 2019/20 Assessment, there should be ongoing dialogue between EnergyAustralia (and other generators) and the NSW Government concerning coal supply (amongst other issues that could cause generation risks).

[102] AEMO, 2020. *2020 Electricity Statement of Opportunities.*

3.2.1.2 Extreme climate conditions

The Panel noted from the 2020 ESOO and the 2019-20 NEM Summer Operations Review Report that the physical infrastructure (gas and electricity) of the NEM is being challenged by high heat and extreme fire conditions, and indicates that there is a "*need to harden these assets to more extreme climatic conditions and consider opportunities to enhance the inherent resilience of the NEM when planning and delivering either new projects or replacing existing infrastructure will be a necessary element of future NEM planning*". This impact is not just on conventional (thermal) generation, but also on renewable and gas generation and associated infrastructure, and includes:

- plant temperature tolerances being approached (and the associated degrading output) and the consequences for equipment longevity and maintenance,
- extensive smoke (and in discussions with BOM, to a lesser extent dust) that makes it difficult to accurately forecast solar output during events,
- environmental limits (such as Environmental Protection Licences (EPL) around water discharge temperatures) increasingly being approached,
- the increasing vulnerability (physical and thermal operating limits) to key transmission lines and other major energy infrastructure, including impacts on gas (temperatures above design tolerance of pipelines and plants) and renewable infrastructure (such as wind generation de-rating, as outlined in Section 2.1.1).

All of these can have an impact on the electricity system, for example, through increasing forecast uncertainty given that supply is dependent on many variables. AEMO and the other electricity market participants are increasingly aware of these issues and are taking steps to improve understanding of these technical limitations, finding solutions (where able to) and increasing the accuracy of their forecasting by understanding this uncertainty.

The Panel has noted that previous assessments have examined issues associated with warmer temperatures, such as EPLs associated with water discharge temperatures for the power stations on Lake Macquarie (Eraring (Origin Energy) and Vales Point Power Stations). This resulted in discussions between the generators and EPA in 2018 (outlined in previous Assessments), ultimately leading to a variation in their EPLs that allows for the generators to operate at a higher discharge temperature for a longer period of time when directed by AEMO. NSW EPA has confirmed that there are no new EPL applications or changes to existing conditions, although notes that there is a pending review on seagrass condition.

3.3 Climatic conditions and extreme weather events

Predictions of climate and weather conditions are an important input into forecasts of electricity supply and demand, further they pose risks to the reliability and resilience of the system. As in previous years, the Panel received a briefing from the BOM to understand the current outlook for 2020/21 summer.

The BOM has announced that the tropical Pacific region is currently in La Niña[103] which is expected to persist until at least January 2021. In conjunction with a negative IOD in the Indian Ocean, the BOM has forecasted a wetter than average summer, especially for regions west of the Great Dividing Range. Rainfall in the lead up to summer (September to November 2020) is also forecast to be above average.

In contrast to the last assessment, drought conditions have eased with 27% of NSW either drought affected or in drought (down from 99.4%).[104] The months January to August 2020 have seen

[103] The Australian BOM defines La Niña as "the positive phase of the El Niño Southern Oscillation. It is associated with cooler than average sea surface temperatures in the central and eastern tropical Pacific Ocean". BOM, *La Niña*, 7 February 2011, accessed 20 October 2020.
[104] NSW Department of Primary Industries, *Combined Drought Indicator,* accessed 20 October 2020.

higher than average rainfall, improving root zone soil moisture in many areas of NSW.[105] However, areas of northern and western NSW are still experiencing the impact of long-term rainfall deficiencies accumulated over several years. The northern ranges and west are being monitored closely for fire risk.[106]

Dam levels increased since last year with supplies in Greater Sydney and regional areas at 93.8% and 53.5% respectively.[107] Noting the La Niña declaration and the current dam levels, prolonged and/or intense rainfall could cause dams to overflow leading to potential localised and/or widespread flooding that could impact on the electricity sector and the broader community.

Fire risk is reduced in comparison to last year. Forecast FFDI is average for most of the state, but above average for northeast NSW. The risk of fire in the northern NSW is expected to decrease as summer progresses due to higher humidity and cloud cover driven by La Niña and negative IOD conditions. The conditions suggest that grass fires could be an issue if spring rainfall supports good growth conditions for grass, with the areas west of and on the Great Dividing Range are being monitored for this risk.[108]

Temperatures along the NSW coast are expected to be above average for the pre-summer months. However, compared to last year, extreme temperature periods are not expected to be prolonged. There are strong signals for higher than average overnight minimum temperatures and rainfall totals exceeding average, especially west of the Great Dividing Range.

In terms of extreme weather, La Niña conditions are associated with increased rainfall and more severe thunderstorms west of the Great Dividing Range. The coastal areas are more likely to see hail and intense rainfall rather than dry thunderstorm activity. Intense rainfall could lead to increased flood risk, particularly in areas around dams that are full. Increased cloud cover and humidity driven by La Niña are also expected to reduce the likelihood of extreme temperature days. However, La Niña conditions increase the likelihood of tropical cyclones in the north and increased wind activity has the potential to worsen the impact of any fires in the north of NSW.

3.4 Summer 2020/21 Preparedness

For summer 2020/21, NSW is well placed from an electricity reliability point of view, however there is a range of risks to the system from extreme weather (storms, floods and fire), hot days and heatwaves and concurrent events across the NEM.

This section explores actions that the NSW Government and market stakeholders have undertaken to prepare for the coming and future summers to ensure the supply of electricity to consumers and respond to emergency situations. This builds upon the previous CSE reports (2018/19 and 2019/20 Assessments), with many of the actions now considered business as usual. The actions below address both these and new actions arising, such as recommendations from the Final Report of the NSW Bushfire Inquiry.

3.4.1 Actions by the NSW Government

As previously mentioned, many of the following actions have been undertaken by the EUSFAC and the EUSFA, with the EUSFAC coordinating the EUSFA for the provision of electricity and utilities (functional areas also include gas, water and liquid fuel) support, and resources for emergency planning, preparation, response and recovery operations. The EUSFAC also provides coordination and advice on these areas to the State Emergency Operations Controller (SEOCON) and other combat agencies, the Jurisdictional System Security Coordinator (JSSC) and other functional area

[105] BOM, Briefing for OCSE, 10 September 2020
[106] Bushfire & Natural Hazards CRC (2020), *Hazard Note: Australian Seasonal Bushfire Outlook: September – November 2020*, Issue 77, accessed 20 October 2020.
[107] WaterNSW figures correct as at 26 October 2020.
[108] Owens, D. and O'Kane, M. (2020) (2020), *Final report of the NSW Bushfire Inquiry 2020.*

participants. Further detail for these structures and procedures can be found in the two previous Assessment reports.

The NSW Government has undertaken a number of actions since the first Assessment on summer preparedness in 2018/19 to prepare for the coming summers, including the implementation of a Summer Readiness Program. Noting these substantial improvements to preparedness, the Panel acknowledges the following actions that have been undertaken, or are planned to be undertaken, by the NSW Government prior to summer, which include (but are not limited to):

- Participation and facilitation of NSW Government staff in summer readiness preparation and electricity market-related exercises (interagency and multiagency with government and electricity market participants), such as System Restart working group and AEMO Gas exercise (October 2020), as well as the NSW Department of Planning, Industry and Environment (DPIE) Summer Readiness exercises. The Panel notes that the new EUSFAC has been recruited and is in place for summer 2020/21. The EUSFAC has undertaken exercises to ensure knowledge and relationships are built prior to summer. The Panel has confidence in this recruitment process.
- Monthly monitoring programs for NSW generators designed to understand any issues of fuel supply and associated status of coal supply contracts
- EUSFA internal document review, including updating contact directory (key contacts throughout the NSW Government and electricity market participants) and communication materials, and the preparation of EUSFA Skills Matrices (as per 2019/20 Assessment Recommendation 2)
- Staff scheduling (summer availability) and training, including alternative communication equipment training (Government Radio Network and satellite phone) and implementing learnings from the 2019/20 bushfire season; briefings to the NSW Minister (including this report and findings)
- Government Energy Action Response (GEAR) preparation into summer: this includes ensuring up-to-date contacts and engaging potential new Voluntary Demand Reduction (VDR) participants. The Panel noted that, given the current COVID-19 situation that has resulted in a distributed government workforce (i.e. working from home arrangements), the activation and use of GEAR may not be as effective as previous years. However, it was noted that this is being considered by the EUSFA team and that they are examining communication material for demand reduction for remote working situations.
- Critical Service Permits for the energy sector: EUSFA has been involved in the screening and approval process for Critical Service Permits for the energy sector (covering the EUSFA functional areas of electricity, gas, water and liquid fuels), that facilitates and allows critical service staff who are NSW-based and work across the border in Victoria (or vice versa) to perform critical works and return to their home state once work is completed. Specifically for the electricity sector, EUSFA approve and expedite Critical Service Permits for staff associated with thermal generators (coal and gas) to perform, for example, planned shutdown and/or maintenance activities, and also permits for solar and wind farm construction and maintenance specialists (to ensure minimal disruption or delays to these projects).
    - However, the Panel notes that there is not a formal process in place for emergency situations, as the above Critical Service Permits process would not allow, for example, a critical worker to respond to an emergency in a timely manner (i.e. cross the border), such as a gas pipeline leak or replacing a transformer that might leave a town without power.

      The Panel understands that this issue is being discussed by EUSFAC, Deputy SEOCON and the relevant emergency organisations.

- Cybersecurity: The Panel understands that representatives from the NSW Government agencies have participated in energy-related cybersecurity exercises, including the AEMO Australian Energy Sector Cyber Security Framework (AESCF) in October 2019 and upcoming AEMO exercises, and the Australian Cyber Security Centre (ASCS) GridEx exercise in November 2019. There are also NSW Government representatives working with the Commonwealth and other states and territories through the National Cyber Security Committee (and associated sub-committees), which includes developments around critical infrastructure work program.

As highlighted in discussions with EUSFA, the Panel noted that one action that arose from the previous summer is the identification (including recruitment) and training of key surge staff (individuals drawn from the NSW Government, on a voluntary basis, to assist key government functions and agencies in emergencies), which is currently being undertaken by the EUSFA team. Given the substantial demand on staff during the summer 2019/20, the Panel views this as an important proactive step to ensure that there is adequate support for the EUSFA during any potential energy (or related) emergency situation.

In discussions with inter-jurisdictional representatives, it was also acknowledged that there was good communication and relationships between the jurisdictions (particularly between NSW and Victoria/Queensland) that assisted efforts in navigating cross-border issues as a result of bushfires. Regular communication between the operational groups should be maintained throughout the year to allow for efficient and effective information sharing and relationship development.

The Panel has confidence in the processes that have been implemented over the last three years, that have improved the preparation of the EUSFAC and EUSFA team moving into summer, as exemplified by their 2019/20 actions and response to the widespread bushfires. For example, the Final Report of the NSW Bushfire Inquiry highlighted that the EUSFAC:

- "*played a critical role during the 2019-20 season The EUSFAC coordinated meetings between electricity distributors and emergency response agencies to increase situational awareness of all parties*", and
- "*worked closely with fuel companies to ensure fuel supply to bush fire affected areas (North Coast, South Coast, Snowy regions of NSW and Mallacoota in Victoria)*".

The Final Report of the NSW Bushfire Inquiry also made a number of recommendations that were accepted in principle by the NSW Government.[109] A number of these have applicability to the EUSFA and, more broadly, the electricity market participants in NSW. For example, there are a number of recommendations that point towards the need to understand and integrate societal expectations of the electricity sector in emergency situations (actions prior to, during and after), understanding potential trade-offs that this might result in and the changes that may need to be made (regulatory, etc.). In the context of this review, the Panel acknowledged the recommendations in Table 4 that are of relevance to the electricity sector (noting that there are other recommendations from the Inquiry that the NSW electricity sector may also contribute to, but to a lesser degree to those outlined in the table):

[109] NSW Government, *"NSW Government releases Bushfire Inquiry"*, 25 August 2020, accessed 13 October 2020.

Table 4: Panel comments on recommendations from the NSW Bushfire Inquiry relevant to the electricity sector

No.	Recommendation	Panel comments
14	*That in order to provide greater consistency in public information and warnings, especially in border areas:* *a) the finalisation of the Australian Warning System be prioritised to provide greater consistency in public information and warnings* b) *the NSW State Emergency Management Committee, including the Public Information and Warnings Sub-Committee, prioritise the implementation of the Australian Warning System and data standards for relevant hazards within NSW.*	The Panel notes that there is a role for the energy sector, via the NSW EUSFA under the SEMC, to provide assistance in ensuring that there is a consistency in public information. The Panel noted that terminology differences exist across the various sectors (emergency management, energy sector, fuel and water, telecommunications, etc.). There needs to be alignment (where possible) or an understanding of the differences. EUSFA undertook this role during the bushfires.
18	*That, in order to equip NSW RFS with comprehensive information on all structures and assets at risk of bush fire, Government ensures that:* • *there is a single whole-of-government procurement and acquisition program for imagery and LiDAR and that Government accelerate the building of the State Digital Twin and associated Digital Workbench* • *owners/managers of assets (apart from private home owners whose information will be provided through local councils) in bush fire prone land are required to provide to the Digital Twin at least the following information/metadata with quality control certification on an annual basis (with annual census at least two months before the start of the fire season):* ○ *precise geolocation* ○ *description of asset including picture* ○ *value level* ○ *fire treatment on asset* ○ *Asset Protection Zone (APZ) details and how it is maintained* ○ *access details* ○ *what redundancy is available if relevant* ○ *any metadata requirements specific to the asset class* ○ *emergency contact and instructions on how to access where more information is held* ○ *any restrictions on data access and sharing.* *The Digital Twin must also be able to incorporate:* • *information about the hazard reduction results for road verges, fire trails, APZs and other defendable space* • *local information supplied by organisations such as local NSW RFS brigades.*	The Panel noted in discussions with NSW electricity market participants that there is broad support for the digital information sharing platforms, such as the Digital Twin (see Section 4.3.1), both for the information that it provides but also as a method to align work programs across the state (thereby reducing duplication and resourcing requirements, such as LiDAR scanning of poles and wires), introducing common standards to these methods and data definitions. In noting this, many stakeholders have already implemented a similar, in-house program (for different purposes) that could assist and feed into the Digital Twin, but this may require further investment to meet standards. For example, the Royal Commission into Natural Disaster Arrangements indicated that the Commonwealth Trusted Information Sharing Network (TISN), which aims to '*facilitate engagement between various sectors on improving critical infrastructure resilience in an all-hazards context*', is in need of improvement to better share information during incidents[110].

[110] Commonwealth Government (2020) Royal Commission into National Disaster Arrangements Report

22	*That, as part of the spatial technology acceleration program, Government support deployment of remote sensing and picture processing technologies to monitor and audit how well Asset Protection Zones and defendable space are being maintained, especially around towns.*	The Panel noted the potential cross-sectorial shared benefits due to co-location of critical infrastructure (thereby optimising sensor placement) and/or using sensing technology that can have other benefits.
24	*That government agencies managing land (at all levels and through all agencies) be the best neighbours possible by considering their neighbours when undertaking activities related to bush fire preparation and having clear, two-way communication about these activities, with the aspiration that government landholders will be seen as highly desirable neighbours.*	The Panel noted from stakeholders that there could be improvements in cross-tenure land management when it comes to APZs. This is also linked to Recommendation 20 of the Inquiry, which considers the coordination of fuel mitigation activities (i.e. hazard reduction activities).
29	*That, in order to maximise the protection of critical infrastructure in a bush fire, Australian governments revise the regulatory framework for the provision to government authorities of information about all critical infrastructure (public and private) including a possible change to compel the owners of critical assets to provide all needed metadata, updated annually, for appropriate planning, preparation and response for bush fire. This would include information about location, ownership, access, details of service the infrastructure supports, and fire treatments of building and surrounding zones.*	The Panel notes that there is a role for the NSW Government and energy sector in providing assistance in the process of changing, and examining their own, regulatory frameworks around the provision of critical infrastructure (public and private) information that will maximise their protection in emergency situations
30	*That, in order to minimise communication outages and extend basic communication coverage during bush fires, the NSW Government work directly, or together with other Australian governments and/or their relevant power and telecommunications regulatory, policy and market bodies, to:* • *ensure there are sufficient redundancy options available (e.g. backup diesel generators, deployed temporary telecommunications facilities, etc.) to supply power to essential telecommunication infrastructure or alternative telecommunications infrastructure* • *ensure that the telecommunication entities' and electricity network providers' Bush Fire Risk Management Plans are updated annually and reported on in the NSW RFS Commissioner's annual statement to Parliament on the upcoming bush fire season and include details of all actions taken to mitigate those risks including maintenance of APZs and access roads* • *ensure there is appropriate auditing of distributors' preparedness for risks arising from network assets being affected by bush fire, as well as the risk of networks initiating a bush fire* • *facilitate cross-carrier roaming arrangements between carriers and the public for basic text, voice and data during the period of emergency in areas directly affected by fire* • *enable NSW RFS to require carriers to provide regular information on the status of outages and areas affected by fire.*	In discussions with electricity market stakeholders, the Panel noted almost unanimous agreement that more work needs to be conducted in collaboration with the telecommunications sector. The Panel noted further that efforts have been made by the NSW Government after the bushfire season 2019/20 to coordinate provision of data from the telecommunications carriers. Subsequent to the release of the NSW Bushfire Inquiry final report, the industry bodies, Energy Networks Australia and the Communications Alliance, signed a Memorandum of Understanding (MOU) to further improve collaboration and the sharing of information between the two sectors. Through a working group chaired by the NBN Co., they are currently developing guidelines aimed at improving the sharing and coordination of information during emergency situations.

54	*That, to ensure mobile generators are sourced and distributed on a priority basis during natural disasters, the EUSFAC work with the NSW Telco Authority, relevant NSW government agencies and commercial stakeholders to develop a mobile asset deployment strategy. The strategy should reduce duplication in purchasing, maintaining and housing mobile generators and improve agility in deployment.*	Linked to Recommendation 30 from the Inquiry, the Panel noted in stakeholder discussions that there was the reactive, rather than proactive, response to bushfires in relation to, for example, the deployment and refuelling of generation assets at key communication infrastructure (i.e. awareness to these issues was raised just prior to, or after, bushfire). The Panel notes that EUSFA confirmed with the NSW Bushfire Inquiry that the intent of this recommendation is for EUSFA to assist in the coordination of a mobile asset deployment strategy with the Engineering Services Functional Area (ESFA) and TELCOFAC.
58	*That, in order to ensure all agencies have a clear understanding of cross-border communication channels during bush fires, all MoUs between state or territory agencies include an agreed protocol about how agencies will communicate across borders and that these are reflected in Incident Action Plans.*	The Panel notes that there is a role here for EUSFA to facilitate an agreed protocol regarding cross-border communication channels in the electricity sector and their reflection in Incident Management Plans.

The NSW Bushfire Inquiry final report also outlined the operational guidelines that allow for the energising/de-energising of power lines, as developed by the NSW Government (NSW RFS and EUSFAC) and the electricity network operators (TransGrid, and the DNSPs: Ausgrid, Endeavour Energy, Essential Energy) and which formed a component of Recommendation 3 of the 2018/19 Assessment, was successfully used for the first time on 16 November 2019 to de-energise power lines to allow for backburning operations. These guidelines were used multiple times over the summer period, with the process becoming more efficient.

Just prior to the release of this Assessment, the Royal Commission into Natural Disaster Arrangements released their report[111]. Two key recommendations relevant to this Assessment were the collective awareness and mitigation of risks to critical infrastructure (Recommendation 9.4) and improving the coordination arrangements between the operators of critical infrastructure (e.g. electricity TNSPs and DNSPs, telecommunications operators, etc.) and the government (local, state and Commonwealth) (Recommendation 9.5).

The Panel noted that many of these actions occur over the short, medium and long-term, and will keep a watching brief in subsequent reviews as to how the EUSFA and energy sector addresses and assists with these recommendations.

3.4.2 Actions by the electricity industry for summer 2020/21

As stated in previous Assessment reports, summer preparedness has become more robust in the electricity sector as learnings from previous years inform future years. The Panel noted the following specific actions that will be undertaken by market participants for summer 2020/21:

- *AEMO Summer Readiness Industry Briefing*: As with previous years, AEMO undertakes a summer readiness program that builds upon the ESOO and provides market participants with AEMO's key focus areas for the summer, forecasts (climatic and electricity supply/demand expectations) and outlines any other risks to the NEM. This is expected to be delivered in November 2020.
- *AEMO RERT tendering*: AEMO maintains a panel of RERT providers for Short Notice and Medium Notice[112], and is in the process of finalising Unscheduled Short Notice RERT Panel for 2020/21, with the Expression of Interest process extended due to COVID-19.[113] This tendering process considers both generation that is not available to the market and demand curtailment from unscheduled load. The RERT guidelines have also been revised to incorporate the IRM.
- *TNSP, DNSP and generator summer readiness programs:*
    - All work programs (maintenance, vegetation removal for Asset Protection Zones, etc.) and emergency repairs are preceding to plan without significant COVID-19 impact: this includes defect programs that prioritise those that will increase resilience and reduce risk. The AER also provides information and guidance on best practice to generators, noting that their advice for generators this year will be to maintain situational awareness and report heightened risks in their assets to AEMO in a timely manner. It was also noted that the (already considerable) vegetation clearance programs have been substantial post-bushfire to ensure that the risk to assets (from weakened/burnt trees etc.) is minimised coming into summer.

[111] Commonwealth Government (2020) Royal Commission into National Disaster Arrangements Report
[112] Short Notice is between three and seven hours; Medium Notice is between seven days to ten weeks.
[113] Commonwealth Government Department of Industry, Science, Energy and Resources, *"Government responses to COVID-19 in the energy sector",* 29 September 2020, accessed 13 October 2020.

  - AEMO noted the postponement of scheduled major outages for some generation assets, and they are monitoring the clustered nature of 'catch-up' works planned for the April/May 2021 shoulder period.
  - *IPART audits:* TransGrid and DNSPs indicated that they are on track with bushfire risk management reports that are part of the IPART audit requirements. The network operators noted their compliance with safety and reporting obligations under the regulation, their licence conditions and IPART's published requirements
  - The Panel noted there is increased use of seasonal forecasts to inform the level of pre-summer actions required. This should expand throughout the electricity sector.
- *Response to the bushfire season 2019/20:*
  - The electricity industry has indicated that, as a result of the 2019/20 bushfire season, they have built and maintained closer relationships with local emergency services. This has allowed the emergency services to understand the requirements and procedures at a local scale, such as the particular assets that need to protected in and around generation.
  - Each of the stakeholders are considering the implications and response to the recommendations of the NSW Bushfire Inquiry to their businesses (Section 3.4.1), and provided the Panel with preliminary information.
- *COVID-19 protocols:* The COVID-19 situation has impacted operations of the electricity businesses and is discussed further in Section 3.4.3.

The Panel also noted that stakeholders are implementing many of the learnings from the previous bushfire season. For example, the proactive management of assets, to mitigate the risk that bushfire poses to assets and to prevent assets from becoming a source of ignition. Another significant area of investigation is the protection of, or complete replacement, of power poles. This includes technologies such as composite material covers that insulate and protect the current timber poles from fire, or concrete and composite fibreglass poles as a complete replacement. These technologies come at a higher cost but provide a benefit in terms of that they are less likely to be damaged in a bushfire situation. This cost/benefit is being assessed by the businesses for their long-term asset management. However, areas most at risk of bushfire have been prioritised (in the short-term).

3.4.3 Coronavirus (COVID-19)

On 11 March 2020, the World Health Organisation (WHO) characterised the novel Coronavirus disease 2019 (COVID-19) as a pandemic: that is, "*an epidemic occurring worldwide, or over a very wide area, crossing international boundaries and usually affecting a large number of people*".[114] In Australia, as with international jurisdictions, COVID-19 has led to the introduction and enforcement of rules and restrictions to safeguard public health including:

- Social distancing measures;
- Region-based lockdowns and limitations on movement;
- Border closures and quarantine arrangements (for both international and interstate entrants);
- Closure of non-essential services (including businesses and industry);
- Changed work arrangements.

As well as causing significant social and economic disruption, COVID-19 poses several potential risks to the electricity sector, both operationally and through a higher level of uncertainty associated with the supply and demand of electricity for summer 2020/21. Managing COVID-19

[114] Porta, Miquel, ed. (2008), *Dictionary of Epidemiology (5 ed.)*. Oxford University Press.

efficiently and effectively has become an important consideration for electricity network operations, maintenance and construction.

Following the large-scale emergency response of summer 2019/20, learnings from the bushfire season in NSW have prepared electricity businesses to adapt rapidly to working with COVID-19. Some businesses utilised established summer preparedness approaches in the formulation of their COVID-19 response. Each of the businesses in NSW that the Panel consulted have well-advanced COVID-19 management plans.

3.4.3.1 Electricity industry operations and operational risk

In relation to regular operations, a similar approach has been adopted by all electricity businesses in management of control centres. This includes, but is not limited to, the following measures:

- limiting control centre access to essential staff only
- segregating control centre teams into shifts and rotations that do not interact
- embedding symptom-checking of staff as a regular process at the start of the shift
- establishing back-up or mirrored control centres to mitigate the impact of a COVID-19 case found in the control centre workforce
- thoroughly cleaning control rooms on a regular basis
- implementing plans to manage control rooms on days of high demand when additional staff are required to support operations.

Construction and maintenance activities are also being managed in terms of COVID-19 response and preparedness. Staff involved in these works, including contractors, would be required to adhere to the companies COVID-19 protocols as it would fall under the Workplace Health and Safety (WHS) obligations of the contracting company (as set out in the *Work Health and Safety Act 2011* and associated regulations). COVID-19 protocols described to the Panel included:

- regularly checking teams for COVID-19 symptoms
- maintaining work teams, where possible, to limit staff interactions outside of their teams
- using video communication to access interstate and overseas expertise that is not able to travel to NSW
- checking that contractors, who often work across multiple projects, are compliant with COVID-19 procedures put in place by electricity sector operators in addition to their own procedures
- checking the NSW Health list of hotspots for the current and two previous days' operations.

In the event of a serious escalation in community transmission of COVID-19, some businesses have established 'dormitories' (local isolated accommodation) where control, construction and maintenance staff can be housed if there are any concerns about COVID-19 transmission.

In this context, the Panel notes that many of the actions taken by the electricity sector businesses are prudent, but also suggest that they should (where practical) run through COVID-19 related exercises or scenarios that may highlight any improvements to their planning processes. The Panel also notes that there are possible external impacts of community transmission, beyond the control of the electricity sector, such as transmission amongst family members or their local community.

3.4.3.2 Fatigue

A number of actions have occurred as a result of the bushfire season 2019/20, to better prepare the electricity sector (and other sectors) for future emergencies, such as bushfires, storms or COVID-19. Conversely, there have been instances of a loss of momentum (i.e. slowing down of work or postponement of work) arising from the bushfire season as a result of COVID-19 following immediately.

In discussions with stakeholders, the Panel noted that there are important considerations for summer 2020/21 with regard to fatigue and staff management across the NSW Government and electricity sector. This has been picked up by the NSW Bushfire Inquiry, in relation to operational fatigue, providing adequate staffing resources (active and supporting staff) and mental health support. There has also been recent media coverage of possible Post-traumatic Stress Disorder (PTSD) for communities coming into summer 2020/21.[115]

COVID-19 may have exacerbated fatigue levels of staff that are still recovering from the bushfire season, with limited respite between the two events. This was highlighted by stakeholders, who indicated that the wellbeing of employees should be prioritised as they deal with the new pressures of the pandemic and any potential emergency situation over summer.

3.4.3.3 Border closures

Border closures, at both the national and international level, have directly impacted the electricity sector. For example, maintenance activities and project delivery have been affected due to travel restrictions placed on skilled staff, increased delivery times for equipment, and limited availability of key supplies and specialised equipment that may have to come from overseas.

Border closures have limited access to expert personnel required to deal with outages. For example, an outage at the Loy Yang Power Station in Victoria had to be spilt into two parts due to the inability to get specialist expertise from overseas. Some generators have indicated that a temporary solution has been to receive expert advice (in some instances, from multiple experts in different jurisdictions) through video conferencing for maintenance activities (with associated live video feeds), with plans to continue the use of this technology into the future as a cost-saving exercise for non-critical maintenance, that has a benefit of potentially involving a larger number of experts than would be feasible if they were being flown in. Continued travel restrictions increase the risk associated with any unplanned generator outages during the coming summer.

COVID-19 has also affected global supply chains, creating potential for delays in receiving specialised equipment and parts, delaying work programs and increasing risk when urgent repairs are required. For example, a DNSP reported that difficulties in receiving specialist aerial monitoring equipment from overseas initially delayed the start of some aspects of their summer preparation program, until local solutions were sourced. NSW generators indicated that they have stockpiled essential equipment and consumables (where possible) in order to mitigate this category of risk.

Concerns were also raised about the time taken to obtain permission for cross-border provision and sourcing of expertise. This is particularly an issue where distribution assets are maintained across a state border. The Panel understands that for Critical Work Permits the EUSFA team is assisting with expediting the process for the electricity sector and other related sectors, and there are discussions being had with other NSW Government agencies to put a framework together for summer 2020/21 emergency situations (see Section 3.4.1)

3.4.3.4 Impacts on construction and maintenance

A concern has been highlighted to the Panel from activity in Victoria, where differences in restrictions between metropolitan Melbourne and regional Victoria have impacted construction and maintenance activities. This has possible implications, and learnings, for NSW if tighter restrictions need to be implemented.

Prior to any COVID-19 restrictions, intrastate and interstate sister businesses provided resources to help restore supply following a major event. This was the case when a number of transmission towers on the high voltage (HV) line connecting the Portland Aluminium Smelter and South Australia, near Cressy in Victoria, were knocked down by a severe storm event on 4 January 2020

[115] Willis, A., *"Recognising the mental health impacts of bushfires as another summer approaches*," ABC News, 13 October 2020, accessed 20 October 2020.

(see Section 2.3.3.1). At that time TNSP Ausnet was well supported with resources from ElectraNet in South Australia and TransGrid.

Since severe restrictions have been introduced in Victoria, limited support has been forthcoming from out of State and within the State. Also, where an electricity business operates in both regional Victoria and Melbourne there has been a reluctance by maintenance and construction staff to cross regions due to quarantine requirements for staff travelling between jurisdictions and returning from hotspots.

The Panel notes it will potentially take longer to re-establish disrupted supply in any NSW region that is declared as a COVID-19 hotspot. This, in many ways, will then become an exercise in communicating clearly and concisely the delays whilst working towards the timely return of supply to the community.

3.4.3.5 Electricity supply

AEMO's outlook for the coming summer is that supply reliability (i.e. USE) for NSW is well below the IRM. However, as highlighted above, if forced outages occur on generation and/or transmission plant, COVID-19 issues could delay the return to service of such plant or cause maintenance to be deferred. Deferral of any maintenance increases the risk of a forced outage occurring with a consequential impact on the ability to maintain supply.

For example, during summer 2019/20 the return to service of Mortlake and Loy Yang A power stations in Victoria were delayed from that forecasted by AEMO and the generators themselves. Whilst this did not have a material impact on electricity supply, as the system was flexible and AEMO and the market participants had prepared for a potential delay, the delays occurred under 'normal' circumstances. This highlights the added uncertainty associated with the ongoing COVID-19 situation, which has the potential to exacerbate any existing risks and unknowns that would be present under 'normal' circumstances when dealing with planned or unplanned interruptions to supply.

AEMO is continuing to carefully monitor the impacts of COVID-19 as the situation evolves and will issue an update to the ESOO should circumstances change materially. This relates to impacts on maintenance activity and also in relation to demand.

3.4.3.6 Electricity demand

The observed impacts of COVID-19 on electricity demand have varied by sector and region, with factors such as the balance of residential and commercial customers, climate and the balance of dependence on gas or electricity for powering residential appliances also influencing outcomes. In the Quarterly Energy Dynamics Report for Q2 2020, AEMO reports that the general impact of COVID-19 has been to increase residential demand and decrease commercial demand as lockdown restrictions meant that more people were working from home and business activity was limited (Figure 8). The demand from large industrial customers has not changed materially as typical operations have continued throughout the period.[116]

[116] AEMO (2020), *Quarterly Energy Dynamics Report Q2 2020*.

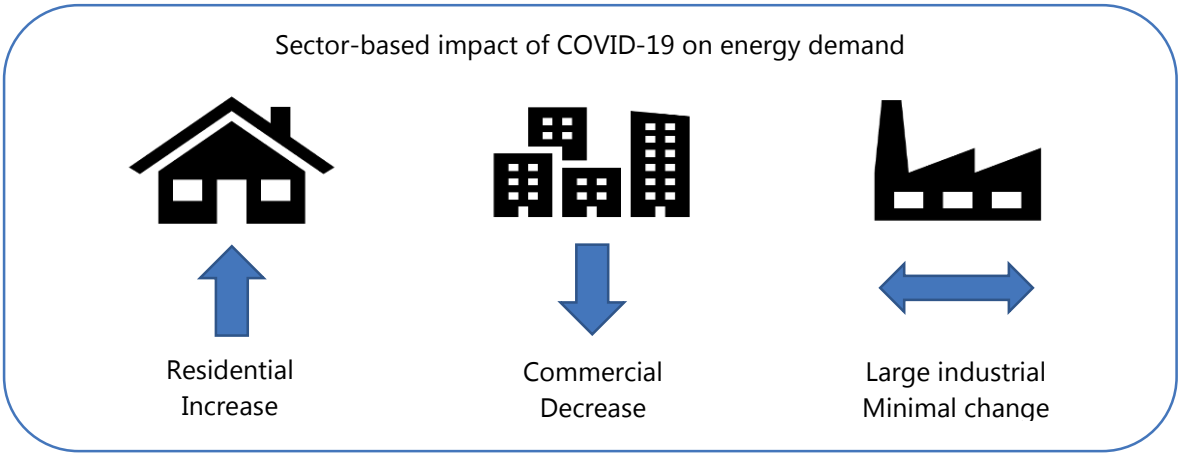

Figure 8: The impact of COVID-19 on electricity demand throughout the NEM

Since residential demand is sensitive to climate (for discretionary cooling and heating), the magnitude of increase has been different in each region of the NEM dependent on the seasonal conditions. For example, in NSW, milder conditions during April 2020 tempered the demand for residential heating and resulted in a greater average reduction in demand related to COVID-19 (5% reduction on average).[117] As temperatures cooled during May and June 2020, residential loads in NSW increased and reduced the COVID-19 related reduction to an average of 1% below pre-COVID-19 controlled conditions. The NSW-average COVID-19 associated change in weekday operational electricity demand for Q2 is depicted in Figure 9 (this analysis was not presented in Q3 for NSW).

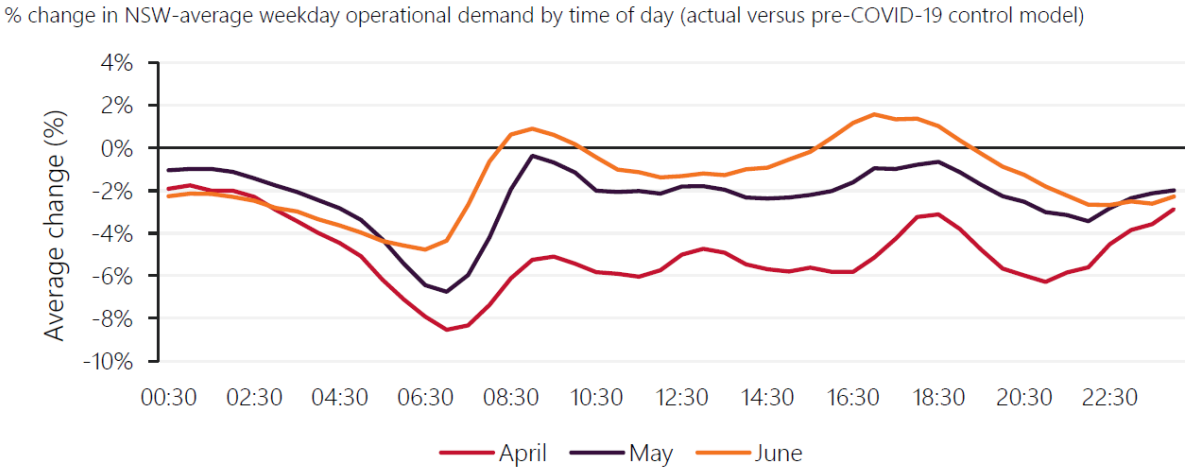

Figure 9: Average percentage change in daily operational demand due to COVID-19 during Q2 2020 in NSW

Source: AEMO[118]

Analysis of demand levels during Q3 2020[119] further supports the observation that residential demand is weather-sensitive and, that due to changes in sectoral demand induced by COVID-19, residential load now has a greater impact on total demand. In Q3, Victoria, Queensland and NSW all recorded reductions in average operational demand – strongly influenced by a combination of lockdown measures, other COVID-19 restrictions and mild weather that reduced heating requirements. By contrast, South Australia experienced an increase in demand due to relatively higher residential heating requirements and higher industrial load. Due to weather sensitivity, a higher evening peak could pose issues during the upcoming summer, particularly on high demand

[117] AEMO (2020), *Quarterly Energy Dynamics Report Q2 2020*.
[118] AEMO (2020), *Quarterly Energy Dynamics Report Q2 2020*.
[119] AEMO (2020), *Quarterly Energy Dynamics Report Q3 2020*.

days, such as was seen in summer 2019/20 (Section 2.3.2). However, various factors associated with COVID-19 create additional uncertainty for forecasting.

As stated in the 2020 ESOO:

> "*While COVID-19 has reduced peak demand and energy consumption expectations for the coming summer, it also creates a significant new uncertainty. The current forecast would require an update if recently observed sector impacts change prior to or during next summer. Furthermore, COVID-19 could cause delays in the return to service of generators on forced outages or defer maintenance required for summer readiness*"[120]

AEMO also notes that ongoing forecasting is occurring, noting that the 2020 ESOO was prepared whilst COVID-19 was spreading and thereby making the forecasts uncertain. AEMO is monitoring COVID-19's impacts on the electricity system and will provide updated information (such as through the Electricity Statement of Opportunities (ESOO) report) should the situation change.

Nevertheless, the 2020 ESOO presents a variety of sensitivity analyses to understand the potential impact of various economic and behavioural assumptions. Common across all sensitivity analyses was a forecasted reduction in peak demand and overall consumption for summer 2020/21, based on the assumption that continual growth in rooftop PV shifts maximum demand later in the day, where commercial cooling loads have come offline. A further assumption contained within this scenario is that domestic cooling will occur throughout the day due to increased working from home arrangements, thereby reducing the peak associated with post-work air conditioning loads (i.e. residential properties are already 'pre-cooled' as a result of daytime air conditioner use). However, as this is uncertain, there are also other potential outcomes flagged: the peak could come earlier in the day due to a combination of commercial and residential cooling occurring simultaneously to create greater demand.

There is an expectation that there will be a gradual reduction in this impact as COVID-19 restrictions ease, as some employees will continue to work from home or employ flexible working arrangements. More broadly, the long-term impacts of COVID-19 (lower economic growth, lower immigration, increased DER uptake, etc.) are expected to decrease electricity demand. A summary of the various COVID-19 factors and their potential impact on electricity demand is depicted in Figure 10.

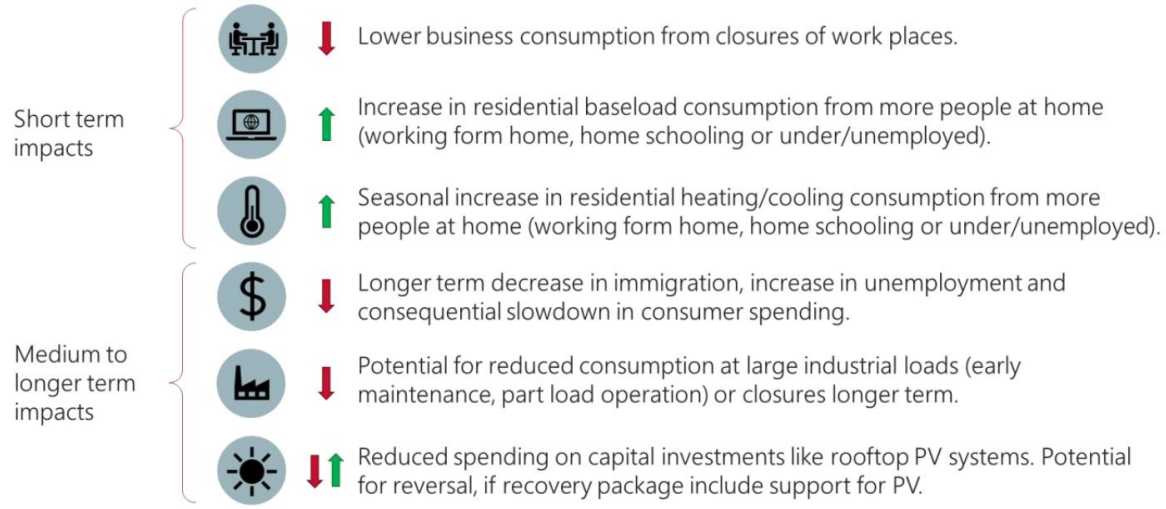

Figure 10: The interaction of COVID-19 impacts influencing electricity demand

Source: AEMO[121]

[120] AEMO (2020), *2020 Electricity Statement of Opportunities*.
[121] AEMO (2020), *2020 Electricity Statement of Opportunities*.

3.4.3.7 International jurisdictions and COVID-19 energy response

International jurisdictions, particularly those in the northern hemisphere that have already gone through summer whilst impacted by COVID-19, could provide a glimpse of trends in the energy sector for NSW going into summer 2020/21.

Data from the International Energy Agency (IEA) indicates that in the early stages of the COVID-19 pandemic (up until mid-April 2020), countries in partial- or full-lockdown experienced an 18% to 25% reduction in electricity demand (respectively)[122]. This is reflected by the estimated 3.8% decline in global electricity demand in the first quarter of 2020. It is worth noting that both global coal and oil (primarily road transport) demand fell (approx. 8% and 5% respectively), whilst there was growth in renewable demand (driven by priority dispatch and larger installed capacity).

However, when COVID-19 related restrictions were eased (such as in Italy and Germany in April, and India, France, Spain and the United Kingdom in May) the electricity demand started to rebound towards 2019 levels: over summer (northern hemisphere), electricity per IEA measured countries stayed approximately 10% below 2019 levels (weather corrected) for most countries in June, and further rebounded to approximately 5% (EU) and was almost on parity for India (noting that, subsequently in August, demand fell well below 2019 level as COVID-19 cases trended upwards and restrictions came in).[123]

The IEA has also noted that across all major regions, the electricity generation mix has shifted towards an increase in renewable generation as a result of COVID-19 based lockdowns, due to a combination of falling electricity demand, lower operating costs associated with renewables, and priority access to the grid.

California and COVID-19: a case study

California is an interesting case study that has COVID-19 lessons for NSW coming into summer, as there are similarities between the northern and southern hemisphere jurisdictions, not least of which is similar climate regime including bushfire seasons. As a summary of the Californian electricity mix, renewables in California (primarily hydropower, and commercial and domestic solar) supplied almost half of the in-state generation in 2018, whilst natural gas provided more than 40%. Expansions to the transmission infrastructure have assisted the reliability of the grid with the increased percentage of renewable generation. Although it has the second-largest hydro-electric generation capacity within the USA, the electricity output from these generators has been variable due to prolonged drought.

As a result of the COVID-19 pandemic, the Californian Governor issued a shelter-in-place order for the San Francisco Bay Area on 17 March 2020, followed days later by the extension of this order to the rest of the state. In the weeks following this order, the Californian grid operator, California Independent System Operator (CAISO), noted a significant drop in electricity demand (load reductions of approx. 5-8% during weekdays, 1-4% for weekends), particularly around the morning peak hours.

The California Energy Commission (CEC) released further analysis that shows similar trends to CAISO data. Additionally, CEC noted that there was a substantial increase noted by three utilities in year-to-date residential electricity use (up 8.9-12.4%), primarily as a result of cooling (air conditioning and other related uses), when compared to the same time 2019, but this was offset by greater demand reduction in the commercial and industrial sectors. This demand reduction was greatest between 11:00 and 15:00, resulting in a steeper evening ramp.

California experienced the most significant electricity shortage for nearly 20 years on the weekend of 14-15 August 2020. State-wide rolling blackouts occurred as a result of the need to shed approximately 1,000 MW by the utilities under the Stage 3 Emergency declared by CAISO (the first

[122] IEA (2020), *Global Energy Review 2020*.
[123] IEA (2020), *COVID-19 impact on electricity.*

declaration of this magnitude since 2001). Approximately 350,000 customers were without power for 1-2 hours, with a further ~58,000 customers taken offline for an hour after these blackouts. This event was attributed to a confluence of the following factors:

- COVID-19 restrictions (including associated reduction in business activity)
- a widespread western-US heatwave (with elevated night-time temperatures, and compounded further by wildfires and related air-quality reduction, with health warnings for staying indoors)
- grid factors (decreased electricity provided from other states via interconnectors, particularly as they grappled with the heatwave demand from their own air-conditioning loads, and technical failures of gas-fired power station)[124].

The record demand, with COVID-19 overlay, has resulted in California and other jurisdictions considering how they operate critical infrastructure for the community, such as cooling centres (a temporary, air-conditioned space set up by authorities to deal with heatwave conditions) for the elderly and those with underlying health conditions, as space restrictions reduced their effectiveness.

[124] Penn, I (2020, August 20) *Poor planning left California short of electricity in a heat wave*, NY Times; Borunda, A (2020, August 25) *Why renewables aren't to blame for California's blackouts*, National Geographic

4 Future Summer Preparedness

The NEM, like many power systems worldwide, is undergoing the transition from a system dominated by large thermal power stations, to a more complex system comprising a multitude of power generation resources. This transition imposes challenges to maintain electricity reliability and security but also presents opportunities to supply low-cost, low-emissions electricity with new and emerging technologies and services. This Chapter provides an overview of those challenges in the medium to long term with a focus on the NSW region of the NEM, summaries of planning and initiatives being undertaken by Commonwealth and NSW governments, and technology and digital solutions to ensure a reliable and secure supply of electricity.

4.1 System reliability and security

The NEM is a complex system that comprises a suite of technical elements that must be maintained to deliver the electricity from generation points to consumers. The system needs to have a high degree of confidence (system reliability) and operate within a safe and acceptable level of performance (system security). This requires adequate generation and network capacity, sufficient and timely system services for safe operation, and a certain degree of flexibility in responding to a disturbance.

4.1.1 Resource adequacy and system reliability

AEMO defines resource adequacy as having a sufficient overall portfolio of energy resources to continuously achieve the real-time balancing of supply and demand.[125] This involves the provision of bulk energy supported by adequate transmission and distribution capability to meet the potential maximum demand conditions. Further, the system needs to have the reserve capacity to respond to continuous and/or significant changes in energy requirements.

4.1.1.1 Maximum demand and reliability

In the next two to five years, operational demand within the NEM will remain relatively steady and close to the 2019/20 level under AEMO 2020 ESOO's Central scenario. Permanent closure of energy-intensive loads, due directly or indirectly to COVID-19, could see further demand reductions. The operational and maximum demands are expected to grow for many NEM regions over the next five to 20 years, despite the current COVID-19 related decline.[126] This includes NSW but the continued investment in rooftop solar and the extension of the Energy Savings Scheme[127] will offset the growth of new residential connections and commercial consumption.[128] The uptake of rooftop solar will further shift the maximum operational demand to later in the day, with potential implications for evening demand.

On the supply side, the NEM has a substantial pipeline of new investment in generation capacity with a total of 57.3 Giga Watts (GW) across all regions. Approximately 16 GW of those new projects are located in NSW, the majority of them are VRE and about 4 GW are dispatchable generation (e.g. gas, hydro and battery).[129]

The 10-year reliability outlook for NSW has improved compared to last year, as noted in the AEMO 2020 ESOO. However, the reliability risk remains for NSW where USE is projected to exceed the IRM and RS in 2023/24 and 2028/29 respectively (Figure 11).

[125] AEMO (2020), *Power System Requirements*.
[126] AEMO (2020), *2020 Electricity Statement of Opportunities*.
[127] NSW Energy Savings Scheme is a market-based instrument requiring participants to meet energy savings target by buying certificates. The Scheme was legislated to operate until 2025 with a target of 8.5% of electricity demand for each year from 2019 to 2025. The Energy Savings Scheme has been extended and expanded as the new Energy Security Safeguard under the NSW Energy Strategy.
[128] AEMO (2020), *2020 Electricity Statement of Opportunities*.
[129] AEMO (2020), *2020 Electricity Statement of Opportunities*.

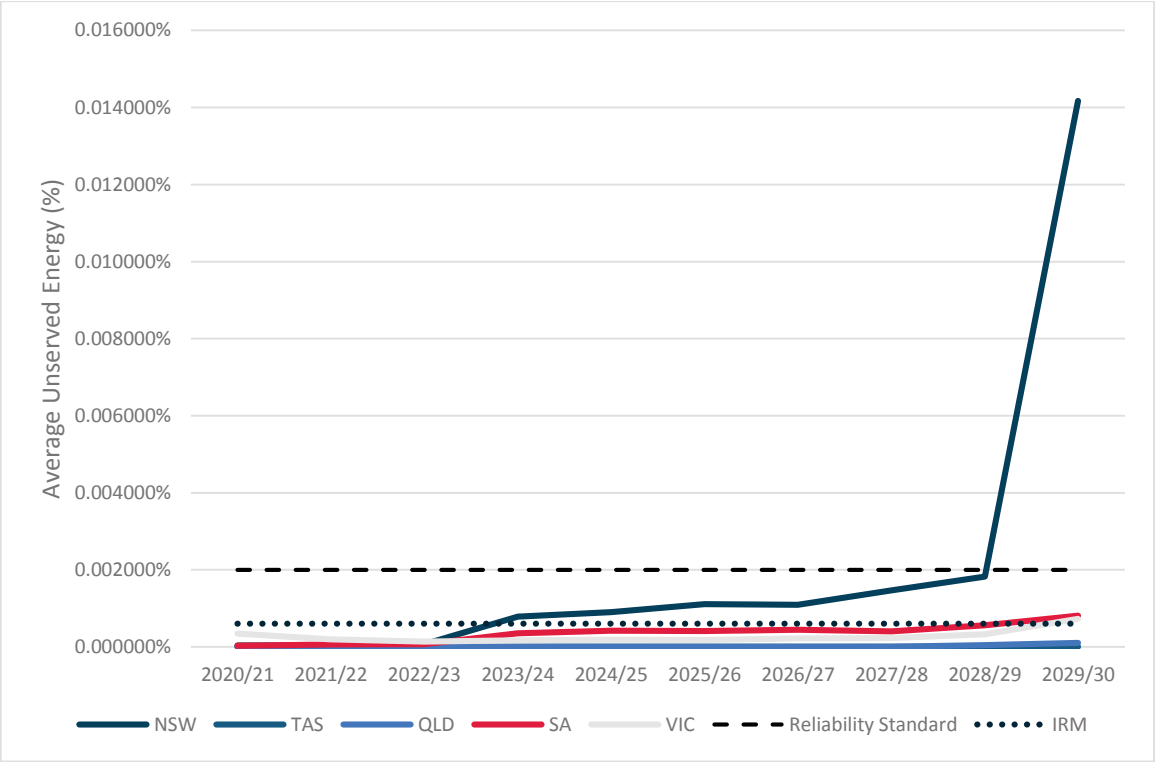

Figure 11: Expected USE for NEM jurisdictions (central scenario)

Source: AEMO[130]

The Queensland-NSW Interconnector (QNI) upgrade in 2022/23 partially offsets some of the impact of Liddell Power Station's retirement. From 2023/24 the forecast level of USE increases due to the impact of increasing forced outage rates associated with plant aging and retirements, and from then continues above the IRM but below the RS. After the retirement of Liddell Power Station the expected USE exceeds the IRM, however the gap can be filled with 170 MW additional dispatchable capacity under NSW Government's Emerging Energy Program.[131] The commissioning of Snowy 2.0 (additional 2,040 MW firm capacity) in 2025/26 only provides a minimal benefit to reliability in NSW without the supporting network infrastructure, even assuming actionable ISP projects are deployed.[132] However, if the HumeLink augmentation proceeds, the reliability outlook improves significantly. The USE is projected to be well above the RS after the retirement of Vales Point Power Station in 2029/30. Table 5 highlights those critical reliability points for NSW regions over ESOO's 10-year forecast period.

[130] AEMO (2020), *2020 Electricity Statement of Opportunities*.
[131] AEMO 2020 ESOO notes that the 170 MW capacity under NSW Government's Emerging Energy Program is not modelled in the 10-year reliability forecast. AEMO (2020), *2020 Electricity Statement of Opportunities*.
[132] AEMO (2020), *2020 Electricity Statement of Opportunities*.

Table 5: Critical points for NSW regarding reliability (as measured against the Reliability Standard, RS, and the Interim Reliability Measure, IRM)

Year	Events	RS and gap	IRM and gap	Key issue and solution
2021/22 (RRO T-1 Period)	Flat demand outlook and minimal changes in supply	Below RS	Below IRM	Relatively flat USE and well below both RS and IRM.
2023/24 (RRO T-3 Period)	Retirement of Liddell Power Station	Below RS	Exceeds IRM with a gap of 154 MW	This gap can be filled with new capacity under the Emerging Energy Program by NSW Government.
2025/26	Commissioning of Snowy 2.0	Below RS	Exceeds IRM with a gap of 525 MW	Snowy 2.0 has negligible impact on USE without HumeLink augmentation[133] Project EnergyConnect (NSW-SA interconnector) can significantly reduce supply scarcity risks if completed by 2024/25.
2029/30	Retirement of Vales Point Power Station	Exceeds RS with a gap of 1,480 MW	Exceeds IRM With a gap of 2,045 MW	Several uncommitted projects are not used in forecasts that may overcome these future gaps.

Source: AEMO[134]

4.1.1.2 Minimum demand issues

There is a growing trend in the NEM of record low minimum demand. This is being driven by the uptake of rooftop solar. AEMO forecast that all NEM regions are expected to experience minimum demand in the daytime period (rather than only during the overnight period) by 2025.[135] The minimum demand for NSW is projected to decrease but less aggressively compared to other NEM regions. Projections for South Australia and Victoria show negative minimum demand scenarios through to 2030.

There are power system security implications when the operational demand approaches the minimum thresholds, that are very different from maximum demand thresholds. This includes challenges for the system to manage and maintain voltage, strength and inertia for safe operation and response to disturbances. This would require possible market operator interventions and/or export to neighbouring states to maintain regional system security. The minimum thresholds for NSW are between 1.6 GW to 2.2 GW according to AEMO's 2020 ESOO. The forecasts suggest NSW is unlikely to fall below this level in the near term, but there is a risk where neighbouring NEM regions (e.g. Victoria and South Australia) are approaching their thresholds faster and exporting to NSW.[136]

There are options to increase minimum demand resilience with technical, market and regulatory arrangements. These options include growing new demand, flexible demand management, improving dispatchability with new capacity, and increasing DER visibility and active management.

[133] AEMO 2020 ESOO notes that HumeLink transmissions augmentation is not modelled in the 10-year reliability forecasting as the project has not yet received regulatory approval. AEMO (2020), *2020 Electricity Statement of Opportunities*.
[134] AEMO (2020), *2020 Electricity Statement of Opportunities*.
[135] AEMO, *"A record breaking winter weekend"*, 1 September 2020, accessed on 26 October 2020.
[136] AEMO (2020), *2020 Electricity Statement of Opportunities*.

4.1.1.3 Reserve capacity

Energy reserve is the additional generation capacity that can be used when required but is not actively participating in the energy market to supply bulk energy. Depending on the timeframe reserves can respond, they can be classified as operating reserves[137] (in minutes to hours) and strategic reserves[138] (in hours to days). At present, the NEM does not include a market mechanism for the provision of operating or strategic reserves. The progressive uptake of renewable generation and the withdrawal of synchronous generation is driving the decline of operating reserve margins across the NEM. AEMO relies on emergency interventions or directing to shed load if the market is not responding to alleviate a LOR condition.[139] There is a need to develop a market mechanism for reverse capacity and the market bodies are considering arrangements for the procurement of operating reserves.

4.1.1.4 Reliance on imports and interconnectors

NSW is a net electricity importer in the NEM. Separation events impose risks for the region to maintain regional reliability and security and may have implications for the rest of NEM. Over the 2019/20 summer, there was an increase in the number of region separation events due to the forced outages of transmission lines impacted by extreme weather.[140] For example, the two separation events that impacted NSW resulting in LOR conditions are discussed in Section 2.3.3.

There are extensive transmission augmentation works planned or underway in NSW under the Regulatory Investment Test for Transmission (RIT-T)[141] process. This includes the QNI and Victoria-NSW Interconnector (VNI) upgrade and the new EnergyConnect projects which have been identified as priority projects to streamline under the RIT-T process.[142] These and other interconnection projects across the NEM will further strengthen the state's connection and capacity with other NEM regions and help mitigate the risks of separation events.

4.1.2 System security

System security is a broad term referring to all the technical attributes for the system to maintain safe operation. Adequate Essential System Service (ESS)[143] and the timely provision of those services are crucial to meet the requirement of each technical attribute. Technical attributes and the ESS are summarised in Table 6 and detailed explanations are included in Appendix 3.

Many of these ESS have been provided by thermal generation as a by-product. With the retirement and reduced capacity of coal-fired power stations and the rapid uptake of renewables, the NEM may be lacking in some ESS and will need new solutions to maintain system security.

[137] Operating reserves have been traditionally provided by synchronous generators in the form of unused capacity when they are generating below their full capacity. Unlike synchronous generators, solar and wind generation has no fuel costs and tends to operate at full capacity whenever possible to maximise their economic return.
[138] Strategic reserves are provided by some generators with plant out of the market who make a commercial decision to keep their plant readily available based on their assessment of improving market prices. In some overseas electricity markets, strategic reserves are capacity that is not in the market but on call to cover unexpected demand growth and/or reductions in supply capability.
[139] AEMO (2020), *Power System Requirements*.
[140] AEMO (2020), *2019-20 NEM Summer Operations Review Report (June 2020)*.
[141] The Regulatory Investment Test for Transmission (RIT-T) is a cost-benefit analysis to seek AER's approval of new transmission infrastructure projects over $6 million. The process involves a series of reporting, consultation and dispute processes and typically takes at least one year to progress. NSW Government (2019), *NSW Electricity Strategy (Detailed).*
[142] NSW Government (2019), *NSW Electricity Strategy (Detailed)*.
[143] Essential System Services (ESS) refers to technologies and services required for the energy system to main its security and strength. These include the management and response of frequency, inertia and voltage.

Table 6 : Technical Attributes and ESS for System Security[144]

Technical Attributes	Services needed to meet the requirement (operation timescales)
Frequency Management – Ability to set and maintain system frequency within acceptable limits	• Inertial response (milliseconds) • Primary frequency response (milliseconds to seconds) • Secondary frequency response (seconds to minutes) • Tertiary frequency control (minutes to days)
Voltage Management – Ability to maintain voltages on the network within acceptable limits	• Slow response voltage control (minutes to days) • Fast response voltage control (milliseconds to seconds) • System strength (milliseconds to days)
System Restoration – Ability to restart and restore the system in the unlikely event of a major supply disruption	• Black start service (hours to days) • Restoration support services (hours to days)

NSW's ESS adequacy assessments are provided in Appendix 3 based on AEMO's modelling results in various publications and key findings are summarised below:

- *Inertia* – The available amount of inertia is projected to fall in NSW driven by the retirement of coal-fired power stations but remains sufficient to meet the regional minimum requirements by 2035.[145] There is a risk of accelerated decline in system inertia if coal-fired power stations operate under increased ramping and flexibility resulting in more outages or early retirement. Further analysis of inertia will be released in AEMO's 2020 System Strength and Inertia Report.
- *Frequency response and control* – At present, there appears to be adequate provision of frequency control services for the NEM, managed by the Frequency Control and Ancillary Services (FCAS) market. FCAS requirements will increase with the reduced system inertia. This will likely be a growing issue in NSW with the retirement of coal-fired units and the development of renewables. AEMO studies indicate that there is likely to be a need for regional inertia and frequency control reserves.
- *System strength* – AEMO's latest system strength assessment shows that south-west NSW has low system strength in 2020/21. This can be improved by the deployment of synchronous condensers (such as those proposed by the EnergyConnect project).[146] Further analysis of system strength will be released in AEMO's 2020 System Strength and Inertia Report.
- *Voltage control and response* – AEMO's 2019 annual review of voltage management has not identified any voltage management gaps in NSW over the next five-year period.[147] Some high-risk areas with conditions are highlighted by the assessment, including southern NSW when Mt Piper Power Station and other firming generation retires, and northern NSW after the retirement of Liddell Power Station in 2022/23.[148]
- *System restoration* - The provision of System Restart Ancillary Services (SRAS) is a NEM-wide issue with the retirement of coal-fired power stations and their replacement with intermittent renewables and there is a potential risk for NSW. Centralised control over DER would help system restoration (e.g. rooftop PV shedding capability as a security backstop mechanism).

[144] AEMO (2020), *Power System Requirements*.
[145] AEMO (2020), *Integrated System Plan Appendix 7. Future Power System Security.*
[146] AEMO (2020), *Integrated System Plan Appendix 7. Future Power System Security.*
[147] AEMO (2019), *2019 Network Support and Control Ancillary Services Report*.
[148] AEMO (2019), *2019 Network Support and Control Ancillary Services Report*.

4.1.3 System operability and flexibility

4.1.3.1 Coal-fired power generation

Ramping and flexibility

The conventional coal-fired power generators are designed to supply baseload electricity and are less flexible in response to rapid changes in demand. Due to high renewable penetration, coal-fired power stations have been operating at increased ramping rates in a 'load-following' mode in recent time and this will continue before their retirements. Further, the coal generation is projected to operate more flexibly with intra-day cycling between morning and afternoon peak demands instead of day-night cycling.[149]

Cycling more regularly can intensify the mechanical and thermal stress on key components of those generators. This may result in extra wear and tear, additional outages, higher failure rates or potential early retirements.[150] Improving the flexibility of coal generation presents a short to medium term solution to accommodate the intermittency of renewables. This supplements other firming capacities such as gas, energy storage and demand management. Increased flexibility could be achieved through process improvement, increased automation and retrofitting certain plant components.[151]

Outage and coincident events

As coal-fired power stations approach the end of their technical life, they become less reliable with ageing parts, increasing the likelihood of planned and forced outages.[152] This could result in reduced availability and capacity from coal-fired generators to meet demand and providing ESS to the system. AEMO suggests that the reliability of NSW black coal generators fell to historically low in 2019/20 with a consolidated outage rate of approximately 17%.[153] Despite some improvements before 2023/24, the effective full forced outage rate is expected to remain around 14% in 2029/30.[154] Further, the NSW coal fleet has a high impact and low probability outage rate of 0.84%, which is much higher than the coal fleet in Victoria or Queensland.

The unplanned outage of coal-fired power stations could have severe impacts on system reliability with the coincidence of other extreme and emergency events. For a NSW example, the event of 10 February 2017 (as described in the NSW Energy Taskforce report[155]) required AEMO to intervene to reduce demand at Tomago aluminium smelter to avoid large scale load shedding. In that period, Liddell Power Station's two units (1,000 MW nameplate capacity) were unavailable due to forced outages.[156] This coincided with summer heatwaves with extremely high temperature, peak operating demand, constrained interconnectors, unavailable gas generators (~1,000 MW capacity) and low renewable generation (300 MW).[157]

NSW Coal Upgrades

Several upgrade/retrofit projects could improve the reliability and efficiency of NSW coal-fired power generation up until their retirement. These projects are private investments and are at various planning and commission stages, including:

[149] AEMO (2020), *2020 Integrated System Plan Appendix 6. Future power system operability*.
[150] Deloitte (2019), *Assessing the flexibility of coal-fired power plants for the integration of renewable energy in Germany*.
[151] International Renewable Energy Agency (IRENA) (2019), *Flexibility in Conventional Power Plants.*
[152] NSW Government (2019), *NSW Electricity Strategy (Detailed)*.
[153] AEMO (2020), *2020 Electricity Statement of Opportunities*.
[154] AEMO (2020), *2020 Electricity Statement of Opportunities*.
[155] CSE (2017), *Final report from the Energy Security Taskforce*.
[156] NSW Government (2019), *NSW Electricity Strategy (Detailed)*.
[157] AEMO (2017), *System event report New South Wales, 10 February 2017*.

- Bayswater Power Station (AGL) – AGL has committed to a 100 MW capacity upgrade which includes turbine replacement, new control system and efficiency improvement.[158]
- Vales Point Power Station – Delta Electricity has received support from the Commonwealth Government to undertake a feasibility study of turbine and high-pressure heating system replacement for the plant.[159]
- Mt Piper Power Station – EnergyAustralia announced an investment plan for the turbine upgrades adding 60 MW capacity to the plant.[160]
- Redbank Power Station - Hunter Energy is proposing to modify the mothballed 151 MW coal-fired power station for biomass power generation.[161]

The changed operating demands placed on the NSW black coal generation fleet such as increased cycling and ramping will impact plant reliability. This, together with the coming retirement of NSW black coal-fired generation will increase the risk of not meeting supply. The NSW Government should support, as needed, planning for new generation or upgrades to existing generation that can provide the required system services is progressed in a timely manner.

The Liddell Taskforce

The Commonwealth Government established the Liddell Taskforce to understand the potential impacts of the closure of AGL's Liddell Power Station in April 2023. Representatives from the NSW Government, including a member of this Panel, were members of the Taskforce. The Liddell Taskforce provided findings and recommendations in relation to closure impacts on reliability, power prices, local industry and community. In terms of recommendations about system reliability, the Commonwealth Government responses are:[162]

- Setting a dispatchable target of 1,000 MW to come online in time for the summer of 2023/24, with a commitment by the private sector by April 2021
- Supporting new investment through a gas-fired recovery plan and other existing initiatives by the Commonwealth Government
- Commonwealth Government intervention to ensure new replacement capacity if private investment cannot meet the dispatchable target.

4.1.3.2 Renewable and distributed energy integration

AEMO's 2020 ISP suggests that the NEM will need an additional 26 GW to 50 GW of new VRE by 2040 and most of this new capacity will be built in the Renewable Energy Zones (REZs).[163] On the distributed energy side, AEMO suggests DER could provide 13% to 22% of total underlying annual NEM energy consumption by 2040.[164] Rapid rooftop solar penetration is expected as all NEM regions (excluding Tasmania) could be operating at ~50% of demand being supplied by rooftop PV at certain times of the day.[165] The integration of new VRE and DER capacity to the system requires better operability through:

- Coordinated investment in VRE and transmission – AEMO's 2020 ISP is converted into an actionable plan for coordinated planning and investment between generation and

[158] AGL, *"AGL invests $70 million at Bayswater to improve reliability and safety"*, 2 January 2020, accessed 7 October 2020.
[159] Fowler, E., *"Vales point coal power station secures upgrade"*, Australian Financial Review, 6 October 2020, accessed 7 October 2020.
[160] Bastow, C., *"EnergyAustralia to invest $80 million to upgrade turbines at Mt Piper power station",* Lithgow Mercury, 9 July 2019, accessed 7 October 2020.
[161] Thompson, S., *"Redbank recall: new name, faces in old power plant play",* Australian Financial Review, 26 May 2020, accessed 7 October 2020.
[162] Commonwealth Government Department of Industry, Science, Energy and Resources (2020), *Report of the Liddell Taskforce: Australian Government statement and response*.
[163] AEMO (2020), *2020 Integrated System Plan.*
[164] AEMO (2020), *2020 Integrated System Plant.*
[165] AEMO (2020), *Renewable Integration Study Stage 1 report.*

transmission projects. Further, the AEMC is working on the transmission access reform as part of the Coordination of Generation and Transmission Investment (COGATI) program.[166] The Renewable Energy Zones (REZs) are an efficient model for new VRE and network development. In NSW, the 3,000 MW Central-West Orana (CWO) Pilot REZ has completed market engagement[167] and preliminary work for the CWO REZ Transmission Link has been commenced by TransGrid.[168]

- DER visibility – currently AEMO and DNSPs have very limited visibility of DER (especially rooftop PV). Without access to accurate and real-time data, it is difficult to model and predict DER performance (individual levels or in aggregate). This creates challenges for DNSPs to manage power flows and outages particularly with the significant increase in DER resources. It presents significant security risks in operating and restoring local networks under emergency circumstances.[169] The access to high-quality information on DER devices and their technical parameters is essential to improve distributed energy visibility and controllability. As we move to a 'smart grid' and customers install equipment with smart technologies (ability to automatically respond to market signals) smarter technologies are required to manage the grid which requires immediate visibility of equipment status and remote intervention. AEMO's DER Register initiative is a first step to establish a NEM-wide database to store and publish such information collected by network operators.[170]
- DER ride-through capability – all types of generation technologies are expected to support power system security by being able to withstand a sufficient number of voltage disturbances of various types and durations without disconnection and continue to provide active and reactive power during and after each disturbance. In 2018, the AEMC made a rule that requires generating systems to be able to maintain operation in the face of certain frequency and voltage disturbances in order to better protect the power system from the risk of cascading failures. After 1 February 2019, new connection applicants are required to comply with the new rule.
- DER support services – system operators must have certain centralised controllability over DER during electricity emergencies. For example, the capability to shed rooftop PV as a security backstop for system black events.[171] Rooftop solar and other DER devices (e.g. home batteries) have some built-in capabilities for network support and essential services. These capabilities could be realised through new system design and market framework. New roles and functional areas, such as DER aggregator, Distribution Market Operator (DMO) and Distribution System Operator (DSO), are emerging with responsibilities to coordinate and optimise DER systems.
- Unintended disconnection of rooftop solar – there are system risks, such as grid instability, related to large-scale unintended disconnection of rooftop PV due to network faults. For example, locations deemed high-risk of such faults in NSW include the Sydney metropolitan 330 kV network or those near the Hunter power stations, which could result in the unintended disconnection of approximately 19-24% of rooftop PV (approximately 8-17% of underlying demand) in NSW.[172] However, this is not expected in NSW in the short term, due to several factors including the geographically-spread rooftop PV installation; synchronous thermal generation reducing voltage disturbances; and, high demand offsetting impacts of disconnections.

[166] AEMC (2020), *Transmission Access Reform: Updated Technical Specifications and Cost-Benefit Analysis.*
[167] NSW Government, *Renewable Energy Zones – Central-West Orana REZ*, accessed 4 September 2020.
[168] TransGrid, *Central-West Orana REZ Transmission Link*, accessed 4 September 2020.
[169] AEMO and NSW DNSPs, personal communications, September 2020.
[170] AEMO, *Distributed Energy Resource Register*, accessed 6 October 2020.
[171] AEMO (2020), *2020 Electricity Statement of Opportunities*.
[172] AEMO (2020), *2020 Electricity Statement of Opportunities*.

4.1.3.3 Dispatchable capacity

The 2020 ISP acknowledges the role of dispatchable resources, with modelling suggesting that 6-19 GW of new dispatchable capacity is required to support renewable generation by 2040.[173] Dispatchable generation can be controlled to balance the electricity supply and demand with a certain degree of flexibility to respond, unlike baseload generation which cannot change their output quickly. These new dispatchable resources could be in the form of thermal fuel, pumped hydro, utility-scale and distributed batteries, and other demand-side technologies and participation. Dispatchability is traditionally in terms of power, but as we move to greater levels of DER will need to be described recognising limits of energy, power and ramping capability at each node. For example, battery storage has dispatchable capacity with high ramping but finite electricity reserves (i.e. storage) compared to thermal generation.

NSW has a range of projects at various stages of planning, approval and commissioning that could provide the dispatchable capacity to the grid. These projects include:

- *Snowy 2.0 and Transmission Project* – The expansion of the Snowy Hydro Scheme could add 2,000 MW dispatchable generation with 350 GWh of storage capacity to the NSW grid and is expected to be commissioned in 2024-25.[174,175] The project has now received planning approval from NSW and Commonwealth Governments for the main construction works.[176]
- *Other firming capacities* – Includes 250 MW gas at Newcastle (AGL), 320 MW gas at Tallawarra (Energy Australia), 200 MW batteries (AGL with Maoneng Group), 50 MW Darlington Battery, 600 MW pumped hydro at Armidale (ARENA and Alinta Energy) and others under the NSW Emerging Energy Program.[177]

With respect to the capacity and dispatchability of existing and new generation, adequate fuel supply (i.e. gas, water and electricity) and supporting infrastructure needs to be ensured. While there may be sufficient dispatchable capacity, with an increase in DER and the variability of its output, older dispatchable plant must be ramped and cycled more often resulting in reduced plant reliability.

4.2 Future electricity system planning

The design and planning of the future electricity system are underway and includes the ESB's post-2025 market design, AEMO's ISP and AEMC's priority work program. NSW Government also has a range of strategies, policies and programs in place to secure electricity supply in NSW region of the NEM and support those future electricity design and planning in the longer term. This section discusses these plans.

4.2.1 Energy Security Board Post-2025 market design

The energy system is evolving with a changing generation portfolio, the rapid uptake of new technologies and emerging services. This imposes challenges to the current systems, tools, market arrangements and regulatory frameworks which are no longer entirely suitable. To address those concerns, the former COAG Energy Council tasked the ESB to develop a long term, fit-for-purpose market design that delivers secure, reliable and affordable electricity to consumers after 2025.

[173] AEMO (2020), *2020 Integrated System Plan.*
[174] NSW Government, *NSW Planning Portal – Snowy 2.0*, accessed 6 August 2020.
[175] Snowy Hydro Limited (2017), *Snowy 2.0 Feasibility Study Report*.
[176] Prime Minister of Australia, Minister for Environment, Minister for Energy and Emissions Reduction, *"Environmental Approval for Snowy Hydro 2.0"*, 30 June 2020, accessed 6 August 2020.
[177] NSW Government (2019), *NSW Electricity Strategy (Detailed)*.

The ESB has established seven workstreams to consider issues and develop solutions for the post-2025 market design.[178] These workstreams are:

1. Resource adequacy mechanisms that consider how to improve real-time and long-term price signals to drive timely and sufficient private investment.
2. Aging thermal generation strategy that works on the effectiveness of current arrangements to reduce the uncertainty of the retirement of thermal generators and additional measures required for a least-cost transition.
3. Essential system services that define the necessary capabilities for system services (e.g. frequency control ancillary services, inertia and system strength) and consider their procurement options.
4. Scheduling and ahead mechanisms that introduce greater visibility and certainty of resources (including DER and demand response) with options for voluntary ahead market to procure and trade services.
5. Two-sided markets that aim to develop a framework to facilitate consumer participation in the electricity trading market and reward load flexibility services provided to the system.
6. Valuing demand flexibility and integrating DER that works on the technical, regulatory and market arrangements required to support effective DER integration.
7. Transmission access and the coordination of generation and transmission that aims to address congestion issues and develop frameworks to support long term investment.

Some early work of electricity market reforms has commenced, for example, AEMO 2020 ISP actions, interim system security and reliability measures and the deployment of REZs that are underway. ESB will build on those early measures for their workstreams for phased market development as illustrated in Figure 12.

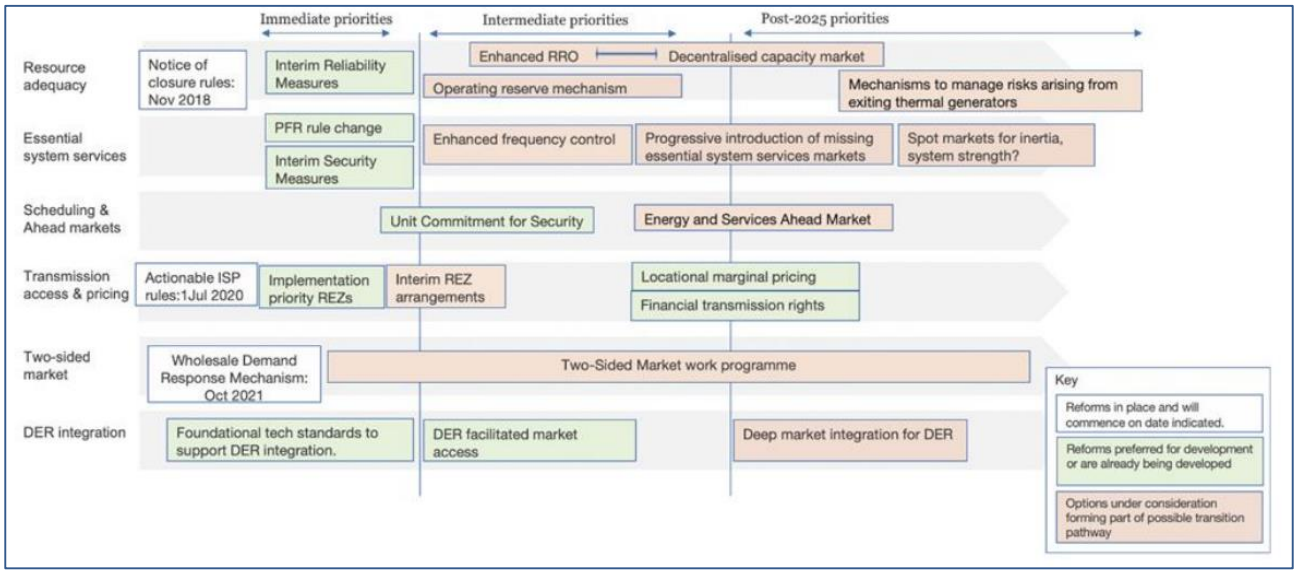

Figure 12: Phased Market Development Demonstration

Source: ESB[179]

4.2.2 AEMO Integrated System Plan

AEMO's 2020 ISP is a whole-of-system plan for NEM to maximise net market benefits and deliver low-cost-secure and reliability electricity to consumers. The 2020 ISP is an actionable roadmap to

[178] Energy Security Board, *Fitting the reforms together*, accessed 10 September 2020.
[179] Energy Security Board (2020), *Post 2025 Market Design Consultation Paper 2020*.

guide the electricity market development through the transition period to 2040.[180] The work comprises electricity market scenario modelling, cost-benefit analysis and stakeholder consultations across power systems. The (then) COAG Energy Council accepted the changes to the National Electricity Rules that convert the ISP into action.[181]

The key findings and suggestions from ISP include that:

- The ISP modellings confirm that the least-cost and least-regret transition of the NEM is from centralised coal-fired power generation towards a highly diverse portfolio of renewable energy sources, both at utility-scale and behind the meter, with the support of dispatchable firming generation and system services. There are significant development opportunities for non-network projects that include distribution assets, generation, storage and demand-side management.
- The ISP Cost-Benefit Analysis work suggests an optimal development path for transmission augmentation projects to unlock potential of new investment. Table 7 summarises NSW projects with expected completion under this optimal development path.
- The ISP prioritises REZ development opportunities in three overlapping phases based on the optimal development path.

[180] AEMO (2020), *2020 Integrated System Plan.*
[181] COAG Energy Council, *Actionable ISP Final Rule Recommendation*, 27 March 2020, accessed 23 October 2020.

Table 7: NSW projects identified under ISP Optimal Development Path

Source: AEMO[182]

ISP Actions	Project	Expected Completion	ISP Note
Commissioned	QNI minor upgrade	2021/22	Critical to addressing cost, security and reliability issues. The project has received their regulatory approval and is underway.
Actionable ISP Projects	VNI minor upgrade	2022/23	Critical to addressing cost, security and reliability issues. These projects have not yet completed their regulatory approval process.
Actionable ISP Projects	Project EnergyConnect	2024/25 (with stating from late 2022)	
Actionable ISP Projects	CWO REZ transmission network	2024/25	
Actionable ISP Projects	HumeLink	2025/26	
Actionable ISP Projects	VNI West	2027/28 (Conditional on decision rules)	Critical to addressing cost, security and reliability issues. The decision rules for this project can be assessed during the RIT-T process.
Future ISP Projects	QNI medium and large upgrade	2032/33 to 2035/36	These projects will support the development of REZs and address network congestion issues.
Future ISP Projects	Reinforcing Sydney, Newcastle and Wollongong supply networks	Between 2026/27 and 2032/33	
Future ISP Projects	New England REZ network expansion	Between 2031 to 2036 (possible to be accelerated by the NSW government to meet REZ targets)	
Future ISP Projects	North West REZ network expansion	2030s, based on connection interest	

In addition to the ISP, AEMO has commissioned the Renewable Integration Study (RIS) as a multi-year plan to maintain future system security with high renewable penetration. The RIS Stage 1 Report states that the NEM could operate securely with up to 75% instantaneous penetration[183] of wind and solar by 2025, given identified challenges are addressed with recommended actions.[184] It is possible for an even higher share of renewables for the future NEM generation portfolio with ongoing technological advancement beyond 2025.

[182] AEMO (2020), *2020 Integrated System Plan.*
[183] Instantaneous penetration of wind and solar is the half-hourly proportion of underlying demand is met by wind and solar resources. AEMO (2020), *Renewable Integration Study Stage 1 report.*
[184] AEMO (2020), *Renewable Integration Study Stage 1 report.*

4.2.3 AEMC Priority Work Program

The AEMC has prioritised five key areas of policy reform. This is in response to an energy sector that is constantly changing. This work is to inform participants on how they access safe, secure, reliable energy at the lowest possible cost as the market transitions. The priority areas of reform are[185]:

- *Generator access and transmission pricing* - This is about how markets are planned and developed so that investment is in the right plant, the right place and the right time. This is part of ESB's post-2025 market design and AEMC's broader system security and reliability action plan to develop future market frameworks for the NEM.
- *Power System Security* - This work is focused on new ways to procure enough system services to maintain power system security. It covers market reforms and rule changes in ESS and also part of the AEMC's system security and reliability action plan.
- *Integrating distributed energy resources* - The adoption of small scale solar and energy storage is increasing. This requires a re-think of how network infrastructure is used to get the most from these technologies.
- *Digitisation of energy supply* - Digital technologies now make it easier to choose and control how, when and where power is delivered. The focus is on how the market frameworks can deliver benefits to customers from these technologies in a future two-way market.
- *Aligning financial incentives with physical needs* - More variable demand and more variable supply makes forecasting challenging and adds risk to operational and investment decisions. The focus here is maintaining the link between the physical needs of the system and the financial incentives facing market participants.

4.2.4 NSW Government Planning, Strategies and Programs

4.2.4.1 NSW Electricity Strategy

The NSW Electricity Strategy is the NSW Government's plan to ensure electricity reliability and affordability in the carbon-constrained future. It outlines the principles to improve the efficiency and competitiveness of the NSW electricity market. Underpinned by those principles, the NSW Electricity Strategy sets out actions to encourage private investments for the least-cost market while ensuring there is sufficient dispatchable generation to meet the reliability targets. These actions cover a range of policy, financial and services support for the electricity industry.[186]

The NSW Electricity Strategy introduces a new Energy Security Target (EST)[187]. The 2019/20 EST is 15,733 MW[188], resulting in a 188 MW firm capacity gap in meeting the target. This shortfall is expected to be addressed by the summer 2020/21, filled by additional capacity provided from QNI and VNI upgrade (190 MW and 170 MW from Queensland and Victoria respectively), the Emerging Energy Program (200 MW) and private sector investment in thermal and renewables (275 MW) through to 2022/23.

Over the 10-year EST project period to 2030/31, there are sufficient proposed dispatchable capacity projects in the pipeline to achieve the target. However, the reserve conditions will be tight in 2023/24 after Liddell's closure and there remains a reliability risk without final investment decisions on proposed projects. The NSW Government has identified options to enhance firm

[185] AEMC, *Our forward looking work program*, accessed 23 October 2020.
[186] NSW Government (2019), *NSW Electricity Strategy (Detailed)*.
[187] The EST is set at an amount equivalent to the maximum demand experienced in NSW every 10 years plus a reserve margin to cover the loss of the State's two largest generating units. NSW Government (2019), *NSW Electricity Strategy (Detailed)*.
[188] Estimate in the NSW Electricity Strategy. The EST is based on 1) AEMO forecasts for a 1-in-10 year peak demand of 14,373 MW for the summer of 2019-20 and 2) the two largest generating units in NSW each having firm supply ratings of 680 MW. NSW Government (2019), *NSW Electricity Strategy (Detailed)*.

supply in meeting the EST, including fast-tracking the HumeLink (500 MW peak capacity), a further upgrade of QNI (378 MW), NSW Government electricity contracts (200 MW), expanding the Emerging Energy Program and the Energy Security Safeguard.[189]

In addition to existing legislative powers under emergencies, the NSW Electricity Strategy confers the NSW Government (Secretary of the Department of Planning, Industry and Environment) with information-gathering powers to assess the EST and address any shortfall.[190] If an electricity emergency occurs, NSW has a robust emergency response system and powers in place and these will be continually reviewed to suit changing market conditions.

4.2.4.2 NSW Energy Package

The NSW and Commonwealth governments have committed over $2 billion investments in improving the reliability, affordability and sustainability of the NSW energy system through the NSW Energy Package Memorandum of Understanding (MOU).[191] The MOU aims to increase gas and electricity supply in NSW and drive investment in transmission infrastructure while reducing emissions. Key initiatives under the MOU concerning electricity reliability are:

- Improving interconnectors transmission networks:
    - Underwriting TransGrid to complete early planning work for NSW interconnectors and further specifics works for QNI upgrade and HumeLink.
    - Investing directly in the planning, coordinating and transmission infrastructure for the CWO Pilot REZ and future REZs.
    - Working with the COAG Energy Council to ensure the RIT-T process remains fit for purpose with the integration of AEMO's 2020 ISP.
- Improving existing generators reliability:
    - Evaluating options to mitigate those impacts on the energy sector and flow-on industries as identified by the Liddell Taskforce.
    - Ensuring no impediments to address coal supply issues faced by Mt Piper Power Station.
- Increasing gas supply:
    - Facilitating investment and infrastructure for the injection of an additional 70 petajoules of gas in the east coast market.
    - Streamlining regulatory assessment for NSW gas import terminals and production projects (if approved).
    - Exploring options to reduce gas demand pressures.
- Supporting new generation investments:
    - Supporting new investment in generation and transmission in NSW through the Underwriting New Generation Investment Program, Grid Reliability Fund and legislative and administrative reform.

4.2.4.3 Other NSW Government initiatives

To support new investments and projects of dispatchable electricity generation across the NSW region, the NSW Government has a number of programs in place that have progressed since the 2019/20 NSW Assessment:

- *Emerging Energy Program* – provides direct grant funding for the development of large-scale dispatchable electricity and storage projects in NSW. To date, the capital projects stream has

[189] NSW Government (2019), *NSW Electricity Strategy (Detailed)*.
[190] NSW Government (2019), *NSW Electricity Strategy (Detailed)*.
[191] Commonwealth Government and NSW Government (2020), *Memorandum of Understanding – NSW Energy Package*.

awarded $37.5 million to four projects totalling 170 MW capacity. This includes a gas/hybrid power station, a Virtual Power Plant (VPP) and two large lithium batteries. The pre-investment studies stream has awarded $5.9 million to eight electricity projects to undertake pre-feasibility and pre-investment activities. These projects are investigating the potential to deliver 2,100 MW to the NSW electricity market.[192]

- *Regional Community Energy Program* – aims to increase renewable energy generation and improve electricity reliability in regional and remote communities by supporting energy hubs, regional on-demand electricity projects and emergency backup energy systems. Seven projects have been awarded under the first round of funding, totalling 17.2 MW of generation and 17.9 MW (39.3 MWh) of energy storage.[193]
- *Smart Batteries for Key Government Buildings Program* – supports the installation of battery storage at schools, hospitals and other key government buildings in conjunction with rooftop solar systems. The program is currently funding several pilot projects in partnership with NSW departments and agencies.[194]
- *Empowering Homes Program* – provides interest-free loans for households in the Hunter region to install solar battery systems.[195]
- *Solar for Low Income Households Program* – provides rooftop solar power systems for low-income homes.[196]

4.3 Opportunities for new and emerging technologies

New and emerging technologies and digital solutions could support the transition of the NEM for system reliability and security while providing better outcomes for consumers. Many of these technologies can provide broader economic and environmental benefits for NSW as outlined in the recent NSW Decarbonisation Innovation Study.[197] This section highlights some of those opportunities in the medium to longer term future.

4.3.1 Digitalisation and data

The uptake of DER, enabled by digitalisation technologies, has fundamentally changed the role of consumers where they can generate, monitor, manage and trade electricity in a more dynamic way.[198] This two-way electricity market is complex but more digitally connected where digitalisation technologies could benefit both the industry and consumers. For example, VPP that could connect DER and integrate into the system as aggregated generation capacities and service providers. The new and emerging applications of Artificial Intelligence (AI), Internet of Things (IoT), blockchain and innovative Information and Communication Technology (ICT) in electricity sector provide new opportunities for better consumer outcomes, for example peer to peer electricity trading. NSW research sector has strong capabilities in many areas of digitalisation technologies and services that could be leveraged for future electricity system solutions.

Digitalisation is economy-wide and a global phenomenon. Digital-enabled solutions in the electricity sector could enhance the interconnections with energy users in other sectors from industry, building and transport. Information exchange and communications between these systems present opportunities for better coordination and management of the electricity markets. This could be achieved through digitalisation tools such as digital twin building on existing

[192] NSW Government, *Emerging Energy Program*, accessed 04 September 2020.
[193] NSW Government, *Emerging Energy Program*, accessed 04 September 2020.
[194] NSW Government, *Smart Batteries for Key Government Buildings Program*, accessed 04 September 2020.
[195] NSW Government, *Empowering Homes Program*, accessed 04 September 2020.
[196] NSW Government, *Solar for Low Income Households Program*, accessed 04 September 2020.
[197] CSE (2020), *NSW Decarbonisation Innovation Study*.
[198] AEMC (2019), *How Digitalisation is Changing the NEM*.

initiatives in NSW like the Spatial Digital Twin project.[199] The widespread deployment of digitalisation technologies requires access to data in a secure and transparent way. The ESB has recently initiated a new data strategy for NEM considering issues around lack of effective data, regulatory barriers and other issues require reforms.[200]

Another initiative that could be investigated in Australia is the COVID-EMDA+ (Coronavirus Disease - Electricity Market Data Aggregation+), a data hub that brings together US electricity marketplaces data (i.e. such as from CAISO) and other variables (coronavirus cases, weather, generation mix, load (actual and forecasted), renewable curtailment and electricity prices, amongst others) to specifically track the potential impacts of COVID-19. Whilst specific for this pandemic, this could be utilised in future for other emergency situations (where applicable).

Data sharing

High-quality data becomes more crucial for the safe and efficient operation of the electricity system as the sector digitalises from both supply and demand sides. Real-time data and accurate translation into communicable information could help decision-makers for emergency response. Long term NEM forecasting and planning require the support of comprehensive datasets and analytical results to understand the future trends and impacts to the system.

The Panel notes that the issue raised by NSW DNSPs around having very limited access to smart meter data to assist bushfire emergency recovery.[201] Smart meters could provide data not only about electricity consumption but also voltage, exports and neutral integrity. If made accessible to DNSPs, this data may assist them to detect potential faults or prevent ignition of fires from electrical assets.[202] At present, NSW DNSPs have only access to smart meter data for billing purposes and additional datasets must be procured through individual agreements with retailers. This causes a major impediment to grid visibility due to the large number of agreements and costs for DNSPs.

For the electricity sector, consumers are electricity data owners and retailers are the most common data holders. The Consumer Data Right (CDR) reform is underway for the electricity sector which will offer energy consumers more access and greater control over their data. The CDR reform has introduced a gateway model where AEMO acts as a conduit between businesses that hold consumer data. Under the gateway model, accredited third parties can request data from AEMO who can collate and release the data to the accredited third party with authorisation/authentication by the consumer.[203] ACCC is undergoing consultations for the detailed design of CDR in the electricity sector for additional rules required to accommodate the gateway model. The CDR is expected to be finalised and implemented in mid to late 2021.[204]

Telecommunications services require power for a reliable and secure operation. The Panel notes that better information and data sharing between telecommunication and electricity sector could support emergency management and response as discussed in Section 2.1.2. Findings and recommendations from the NSW Bushfire Inquiry support this and better coordination between the two sectors for bushfire situations (summarised in Chapter 3).

[199] The NSW Spatial Digital Twin is a government initiative working with CSIRO Data61, updating the existing NSW Foundation Spatial Data Framework to a four-dimensional model of the state's physical environment, capable of recording past conditions and visualising future scenarios. The first stage, a Minimum Viable Product Digital Twin, will focus on eight LGA's (comprising the Western Parkland City, Greater Parramatta and the Olympic Peninsula areas) that have significant infrastructure investment, and economic and social significance. NSW Government, *Digital Twin*, accessed 27 October 2020.
[200] Energy Security Board (2020), *Data Strategy Consultation Paper.*
[201] Essential Energy, personal communications, 10 September 2020.
[202] Essential Energy (2020), *Essential Energy response to the NSW Independent Bushfire Inquiry.*
[203] AEMO, *Consumer Data Right*, accessed 7 October 2020.
[204] AEMO, *Consumer Data Right*, accessed 7 October 2020.

Cybersecurity

The Australian energy sector has its cybersecurity framework, Australian Energy Sector Cyber Security Framework (AESCSF), developed by AEMO in 2018. This framework enables participants to undertake assessments of their cybersecurity capability and maturity. Under the AESCSF, a Cyber Security Industry Working Group was formed with several workstreams to examine, explore and adopt cybersecurity practices for the energy sector. Further, a National Energy Cyber Security Exercise (GRidEx V) was conducted in November 2019 and examined the coordination and responses for cybersecurity threats.[205]

Electricity infrastructure is identified as one of the critical infrastructures by the *Security of Critical Infrastructure Act 2018* with regulatory obligations on specific entities. The secure and safe operation of other critical infrastructures from gas, water and maritime ports dependent on electricity supply. Further, electricity cybersecurity will become more critical with the progress of electrification in transport, industry and other sectors. As one key initiative under Australia's Cyber Security Strategy 2020, the Australian Government is undertaking consultations for the Protecting Critical Infrastructure and Systems of National Significance package of reforms.[206]

4.3.2 Decentralised electricity systems and smart grids

Decentralised electricity systems, such as microgrid and SAPS[207], are emerging electricity supply arrangements that can help enhance overall electricity system reliability and security. These smaller electricity systems can utilise local renewable energy resources that are located closer to the load centre for reduced electricity transmission losses.

Microgrids present a cost-effective alternative to connect new electricity consumers, particularly with high DER potentials. Aggregated rooftop solar, behind-the-meter batteries and Electric Vehicle (EV) means local communities can be electricity self-sufficient and actively engaged in the two-way market. Connecting to the main grid increases their resilience to extreme weather or emergency conditions but also can provide additional capacity and reserve in terms of generation and ESS to the NEM. There are some successful microgrid pilots and trial projects at university campuses, industrial precincts and residential communities in NSW for example the Byron Bay Arts & Industry Estate Microgrid.[208]

SAPS are practical options to provide reliable and secure electricity to remote and fringe-of-the grid communities especially those under high risks of natural disasters. SAPS offer cost savings for DNSPs from asset maintenance, vegetation management and emergency repair and power restoration services. Similarly, SAPS could replace the grid electricity supply and diesel backup for some regional telecommunication infrastructures. At present, there are some regulatory barriers for the widespread deployment of SAPS by the network services providers. The (former) COAG Energy Council has agreed to implement a new regulatory framework for DNSPs to provide SAPS as long-term solutions in NEM.[209]

Smart grids optimise the balance of demand and supply through the use of digital technologies for better energy monitoring and management. There are many components in a smart grid and some of these technologies are mature. The key challenge is integrating these complex systems into the existing grid. Innovative thinking and new approaches could incentivise consumers to upgrade to smart appliances, systems and platforms for smart grids. There are good examples of smart grid

[205] AEMO (2020), *Integrated System Plan Appendix 8. Resilience and Climate Change.*
[206] Commonwealth Government (2020), *Protecting Critical Infrastructure and Systems of National Significance Consultation Paper.*
[207] Microgrids are small and autonomous grids that are connected to larger grids but have the ability to operate independently, or 'islanded'. In contrast, SAPS are not physically connected to the grid electricity system due to a desire for energy independence or remoteness (e.g. regional area power system).
[208] NSW Government, *Case Study: Business share solar power to save money and reduce emissions. Clean Energy Knowledge Sharing Initiative*, accessed 18 October 2020.
[209] Owens, D. and O'Kane, M. (2020) (2020), *Final report of the NSW Bushfire Inquiry 2020.*

projects envisioned by local communities with government support, such as the NSW Narara Ecovillage Smart Grid Project.[210]

4.3.3 Energy efficiency

Energy efficiency is an important form of energy capacity. AEMO's 2020 ESOO indicates that the total energy efficiency represents around 10% to 13.4% of total consumption in 2039/40.[211] NSW has an existing energy efficiency market, the Energy Savings Scheme[212], which is reconstituted as the Energy Security Safeguard under the NSW Electricity Strategy. The Energy Security Safeguard includes a 13% efficiency target to 2050 and new certificate scheme for peak demand reduction technologies (e.g. home batteries, smart pool pumps and smart EV chargers).[213]

Energy efficiency reduces operational demand for the system therefore could delay or avoid investment in new generation and networks while meeting the energy requirements from population and economic growth. Energy efficiency helps system reliability and security by reducing operational demand and shifting the peak demand to match renewable generation profiles. Further, efficiency improvement offers fuel savings for thermal generators and mitigates risks associated with fuel supply and networks. This improves energy productivity for the generators and contributes to their emission reduction efforts.

Energy efficiency improvements become increasingly important for the demand side as consumers are more actively engaged with their DERs, smart appliances and energy management systems. Further, working from home and other flexible working arrangements are likely to continue post-COVID-19, demand will become more dispersed and distributed at household levels. Home appliance upgrades, air-conditioning with built-in demand response, lighting replacement and other residential energy efficiency improvement would have accumulated and long-term benefits for the system.

4.3.4 Electrification and synthetic fuels

Electrification has potential for decarbonisation and cost savings across manufacturing, agriculture, transport and building sectors. Some technologies are mature and commercially available, for example heat pumps, electric boilers and furnaces, while some require research and development for cost reductions. The widespread deployment of electrification technologies with optimised integration to the electricity system could have multidimensional benefits for electricity security and reliability.

Taking the transport sector as an example, the uptake of EV could have significant impacts on energy systems. Like any other form of DER, EV could benefit both consumers and electricity industry but faces emerging challenges of integration to the electricity system. For example, EV charging has implications for system operations, impacting the transmission as well as a distribution network. If deployed at scale and managed well, EV could help flatten daily fluctuations of supply from solar generation and provide additional grid services such as FCAS.[214] Vehicle to Home and Vehicle to Grid, enabled by two-way charging technologies, could support the electricity systems as distributed energy storage and demand response. Smart EV chargers could provide energy efficiency sector coupling benefits between the energy, transport, infrastructure and buildings sectors.

[210] The Narara Ecovillage is designed as a carbon neural community with smart grid system connecting 150 homes. The smart grid system comprises rooftop PV, battery, EV charging, centralised energy storage and control. The smart grid is connected to NEM through a transformer. NSW Government, *Case Study: Narara Ecovillage. Clean Energy Knowledge Sharing Initiative*, accessed 18 October 2020.
[211] AEMO (2020), *2020 Electricity Statement of Opportunities*.
[212] The NSW Energy Savings Scheme is a market-based instrument requiring participants to meet energy savings target by buying certificates. The EES was legislated to operate until 2025 with a target of 8.5% of electricity demand for each year from 2019 to 2025.
[213] NSW Government (2019), *NSW Electricity Strategy (Detailed)*.
[214] AEMO (2020), *2020 Integrated System Plan Appendix 10. Sector Coupling*.

Utility-scale production of hydrogen, synthetic fuels and chemicals through electrolysis involve the integration of those energy-intensive processes into the energy systems. If well placed in the electricity networks, these additional loads present opportunities to manage load profiles through load shifting and reducing curtailed energy. Further, electrolysers and/or co-located hydrogen-powered turbines could provide fast frequency control services and voltage management to the electricity system. With technology advancement, hydrogen can provide cost-effective bulk energy storage and dispatchable generation solutions.[215] The development of the hydrogen industry has gained momentum in Australia with the National Hydrogen Strategy and a cost reduction target.[216]

[215] AEMO (2020), *2020 Integrated System Plan Appendix 10. Sector Coupling*.
[216] Commonwealth Government (2019), *National Hydrogen Strategy.*

Acronyms

Acronym	Complete Term
AEMO	Australian Energy Market Operator
AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
AESCSF	Australian Energy Sector Cyber Security Framework
ARENA	Australian Renewable Energy Agency
ACSC	Australian Cyber Security Centre
BAU	Business as Usual
BFDP	Bush Fire Danger Period
BNHCRC	Bushfire and Natural Hazards CRC
BOM	Bureau of Metrology
CBD	Central Business District
CER	Clean Energy Regulator
CDR	Consumer Data Right
CIC	Critical Infrastructure Centre
CISO	California Independent System Operator
COAG	Council of Australian Governments
ConOps	Concept of Operations
COVID-19	Coronavirus Disease 2019
CSE	NSW Chief Scientist & Engineer
CWO REZ	Central-West Orana Pilot Renewable Energy Zone
DER	Distributed Energy Resources
DNSP	Distribution Network Service Provider
DPI	Department of Primary Industries
DPIE	Department of Planning, Industry and Environment
DSP	Demand Side Participation
EA	EnergyAustralia
EAAP	Energy Adequacy Assessment Projection
ECCS	Energy Climate Change and Sustainability Directorate, DPIE
EOCON	Emergency Operations Controller
EPL	Environmental Protection Licence
ESB	Energy Security Board
ESOO	Electricity Statement of Opportunities
ESS	Essential System Service
EST	Energy Security Target
EUSFA	Energy and Utilities Services Functional Area
EUSFAC	Energy and Utilities Services Functional Area Coordinator
EV	Electric Vehicle
FCAS	Frequency Control Ancillary Services
FFDI	Forest Fire Danger Index
FUM	Forecast Uncertainty Measure
GEAR	Government Energy Action Response
GW	Giga Watts
JDR	Jurisdictional Designated Officer
JRO	Jurisdictional Responsible Officer
JSSC	Jurisdictional System Security Coordinator
HILP	High Impact Low Probability
Hz	Hertz
IBR	Inverter-Based Resources
IOD	Indian Ocean Dipole
IRM	Interim Reliability Reserve
IPART	Independent Pricing and Regulatory Tribunal

ISP	Integrated System Plan
LOR	Lack of Reserve
MOG	Machinery of Government
MT-PASA	Medium Term Projected Assessment of System Adequacy
MW	Mega Watts
NEM	National Electricity Market
NER	National Electricity Rules
NSW	New South Wales
NSW EPA	NSW Environment Protection Authority
NSW RFS	NSW Rural Fire Service
PFR	Primary Frequency Response
POE	Probability of Exceedance
PV	Photovoltaics
QNI	Queensland to NSW Interconnector
RERT	Reliability and Emergency Reserve Trader
REZ	Renewable Energy Zone
RIT-T	Regulatory investment test for transmission
RO	Relevant Official
RRO	Retailer Reliability Obligation
SAPS	Stand Along Power System
SAM	Southern Annular Mode
SEOC	State Emergency Operations Centre
SEOCON	State Emergency Operations Controller
SEMC	State Emergency Management Committee
SES	State Emergency Service
SOPs	Standard Operating Procedures
TNSP	Transmission Network Service Provider
TELCOFAC	Telecommunications Services Functional Area Coordinator
TWh	Terra Watt hours
USE	Unserved Energy
VDR	Voluntary Demand Response
VNI	Victoria to NSW Interconnector
VPP	Virtual Power Plant
VRE	Variable Renewable Energy
WHS	Workplace Health and Safety

Appendix 1 – Terms of Reference

The 2019/20 review of the Assessment of Summer Preparedness for the NSW Energy Market will:

1. provide an assessment by 30 October 2019, that:
    a. synthesises work undertaken by the Australian Energy Market Operator (AEMO) and other national bodies in relation to the supply and demand outlook in NSW, including the adequacy of firm generation, transmission and demand response;
    b. considers national measures, ongoing work by AEMO and other market bodies, and current NSW Government actions, to address energy reliability and security risks;
    c. builds on previous NSW Chief Scientist & Engineer assessments of summer preparedness of the NSW energy market and reviews the work completed by the NSW Government in response to the recommendations from those reports;
    d. identifies any emerging risks for the 2019/20 summer and makes recommendations on actions to address any vulnerability identified; and
    e. examines opportunities for enhanced working relationships between AEMO, TransGrid and the NSW Government regarding energy emergencies.
2. Upon request, provide an update to the assessment and yearly thereafter to 2023, that:
    a. accounts for market developments, ongoing monitoring and work from national bodies, including updates to AEMO's Integrated System Plan (ISP) and Electricity Statement of Opportunities (ESOO);
    b. includes ongoing assessments of summer preparedness for the NSW energy market; and
    c. identifies any emerging risks for NSW and makes recommendations on actions to address any vulnerability identified.

In undertaking this work, an expert Panel as well as staff selected by the NSW Chief Scientist & Engineer consulted with, and considered work being undertaken by, the NSW Government and other relevant organisations including TransGrid, AEMO, the Australian Energy Regulator, the Australian Energy Market Commission and the Energy Security Board.

Appendix 2 – Stakeholder Engagement

Table 8: List of stakeholders

Name/Organisation
AGL
Ausgrid
Australian Energy Market Operator (AEMO)
Australian Energy Market Commission (AEMC)
Australian Energy Regulator (AER)
Bureau of Meteorology (BoM)
Mr Dave Owens, NSW Bushfire Inquiry
Delta Electricity
Endeavour Energy
EnergyAustralia
Energy Security Board (ESB)
Essential Energy
NSW Department of Planning, Industry and Environment (EUSFA and Energy Division)
NSW Health
NSW Telco Authority
Origin Energy
Queensland Government
SafeWork NSW
Tomago Aluminium Smelter
TransGrid
Victorian Government

Appendix 3 – System Security Technical Attributes and NSW Assessments

This Appendix supports Section 4.1.2 on system security and provides an assessment of NSW in regard to some of these technical attributes. The level of adequacy of NSW's ESS in meeting regional standards for each technical attribute is based on AEMO's modelling in the 2020 ESOO, 2020 ISP, 2020 Renewable Integration Study and 2019 Network Support and Control Ancillary Services Report. This appendix also provides explanations of the technical attributes of the power system and services required to maintain system security based on AEMO's 2020 Power System Requirements Report.

Frequency management

Inertial response

Inertial response provides a rapid and automatic injection to suppress frequency deviations and slowing the rate of change of frequency. Traditionally, inertia has been provided by the large rotating mass of synchronous generation (e.g. turbine and rotor). However, the capacity of inertial response has declined especially in areas with high penetration of Inverter-Based Resources (IBR). A lack of inertia can become a risk to system security when these areas are separated from the rest of NEM. AEMO assesses inertia shortfall for each NEM inertia sub-network and the local TNSPs responsible for providing inertia system services to meet the minimum requirements. The minimum and secure inertia level for a NEM region is based on the operational requirements of stability and security if the region were to become islanded (i.e. separated from the NEM). There is a very low probability for an island event in NSW as it is supported by a number of interconnectors and upgrade projects.[217]

The available amount of inertia is projected to fall in NSW driven by the retirement of coal-fired power stations. The minimum threshold (required to be provided by synchronous generators and condensers, while additional required inertia can be provided by frequency response) and secure operating level of inertia for NSW is 10,000 MWs and 12,500 MWs respectively. [218] In noting this forecasted reduction in inertia, there is sufficient inertia to meet NSW's regional minimum requirements to 2035.[219] AEMO notes that an accelerated decline in inertia level is possible if synchronous generations operate more flexibly or retire early.

Going forward AEMO recommends consideration of an inertia safety net for system intact. This would operate in parallel with the existing regional inertia requirements.[220]

Frequency response

Primary frequency response

Primary frequency response (PFR) is the first stage of the frequency control mechanism to maintain within the normal operating band (49.85 Hz to 50.15 Hz). PFR is when a generation system or load adjust their active power[221] output/input as a response to arrest and correct locally detected changes in frequency. PFR automatically occurs immediately following a frequency disturbance, without a centralised system of controls. Historically, PFR was sourced from synchronous generators and large industry load (e.g. steel and aluminium smelters) through their local controls. Utility-scale wind, solar, batteries and VPPs can provide PFR services and are

[217] AEMO (2020), *2020 Integrated System Plan Appendix 7. Future Power System Security*.
[218] AEMO (2020), *Renewable Integration Study Stage 1 Appendix B Frequency Control*.
[219] AEMO (2020), *2020 Integrated System Plan Appendix 7. Future Power System Security*.
[220] AEMO (2020), *Renewable Integration Study Stage 1 Report.*
[221] Active power is one of the unique characteristics of alternating current (AC) where energy is moving forward and backward directions and reacting upon itself.

currently making up a portion of the FCAS provider pool. DERs have the capability of providing frequency support in aggregate, with standardised requirements under review for the possible implementation in future.

A recent rule change by the AEMC on Mandatory Primary Frequency Response now requires all scheduled and semi-scheduled generators to operate within performance parameters set out in the PFR requirements.[222] A new frequency control framework has commenced under which AEMO produces frequency performance reports and AER produces FCAS market performance reports. As part of the rule changes, the energy bodies are working collaboratively on an updated frequency control work plan.

Secondary frequency response

After PFRs arrest frequency excursions, secondary frequency control services provide an injection or removal of power from the grid to return the system frequency to 50 Hz. Secondary frequency control is managed through the use of regulation FCAS services and energy re-dispatch. Regulation FCAS bids and offers are co-optimised with energy as part of the dispatch process, and is provided by generation plant controlled by AEMO's AGC system.

Tertiary frequency control

With a dispatch interval of five minutes, tertiary frequency control is effectively achieved through the re-dispatch process. In overseas power markets with a longer dispatch interval, tertiary frequency control products may need to be procured as a separate service. This is not the case in the NEM.

Voltage management

In the power system, it is important to maintain voltages in the network within acceptable limits. Excursions outside of these limits may result in damage to consumer's electrical equipment or disconnection. Voltage control maintains power system voltage levels within acceptable ranges during normal operation and to enable recovery to acceptable levels following a disturbance.

Voltage management is achieved through three mechanisms

- Provision of system strength
- Fast response voltage control
- Slow response voltage control

System strength

System strength affects to the stability and dynamics of the energy system. AEMO defines system strength as the ability to maintain and control the voltage waveform at any location during the steady-state and following a disturbance. The system strength in the NEM regions has been provided as a by-product of large synchronous generations. For regions that have a high level of IBR but low availability of synchronous machines, online system strength has become an issue. System strength is traditionally seen in terms of fault levels at buses (nodes) of the network. AEMO assesses the system strength across the NEM by determining fault level shortfall exits at identified nodes. The local TNSPs are responsible to provide system strength services to meet the minimum requirements.

AEMO's latest system strength assessment shows that south-west NSW has low system strength in 2020/21. This can be improved in future years by the proposed EnergyConnect project which includes new synchronous condensers to be installed in NSW.[223] In 2029/30, it has been identified that concentrated IBR areas in northern NSW will require system strength remediation. There are

[222] AEMC (2020), *National Electricity Amendment (Mandatory primary frequency response) Rule 2020 No. 5.*
[223] AEMO (2020), *2020 Integrated System Plan Appendix 7. Future Power System Security*.

also projected system strength shortfalls in NSW following the retirement of coal-fired power stations during that period. The fault level node with shortfall gaps are Sydney West (1600 Megavolt-ampere (MVA) to 2700 MVA) and Newcastle (1900 MVA to 2700 MVA) by 2035, depending on scenarios.[224] Putting this into perspective, the four new synchronous condensers in South Australia can provide 575 MVA each with a total project capital cost of $166 million.[225] Further analysis of system strength will be released in AEMO 2020 System Strength and Inertia Report.

Voltage control and response

The electricity system needs to maintain voltage levels at different points in the network within acceptable ranges during normal operation and the ability to recovery to those operating levels after disturbance. This is achieved through voltage control by balancing the production or absorption of reactive power. NSPs are responsible for designing and operating their assets so that voltages at connection points are within technical limits. Generators are required to provide voltage support at their connection points. AEMO oversees the voltage levels across connection points and coordinates the voltage management.

Voltage management services include fast response voltage control (milliseconds to seconds) and slow response voltage control (seconds to minutes). Other measures are available to system operators to manage voltages are:

- Network reconfiguration
- Contracts with generators and TNSPs for specific reactive support
- Load shedding, automatic and manual.

Fast response voltage control (FRVC) is related to load characteristics and system strength. There is a range of equipment that can provide FRVC, such as synchronous condensers, wind turbines and solar inverters and synchronous generation through automatic voltage regulation.

Slow response frequency control *(*SRFC) is used to manage small adjustments to reactive power during normal system operation. SFRC is primarily provided locally by;

- Voltage regulators in the distribution networks
- Transformer load-tap changes to increase or decrease voltages
- Passive reactive power compensation from capacitors and reactors within substations.

AEMO undertakes an annual review of voltage management and identifies potential gaps as part of the Network Support and Control Ancillary Services (NSCAS) process. The 2019 NSCAS assessment has not identified any voltage management gaps in NSW over the five year period.[226] Some high-risk areas with conditions are highlighted by the assessment, including southern NSW when Mt Piper Power Station and firming generation offline and northern NSW after the retirement of Liddell Power Station in 2022/23.[227]

System Restoration

AEMO's role as the power system operator is to maintain system security and reliability. A major disturbance such as sudden equipment failure, failures in close succession or extreme weather

[224] AEMO (2020), *2020 Integrated System Plan Appendix 7. Future Power System Security*.
[225] AER (2019), *Final Decision ElectraNet Contingent Project. Main Grid System Strength.*
[226] AEMO (2019), *2019 Network Support and Control Ancillary Services Report.*
[227] AEMO (2019), *2019 Network Support and Control Ancillary Services Report.*

can lead to cascading failures across the system resulting in an insecure operating state, significant load disruption or at worst a black system[228].

Black system events are rare but impose significant risks of catastrophic disruptions to the electricity system and the community. The market operator must have the capability to restore the system safely and securely from those situations. AEMO manages the System Restart Ancillary Services (SRAS) market and procures services to meet the system restart standard set by the AEMC's Reliability Panel for each NEM region. As for NSW, this is the restoration of 1,500 MW capacity in two hours.[229]

During a black system event, it requires at least one SRAS source (generation) to restart independent of a connection to the grid and to re-energise part of the system to supply a commensurate amount of load before another generation is brought online and further areas of load are restored.

A number of different technologies provide SRAS in the NEM, including

- Generating units that can restart independently of the grid (hydro, gas turbines and diesel units)
- Large generating units that can disconnect from the grid and continue to supply their auxiliaries
- Large generating units that can be restarted from a nearby small power station without grid supply.

There are fewer traditional sources of SRAS available in some regions of the NEM, and those that remain are potentially less capable of restoring the power system. A recent rule determination by the AEMC[230] has changed the definition of SRAS which is intended to provide AEMO with a greater range of SRAS which can now include alternative technologies such as battery storage systems and new technologies utilising grid-forming inverters. At present none of the existing installed IBR has black start capability sufficient to energise the transmission network and other generation. However there is an emerging interest the alternative black start technologies which are under development by some manufacturers.[231]

With the retirements of the large coal-fired generating fleet and its replacement with intermittent renewables, if the development these alternative black start technologies are not progressed in a timely manner, this will present a risk for NSW in the event of a major supply disruption.

It is critical to have certain centralised controllability over DER during electricity emergencies. During a black system event, the system requires sufficient load to bring the first generators online. Lack of stable load due to high levels of rooftop PV generation create challenges for the market operator's capability for a system restart. This reaffirms the need for shedding capability for rooftop PV as security backstop mechanism during the emergency events such as black system conditions.[232]

[228] Black system event is where a large blackout of the power system occurs. NEM has had three black system events: South Australia in 2016, northern Queensland in 2009 and NSW in 1964. The most recent was SA in September 2016. AEMC (2016), *Fact sheet: Black System Events*.
[229] AEMC (2016), *The System Restart Standard*.
[230] AEMC, *National Electricity Amendment (System Restart Services, Standards and Testing) Rule 2020.*
[231] AEMO (2020), *Power System Requirements*.
[232] AEMO (2020), *2020 Electricity Statement of Opportunities.*