NSW GOVERNMENT | Chief Scientist & Engineer

Assessment of Summer Preparedness of the NSW Energy Market: 2021/22

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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: 2021/22

In September 2019, you requested that I provide annual advice until 2023 on the risks within the National Electricity Market (NEM), 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 of Energy Systems, UNSW Sydney). Secretariat support was provided by the Office of the Chief Scientist & Engineer.

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

The Panel examined issues including:

- summer 2020/21 and events throughout the year, including the impact of floods, storms, the Callide Power Station outage
- ongoing risks and impact of the COVID-19 pandemic
- NSW Government and the electricity sector preparedness for the upcoming summer as well as situational awareness and potential risks identified
- increase in Lack of Reserve (LOR) conditions
- 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 regard to the supply of electricity, however there are a number of risks to the system due to the potential impacts of extreme weather (floods and storms), increased penetration of renewables (both grid-scale and rooftop solar), delayed maintenance and increased outages of coal generation, and the uncertainty associated with the ongoing COVID-19 pandemic that could affect the security and reliability of electricity supply.

The transition of the network poses risks to the energy market. The NSW Government and the ESB, along with the market bodies, are developing policies and strategies to support the transition, and the Panel have provided complementary recommendations.

Yours sincerely,

H. Durrant-Whyte.

Hugh Durrant-Whyte
Chief Scientist & Engineer
29 October 2021

Findings & Recommendations

The scope for the 2021/22 Assessment requests both summer preparedness as well as more situational awareness/year-round preparedness for the energy system. This aligned with the observations of the Panel with a greater number of impacts on the energy system since the 2020/21 Assessment occurring outside of the summer period. Therefore, the Panel has considered year-round preparedness and risks to the energy system and highlighted where these issues are of particular relevance to the upcoming summer.

Review of 2020/21 and preparedness for 2021/22

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 2020/21 summer and throughout the year, how risks have changed and preparedness for the 2021/22.

Table 1: Panel summary of the 2020/21 review and 2021/22 preparedness risk assessment

Category	2020/21 review	2021/22 risk comparison to 2020/21	2021/22 preparedness
Generation capacity in meeting demand	 Market responded to LOR situations, with no load shedding. Longer term residual impacts on the system e.g., reduced coal stockpiles, increased outages. Reduced confidence in the reliability of generating plant.	 Slightly increased risk to thermal plant because of overhaul deferrals, fuel supply and increased cycling.	 Well prepared. However, there are concerns over the supply of coal to some power stations, and the impact from deferring maintenance.
System reliability, strength and security	 System showed resilience. Immediate resilience to Callide explosion better than expected. Note, risk exist beyond summer (incl. high winter demand, extended planned outages.)	 Slightly increased, due to ongoing outages and minimum demand reductions.	 Well prepared.
Extreme weather	 Milder climate conditions overall compared with 2019/20. Shoulder season disruptions and damage due to floods and storms. No major impacts on supply.	 Grass fires more likely in Northern NSW Similar flood and storm risk. Forecast above median rainfall for Latrobe Valley in spring and early summer which could impact coal supply to Yallourn Power Station	 Well prepared, mild conditions for summer expected due to forecasted weak La Nina conditions. Uncertainty on the severity of flood and storms in summer and throughout the year.

COVID-19		Protocols effectively mitigated risk in workplaces.		Impacts of delayed maintenance and border restrictions.		Well prepared, but uncertainty with impacts of delayed maintenance and COVID-19. International border situation improved for NSW, but state border situation still uncertain.
Future market design, planning & policy		NSW Government roadmap released.		Improvement. Energy Ministers agreed to reforms proposed by Energy Security Boards (ESBs) post 2025 market design.		Unlikely to have material impacts in short term. As transition accelerates, work must maintain pace.
Overall		Mild summer with no major impacts on the system.		Similar		Well prepared, noting uncertainty associated with delayed maintenance and coal supply.

Risk level	High	Medium	Low

Review of 2020/21

- There were consistent reports from all businesses that the summer 2020/21 period was characterised by mild climatic conditions with limited operational impacts on generation and networks.
- Sustained improvement has been made by the industry in its capacity to deal with emergency situations. Businesses appear better equipped to manage all manner of emergency situations including natural disasters and COVID-19. The Panel notes that the industry is now in a period of significant transition and is adapting by putting in place appropriate risk management procedures, in addition to acquiring the required resources and skills to adapt to the changes brought about by the transition.
- Daytime minimum demand levels are continuing to reduce, resulting in a need to alter operational strategies, particularly for conventional thermal generators which are subjected to increased cycling as minimum demand lowers.
- Several network incidents occurred in the post-summer period, highlighting a need to be prepared all year round. In the autumn and winter seasons of 2021, the National Energy Market (NEM) was impacted by flooding (e.g., the Hawkesbury and Mid North Coast regions in NSW, coal mine closure at Yallourn Power Station in the Latrobe Valley), severe weather in the Dandenong Ranges, a battery fire at Moorabool and a generator unit explosion at Callide Power Station in Queensland.
- Elevated level of forecast and actual Lack of Reserve (LOR) activity was observed across the NEM during Q2, 2021. Several factors contributed to this including delayed return from planned outages, forced outage of Callide Power Station units following the explosion, and variable renewable generation dynamics.
- The COVID-19 situation has further served to reinforce risk management and communication procedures in the sector. All businesses were well-prepared and, where positive cases were identified, processes effectively prevented transmission within the work environment.
- COVID-19 restrictions have created challenges for state and international border crossings, impacting the movement of skilled technicians, outage workers and spare parts. However,

businesses have adapted well to accommodate extra lead times and workarounds that may be required. Some large maintenance work has been delayed until next year.

- Energy businesses reported uncertainty about what power NSW Health would have to force a site closure in the event of an on-site outbreak. A theme was that there is a general lack of understanding around the impacts given the essential and transient nature of some of the electricity sector workforce. NSW Health participated in a briefing session with industry participants and encouraged businesses to establish a relationship with the local public health unit, who would be the first point of contact in the event of a site outbreak. In the case of the Hunter New England Local Hospital District, for large businesses, Safe Work NSW is the first point of contact
- There is a good level of industry sharing of best practice. Businesses proactively seek to learn from each other's expertise, and 'mutual aid' agreements in the sector have proven effective in disaster response and dealing with COVID-19 border restrictions.
- Redundancy in power supplies to essential telecommunications infrastructure in bushfire and flood risk areas is lacking with most having a maximum of 4 hours battery backup. Physical access to sites is unlikely to occur within such a timeframe in terrain and locations which may still be in an active fireground or in a flood zone where water must recede before crews can be safely admitted. Little appears to have been progressed in providing sufficient redundancy options and further work is required at the Commonwealth level to progress this issue (Refer recommendation 30 of Final Report of the NSW Bushfire Inquiry).
- It is encouraging that automated systems in place to control failures during energy emergencies have largely worked as expected (e.g., Callide, Victorian Big Battery).
- An investigation into the Victorian Big Battery[1] fire by Energy Safe Victoria (ESV) identified the likely cause to be a Megapack cooling leak that caused a short circuit resulting in overheating that led to a fire in a nearby battery compartment. ESV has required the site's owners and operators to implement several additional safety measures.
- In NSW, the Independent Pricing and Regulatory Tribunal (IPART) regulates the safety and reliability of electricity networks, including batteries installed as part of electricity networks. However, the installation of batteries at customer sites is regulated by NSW Fair Trading. While no specific legislation exists for the regulation of grid-scale batteries in NSW, there are general duties that all designers, installers and operators of grid-scale batteries must perform in relation to safe installation, commissioning, maintenance and decommissioning activities under the *Work Health and Safety Act 2011 (NSW).* The regulation of large-scale batteries at generator sites falls under the general regulatory remit of SafeWork NSW.
- The Panel notes that with the increased uptake of several new and emerging technologies, including large-scale and consumer battery storage systems, there is the potential that there may be gaps in existing safety regulation for new products and systems. There may be benefit in conducting a review of existing energy, including for electricity and gas, legislation and regulation to ensure it has the scope to effectively cover a broad range of emerging technologies and situations, including those not directly connected to the grid.

Recommendation 1

The Department of Planning, Industry and Environment should lead a review of legislation with relevant agencies to determine gaps in the regulation of safety for emerging gas and electricity technologies such as batteries and hydrogen/electric products at both consumer- and grid-scale.

[1] 300 MW battery being installed at Moorabool Terminal Station in Victoria.

- Some generators experienced constraints around transmission lines during times of peak renewable generation, and this is going to be an ongoing issue. For example, generation at Snowy Hydro occasionally gets constrained off (the dispatched amount is less than the amount they can supply) during the day due to competition from wind generation input to the transmission system.
- The number of Lack of Reserve (LOR) declarations during Q2 2021 in NSW and across the NEM was uncharacteristically high and greater than for the 2020/21 summer period, however none progressed to an LOR3 (imminent load shedding). LOR1 and LOR2 conditions arose because of a tightening supply situation caused by delayed return of generator plant from outage, impacts of the Callide Power Station explosion, periods of low wind during April to June and renewable generation dropping off before the evening peak demand.
- The LOR notices are designed to alert the market to pending tightening of the supply/demand outlook. In most cases the market responded by making resources available and no LOR events progressed to an actual LOR3 declaration. Information on the supply/demand outlook is continually provided by the Australian Energy Market Operator (AEMO) to market participants, such as pre-dispatch and Short-Term Projected Assessment of System Adequacy (ST-PASA) which participants readily assess via their comprehensive analysis systems so that they understand what is causing any LOR situation and the actions that can be taken.
- The Energy and Utility Services Functional Area (EUSFA) team is notified of a need to prepare for energy emergency responses through the Jurisdictional System Security Coordinator (JSSC). The JSSC obtains comprehensive information on market status from TransGrid and AEMO, whereas the EUSFA team has relied on LOR notices to aid situational awareness. An understanding of the forecasting mechanism can assist with determining the appropriate level of preparedness required, and guidance on appropriate reference material has been provided in Section 2.4.4.

2021/22 Preparedness Assessment

- For many businesses, established summer preparedness programs are now regular workstreams. The 2019/20 bushfire season prompted businesses to further enhance programs that were already strong by exposing weak areas (e.g., spares stockpile, communication procedures).
- Electricity business preparations for 2021/22 have progressed well despite delays and restrictions caused by the COVID-19 Delta outbreak. However, several planned generator outages have either been cancelled or had their scope of works reduced. While full risk assessments have been undertaken, there is always a risk that plant could fail when required to operate at a high level on a hot day or under minimum demand conditions. There is also potential for impact in the post-summer season, where an accumulation of postponed outages could create similar conditions to Q2 2021 (i.e., tightened reserve conditions).
- The level of risk management and preparedness for the ongoing COVID-19 situation is good. International and national border restrictions are slowly easing for vaccinated persons which should make it easier for essential workers. Businesses expressed concerns around the full relaxation of public health restrictions on 1 December 2021 and risks associated with unvaccinated personnel. Adaptation of COVID-19 safety plans and procedures is required, and this may include the use of continual rapid on-site testing.
- NSW generators have issues with coal supply being tighter than they would like due to higher demand in winter and suppliers needing to meet export backlogs. Some generators reported that coal stockpile levels were lower than targeted levels but believe it should have limited impact on summer operations.
- Operational risks faced by renewable generation operators differ from those faced by traditional generators and it will be important to understand how this impacts the NEM as the renewable transformation accelerates.

- The climate outlook highlights the potential for increased risk of flooding along the east coast. Risk of severe storms is similar to summer seasons of the previous decade. Northern NSW has above average fire risk due to higher grass loads, and areas of the east coast have below average fire risk due to forested regions still in recovery from 2019/20 fires.
- Several issues are emerging which should shift the posture of preparedness from a summer focus to all year-round situational preparedness. These include the continual reduction of daytime minimum demand levels, reliability issues with an ageing coal fleet, variability in renewable generation, tightening of reserve through winter and the increased chance of extreme climate events because of climate change.

Challenges and opportunities for future preparedness

- AEMO's ESOO notes that the reliability forecast has improved in the short to medium term – generation, storage and transmission developments currently progressing will close reliability gaps forecast later in the outlook to 2030/31.
- Over the next ten years in NSW there is expected to be strong growth in distributed photovoltaic (PV) generation and wind and a slight increase in normal electricity consumption, but allowance should be made for pickup with more electrification (transport) and the development of the hydrogen economy following the recent release of the NSW Hydrogen Strategy. During this period there will be the closure of Liddell and around the end of the decade retirements of Yallourn W, Vales Point B and Eraring Power Stations. Whilst there is expected to be significant growth in renewables in this period there is the need for a complimentary development of firming and dispatchable resources such as gas-fired generation and energy storage (hydro and battery) so that times of light wind and/or solar input can be managed.
- The risk to future preparedness is early closures of coal generation. The aging coal fleet is now operating in a regime that is no longer just 'base load'. Plant is now being called upon to operate for times at reduced output and to cycle more frequently as the input from renewables lowers the daytime minimum demand. Minimum cycling conditions for coal generating units can only be a temporary solution for this issue. This operating regime is likely to increase wear and tear which could result in failures which are not economic to repair.
- Any large-scale incident at a generator (the size of which occurred at Callide) and depending on location in the transmission network, could potentially give rise to a major supply interruption. However as demonstrated with the Callide incident, the power system performed as expected with no interruption of supply. Going forward it is important that the HV transmission upgrades, such as Hume Link, Victoria-NSW Interconnector (VNI) and Queensland-NSW Interconnector (QNI) are progressed such that the system can withstand the sudden loss of a large-scale generator and to cover the retirements of coal-fired plant.
- Generators are working out transition/transformation plans as options become economically viable – mix of technology in implementation and planning. For example, battery technologies, and gas turbines that can be used with natural gas and hydrogen blends
- The transition to more renewable and less fossil-fuelled generation is occurring in many power systems across the world, such as in China, the United Kingdom and Germany and lessons can be learnt on how the transition is being planned and progressed. Some of these are facing 'Dunkelflaute' or renewables drought - a term used to describe a period of time in which little generation is coming from wind and solar generation resources.
- In July 2021 the Energy Security Board (ESB) provided advice to the Energy National Cabinet Reform Committee (ENCRC) on design changes required in the NEM as it transitions to an increasingly diverse and distributed generation mix. The Post-2025 Market Design report sets out reforms and a timetable for their implementation towards the year 2025. In October 2021, the National Cabinet agreed to the recommendations of the ESB.

- It will be important that the ESB's Post-2025 work is progressed in a timely manner to successfully integrate the transition to renewable generation which is already underway so that system reliability and security is maintained.
- The NEM jurisdictions need to ensure state-based approaches to the renewable transformation can be harmonised at the national level. The NSW Electricity Infrastructure Roadmap is building in this ability through use of AEMO Services as a key body in facilitation of the Roadmap process. The development of the Roadmap needs to be in sync with the work of the ESB.
- Work needs to be progressed on the design for a capacity mechanism in order to achieve an efficient mix of variable and firm generation capacity particularly as the market transitions to more renewables. The Energy Ministers have provided the ESB with a set of principles to guide the development of a capacity mechanism. The outcome of this design will have a direct bearing on the work of the Australian Energy Market Commissions (AEMC) Reliability Panel's determination of the Reliability Standard and Settings.
- As the large coal-fired plant retires, consideration should be given to not entirely mothballing these plants. An opportunity exists to provide system security services with this plant even though they no longer generate power. For example, the Deeside Power Station in the United Kingdom, which was mothballed in 2018, has just commenced repurposed operations to provide services in terms of inertia and reactive power to assist in keeping the system stable. The novel system allows the steam plant and the turbine to be mothballed but the rotors are driven by energy from the system to provide rotating inertia and reactive power as conventional synchronous condensers have done.

Recommendation 2

The NSW Government should ensure that NSW Electricity Infrastructure Roadmap developments/framework tie into/enable harmonisation with NEM/work at national level.

Work should also be undertaken to assess the feasibility of repurposing parts of coal-fired power stations, that are due to be retired, to provide system services. The NSW Government should work with the plant operators, the ESB and AEMO to assess the feasibility of the retiring plant providing such services.

- As the market transitions to net zero emissions, driven by the penetration of renewable energy, with effectively zero fuel costs, there is the need to accelerate the integration of DER and flexible demand into the market systems in order to ensure the flexibility needed for power balance and stability.
- DER visibility, control and integration continue to be raised as a key issue by Distribution Network Service Providers (DNSPs) and generators. This issue was discussed in the 2020/21 Assessment and presents security risks in operating the distribution network, particularly operating and restoring local networks under emergency circumstances. DNSPs can to some extent find locations with PV installations by interrogating smart meter data, however not all installations have smart meters that have remote interrogation are installed. Comment was made that it is possible that some installations are not performed by Accredited Service Providers.
- Guidance on the installation of solar panels is provided by NSW Fair Trading and this states that permission must be granted from the DNSPs prior to the connection of a solar installation to the electricity distribution network. Also, smart Type 4 or 4A meters are required to be installed with PV installations.
- Cyber security issues are an ongoing concern; however, the industry is aware and taking steps to improve security.

Recommendation 3

The NSW Government should continue to progress regulation or requirements for relevant market organisations to have better visibility, control and protection of DER assets, including protection from cyber security threats, in alignment with the assessment of the legislative elements in Recommendation 1. This should include:

a) a review of the requirements around installation processes to assess the levels of procedural compliance and ensure that DER information is provided to DNSPs.

b) ensuring the DNSPs are able to obtain sufficient information on the installations.

- DNSPs have been developing and trialling stand-alone power systems (SAPS) at various scales: for individual customers, to increase resilience in emergency situations (i.e., floods or bushfires) until grid connections can be restored, and larger microgrids in remote locations that could effectively operate in an islanded state during emergencies.
- Efforts to examine SAPS and microgrids are aligned with other government policies and strategies, such as the NSW Electricity Infrastructure Roadmap, as it provides a method to ensure the affordability, reliability, resilience and energy security for rural and/or remote communities.
- The Panel notes that a final rule change package on SAPS is expected in November 2021 from the South Australian Government. The AER is also examining ring-fencing guidelines in anticipation of these changes, also expected in November 2021.

Recommendation 4

In anticipation of the release of the rule change package on SAPS and associated developments (including, but not limited to, the AER ring-fencing guideline review), that:

- the EUSFA continues to support the DNSPs in utilising SAPS in emergency situations
- the NSW Government continue to support DNSPs as they progress SAPS and microgrid models for rural and/or remote locations, as a way to effectively ensure the reliability, affordability and security of electricity whilst also providing a pathway to decarbonisation outcomes.

- Developers of generation projects, particularly renewables, have commented that they need access to system models to better inform their planning and risk assessments. Connection applicants currently provide data and models of their proposed generating plant to AEMO, and AEMO undertakes system modelling to determine impacts on the power system and any constraints and connection requirements. AEMO's system model contains proprietary and protected models of other generating units. Connection applicants undertake several modelling iterations with AEMO to refine their project and complete the connection process. The Australian Renewable Energy Agency (ARENA) and AEMO are developing a 'Connections Simulation Tool' which will provide access to protected wide-area models equivalent to those used by AEMO. Commercial and confidentiality of other generators will be maintained. This tool is to be available to connection applicants to use and through using a full power system model it will enable them to better design their generating system for specific grid locations. This will reduce the iterations required with AEMO.
- AEMO and Network Service Providers (NSPs) are still relying on models that typically have highly simplified representation of fast dynamics and the demand-side. These become inaccurate for simulations when the system has more power inverter interfaced generation and less synchronous generation. AEMO is working to develop simulation models that will overcome these deficiencies.

- There needs to be an improved awareness/understanding of the scale of transformation required to decarbonise across the whole NEM. AEMO is already preparing to operate the power system with 100% renewable penetration, at any moment in the day, by 2025.[2] For operators, planners and participants this transition will require new skills and tools in terms of system operation, planning and analysis.
- A workforce transition is going to be required to manage and deliver all the required changes. While pleased with graduate quality, there is some industry concern that the number of resources and resources with the required skill sets, particularly in power system engineering and renewables integration, will not be adequate to meet impending demand.

Recommendation 5

The NSW Government should consider the workforce planning needs as the grid increases in system complexity and digitalisation, such as through the NSW Electricity Infrastructure Roadmap and the Net Zero Plan.

[2] AEMO CEO Daniel Westerman's CEDA Keynote Address, 14 July 2021

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

System	Requirements	NSW assessment	Risk level (indication only)
Reliability	Reliability	• Low levels of Unserved Energy (USE) forecast before 2028/29, when Vales Point Power Station and Eraring Unit 4 are due to retire. After that USE increase to above the reliability standard in some scenarios, but this may be mitigated by generation, storage and transmission projects. • USE is no longer forecast to increase above the Interim Reliability Measure (IRM) after the retirement of Liddell, due to newly committed gas and Variable Renewable Energy (VRE) generation. • Risks around early retirement and unplanned outages that are not economic to repair • Interconnector upgrades and reduction in peak demand forecasts contribute to lower reliability risk.	
	Maximum demand	• In the short-term - maximum operations demand is due to decrease because of lower demand from business mass market sector and distributed PV. • In the medium to long-term – max operational demand is forecast to grow due to Electric Vehicle (EV) uptake and electrification.	
	Minimum demand	• Expected to decrease due to increased forecast distributed PV uptake. • Presents market opportunity in the medium to long-term for market-based solutions to increase demand ‘solar soaking’ (e.g., EV charging, new pumping load) and ‘solar sponge’ tariffs. • Minimum levels of dispatchable resources are needed to ensure system security (system strength, inertia, etc.)	
	Reserve capacity	• NEM is reliant on Reliability and Emergency Reserve Trader (RERT) for response to LOR conditions • Ministers have agreed for the ESB with a set of principles for the design of a capacity mechanism	
	Interconnection reliance	• NSW has strong connections with neighbouring states but is heavily reliant on imports • Extensive augmentation of transmission network and interconnectors is underway • Continued risk to interconnection from extreme events including bushfires and storms • Progressing HumeLink is essential to be able to fully access available Snowy Hydro capacity.	
Security	Frequency management	• Adequate inertia and low probability to have island events for NSW • Adequate frequency control services but requirements will likely increase • ESB Post- 2025 has recommendations for procurement and scheduling of essential system services • Prior to coal-fired plants being retired, the opportunity for these plants to provide inertia and reactive power should be explored.	

	Voltage management	• Emerging challenge in the NEM of maintain transmission voltage when operational demand is low • System strength gap in 2035 after coal retirements based on AEMO Integrated System Plan (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 • An emerging challenge is performing a system restart under conditions of low operational demand. That is, in high DER periods there may be a lack of stable load in the vicinity of the start-up generators that require a minimum load to operate.	
Operability and Flexibility	Coal generation	• NSW coal generation reliability and availability declines • Possible early retirement and uneconomic repairs	
	Renewable and distributed energy	• Large scale renewable development and network development • DER aggregation and interoperability issues for NEM • ESB Post-2025 work on integration of DER and flexible demand	
	Dispatchable capacity	• New capacity being developed by industry and with government support, in NSW this is through the NSW Electricity Infrastructure Roadmap	
Transmission		• ESB proposal to support the integration of the Renewable Energy Zones (REZs) • Work needs to be progressed on the congestion management model	

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[3]).

In September 2019, the Minister for Energy and Environment requested that the CSE provide annual expert advice on the risks within the National Electricity Market (NEM) in relation to summer. Annual assessments have been submitted for 2019/20[4] and 20/21[5]. The full term of reference is at Appendix 1.

This 2021/22 assessment of summer preparedness for the NSW energy market report (2021/22 Assessment) was requested as per Term of Reference 2 and additional advice requested on identified risks. This report updates the 2020/21 Assessment, accounting 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 2021/22. Further, the report considers risks such as COVID-19, transition from summer preparedness to situational preparedness, and Energy & Utility Services Functional Area (EUSFA) preparedness and response to the Australian Energy Market Operator (AEMO) Lack of Reserve (LOR) notifications. The full scope for the 2021/22 Assessment is at Appendix 2.

1.1 Assessment process

To undertake the 2021/22 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 and 2020/21 Assessment Expert Panel) and Professor David Hill (Professor in the School of Electrical Engineering and Telecommunications UNSW Sydney and member of the 2020/21 Assessment Expert Panel). 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 (NEM) bodies including Australian Energy Market Operator (AEMO), Australian Energy Market Commission (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 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 3.

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

- 2021 Electricity Statement of Opportunities

[3] CSE (2018), *Assessment of summer preparedness for the NSW energy market*.
[4] CSE (2019), *Assessment of summer preparedness for the NSW energy market: 2019/20*.
[5] CSE (2020), Assessment of summer

- NEM Lack of Reserve Framework Reports
  - Q4 2020
  - Q1 2021
  - Q2 2021
- Quarterly Energy Dynamics
  - Q4 2020
  - Q1 2021
  - Q2 2021
  - Q3 2021
- 2020 Integrated System Plan
- RERT Reporting
  - End of Financial Year Report 2020-21
  - Quarterly Report Q2

The Panel also examined and relied upon the information from:

- AEMO NEMWEB Data Portal
- ESB Post 2025 market design final advice to energy ministers and ministers' response.
- Australian Bureau of Meteorology climate outlooks
- AFAC Seasonal Bushfire Outlook
- AER State of the energy marker 2021

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 2021-22 Readiness Plan (November 2021)
- AEMO Energy Adequacy Assessment Projection (EAAP) (November 2021)
- AEMO 2021 Forecast accuracy report (December 2021)

1.2 Structure of this report

- Chapter 2 – provides an overview of summer 2020/21 and impacts on the energy system post throughout the year, this includes responses to prior Assessments, climate and extreme weather, COVID-19 and NEM operations.
- Chapter 3 – provides an overview supply and demand and climate forecasts, actions by government and the energy market, the status of generation and network infrastructure and the impact of COVID-19. The chapter looks at summer as well as situational awareness.
- Chapter 4 – provides an overview on future preparedness including potential risks and opportunities.

2 Review of 2020/21

The NSW 2020/21 Assessment found that:

- AEMO's forecasting performance for summer 2019/20 was good, but solar forecasts were impacted by smoke haze from the extensive bushfires 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.
- The outbreak of the COVID-19 pandemic and associated community and movement restrictions impacted the use and the management of electricity. This gave a level of uncertainty for forecasting electricity demand, ability to manage planned and unplanned outages and how emergency situations were dealt with.
- The reliability forecast for 2020/21 summer had improved compared to the previous summer with expected Unserved Energy (USE) remaining below the new Interim Reliability Measure (IRM) for all NEM regions.
- The extreme events of the 2019/20 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 included access to information on the locations of telecommunication network infrastructure.
- The NSW Bushfire Inquiry provided several recommendations that had implications for the electricity sector and associated emergency management. The Panel noted that the NSW Government had accepted all recommendations in principle and that the NSW electricity market utilities indicated to that they are responding to or applying the recommendations where relevant.

The Panel made three recommendations based on the findings of the 2020/21 Assessment. These were related to exercises to improve preparedness, contingencies for spare equipment and supplies for transmission and distribution businesses and around sharing and utilisation of data.

The scope for the 2021/22 Assessment requests moving from summer preparedness to more situational awareness/year-round preparedness for the energy system. Whilst the focus for this Chapter is summer 2020/21 the impacts and events that occurred between November 2020 and September 2021 are considered.

2.1 Response to prior Assessments and Inquiries

2.1.1 2020/21 Assessment Recommendations

The Panel received a progress report and update from the NSW Government Energy and Utility Services Functional Area (EUSFA) Team in August 2021 including status of the response to the recommendations from the 2020/21 Assessment (see Table 3). Overall, the recommendations are completed and/or well progressed.

Table 3: NSW Government response to recommendations from 2020/21 Assessment

Recommendation	NSW Government Response
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.	On 26 August 2021, the EUSFA team of the Department of Planning, Industry and Environment (DPIE) undertook a virtual exercise using Microsoft Teams. The exercise was called "Rolling Thunder" and was facilitated by a third-party organisation named Tigertails. On this day, the Greater Sydney region was in lockdown, so COVID-19 restrictions were tested fully in the virtual environment. The aim of the exercise was to test the effectiveness of the NSW load shedding processes and coordination mechanism during a major electricity disruption event. Participants included representatives from AEMO, TransGrid, Ausgrid, Endeavour Energy, Essential Energy and DPIE. The final report, still in draft, summarised that the exercise achieved its stated objectives. Points to note are: • Each agency understands their role during a power supply emergency; however, further clarity is required for notification, escalation, and transfer of critical information to EUSFA and the Jurisdictional System Security Coordinator (JSSC). There is an opportunity for provide more clarity around the interaction between the Guidelines and the Section 94 emergency powers. • Each agency has public information plans and tools; however, there is no documented coordinated public information approach between TransGrid, Distribution Network Service Providers (DNSPs) and Government. • Participating agencies demonstrated their capability and capacity to respond to power supply emergencies. The Draft Jurisdictional Load Shedding Guidelines provide clear guidance of DNSPs obligations, load shedding priorities and percentage parameters to contribute to maintain power supply security or public safety in NSW, although the status of data centres is uncertain. The exercise delivered a positive result and while remote interaction created some difficulties with the technology, this added reality to the exercise. Participants overwhelmingly reported that the exercise was relevant to their role and a good use of their time.
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.	EUSFA has sought clarification from AER on this recommendation. At present, some businesses include a separate line item for back-up inventory when reporting capex to the AER. AER is aware that some transmission network operators have a separate asset class for inventory/spares and from time to time this may come up in a revenue proposal after the spare has been used and then needs to be replaced. For distribution networks to date, AER has not been factoring in contingency costs in their allowances. It is possible that networks have extra inventory on hand for this type of event or have a deal with contractors, but AER does not consider this as part of their capex assessment.
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.	Whilst the NSW Digital Twin is being progressed, led by the Emergency Information Coordination Unit in NSW Spatial Services, EUSFA has another project underway called Project Video. The project is to provide the DPIE Energy Operations Emergency Management teams with a state-wide overview of real time energy disruptions, as well as environmental threats such as from bushfires and storms. The project is well progressed with data now available for viewing.

2.1.2 Response to NSW Bushfire Inquiry

Businesses that discovered weaknesses in their bushfire response have continued to take steps to address issues, such as improving management of spare assets and network resilience in areas of high risk through installation of composite, concrete, or steel poles.

Several actions relevant to the energy sector have also been progressed by NSW Government. These include:

- Proof of concept trial and development of requirements for the Public Service Mobile Broadband network (Recommendation 57)
- Work to progress cross-border interoperability for communications on the Public Safety Network (PSN) (Recommendation 55b)
- Increasing battery backup at identified high risk sites on the PSN, increasing mobile assets for power and communications, and developing procedures to share and deploy assets strategically across the state (part of Recommendation 30)
- Development of a geospatial tool, Joint Information Management System (JIMS) which provides portal access into NSW Digital Twin. Telecommunication infrastructure datasets can be overlaid with other spatial data to enable threat assessments (part of Recommendation 30)

In addition, the NSW Government formed Resilience NSW on 1 May 2020. The agency is tasked with leading government disaster and emergency efforts from prevention to recovery and is in the process of developing a State Resilience Strategy.

2.1.3 Hospital Back-up Generation

The final report of the Energy Security Taskforce in 2017[6] discussed the identified risks to hospitals during a black electricity system with discussion around back-up generation and the need for regular testing.

On 12 July 2021, on outage on the Eastern Suburbs of Sydney left ~43,000 homes without power. It was reported to the Panel that the generator on the Randwick campus did not start during this outage. NSW Health noted that the failure was due to an automatic transfer switch (ATS) malfunction rather than an issue with the backup generator. The issue has since been rectified and a new replacement ATS is being planned to be installed.

The Panel requested further information from NSW Health around the process for testing of generators. NSW Health confirmed that all NSW Local Health Districts, Specialty Networks and NSW Ambulance have business continuity plans in place which consider service delivery during an extended power outage. Further, that the plans are regularly updated and exercised which includes the testing of emergency power supplies in hospitals. The plans are reviewed and updated following periodical testing, as well as following an incident or in response to a change in policy, and are required to comply with the Australian Standard, AS_NZS 3009:1998 Electrical installations - Emergency power supplies in hospitals.

2.2 Climate and extreme weather

The summer of 2020/21 was mild dominated by La Nina conditions making it the state's coolest and wettest (rainfall 29% above average) summer since 2011/12.[7] Whilst it was mild there were still hot days and severe and extreme heatwave conditions occurred in late November and late January. Many regions experienced record high temperatures in late November. Sydney,

[6] Energy Security Taskforce (2017), Final Report.
[7] BOM (2021), New South Wales in summer 2020-21: wet and cool, issued 1 March 2021.

Observatory Hill, recorded maximum temperatures of 40.8°C and 40.5°C on 28 and 29 November respectively.[8]

Storm activity, extreme rainfall and flooding impacted the power supply to homes and businesses in NSW over the summer and shoulder seasons. Table 4 provides a summary of major weather events and impacts. March was dominated by heavy rainfall and flooding and was the second wettest on record.[9] Record heights on the Camden Haven and Manning Rivers were experienced and significant flooding of the Hawkesbury–Nepean catchment (largest in more than 30 years).

Severe storms in Victoria on 9 June 2021 led to fallen trees and damage to poles and wires over the state with more than 245,000 homes and businesses losing power. There was significant impact to the network with many homes without power for weeks. Crews from NSW DNSPs provided crews to assist AusNet Services in their response to the significant damage.

In June, significant flooding in the Morwell River in Victoria resulted in cracks in the river diversion that threatened to flood the mine that supplies Yallourn Power station. The mine was evacuated as a safety precaution, and Yallourn operated on a single unit for about 3 days in order to conserve coal.

Table 4: Weather events and impacts on electricity supply in NSW

Date	Event and Impact
16/11/20	• Strong winds, rain and electrical storm • Outages to ~20,000 homes and business the Hunter[10]
1/12/20	• Severe thunderstorms, high winds (up to 160 km/h) and tree damage[11] • Outages to ~20,000 homes and business across Sydney, Central Coast and Hunter[12]

March 2021	• Major flooding of the Hawkesbury-Nepean Catchment (Windsor flood levels reaching 12 m)
	• Loss of supply to ~17,000 homes and businesses
	• Supply could not be restored until flood waters had receded and properties could be checked for ele integrity
	• Endeavor Energy response
	  ○ Sought advice from Energy Queensland with flood response experience
	  ○ Helicopters used to survey and inform restoration plan

2.3 COVID-19

COVID-19 has continued to have social and economic impacts across Australia. The outbreak of the COVID-19 Delta variant in NSW has led to a range of restrictions for workers and has limited the ability for cross border movements both nationally and internationally.

The generators and network operators interviewed as part of the Assessment have proactively implemented comprehensive and robust COVID-19 risk management plans, that have so far proved effective. This is described in the 2019/20 Assessment and included limited control centre access and team segregation, back-up control centres and regular cleaning protocols.

The Public Health Orders in NSW led to a range of restrictions which varied across the state. This included requirements to stay and work from home, testing and vaccination requirements in certain local government areas (LGAs), and travel restrictions. The stakeholders interviewed noted that they had to stay up to date with the changes in the Public Health Orders, but this did not cause major disruptions to operations.

[8] BOM (2020), Greater Sydney in November 2020: a hot finish to the month, issued 1 December 2020.
[9] BOM (2021), New South Wales in autumn 2021: cool and wet, issued 1 June 2021.
[10] https://www.9news.com.au/national/national-weather-forecast-tuesday-november-17-newcastle-hit-with-violent-storms-power-outages/84205123-b191-4ddf-8746-969c1e7a049b
[11] 9News Staff (17 November 2020), Powerful storms wreak havoc leaving 20,000 without power, fallen trees and damage. 9News.
[12] 9News Staff (2 December 2020), Thousands remain without power after ferocious storm lashes Sydney. 9News.

The stay and work from home orders and school closures meant that residential electricity supply, especially during working hours was essential. DNSPs noted that they deferred maintenance in some areas as this would cause significant disturbance to homes. In addition, prior to the Higher School Certificate (HSC) Trials, the DNSPs informed homes if outages were planned so that alternative arrangements, such as permission to access school facilities or provision of a generator to the home, could be made for impacted students.

The improved availability of COVID-19 vaccines led to many businesses encouraging vaccination and most have provided paid leave for staff to access vaccination. Rapid antigen testing has also been used to test workers presenting for work each day.

Energy businesses reported uncertainty about what power NSW Health would have to force a site closure in the event of an on-site outbreak. A theme was that there is a general lack of understanding around the impacts given the essential and transient nature of some of the electricity sector workforce. NSW Health participated in a briefing session with industry participants and encouraged businesses to establish a relationship with the local public health unit, who would be the first point of contact in the event of a site outbreak. In the case of the Hunter New England Local Hospital District, for large businesses, Safe Work NSW is the first point of contact

COVID-19 restrictions created challenges for state and international border crossings, impacting the movement of skilled technicians, outage workers and spare parts. However, businesses adapted well to accommodate extra lead times and workarounds that were required. Several planned generator outages have either been cancelled or had their scope of works reduced and some large maintenance work has been delayed until next year. In relation to borders 'mutual aid' agreements in the sector have proven effective dealing with COVID-19 border restrictions (e.g., Essential Energy and Energy Queensland, with both having assets that lie across their state border).

2.4 National Electricity Market (NEM) Operational Review

2.4.1 Supply and Demand

The mild summer coupled with the installation of distributed PV reduced the overall operational demand across the NEM and in NSW. This is demonstrated in Figure 1 with the operational demand generally lower than MT-PASA forecasts across the summer months and more accurate estimates for demand through the shoulder and winters seasons.

The mild summer reduced the need for cooling (air conditioners) with Q1 2021 in NSW having a 50% reduction in cooling requirements in comparison to Q1 2020. This also led to a reduction in maximum demand. In NSW, the Q1 2021 maximum peak demand was 12,273 MW which is 1,562 MW lower than in Q1 2020.[13]

In 2020, ~3 GW of distributed PV was installed across Australia, with large increases in NSW. Over Q4 2020 and Q1 2021, NSW had high distributed PV output with an increase of on average 124 MW and 169 MW respectively.[14] The increase in distributed PV has led to a reduction in minimum demand which generally occurs in the middle of the day. On 25 December 2020, NSW recorded a minimum demand of 5,331 MW at around 2 pm (AEST). The minimum demand records have continued, on 17 October 2021 the NEM set a minimum demand record of 12,936 MW, with NSW having a new record of 4,425MW. Figure 2 illustrates generation in the NEM and in NSW around and on October 17 and shows the time of minimum demand and the level of distributed (rooftop) PV during the middle of the day leading to the minimum demand event.

[13] AEMO (2021) Quarterly Energy Dynamics Q1 2021
[14] AEMO (2021) Quarterly Energy Dynamics Q4 2020, AEMO (2021) Quarterly Energy Dynamics Q1 2021

Overall, there was reduced output and reliability of thermal generation and increased output from grid-scale VRE (Figure 2).

Table 5 provides a summary of the generator and distributor operations over the period.

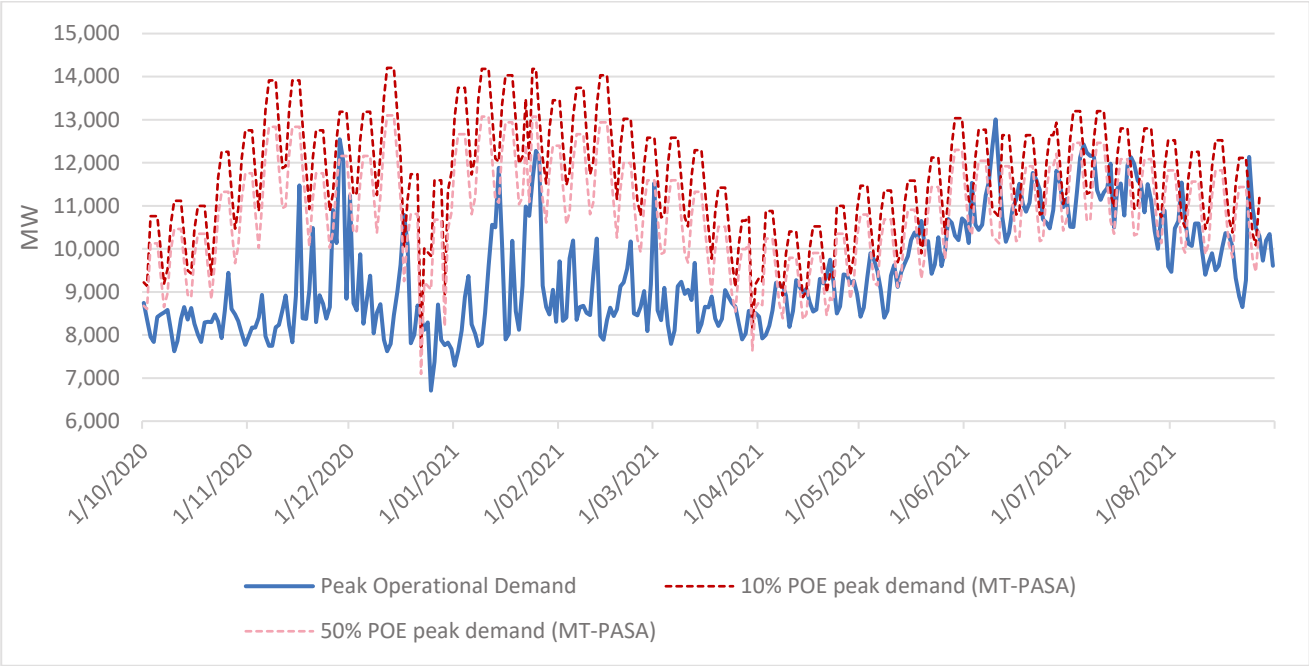
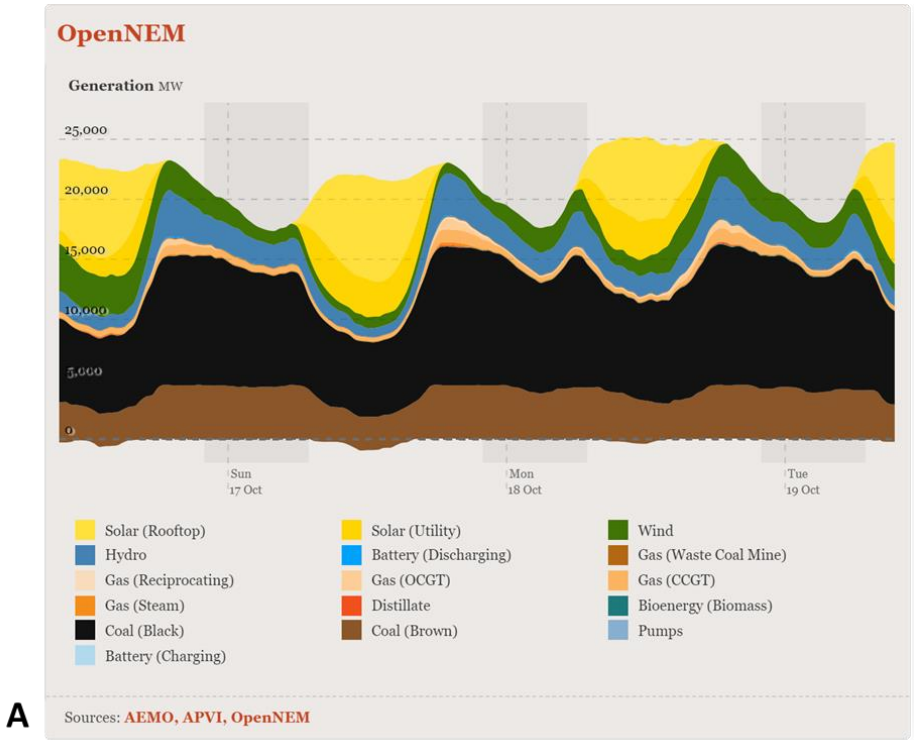
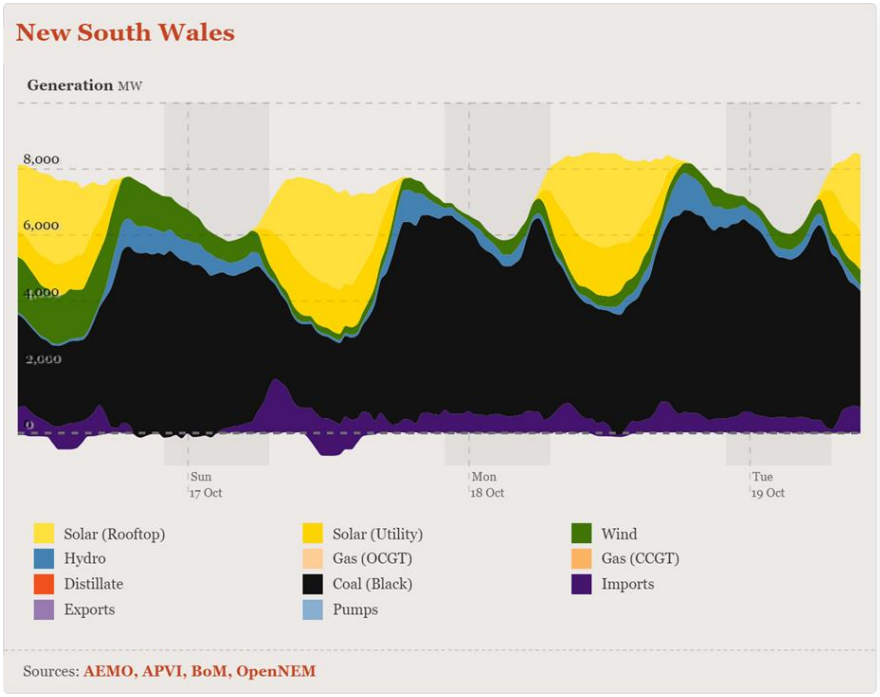


Figure 1: NSW peak operational demand and forecasts (MT-PASA) for 2020/21
Source: AEMO[15,16]



A

[15] AEMO (2020). Market data – NEMWEB. Medium Term PASA 1 October 2020, accessed 6 October 2021.
[16] AEMO (2020, 2021). Market data – NEMWEB. Operational Demand – Actual Daily (Archive), accessed 6 October 2021.



B

Figure 2: Generation by fuel source in the (A) NEM and in (B) NSW between 17 and 19 October 2021
Source: OpenNEM[17]

[17] OpenNEM Dashboard 17 October 2021 to 19 October 2021, https://opennem.org.au/about/

Table 5: Operations of generators and networks in NSW

Operator	Overview
Black Coal	• Coal generator reliability and output has been reduced over the period. This reduction has been driven by reduced operational demand, increased grid-scale solar generation, and unit outages. • As shown in Figure 2 (NSW), the coal fleet is operating at a high level during the non-daylight hours and as solar penetration increases, the coal fleet generation is significantly reduced or offloaded (minimum demand on the coal fleet). This cycling of the coal fleet continues day after day in response to variable inputs of renewable generation. • In Q1 2021, average black coal-fired generation in NSW had its lowest output since NEM start (5,516 MW) • Eraring – increase in mostly planned outages and displacement by daytime solar reduced output on average to 557 MW in Q1 2021 (lowest output since 2013). The utilisation rate in Q1 2021 was 62% (down from 74% in Q1 2020) which is lower than the rest of the NSW coal fleet at 78%. • Liddell – reduced generation due to increased outages and Unit 3 was out of service from December 2020 due to a transformer outage (see • Table 6). • Mount Piper – fewer outages led to increased average output by 395 MW in Q1 2021 (average availability 87%). • Coal stockpiles used at a faster pace over winter due to higher usage requirements, likely due to the Callide Power Station outage.
Gas	• Gas generation decreased to its lowest quarterly average since 2005 in Q1 2021 which as 787 MW lower than Q1 2020. • There is a trend of decreased gas generation across the NEM which is being driven by low NEM spot process and increasing wholesale gas prices. • In NSW, gas generation decreased to 47 MW – the lowest since the start of the NEM. Tallawarra averaged 35 MW which was attributed to substitution from Energy Australia's other power station Mount Piper.
Grid-scale VRE	• Grid-scale VRE output averaged 3,458 MW, 786 MW higher than Q1 2020. • In Q1 2021 NSW, combined wind and solar availability during high demand periods increased by an average of 346 MW compared with Q1 2020. • The high solar output in the NSW was mostly driven by new installed capacity with Darlington Point, Bomen and Sunraysia Solar Farms making up 51% of the increase.
Hydro	• Water quality after the 2019/20 bushfire season has been poor, with additional debris and runoff reducing efficiency of plant at Snowy Hydro. • This has been (and will continue to be) managed with regular outages for cleaning, or derating of plant during peak generation times. • Snowy Hydro indicated that transmission line congestion impacts their ability to supply the market. Noted the importance of HumeLink.

Distributed PV	• Over Q4 2020 and Q1 2021 NSW had high distributed PV output with increases on average 124 MW and 169 MW respectively. • In 2020, there were over 362,000 rooftop solar PV installations across Australia, with 108,922 in NSW.[18]
Transmission and distribution	• Electricity distribution was impacted across the NEM by storms and floods, this is described in Table 4.

2.4.2 Energy Market Incidents

[18] Cranney, K. (13 May 2021), Australia installs record-breaking number of rooftop solar panels. CSIRO.

Table 6 describes energy market incidents that occurred across the NEM. Only one of these was in the NSW region and there were no major power system separation events. A key incident was the turbine explosion at Callide Power Station in Queensland. The explosion led to multiple generators and transmission lines in Queensland to be tripped and under-frequency load shedding to occur leaving ~470,000 homes and businesses without power.[19] Following the incident, the outage at Callide Power Station combined with other outages led to a tightening of the supply-demand balance in NSW and Queensland.[20]

[19] Callinan, R (28 May 2021), Callide Power Station turbine that sparked mass power outage had overhaul last year, documents reveal. ABC News.
[20] AEMO (2021) Quarterly Energy Dynamics Q2 2021. Market Insights and WA Market Operations

Table 6: Energy events and impacts on the Energy System

Date	Event	Impact
17/12/21	Unplanned outage at Liddell Unit 3	This was coupled with: • Tight supply/demand conditions • Warm Sydney temperatures (~30°C during the day and ~20°C overnight) • Black coal-fired units on planned outages (3,045 MW) • Restricted imports from Victoria Led to Forecast LOR2 and activation of RERT in NSW
25/5/21	Incident at Callide Power Station (QLD)	• Turbine explosion at one of the units • Multiple generators and transmission lines in QLD tripped leading to under-frequency load shedding • Loss of >2,000 MW in 5 minutes • This was combined with a number of planned outages in QLD, as follows. Led to actual LOR2, forecast LOR3 and activation of RERT in QLD. In the AEMO Q2 2021 RERT report it was noted that "*the forecast availability of generation over that period was substantially less certain than prior to the event, due to the amount of time each affected generating unit required to stabilise, assess, and recover its plant operations. At this time approximately 4,500 MW of scheduled generation was expected to be unavailable in Queensland at 1730 hrs, including:* • *Callide B1 (350 MW) – on long-term outage.* • *Callide B2 (350 MW).* • *Callide C3 (420 MW).* • *Callide C4 (420 MW).* • *Darling Downs Power Station (660 MW) – on long-term outage* • *Gladstone 1 (280 MW) – on long-term outage.* • *Gladstone 2 (280 MW).* • *Gladstone 3 (280 MW).* • *Gladstone 4 (280 MW).* • *Milmerran 2 (426 MW) – on long-term outage.* • *Stanwell 2 (365 MW) – on long-term outage.* • *Swanbank E (365 MW) – out of service since 21 May 2021.* • *Tarong 1 (350 MW) – on long-term outage.*"

11/6/21	Flooding at Yallourn Mine (Vic)	• Flooding in Yallourn Mine impacted supply to Yallourn Power Station • 3 Units offline while repairs undertaken • This is a key risk for the NEM in terms of electricity supply
30/7/21	Battery Fire in Moorabool (Victoria)	• A battery bank caught fire while being set up • The 300 MW battery is being built by Neoen Australia • The site was disconnected from the grid with no impact to electricity supply. • Energy Safe Victoria (ESV) concluded that the fire *"most likely resulted after a cooling system leak caused a short circuit in an electrical component in a Megapack."*[21] • ESV has required the site's owners and operators to implement a number of additional safety measures such as Megapack cooling systems to be fully pressure tested and inspected for leaks, shorter connection times to SCADA system to help alert Tesla with alarms, new battery isolation loss alarms and procedure changes for Megapack protection systems. • Commissioning recommenced from 29 September 2021.

2.4.3 Electricity Safety Regulation in NSW

In light of the Victorian Big Battery Fire, the Panel sought to understand which government agency in NSW would be responsible for safety regulation of large-scale batteries. In Victoria, Energy Safe Victoria (ESV) is responsible for the regulation of safe generation, supply and use of electricity, gas and pipelines. Their role spans from licensing of electrical workers in Victoria, through to investigation of gas and electrical incidents, and overseeing industry safety cases and management schemes for the design, construction and maintenance of electricity and gas infrastructure.[22]

In NSW, the Independent Pricing and Regulatory Tribunal (IPART) is responsible for the regulation of electricity networks. IPART has a role in the investigation of serious electricity works accidents, under Division 4 of the *Electricity Supply Act 1995 (NSW)*, and is a member of the Electrical Regulatory Authorities Council. This Council meets twice each year with the aim of coordinating the development of consistent regulatory policy across Australian jurisdictions and New Zealand.

IPART has a Memorandum of Understanding in place with SafeWork NSW to enable cooperation in response to serious electricity work accidents. IPART has discretionary power to publish information about serious electricity works accidents and can do this through Safety Alerts. SafeWork NSW publishes incident information releases as a means of keeping industry stakeholders updated with key learnings and safety messages.

While IPART's remit includes safety regulation for large-scale batteries installed as part of electricity networks, the installation of large-scale batteries at customer sites is regulated by NSW Fair Trading. While no specific legislation exists for the regulation of large-scale batteries in NSW, there are general duties that all designers, installers and operators of large-scale batteries must perform in relation to safe installation, commissioning, maintenance and decommissioning

[21] Energy Safe Victoria (2021), Cooling system leak led to Victorian Big Battery fire.
[22] Energy Safe Victoria (2021), About ESV.

activities under the *Work Health and Safety Act 2011 (NSW).* The regulation of large-scale batteries at generator sites falls under the general regulatory remit of SafeWork NSW.

The Panel notes that with the increased uptake of a number of new and emerging technologies and systems, including large-scale and consumer battery storage systems, there is the potential that there may be gaps in existing safety legislation, regulation and standards. This is particularly relevant with sector-coupling technologies, such as hydrogen storage to generate electricity, where equipment may need to comply with both electricity and gas regulations, or where current definitions need to be updated. Therefore, there would be benefit in conducting a review of existing energy and gas regulations to ensure there is the scope to effectively cover a broad range of emerging technologies, including those not directly connected to the grid.

2.4.4 Lack of Reserve (LOR)

An increase in forecast and actual LOR conditions was observed across the NEM in Q2 2021. Figure 3 and Figure 4 show the LOR trends across the NEM and NSW respectively. Response to LOR conditions was a key risk identified by EUSFA for the 2021/22 Assessment and was explored by the Panel as part of the Assessment.

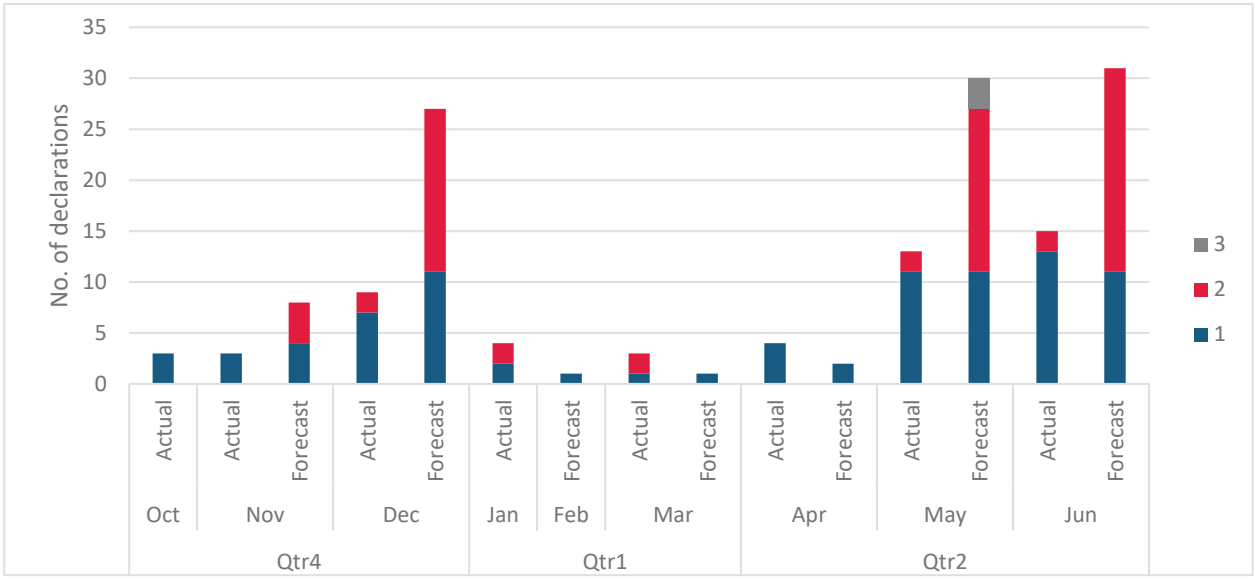


Figure 3: LOR declarations by level – whole of NEM 2020/21
Source: AEMO[23,24,25]

[23] AEMO (2021). NEM Lack of Reserve Framework Report - Reporting period 1 October 2020 to 31 December 2020.
[24] AEMO (2021). NEM Lack of Reserve Framework Report - Reporting period 1 January 2021 to 31 March 2021.
[25] AEMO (2021). NEM Lack of Reserve Framework Report - Reporting period 1 April 2021 to 30 June 2021.

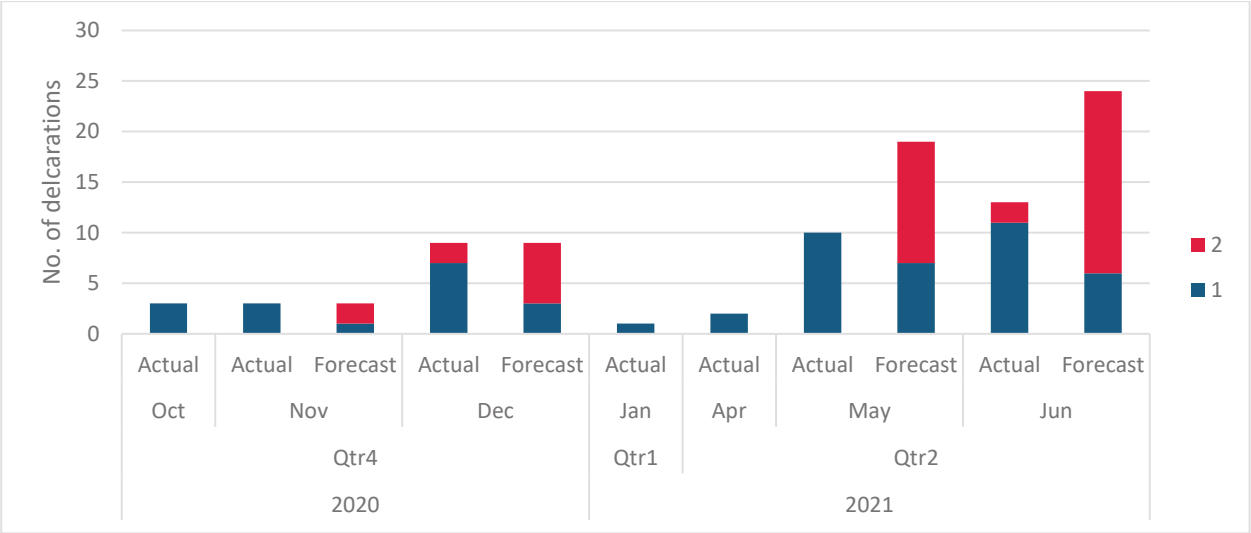


Figure 4: LOR declarations by level – NSW region
Source: AEMO[26,27,28]

The number of actual LOR conditions declared in NSW during Q4 2020 and Q1 2021 (summer period, including shoulders) was higher than the same period in 2019/20 (16 vs. 9), with the increase accounted for by LOR1 conditions. Fewer actual LOR2 declarations were issued in the 2020/21 summer period compared to 2019/20 when regions of the NEM were significantly impacted by bushfire. While there was an increase in LOR conditions overall, only 4 actual LOR2 declarations were made over the period. There were no forecast or actual LOR3 declarations for NSW.

The Reliability and Emergency Reserve Trader (RERT) scheme was only activated twice in the NEM during the 2019/20 financial year (once in QLD and once in NSW).[29] This occurred on:

- December 17, 2020 - in response to a forecast LOR2 in the NSW region when a unit at Liddell Power Station went offline.
- May 25, 2021 - in response to an actual LOR2 and forecast LOR3 triggered by the explosion and loss of operating units at Callide Power Station in Queensland.

The previous summer period had seen a total of four RERT events across the NEM, three of these involving the NSW region.[30] All RERT activations in the 2019/20 financial year were confined to the summer period.

As seen in Figure 3 and Figure 4, the number of LOR declarations during Q2 2021 was greater than for the summer period. This observation was explored with stakeholders and explanations for this unusual situation included:

- tightened supply due to delayed return of generation from planned outages[31]
- impacts of the Callide Power Station incident and prolonged outage[32]
- periods of low wind during April to June, and
- timing of evening peak demand as solar generation output declines.

[26] AEMO (2021). NEM Lack of Reserve Framework Report - Reporting period 1 October 2020 to 31 December 2020.
[27] AEMO (2021). NEM Lack of Reserve Framework Report - Reporting period 1 January 2021 to 31 March 2021.
[28] AEMO (2021). NEM Lack of Reserve Framework Report - Reporting period 1 April 2021 to 30 June 2021.
[29] AEMO (2021). Reliability and Emergency Reserve Trade End of Financial Year 2020-21 Report.
[30] AEMO (2020). Reliability and Emergency Reserve Trader End of Financial Year 2019-20 Report.
[31] At the time of the incident at Callide in May 2012, seven Queensland generators were already on extended outage, a total of 2,796 MW. AEMO (2020). Reliability and Emergency Reserve Trader (RERT) Quarterly Report Q2 2021.
[32] Callide Unit B1 returned to service on 1 June 2021, B2 returned on 22 June 2021, and C3 on 26 July 2021. Unit C4 is expected to return on 1 December 2021. Queensland Government, Callide Unit C3 back online, 26 July 2021.

Market bodies AEMO, AEMC, AER and the ESB did not express any high level of concern about the increased LOR forecasts. That the majority of forecast LOR notices, particularly forecast LOR2s, did not progress to actual LOR is reflective of the market signal being effective. An additional observation provided was that the increased LOR activity could be interpreted as supply and demand being better balanced in the system (i.e., there was not unnecessary excess capacity in the market).

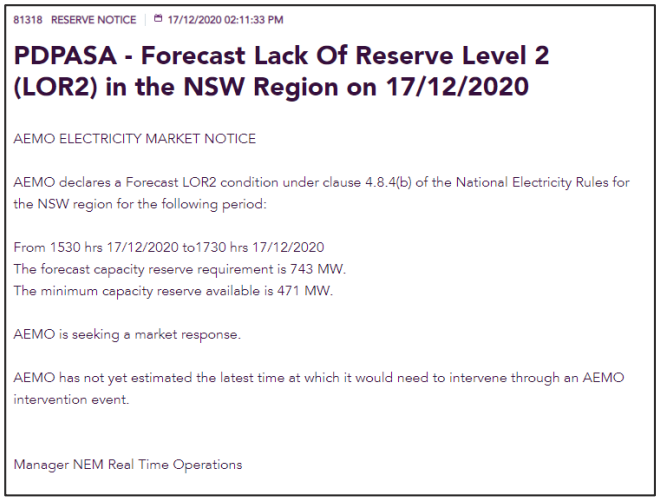
The 2021/22 Scope of Assessment requested that the Panel consider if new response procedures needed to be implemented in order to improve the preparedness and coordination activities of NSW Government in response to AEMO LOR notices. These ideas included:

- Triggers for information flow between the Jurisdictional System Security Coordinator and EUSFA;
- Engagement between EUSFA and the AEMO Liaison Officer upon receiving LOR notifications (at a certain threshold – LOR 2 for example); and
- Time based guidelines with regards to preparedness and response measures upon receiving a LOR notification and the actual forecasted LOR period.

In response to this request, the Panel first considered the nature of the information contained within a public LOR market notice. A typical public LOR forecast notice (such as Figure 5) issued on AEMO's website contains the following details:

- LOR level (1, 2 or 3)
- Period of forecast condition
- Capacity reserve required
- Minimum reserve available
- The latest time at which AEMO would need to intervene in the absence of a market response

Subsequent updates maybe issued by AEMO if a change occurs in any of the included parameters (Figure 6). Actual LOR notices contain similar levels of information (Figure 7).



81318 RESERVE NOTICE | 17/12/2020 02:11:33 PM

PDPASA - Forecast Lack Of Reserve Level 2 (LOR2) in the NSW Region on 17/12/2020

AEMO ELECTRICITY MARKET NOTICE

AEMO declares a Forecast LOR2 condition under clause 4.8.4(b) of the National Electricity Rules for the NSW region for the following period:

From 1530 hrs 17/12/2020 to1730 hrs 17/12/2020
The forecast capacity reserve requirement is 743 MW.
The minimum capacity reserve available is 471 MW.

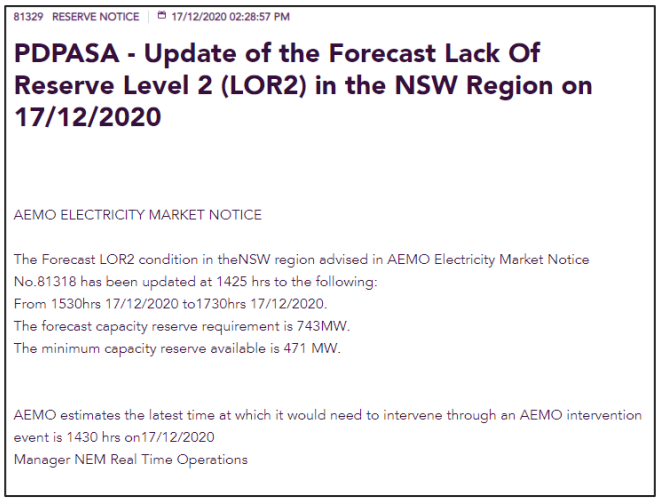
AEMO is seeking a market response.

AEMO has not yet estimated the latest time at which it would need to intervene through an AEMO intervention event.

Manager NEM Real Time Operations

Figure 5: Example of forecast LOR 2 notice available the public on AEMO website
Source: AEMO[33]

[33] AEMO, Market Notices. Accessed 14 October 2021.



81329 RESERVE NOTICE | 17/12/2020 02:28:57 PM

PDPASA - Update of the Forecast Lack Of Reserve Level 2 (LOR2) in the NSW Region on 17/12/2020

AEMO ELECTRICITY MARKET NOTICE

The Forecast LOR2 condition in theNSW region advised in AEMO Electricity Market Notice No.81318 has been updated at 1425 hrs to the following:
From 1530hrs 17/12/2020 to1730hrs 17/12/2020.
The forecast capacity reserve requirement is 743MW.
The minimum capacity reserve available is 471 MW.

AEMO estimates the latest time at which it would need to intervene through an AEMO intervention event is 1430 hrs on17/12/2020
Manager NEM Real Time Operations

Figure 6: Example update to forecast LOR2 market notice available to public on the AEMO website
Source: AEMO[34]

81347 RESERVE NOTICE | 17/12/2020 05:19:09 PM

Actual Lack Of Reserve Level 2 (LOR2) in the NSW region - 17/12/2020

AEMO ELECTRICITY MARKET NOTICE

Actual Lack Of Reserve Level 2 (LOR2) in the NSW region - 17/12/2020

An Actual LOR2 condition has been declared for the NSW region from1710 hrs.
The Actual LOR2 condition [is forecast to exist until 1830 hrs.
The capacity reserve required is 680 MW
The minimum reserve available is 588 MW

An insufficient market response may require AEMO to implement a AEMO intervention event.

Manager NEM Real Time Operations

Figure 7: Example of an actual LOR2 market notice available to public on AEMO website
Source: AEMO[35]

According to AEMO's Reserve Level Declaration Framework, a LOR forecast is declared for a period within the LOR assessment horizon when the forecast of available capacity reserves in the short term PASA or pre-dispatch schedules is:

- less than a defined amount of credible risk[36] for the region (as outlined in Table 7); or
- less than the Forecast Uncertainty Measure[37] (FUM) for the relevant period and region.[38]

[34] AEMO, Market Notices. Accessed 14 October 2021.
[35] AEMO, Market Notices. Accessed 14 October 2021.
[36] The two largest credible contingency events for each region are determined by AEMO.
[37] The Forecast Uncertainty Measure for a region is "*the number of MWs representing the quantity of [Forecast Regional Excess Supply] RXS for which AEMO determines a specified confidence level of the RXS error not exceeding that number of MWs*." The RXS error is defined as follows: RXS Error = Forecast RXS – Actual RXS. The prevailing conditions that are included in calculation of the FUM are a) Temperature forecast, (b) Solar irradiance forecast, (c) Forecast output of semi-scheduled generating units, (d) Current demand forecast error for forecast lead times below 24 hours, and (e) Current supply mix by fuel type (gas, coal or hydro).
[38] AEMO (2018). Reserve Level Declaration Guidelines.

Table 7: LOR level thresholds

LOR Level	Actual Declared when these events would result in LOR Load Shedding occurring as a shortfall of available capacity reserves:	Forecast Declared when the available capacity reserves in short term PASA or pre-dispatch schedules is:
1	Consecutive occurrence of largest and second largest relevant credible contingency events	• < two largest credible risks for the region; or • < FUM for the relevant period and region
2	Occurrence of the largest relevant credible contingency event	• < largest credible risk for the region; or • < FUM for the relevant period and region
3	LOR Load Shedding is occurring	• ≤ zero.

Source: AEMO[39]

When a forecast LOR is declared based on the level of credible risk in the region, an LOR1 will usually represent a sizeably lower risk than for an LOR2. Examples of single large credible contingency events include the failure of generation units and transmission lines. The detail on the public forecast LOR notice enables estimation of the anticipated size of reserve capacity shortfall, which can be used to gauge the size of the risk.

When a forecast LOR is declared based on the FUM, the forecast horizon of the notification is important, in addition to the volume of the capacity shortfall. This is because the range of the FUM for more distant time horizons is wider, as depicted in Figure 8. The average FUM from the 12 Hours ahead horizon is nearly half that of the 60 Hours ahead horizon. The range of the FUM also tightens as the event horizon draws closer. This represents reducing levels of uncertainty as the forecast period is approached.

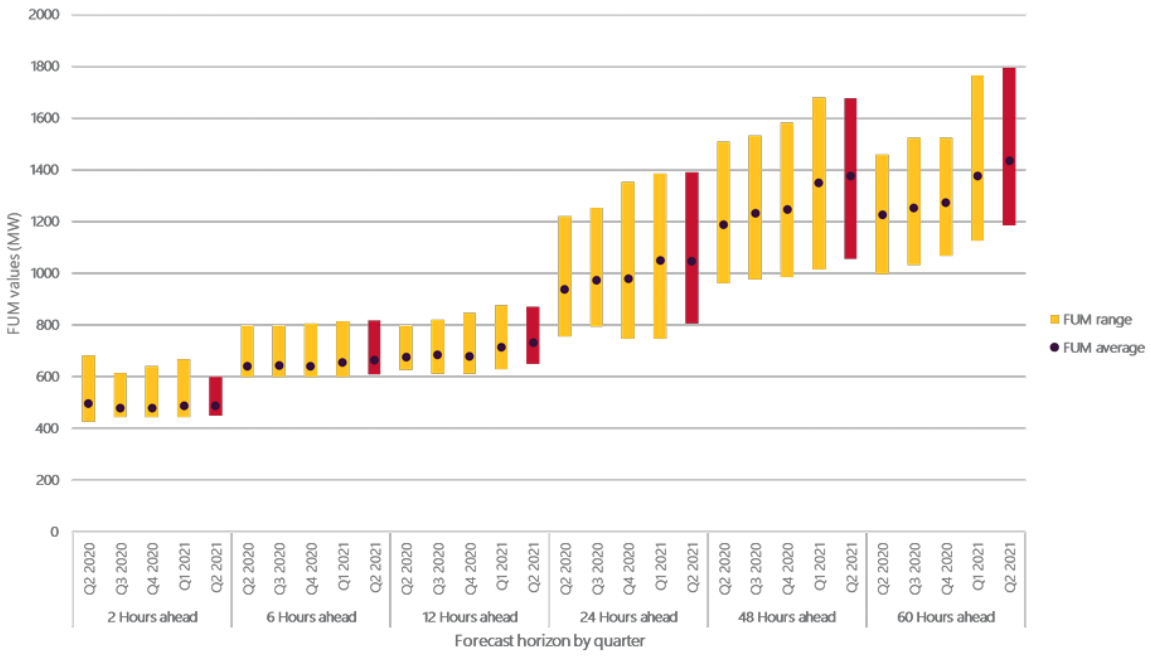


Figure 8: Forecast Uncertainty Measure (FUM) for different time horizons in the ST-PASA framework in NSW (maximum, minimum and mean FUM values for Q2 2020 to Q2 2021)
Source: AEMO[40]

[39] AEMO (2018). Reserve Level Declaration Guidelines.
[40] AEMO (2021). NEM Lack of Reserve Framework Report, 1 April 2021 to 30 June 2021.

Therefore, if a forecast notice is to be used as proxy signal for action, three key pieces of information on the public notice can assist in determining the required level of 'alertness' required; the level of the forecast LOR, the projected shortfall in capacity, and the time until the forecast LOR period. While the LOR mechanism appears to work well in signalling the market, market notices do not provide information on the underlying cause of potential reserve shortfalls (i.e., whether caused by generation, transmission or demand-side issues). This is because the notices are a mechanism to signal the need for increased capacity to the market, and not to signal emergency responses.

Additional intelligence on the market could also be used to inform the level of watchfulness required by energy emergency responders. For example, a program of communication with NSW generators on their status and anticipated outages on a regular basis could assist EUSFA to identify specific periods of risk. This type of approach is used by the Energy Emergency team in the Queensland Department of Energy and Public Works to inform regular communication with the Queensland Minister for Energy, Renewables and Hydrogen.

The Panel understands that there is an existing process through which the EUSFA team is notified of a need to enact emergency energy responses through the JSSC. The JSSC has access to intelligence on market status through communication with AEMO and TransGrid, and it is appropriate for the JSSC to be the single point of contact. However, to further assist situational preparedness, an understanding of the methodology used to produce LOR forecasts can inform the level of alertness required for the EUSFA team. This may enable improved anticipation of a request by the JSSC to activate protocols such as the Government Energy Action Response (GEAR) or Large Energy User Voluntary Demand Reduction (VDR). Additionally, in times when uncharacteristic LOR patterns are observed, the EUSFAC may opt to seek information from AEMO, through the JSSC, that will provide clarity around the underlying cause.

Reference material that covers the methodology for Lack of Reserve declarations and the ongoing development of the forecast model is publicly available from the AEMO website:

- Reserve Level Declaration Guidelines – a detailed description of the process used to determine Lack of Reserve declarations.
- Lack of Reserve Framework Reports – provide a quarterly assessment of the FUM.
- Annual Forecast Accuracy Report.

The Panel notes that there are programs underway that are likely to have impacts on Lack of Reserve issues. These include:

- AEMO's ST PASA Replacement project[41]
- AEMC rule change ERC0322: "Updating Short Term PASA"[42]
- AEMC rule change ERC0306: "Capacity commitment mechanism for system security and reliability services". [43] Note that this aligns with recommendations proposed by the ESB post-2025 market design work.

[41] AEMO (2021), ST PASA Replacement project, accessed 19 October 2021.
[42] AEMC (2021), Rule change: Updating Short Term PASA, accessed 19 October 2021.
[43] AEMC (2021), Rule change: Capacity commitment mechanism for system security and reliability services, accessed 19 October 2021.

3 Summer 2021/22 and beyond – Forecasts, Risk Assessment and Preparedness

This chapter provides an overview of supply and demand forecasts, the status of and risks to generation, transmission and distribution infrastructure and the expected climatic conditions for summer 2021/22.

3.1 Supply and demand forecasts

3.1.1 Supply

AEMO's 2021 ESOO states that overall supply scarcity risks for the coming summer are relatively low under normal conditions. For NSW the supply scarcity risk is very low, with AEMO projecting that expected unserved energy (USE) will remain well below 0.0006% of annual consumption for the next five years (Figure 9). Between last summer and the coming summer, an additional 1,066 MW of additional VRE generation and 50 MW of large-scale batteries is expected to become operational in the NSW region. This includes the Darlington Point Solar Farm which is on track to be fully operational for this summer season.

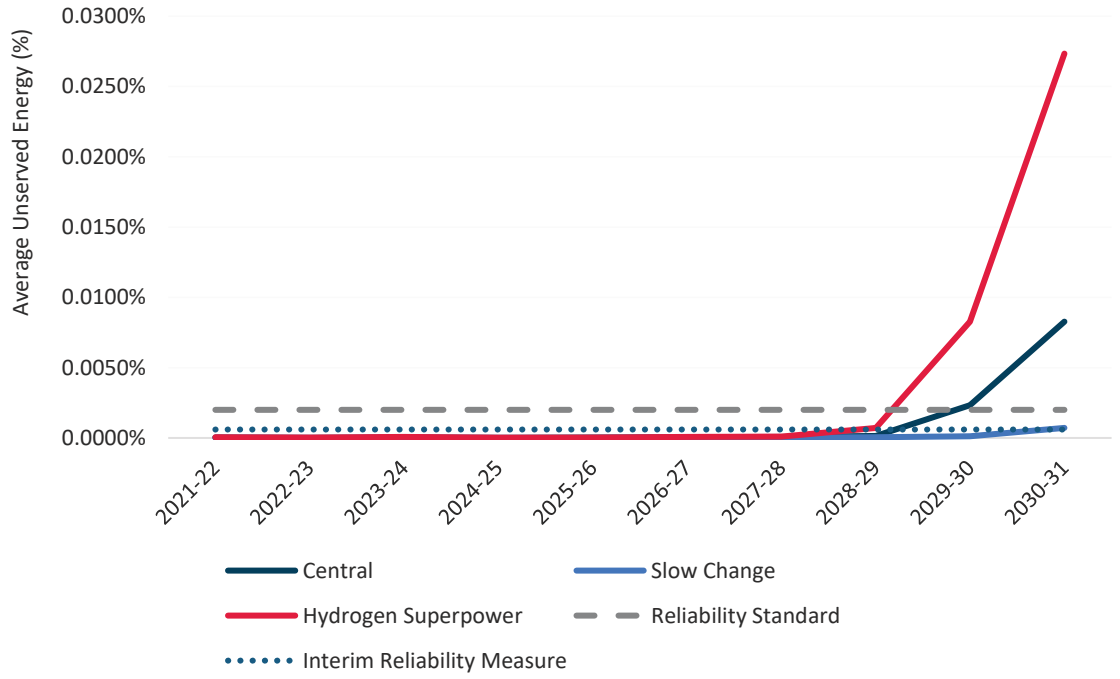


Figure 9: AEMO's ESOO 2021 forecasted expected unserved energy for NSW
Source: AEMO[44]

In addition to the usual risks presented by factors including severe weather, power system events, forced outages and delays to the commissioning of new generation and storage, a specific identified supply risk in the NEM is in the Victorian region if significant flooding results in a prolonged outage at Yallourn Power Station. AEMO performed a sensitivity analysis based on the following assumptions:

- Yallourn is fully unavailable for summers 2021/22 and 2022/23
- Torrens Island B1 is not mothballed as planned

[44] AEMO (2021), 2021 NEM Electricity Statement of Opportunities.

- Snapper Point Power Station is prioritised for commissioning before summer 2021/22.

Under this scenario, the analysis forecasts that 150,000 to 500,000 Victorian households could experience at least one blackout of up to eight hours during a 1-in-10-year peak demand event during summer 2021/22. However, the analysis forecasts that NSW would be relatively unimpacted, with expected USE in the NSW region remaining well below the Interim Reliability Measure (IRM).

AEMO has a range of mitigation actions that can be applied in situations where adequacy of supply is impacted, including the contracting of reserves through medium- and short-term notice RERT.

3.1.2 Demand

AEMO reports that maximum demand for the NSW region is expected to trend downwards for the next five years driven by reduced business demand and, to a lesser extent, continuing uptake of distributed energy resources (DER). Minimum demand levels are also expected to reduce at a faster rate than forecast in the 2020 ESOO, due to increased forecast uptake of distributed PV.[45]

The MT-PASA forecasts for the upcoming summer and first half of 2022 show that projected generation availability exceeds the demand for the region at both the 50% and 10% Probability of Exceedance (POE)[46] levels (Figure 10). Note that this excludes import capacity from interconnectors. A discussion on interconnector capacity is available in the 2020/21 Assessment Supplementary Material.[47]

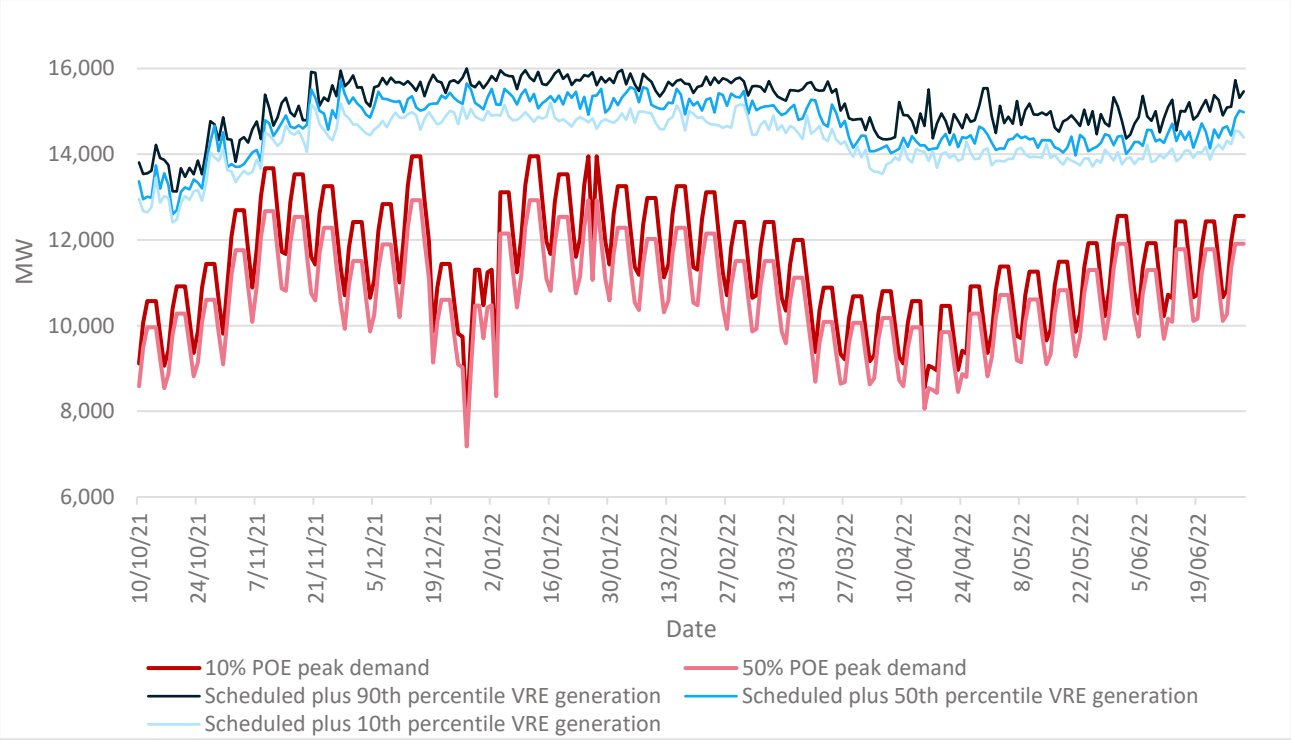


Figure 10: MT-PASA Outlook for NSW Region from October 2021 through till June 2022
Source: AEMO[48,49]

[45] AEMO (2021), 2021 NEM Electricity Statement of Opportunities.
[46] POE is the likelihood that the demand forecast will be met or exceeded. For example, a forecast with 10% POE represents a demand forecast that is expected to be exceeded 1 year in 10, on average. It represents a high demand forecast.
[47] 2020 (CSE), Assessment of Summer Preparedness of the NSW Energy Market: 2020/21. Supplementary Material
[48] AEMO (2020), Market data – NEMWEB. Medium Term PASA 5 October 2020, accessed 7 October 2021.
[49] AEMO (2020), Market data – NEMWEB. Medium Term PASA Region Availability 5 October 2020, accessed 7 October 2021.

3.2 Climate outlook

The Bureau of Meteorology is currently on La Niña alert, with a 70% likelihood of La Niña conditions to develop for the upcoming summer season (as of 26 October 2021 and based on previous criteria).[50] For the period December 2021 to February 2022, current forecasts for the NSW region predict, dependent on region:

- Low chance of exceeding median maximum temperatures (Figure 11)
- Moderate to high chance of exceeding median minimum temperatures (Figure 12)
- Moderate to high chance of exceeding median rainfall (Figure 13)

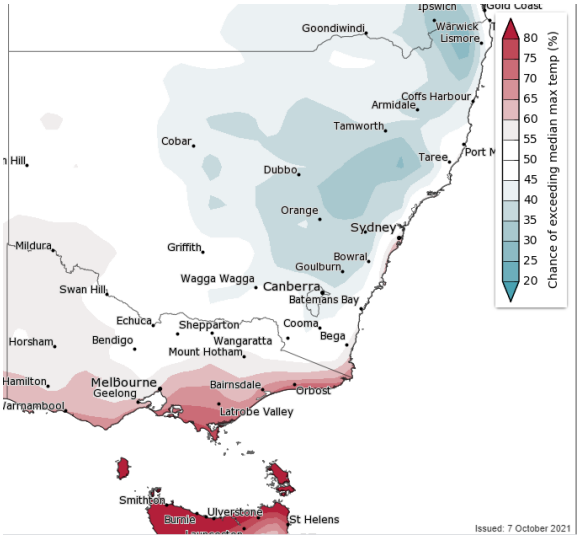


Figure 11: Likelihood of exceeding median maximum temperatures (Dec 2021-Feb 2022)

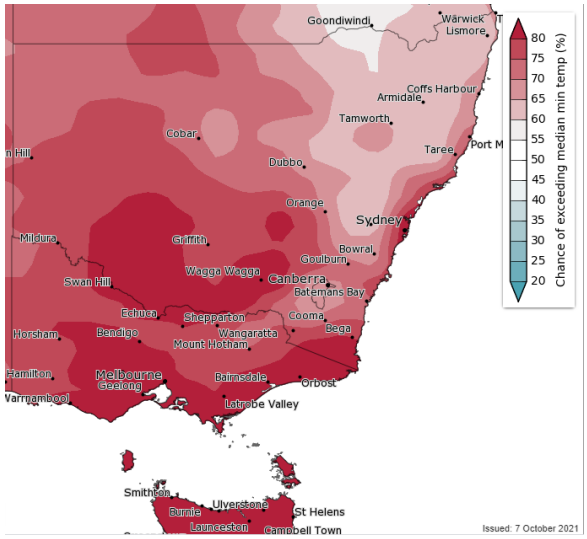


Figure 12: Likelihood of exceeding median minimum maximum temperatures (Dec 2021-Feb 2022)

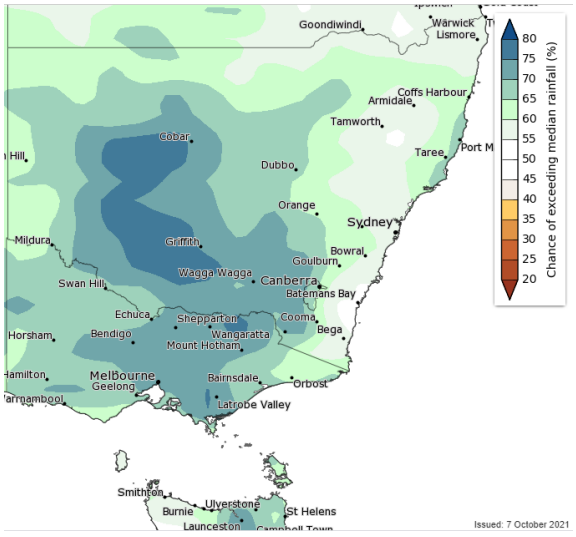


Figure 13: Likelihood of exceeding median rainfall (Dec 2021-Feb 2022)
Source: BOM[51]

[50] BOM (2021), Climate Driver Update, issued 26 October 2021.
[51] BOM (2021), Climate outlook overview, issued 7 October 2021.

In terms of severe weather, the upcoming summer period has increased likelihood of widespread flooding, coastal flooding/erosion and heatwave compared to summers over the past decade. Likelihood of severe storms is similar. Likelihood of drought and dust are reduced.[52] Increased rainfall combined with higher minimum temperatures increases the likelihood of warm, humid nights.

Compared to the same time last year, there is increased risk of fire in Northern NSW due to increased grass loads (Figure 14). Forested areas along the east coast that were burnt during summer 2019/20 are still in recovery, resulting in lower-than-average fire risk in those areas for the forecast conditions.

The current outlook suggests above median rainfall is likely across the Morwell / Latrobe Valley region during the remainder of spring and early summer. Any major flood event could impact the repairs to the damage in the Morwell River Diversion in Victoria near the Yallourn coal mine and thus restrict output from the 1480 MW Yallourn power station. However, AEMO's sensitivity analysis outlined in Section 3.1.1 above indicates that NSW would experience minimal impacts.

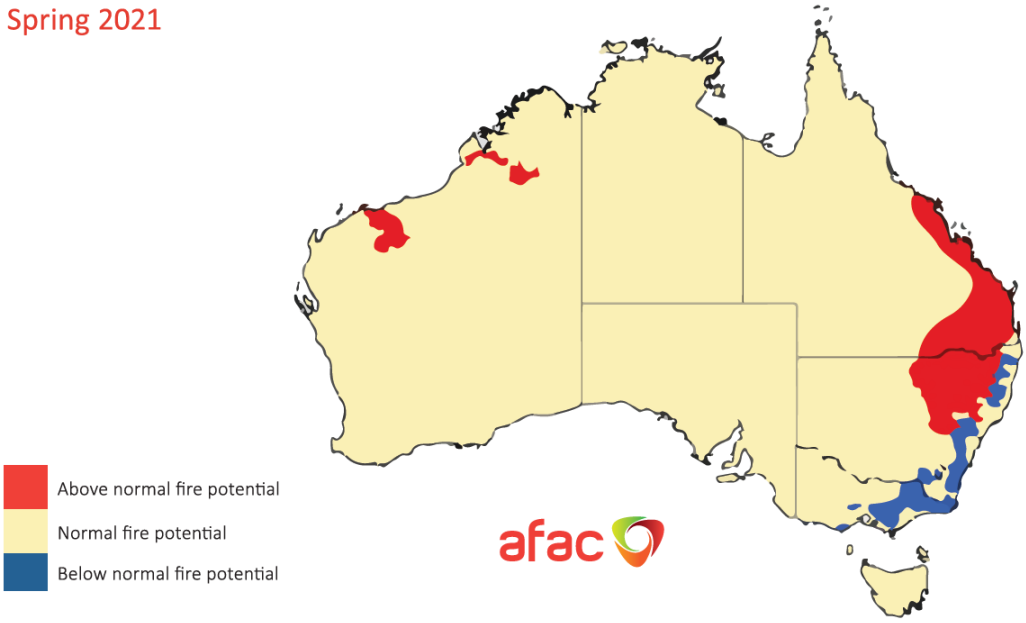


Figure 14 Seasonal bushfire outlook for September to November 2021.
Source: AFAC[53]

Given the forecast conditions, NSW energy businesses are likely to be impacted by either bushfire or flooding, dependent on the location of assets. The high likelihood of above median minimum temperatures and potential for humid conditions across NSW may also impact night time generation loads through summer.

3.3 Preparedness Activities

3.3.1 Actions by the NSW Government

In addition to the responses to the 2020/21 Assessment recommendations detailed in Section 2.1, the EUSFA team has closely engaged with the industry to assist with COVID-19 issues. This included the coordination of an industry briefing session with NSW Health where the approach to risk management of large gatherings of critical workers was shared, based on an actual power station outage involving a workforce of up to 300-350 personnel. NSW Health communicated the

[52] BOM (2021), Summer Climate Outlook Briefing for the NSW Office of the Chief Scientist & Engineer, 27 September 2021.
[53] AFAC (2021), Seasonal Bushfire Outlook – Spring 2021.

principles of COVID-19 management and provided information that would help businesses to prepare for a site outbreak, including the details they would need to provide the public health unit to assist contact tracing. There was strong encouragement to form relationships with the local public health unit, who would be the first point of contact if an outbreak did eventuate.

A presentation delivered by a generation business on their approach to risk management procedures for a large-scale outage received high praise from NSW Health, who stated that the planning demonstrated by the business was an exemplar and should be shared with other industries.

3.3.2 Actions by the energy market

Summer preparedness programs have been well-integrated into the workstreams of the energy businesses that participate in the consultation for this Assessment. Pressure from the 2019/20 bushfire season, and the COVID-19 pandemic that followed, has served to further consolidate and strengthen risk management activities of an industry already equipped to manage the dangers of electricity. Under COVID-19 restrictions, summer preparedness workplans have progressed and been completed satisfactorily, but with higher level of logistical challenge and effort required.

Some major generation plant outages have been delayed or scaled back due to COVID-19. Electricity businesses have conducted risk assessments to balance factors but acknowledge there is some risk carried forward as a result of postponements of major overhauls or reduced scopes of work. By not conducting a major overhaul, the businesses are unable to carry out inspection work which could identify potential failures or weakening of internal equipment.

Several generators reported that they had work programs for the optimisation of minimum cycling conditions to cope with lower daytime minimum demands. This is an issue that has continued to grow since the 2020/21 Assessment.

No concerns have been reported by transmission and DNSPs in terms of vegetation and defect management. All work programs were reported as on track, despite the challenges to worker movement posed by COVID-19 restrictions.

There is a culture of proactive risk management and knowledge sharing within the sector. The panel was encouraged by reports that businesses had sought to understand what learnings could be applied from the Callide Power Station incident, that businesses sought expertise from others on how to deal with new experiences such as major flood response, and that ‘mutual aid’ agreements were effective in the cases where large-scale disaster response was required across borders

3.4 Generation and transmission infrastructure status

3.4.1 Summary of risks identified, and mitigation actions undertaken

The risk of forced generation outages is managed by a schedule of preventative maintenance works that typically occurs in the shoulder seasons (spring and autumn). Specific to this year, COVID-19 has caused disruption to some of these intended works, with a number of cancellations or reduced scope outages. In all cases, generation businesses have undertaken thorough risk analysis to determine which aspects should be postponed, if any. In the case of one generator, it was determined that the full outage could not be postponed, and this had to be carefully managed to proceed under COVID-19 restrictions. Generators are confident that generation infrastructure is prepared for summer, while acknowledging the risk of contingent events remains.

Table 8 provides a summary of other risk categories identified by energy businesses that are planned for and mitigated by preparedness activities. New to the Assessment for this year are participants from the renewable generation sub-sector.

Table 8: Summary of preparedness risks and mitigation actions taken by energy market participants

Participant	Mode	Main Risks	Mitigation
Generation - Conventional	Coal	Fuel – coal supply Minimum demand issues	Rebuilding stockpile, exploring alternative sources, planned outages Minimum cycling optimisation programs
	Gas	Fuel – gas supply	Gas storage Secure supply
Generation - Renewable	Solar	Electrical and mechanical faults Fire – external or asset-related Derate due to extreme heat	Preventative maintenance schedule Fire breaks Installation of excess capacity
	Wind	Fire[54] Derate due to extreme heat at hub temperatures > 40°C	Vegetation management Rock installation under turbine Temperature at turbine is lower than ground temperature
	Hydro	Water storage levels Post-bushfire water quality Dam spills	Water collection and storage program Regular outages for clearing debris Airspace agreements
Transmission	-	Fire – external or asset-related Storms	Vegetation management Monitoring and defect management
Distribution	-	Fire – external or asset-related Storms	Vegetation management Monitoring and defect management Undergrounding of lines Composite pole program Microgrid trials

3.4.2 Specific issues identified

A number of specific issues have been identified for the 2021/22 summer season. These are outlined below.

3.4.2.1 Coal supply

Coal stockpiles are below target reserve levels for some generators due to higher-than-expected winter generation levels. Businesses are working to restore stockpile levels but raised difficulties in securing coal supplies due to general supply and price issues. There are still coal quality issues at the Springvale Mine which supplies Mt Piper Power Station, and alternative sources are being tested for suitability. The mine which supplies Vales Point Power Station is currently experiencing a reduction in productivity due to a switch from longwall to miniwall mining techniques. Despite tightened domestic coal supply, coal generators are satisfied overall that they have enough coal to meet summer operation requirements, having conserved coal through Autumn, and with some also taking planned outages.

[54] In addition to fire caused by ignition of vegetation in the vicinity, ground fire may also be caused in the event of bird strike on the blades, if a bird catches fire and lands in dry grass at the base of the turbine.

3.4.2.2 Minimum demand

Daytime minimum demand is continuing to trend downwards as solar penetration increases with minimum demand records already broken 3 times in October 2021 (Figure 2 and Figure 15). These conditions create economic constraints for conventional coal generators who cannot remain price competitive during these times. Conventional generators are adjusting to new economic constraints by establishing programs to optimise minimum cycling of generation units. However, this is not ideal for ageing plant which was not designed to be operated in such a manner and is likely to have impacts on longevity of the units (See Section 4.1.1).

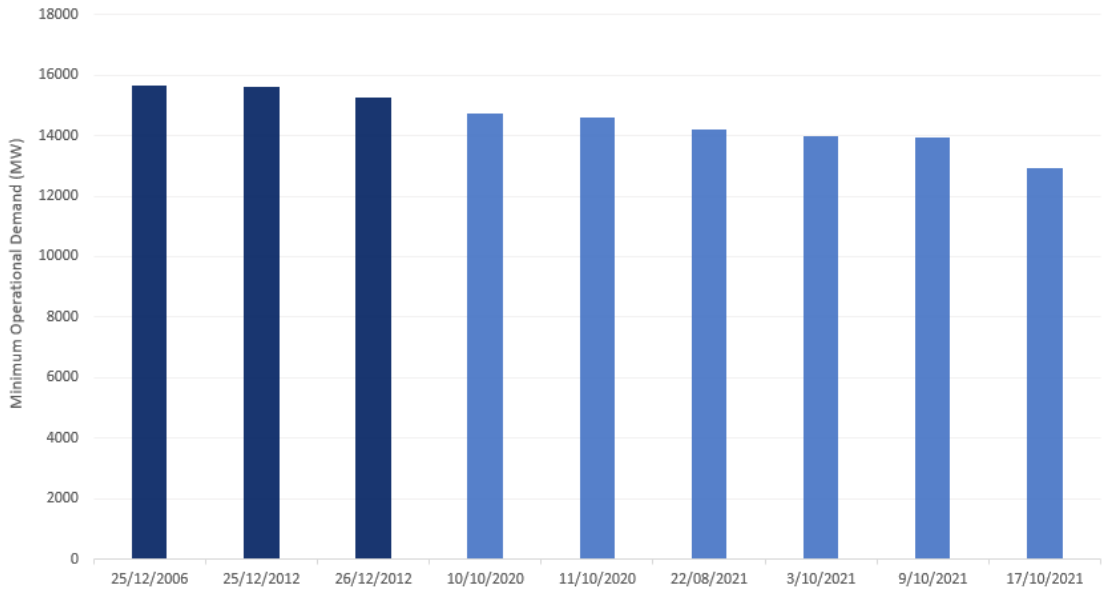


Figure 15: NEM Minimum Operational Demand Records
Source: AEMO[55]

3.4.2.3 Transmission

Lack of adequate transmission infrastructure in some regions is impacting the ability of generators to supply to the market. Capacity at Snowy Hydro is underutilised due to transmission constraints, impacted by the volume of renewable generation in the region. Similarly, solar and wind farms are impacted by network congestion and can experience curtailment during periods of high generation. While not a high risk for the 2021/22 summer specifically, the risk grows overall as the renewable transition continues and coal generation closes.

The Panel notes that current grid was designed for one-way flow of power from big coal-fired generators to load centres with relatively gentle cycling and now must cope with a vastly different variability. Thus, grid flexibility at HV levels requires urgent development as we move to post-2025 as its too expensive to build a grid that can cope with all possible maximum flows. Planning of the HV grid needs to take account of the significant generation and battery inputs that will occur at the distribution level.

3.4.2.4 Distribution

With the high penetration of distributed PVs, DNSPs have at times seen reverse power flows during period of high generation from these generators. Most of the DNSPs were not designed for this situation and considerable re-engineering of assets and controls are needed to handle the potential influx of distributed PVs.

[55] @AEMO_Energy, Twitter post 18 October 2021. AEMO has seen NEM minimum operational demand records continuing to fall, from 14,193MW in late August to Sunday's new record of 12,936MW. AEMO's 2021 electricity outlook forecasts that records could reach 4 to 6 GW by 2025.

3.4.3 Risks and mitigation strategies for solar, wind and hydro

The Panel consulted with a range of renewable generation businesses for the first time in this series of Assessments. Typical sources of risk and accompanying mitigation actions are outlined below.

3.4.3.1 Grid-scale solar generators

- The main risk for grid-scale solar generators is electrical or mechanical faults. Preventative maintenance can be undertaken in a rolling manner due to the modular nature of installations. Individual inverter units can be taken offline and maintained during winter daytime hours as overall impacts to generation are small. Each unit may be offline for only a couple of hours each year. Maintenance of the main transformer for a plant is conducted during the night.
- To protect from fire, wide firebreaks are maintained around the site and between sections of the plant. Water tanks are kept onsite, with fixtures compatible with the fire agency equipment.
- Cables are routed and buried in a manner that protects against rodent activity.
- Generation output from solar panels is impacted by extreme temperatures, and rapidly decreases from about 50°C ambient temperature. Solar farms typically have a proportion of over-installed capacity that can provide some buffer as efficiency is impacted by heat.

3.4.3.2 Wind generators

- In addition to vegetation fire in the vicinity of turbines, bird strike on turbine blades is an additional source of fire risk if a bird catches fires and lands in dry vegetation. As a result, vegetation is cleared around the base of turbines and, in some cases, rock ground cover is also installed.
- Smoke detectors are installed inside the turbines.
- Landholders also maintain a watch over the site.

3.4.3.3 Hydro generators

- Poor water quality is a risk to plant efficiency, as described in

- Table 5.
- There is risk of dam spills in the Snowy region, which may be exacerbated given the climate outlook for potential increased rainfall. Snowy Hydro has agreed airspace agreements and established communication arrangements with WaterNSW and relevant authorities for flood and water management.

3.5 COVID-19

As discussed in Chapter 2, businesses have been proactive in managing COVID-19 risk for both workforce and operations. The level of risk management and preparedness for the ongoing COVID-19 situation is good.

3.5.1 Personnel

Businesses expressed concerns around the full relaxation of public health restrictions on 1 December 2021. Internal polling indicates that vaccination rates within businesses are high and consistent with community rates of uptake. However, concern remains around risks associated with unvaccinated personnel attending site. Only one business out of those consulted intends to implement a company policy for mandatory vaccination.

Current procedures have effectively prevented transmission of virus between identified positive cases and other members of the workforce. However, adaptation of COVID-19 safety plans and procedures will be required as vaccinated and unvaccinated personnel begin to mingle. This may include the implementation of regular on-site testing using rapid antigen kits, plans on how to manage rosters which include unvaccinated staff, and guidelines on how to manage exposures of vaccinated staff to positive cases. The relationship between businesses and NSW Health, through their local public health unit, will be important in navigating these changes.

Business leaders are aware that fatigue could be a concern for their staff, having worked tirelessly under pressure since the 2019/20 bushfires. Leave management and shutdowns over the New Year period are being used to encourage staff to take a break.

3.5.2 Cross-border travel

International and national border restrictions are slowly easing for vaccinated persons which should make it easier for essential workers to travel for work, reducing the logistical challenges that have existed for maintenance, construction and response to energy emergencies in the industry.

From 1 November 2021, NSW is due to open international borders, with no quarantine requirement for fully vaccinated persons. Whilst this is only for Australian Citizens and Residents, it is a welcome first step towards enabling the return of international skilled experts from the energy sector to Australia.

Domestically, as of 20 October 2021, the border between Victoria and NSW has been reopened with no quarantine requirement for fully vaccinated travellers. The border between Queensland and NSW is also expected to open on 17 December 2021, without quarantine restrictions for fully vaccinated travellers, once 80% of the eligible Queensland population is vaccinated. This will enable easier transit for skilled personnel who travel to undertake work on interstate outages, emergency repair work and construction projects.

4 Future Preparedness

The challenges and opportunities in the transition of the energy market have been discussed in previous Assessments. The Panel noted for this assessment several themes that arose in discussions with stakeholders on future issues, and include:

- reliability & security as coal-generation retires
- network congestion
- issues created by increasing levels of DER, such as reducing daytime minimum demand levels, visibility over installations, market operator control and cyber security
- scale of work required to decarbonise and achieve net zero targets
- the need for coordination of reforms at the national level
- grid resilience under climate change
- increasing system complexity.

This chapter explores the future challenges, opportunities and solutions presented by the rapidly evolving grid and outlines the planning and strategies that have been put in place, or are being developed, by the NSW Government and market bodies to support the ongoing renewable transformation. The Panel acknowledges the large body of work that is currently being progressed but highlights the need for this to continue more rapidly and in a coordinated manner to ensure the best outcomes for NSW and the NEM.

4.1 System reliability and security

The 2021 ESOO focused on the management of the accelerated transition of the energy market *"towards high instantaneous penetration of renewable generation, thermal generation withdrawal, and 'green' hydrogen consumption."*[56] The report notes that there are multiple interrelated drivers of this acceleration which make the management of system reliability and security more complex. These include the following, which will be discussed in this section:

- accelerated exit of coal and increasing risk of plant failures
- accelerated deployment of large-scale and distributed renewable resources
- accelerated interest in hydrogen production and greater electrification.

The changes in the system have led to additions to the modelling undertaken by AEMO including a scenario for Net Zero 2050[57] and hydrogen superpower[58] reflecting various government and business polices and technological advancements. These issues are of key concern to both the market bodies and operators, and the ESB have provided recommendations on actions to support the transition as part of the Post-2025 Market Design discussed in Section 4.2.1.

The 2021 ESOO[59] outlined the following outlook for NSW:

[56] AEMO (2021), 2021 NEM Electricity Statement of Opportunities.
[57] *"The Net Zero 2050 scenario represents a future that delivers action towards an economy-wide net zero emissions objective by 2050 through technology advancements. This transition focuses on short-term activities in low emission technology research and development to enable deployment of commercially viable alternatives to emissions-intensive activities in the 2030s and 2040s. Stronger economy-wide decarbonisation, particularly industry electrification, occurs in later years as the 2050 deadline approaches. Consumers are initially continue to heat their homes in the same manner they do today, but by the mid-2030s nearly half the current gas heating has been electrified, and in the final years of the horizon nearly all residential heating is electrified."* AEMO (2021), Inputs, Assumptions and Scenarios Report.
[58] *"The Hydrogen Superpower scenario reflects strong global action towards emissions reduction, with significant technological breakthroughs and social change to support low and zero emissions technologies. Emerging industries such as hydrogen production present unique opportunities for domestic developments in manufacturing and transport, while NEM-connected renewable energy exports via hydrogen become a significant part of Australia's economy. New household connections tend to rely on electricity for heating and cooking, but those households with existing gas connections progressively switch to using hydrogen – first through blending, and ultimately through appliance upgrades to use 100% hydrogen."* AEMO (2021), Inputs, Assumptions and Scenarios Report.
[59] AEMO (2021), 2021 NEM Electricity Statement of Opportunities.

- **Maximum operational demand** – In the short-term (0-5 years), this is expected to decrease. In the medium to long term (5-30 years), maximum operational demand is likely to increase due to electric vehicle (EV) uptake and electrification.
- **Minimum operational demand** – In the short-term, this is due to decrease at a faster rate due to distributed PV uptake. In the medium to long term, it will continue to decline over the next decade. It is noted that decreasing minimum operational demand will provide opportunities for market-based solutions including EV charging and new hydro-pumping, solar sponge and load shifting.
- **Supply** – There are several changes in existing and committed supply in NSW since the 2020 ESOO. This includes 1,066 MW of additional VRE and 50 MW of large-scale battery due to be connected between summer 2020/21 and 2021/22. Commissioning of the 750 MW Kurri Kurri gas generator is expected in 2023/24, and Snowy 2.0 (2,040 MW) is expected in the period 2025/26 to 2026/27. A number of coal power generators are due to be retired (See section 4.1.1).

As discussed in Section 3.1 and Figure 9 there are low levels of expected USE until 2028/29, when Vales Point Power Station and Eraring Unit 4 are due to retire. The USE increases rapidly post 2028/29, however there are many generation, storage and transmission projects planned that may mitigate the risk.

4.1.1 Accelerated exit of coal-fired power generation

In NSW, the next decade will see the closure of several coal-powered generators. There is an increasing risk of early closures due to economic considerations and reduced reliability of ageing fleet, exacerbated by the changed operational requirements caused by reducing daytime minimum demand in the NEM.

The 2021 ESOO considers the retirement of coal-fired generators, and notes that the retirement of Yallourn Power Station and two units at Eraring Power Station have been brought forward since the 2020 ESOO.[60] The ESOO also suggests that there are further indicators that the retirement of some coal-fired generators will be brought forward, and includes factors such as:

- Increased penetration of renewable generation from both connection of DER and large-scale renewable generation. This has resulted in the aging coal fleet now operating in a regime that is no longer just ‘base load’. Rather, plant is increasingly called upon to operate for times at reduced output and to cycle more frequently as the input from renewables lowers the daytime minimum demand. Minimum cycling conditions for coal generating units can only be a temporary solution for this issue. This operating regime is likely to increase wear and tear which could result in failures which are not economic to repair.
- Reduced reliability indicates a continued trend of lower performance of the coal-fired generators. Key factors include announcements of reductions in plant expenditure, especially as the generator gets closer to retirement, and prolonged outages of several power stations (e.g., Unit 4 of Callide Power Station in 2021 and Loy Yang A and Mortlake units in 2019).
- If a catastrophic failure occurs, it may no longer be economic for an operator to bring the unit(s) back into service.

It is likely the trend of early retirement of coal-fired power stations will continue. Since the 2021 ESOO was released, EnergyAustralia has announced that the closure of Mt Piper Power Station will be brought forward by two years from 2042 to 2040.[61] Table 9 sets out the expected closure time for several coal generators and their closure risks.

[60] AEMO (2021), 2021 NEM Electricity Statement of Opportunities.
[61] Gregory, X (23 September 2021), EnergyAustralia pledges to ditch coal by 2040, closing coal-fired power stations. ABC News.

Table 9: Expected Closure Years from AEMO Generator Information, ordered by Ownership

Station	Units	Owner	Expected Closure	Closure Risk
Eraring	4 x 720 MW	Origin Energy	1 unit (ER04) 2030 1 unit (ER01) 2031 2 units (ER02 & ER03) 2032	Risk that closures could be earlier if it is not economically feasible to repair plant suffering major failure.
Bayswater	4 x 685 MW[62]	AGL	4 units 2035	AGL is currently progressing plans to split company into two separate businesses 1. electricity and gas retail business and bulk of its clean energy portfolio, and 2. Accel Energy which will hold the bulk of AGL's fossil fuel assets. Accel committed to the acceleration of decarbonisation.[63] Including publishing of a detailed climate change road map with specific emissions targets in line with baseline targets to cut CO_2 emissions by 23% by 2024, 60% by 2036 and 100% by 2050. Risks that closures could be earlier than expected if: a. Accel's financial position is insufficient to keep the stations going, or to cover a major plant failure, or b. there is shareholder and investor pressure for AGL to reduce emissions in line with Paris Agreement meaning closure of their coal-fired stations by 2030[64]
Liddell	4 x 500 MW	AGL	1 unit (LD03) 2022 3 units (LD01, 02 & 04) 2023	
Loy Yang A	3 x 560 MW 1 x 545[65]	AGL	4 units 2048	
Loy Yang B	2 x 580 MW	Alinta	4 units 2047	Risk that closures could be earlier if it is not economically feasible to repair plant suffering major failure.
Vales Point B	2 x 660 MW	Delta	2 units 2029	Risk that closures could be earlier if it is not economically feasible to repair plant suffering major failure.
Mt Piper	2 x 700 MW	Energy Australia	2 units 2040	In September 2021, EnergyAustralian announced that the closure of Mt Piper Power Station will be brought forward by two years from 2042 to 2040.
Yallourn W	2 x 350 MW 2 x 375 MW	Energy Australia	4 units 2028	AEMO comment that main risk to Yallourn W is further rainfall leading to flooding of the mine. Coal mine that supplies Yallourn W has recently been subject to flooding from the Morwell River Diversion. Work to repair the damage to the Diversion has been agreed between Victorian Government and Energy Australia. Risk that closures could be earlier than expected if it is not economically feasible to repair plant suffering major failure or a significant mine collapse.

[62] Includes existing and committed upgrades of 25 MW.
[63] AFR (30 June 2021), Investors recoil as AGL details demerger plan
[64] AGL, 2021 Annual General Meeting
[65] Includes anticipated upgrade of 15 MW.

4.1.1.1 An opportunity for retiring coal-fired power stations

As the large coal-fired plant retires, consideration should be given to not entirely mothballing these plants. An opportunity exists to provide system security services with retired plant even though power generation is ceased.

An example of this is the Deeside Power Station in the UK.[66] The Deeside Power Station is a 498 MW gas-fired combined cycle (CCGT) power station in Wales. The station was shut down in March 2018 and placed in preservation (mothballed) but has since undergone redevelopment to enable the station to provide system support services, including inertia and reactive power (to control voltage levels). These services were traditionally a by-product of the kinetic energy in the spinning parts of large traditional power stations. Refer to Appendix 4 for further details.

The ESB noted in its Post-2025 Market Design Report that with the retirement of coal-fired generation, several essential services are lost including frequency control, inertia, operating reserves and system strength – all being essential for the security of the electricity system. As part of a long-term reform measure, the ESB proposed changes to AEMO's dispatch mechanisms so that the system operator can efficiently procure and schedule the essential services that are required for system stability. This work is now to be progressed.

With the imminent retirement of several large coal-fired units, consideration should be given to the technical feasibility and economics of repurposing some of these units just as has been done at Deeside Power Station. This example has been identified by the CEO of AEMO, Daniel Westerman, as an innovation making use of technology that will *"otherwise just sit there"*.[67]

4.1.2 Accelerated deployment of large-scale and distributed renewable resources

The ESOO 2021 states that the "*NEM is pioneering world-first operation of a major power system with unprecedented levels of underlying demand supplied by DER."* It is noted that this operation will require adaptations for the system. AEMO believes that a range of actions need to be taken to ensure that the system operates secure beyond 2025, these include:

- Improving foundational power system security capabilities
- Developing suitable regulatory and market frameworks
- Building social licence
- Creating opportunities for new services delivered by market participants.

Modelling from the ESOO 2021 projects that, within five years, the entire demand in the NEM may at times be met by 100% renewable generation (Figure 16).

[66] National Grid ESO (2021). Deeside Power Station begins world first power system stability contract with National Grid ESO.
[67] AEMO (2021), EMO CEO Daniel Westerman's CEDA keynote address: 'A view from the control room'.

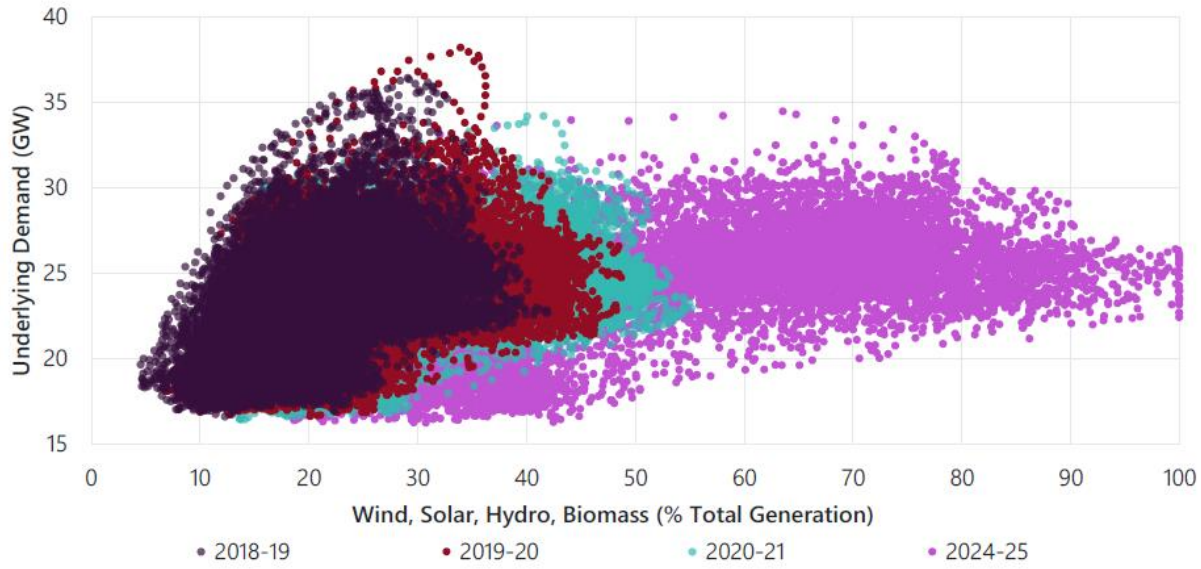


Figure 16: NEM-wide penetration of renewable resources (large-scale and distributed) 2018/19 to 2020/21, with indicative resource potential forecasts for 2024/25 based on existing, committed, and anticipated and distributed PV forecasts
Source: AEMO[68]

4.1.2.1 Managing DER issues

There are a range of technical challenges described in the 2021 ESOO that are required for the transition to a power system with high levels of distributed PV. This includes (described in full in the 2021 ESOO):

- Ensuring sufficient operational demand for delivery of essential security services
- Managing and minimising the unintended disconnection of distributed PV
- Maintaining transmission voltages
- Maintaining a sufficient emergency under-frequency response
- Maintaining the ability to perform a system restart.

The 2020/21 Assessment outlined many of these issues and risks posed to the NEM and NSW, including commentary on minimum demand issues (Section 4.1.1.2), system security (Section 4.1.2) and renewable and distributed energy integration (Section 4.1.3.2).

An emerging issue raised by stakeholders was the management of the energy system when there is minimal, or no, sunshine and wind for extended periods, with this generally occurring during winter periods. This phenomenon has been described by the German word '*Dunkelflaute*' (translated as the 'dark doldrums') and in Australia has been referred to as a 'renewable drought'. For example, this situation occurred in South Australia in June when renewable generation dropped from approximately 63% to 8.7% of the total generation.[69] Solutions have been suggested to this, including a geographically diverse renewable generation fleet across the NEM, sufficient interconnection and transmission, storage and dispatchable generation. This issue and solutions are considered as part of the ESB Post-2025 market design (see Section 4.2.1).

Another concern raised again by stakeholders during the meetings with the Panel was the visibility, control and integration of DER. As discussed in the 2020/21 Assessment, it presents security risks in operating the distribution network, particularly operating and restoring local networks under emergency circumstances. DNSPs can to some extent validate the size of PV installations by

[68] AEMO (2021), 2021 NEM Electricity Statement of Opportunities.
[69] Energy Networks Australia (2021), 2021 Energy Insider: It's dark, it's still – it's dunkelflaute.

interrogating smart meter data, however not all installations have smart meters with remote interrogation facilities. The Panel sought to understand whether regulatory settings in NSW could be used to assist better visibility.

The safety regulation of electrical meters, including smart meters, and installation of solar generation is the responsibility of NSW Fair Trading.[70] Guidance on the installation of solar panels provided by NSW Fair Trading states that permission must be granted from the DNSPs prior to the connection of a solar installation to the electricity distribution network. It is also a requirement that PV installations be installed with smart Type 4 (having remote interrogation capability) or 4A meters (in areas with little or no mobile phone coverage).

Inspections of solar installations are being carried out by some local electricity businesses and the Clean Energy Council. The proportion of solar installations being inspected is very small. If either the distributor or the Clean Energy Council find non-compliant installations, such as the installation not being pre-approved, the installation is of a higher capacity than what was proposed or undertaken by non-authorised installers, the owner of the system (householder) is notified and requested to undertake rectification works. NSW Fair Trading is occasionally made aware of non-compliant work via complaints from an electricity customer. In these instances, they will undertake an investigation and take action as deemed necessary following the inspection.

The Panel notes that there needs to be some mechanism to improve access of the DNSPs to obtain the information required for them to validate the size of installations to enable safe and reliable operation of the local distribution network.

4.1.2.2 Large-scale renewable infrastructure in NSW

In NSW, large-scale renewable generation infrastructure for the state is being delivered strategically under the NSW Electricity Infrastructure Roadmap which was released by the NSW Government in November 2020.[71] The implications of this Roadmap for energy reliability and security were discussed in the Supplementary Material of the 2020/21 Assessment.[72]

Since then, work has progressed with the establishment of the Central-West Orana Renewable Energy Zone (REZ) and exhibition of the draft declaration was recently completed.[73] The Registration of Interest process for the New England REZ has been completed, with 34 GW offered by 80 projects (four times the level of interest required to construct the REZ).[74] The New England REZ draft declaration is currently on exhibition.[75]

A Pumped Hydro Recoverable Grants Scheme was also launched in 2021, providing $50 million for early-stage feasibility studies for pumped hydro projects.[76] The objective of the program is to build a pipeline of up to 3 GW of projects that can bid competitively for Long-Term Energy Services Agreements for long duration storage under the Electricity Infrastructure Safeguard.

The NSW Government has also appointed AEMO Services Ltd. as the Consumer Trustee for the Electricity Infrastructure Roadmap. The Consumer Trustee will have a key role in the planning and procurement processes of the Roadmap, including in the authorisation of network infrastructure projects and administering the tender process for Long-Term Energy Services Agreements.

The Panel noted that NSW Government Roadmap work should be coordinated and aligned with the ESB's post-2025 market design work, with an ability for reforms to be harmonised at the national level. The Panel is aware that the NSW Government is already working closely with the ESB to progress Roadmap plans. The underpinning legislation for the Roadmap, the *Electricity*

[70] NSW Fair Trading, Smart Meters.
[71] NSW Government, Electricity Infrastructure Roadmap.
[72] CSE (2020), Assessment of Summer Preparedness of the NSW Energy Market: 2020/21. Supplementary Material
[73] Exhibition of the draft closed on Friday 15 October 2021. NSW Government, Central-West Orana Renewable Energy Zone Draft Declaration.
[74] NSW Government, New England Renewable Energy Zone.
[75] NSW Government, New England Renewable Energy Zone Draft Declaration.
[76] NSW Government, Pumped Hydro Recoverable Grants Program.

Infrastructure Investment Act 2020, provides for independent statutory roles, with existing capabilities in the NEM currently being utilised in the governance framework of the NSW Roadmap. As mentioned above, AEMO Services Ltd. has been appointed as the Consumer Trustee, and the Integrated System Plan (ISP) would be used to guide investment decisions in the case of a breach of the Energy Security Target.

4.1.3 Accelerated interest in hydrogen production and greater electrification

In the longer term, AEMO forecasts that electricity consumption will grow through the development and connection of new electrical loads. The 2021 ESOO modeling considers four main types of fuel-switching that could grow electricity consumption, these are:

- Hydrogen production – electrolysis could be a large consumer of electricity.
- EVs – vehicle charging. EVs could also play a role in supply by connecting the EV to the grid
- Business electrification – as businesses switch away from fossil fuels (oil, gas and coal)
- Residential electrification – e.g., switching hot water systems and heaters from gas to electric.

These will have an impact of operational demand. For example, the electrification of heating in Victoria could impact the magnitude and timing of operational demand, making the state a winter peaking jurisdiction.

A key driver of hydrogen production and greater electrification will be government policy and strategy that promotes these activities to occur in industry and amongst consumers. In NSW, the two key pieces of work in these areas are the NSW Hydrogen Strategy and Net Zero Plan (See Appendix 5).

4.2 Energy System Planning for the NEM

Across Australia, net zero targets and decarbonisation strategies are currently being pursued on an individual state/territory basis. As is the case in NSW, complementary strategies for delivery of renewable energy infrastructure are also being developed at the state jurisdictional level. A key risk identified by the ESB is that the approaches may become disjointed and create challenges for reforms proposed for the wider NEM. An important piece of work at the national level is the ESB's post-2025 market design, which will address many of the challenges and risks identified by stakeholders in the NEM.

4.2.1 ESB Post-2025 Market Design

The ESB was tasked by the former Council of Australian Governments Energy Council (COAG Energy Council) to advise on design changes required in the NEM as it transitions to an increasingly diverse and distributed generation mix. The Post-2025 Market Design report, delivered to the Energy National Cabinet Reform Committee (ENCRC) in July 2021, sets out reforms and a timetable for their implementation towards the year 2025.[77]

The ESB's work focused on four interrelated pathways.

1. **Resource adequacy and aging thermal generation retirement**

   The objective of this pathway is to support the orderly retirement of the ageing thermal fleet and have sufficient replacement generation in place. To achieve this, investment is needed that provides an efficient mix of generation, storage and demand response, and comes to market in a timely manner so the exit of ageing thermal generation does not cause significant price or reliability shocks to consumers.

[77] ESB (2021), ESB Post 2025 Market Design Final Advice to Energy Ministers.

To achieve this the ESB proposes:

- a Jurisdictional Strategic Reserve that jurisdictions can use to reduce reliability risk as an out of market reserve,
- a set of principles to guide development of any jurisdictional schemes to ensure a common approach, and
- development of a capacity mechanism (the ESB straw proposal is for a decentralised mechanism which is volume based).

2. Essential system services and scheduling and day ahead mechanisms

The objective of this pathway is to ensure that essential system services are properly valued and continue to be provided by the market. With the retirement of thermal generation, several essential services are lost (along with energy) including frequency control, inertia, operating reserves, and system strength – all are essential for the security of the electricity system.

AEMO's current dispatch engine aims to maximise the value of spot market trading by satisfying all energy demand and frequency control ancillary services (FCAS) requirements. This is achieved by co-optimisation of offers in the central dispatch process.

To achieve this the ESB propose, as a long-term reform measure, changes to AEMO's dispatch mechanisms so that the operator can efficiently procure and schedule the essential services on hand that are required for system stability.

3. Integration of Distributed Energy Resources and flexible demand

As the market transitions to net zero emissions, driven by the penetration of renewable energy with effectively zero fuel costs, there is the objective to enable the integration of DER and flexible demand into the market systems. ESB comment that acting now to achieve this integration also provides more far-reaching benefits. Further, getting the energy transition right provides the path to a decarbonised economy, providing economic stimulus.

To achieve this the ESB:

- proposes expanding responsibilities of DNSPs to host distributed generation and storage, and
- comments that changes are needed to make it easier for innovative new retailers and service providers to enter the market (ESB suggests a barrier to entry by these retailers and providers is an inability of such to access data.

4. Transmission and access

AEMO's ISP describes a least cost pathway for new transmission and REZs to meet the needs of the sizeable investment in variable renewable generation that is occurring.

ESB comment that work needs to be undertaken to further facilitate 'actioning the ISP' at the national level. The Panel notes that the NSW Electricity Infrastructure Roadmap, released in December 2020, sets out development of REZs in NSW. Specific policy development is underway for NSW.

The ESB highlights that once the new transmission and REZs are developed, congestion on the grid is expected in some places and/or times. This congestion needs to be managed.

The objective of this pathway is to deal with the challenges that are emerging in getting the new transmission projects built in a timely manner, and the costs of investing too late can be substantial for consumers.

To support the integration of REZs, to achieve this the ESB recommends Energy Ministers agree to the following reforms:

- adopt rules and principles for an Interim REZ framework, and
- instruct the ESB to prepare rule change to progress a congestion management model.

On 24 September 2021, the ENCRC provided support for the reforms proposed by the ESB. The recommendations were presented to National Cabinet and agreed on 1 October 2021. The agreed reforms included:

- adoption of principles for jurisdictional investment schemes
- the option of a ministerial lever for the T3 instrument under the existing Retailer Reliability Obligation
- progression of a Distributed Energy Resources (DER) Implementation Plan
- adoption of a Ministerial lever for emergency backstop measures for minimum load conditions
- enhancements to the transparency of generator availability
- implementation of a jurisdictional strategic reserve
- progress further design work on a Capacity Market and a Congestion Management model.
- transmission reforms including interim framework for REZs

The ENCRC established a set of 14 principles to guide the Capacity Mechanism development.[78] The objective of the work is to develop the design for a market mechanism that ensures investment in an efficient mix of variable and firm capacity that meets reliability at lowest cost, noting that:

- Jurisdictions can derogate from the National Electricity Rules (NER) if they wish, following the process set out under the National Electricity Law (NEL)
- The Australia's Emissions Projections 2020 report anticipates reductions in the NEM of approximately 50% on 2005 levels by 2030, driven by increased levels of renewables and the closure of coal-fired generation, with further reductions expected beyond 2030.

The Panel notes that the NSW Electricity Infrastructure Road Map was released prior to finalization of the ESB report and further work is being done to examine alignment. For example, with development of the Capacity Mechanism, incumbent generation assets, and timely access for new entrants.

The AEMC are scheduled to report on the review of the Reliability Standard and Settings in April 2022 but anticipates this will be delayed. This work needs to be done in conjunction with ESB's work on a Capacity Mechanism and Operating Reserves.

The Reliability Standard is determined by balancing the costs of meeting demand against the value that customers place on power system reliability. The Reliability Settings include the Market Price Cap, Cumulative Price Threshold, the Administered Price Cap, and the Market Floor Price. The reforms being progressed as part of the Post-2025 Market Design work, particularly the work on the Capacity Mechanism, will be relevant to investment decisions and have an impact on analysis and decisions in respect of the Standard and Settings.

4.2.2 Grid Resilience: Stand Alone Power Systems (SAPS) and microgrids

In the context of a changing climate, it is expected that electricity networks will have to withstand increased physical pressures from extreme heat and more frequent severe weather events. A taste

[78] https://energyministers.gov.au/news/principles-guide-capacity-mechanism-development-0

of these conditions was experienced in the NEM during the 2019/20 summer. Resilience of the network elements will be paramount to ensuring energy reliability and security for customers.

Previous reports from the Panel have recognised that decentralised electricity systems are increasingly being demonstrated as an option to enhance overall electricity reliability and security in emergency situations and/or rural locations. For example, the Panel noted that "*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*."[79] The realisation of systems such as Stand Alone Power Systems (SAPS) and microgrids is enabled via the increased intelligence in the energy and associated data systems, and the advancements in small- to grid-scale storage and generation.

The AEMC recommended a three-tier approach for the regulation of third-party SAPS in their 2019 report[80], as this framework would account for the variation in customers and their associated needs (and thereby complexities required):

- Category 1 SAPS are larger microgrids (i.e., city or large town) that would allow a number of competitive generators to be involved and, therefore, should be subject to the current rules and regulatory determinations by the AER.
- Category 2 SAPS would be smaller microgrids that should be subject to a comprehensive licensing process in order to protect all participating customers and provide an energy supply experience (reliability, security, resilience) comparative to other models (such as current grid connections). This is because retail competition would be unlikely at this size, and therefore it is expected that this category would be formed by vertically integrated entities.
- Category 3 SAPS would be microgrids with either very few customers or, alternatively, only large customers (where there are independent power systems (IPS) that involve the sale of energy). This category would be regulated via jurisdictional exemptions and/or licences, whilst also having a view towards the obligations for customer protections and safety operation of the network.

Developments in SAPS since the last Assessment include agreement, in principle, by the Energy Ministers to amendments in national energy laws that would support DNSPs in the efficient delivery of SAPS. Following this, the *Statutes Amendment (National Energy Laws) (Stand-Alone Power Systems) Bill* was introduced in the South Australian Parliament (November 2020).[81] This built upon the AEMC rule change package in 2020, examining the amendments that would be required to the National Energy Rules (NER) and National Energy Retail Rules (NERR). The consultation period closed in April 2021, with a final rule change package expected in November 2021.

In their submission to this consultation process, the AER note that they are "*currently reviewing [their] ring-fencing framework in anticipation of the SAPS legislation and rules changing… are exploring amendments to [their] ring-fencing guideline that provide additional flexibility for a distributor to provide this service*".[82] Findings from this review are also expected in November 2021.

In talking to stakeholders, the Panel noted Endeavour Energy's proposed Bawley Point microgrid as a progression in microgrid systems in the NEM. The Bawley Point to Kioloa region is geographically isolated with dense bushland surrounding, resulting in a heightened risk to electricity services in bushfire situations for the ~1,030 customers connected to the network.

[79] CSE (2020), Assessment of Summer Preparedness of the NSW Energy Market: 2020/21, pg. 7
[80] AEMC (2019), Review of the regulatory frameworks for stand-alone power systems.
[81] Commonwealth Government (15 March 2021), Stand-Alone Power Systems Legislative Amendments – Consultation on Revised National Electricity Rules and National Energy Retail Rules
[82] AER (6 April 2021), Submission to the Stand-alone power systems – consultation on revised National Electricity Rules and National Energy Retail Rules

Further, the region is home to an equestrian park and tourist-orientated businesses such as caravan parks and shops, with Endeavour Energy noting that in holiday periods the approximate energy load can increase by up to four to five times above normal. The intent behind the Endeavour Energy proposal is to orchestrate the DER components (generation, such as the equestrian parks solar array or rooftop PV; storage at the residential or grid level via a community battery; and customer loads) to optimise the use of these assets and allow the system to functionally operate in an islanded state if upstream connection to the grid is interrupted.

Further, Ausgrid is currently trialling SAPS in the Greater Hawkesbury, Hunter and Upper Hunter regions and has undertaken preliminary research in March 2021.[83] The trials metrics are around the delivery of cost savings to customers, the provision of a safer network (to customers and employees alike), testing reliability and resilience in remote locations (particularly from extreme weather events) and to support the transition to renewable energy generation. Early feedback from customers indicated their comfort with DNSPs providing SAPS solutions, and that their interest in SAPS stemmed from improved reliability and protection from increasing impacts from storms and bushfires. The third DNSP in NSW, Essential Energy, is also undertaking SAPS trials across their network and has indicated that, once the SAPS Regulatory Framework is finalised, they will install SAPS to address the fringe-of-grid, low-resilient and high-cost-to-serve areas of their network (based on modelling outcomes).[84]

4.3 Understanding and working with a complex grid

4.3.1 Network Models

AEMO notes in its 2021 ESOO notes that by 2025 there will be periods of time when all customer demand could be met by 100% instantaneous renewable generation. With this transition, the grid is also evolving in complexity incorporating more digital controls and systems. This will bring new operational conditions and AEMO needs to enhance its toolkit to manage the operation of the power system.

Currently, AEMO uses PSS®E software[85] as its primary tool for analysing the power system and for connection studies. PSS®E can be used to perform a variety of analysis functions including power flow, dynamics, short circuit, contingency analysis, optimal power flow, voltage stability, transient stability simulation. PSS®E was developed for systems comprising synchronous machines. As the system develops with a high proportion of renewable generation (non-synchronous machines), power system simulation models need to be developed that can handle wind and solar dynamic models.

AEMO's Engineering Framework is focused on delivering a roadmap to enable a secure and efficient energy transition.[86] Potential operational conditions have been developed through consultation with stakeholders. These conditions are generation mix and loading combinations 5 to 10 years in the future that necessitate changes to current operational practices.

By October 2021, AEMO is scheduled to identify gaps and opportunities and by early 2022 develop implementation workplans for priority action. The Engineering Framework program of work will interact with other AEMO processes such as the 2021 Network Support and Control Ancillary Services Review (Oct-Dec 2021), the 2021 System Strength and Inertia Report (Dec 2021) and the Draft 2022 ISP (Dec 2021).

AEMO is further developing its system simulation tool which includes HYPERSIM, a state-of-the art Electromagnetic Transient (EMT) real-time power system simulation platform. With the transition to more inverter-based generation, these generators operate differently compared to synchronous

[83] Ausgrid, Stand Alone Power Systems; In your Community (viewed 21 October 2021)
[84] Essential Energy, Stand-alone Power Systems (SAPS) (viewed 21 October 2021)
[85] Siemens, PSS®E – high-performance transmission planning and analysis software.
[86] AEMO, Engineering Framework.

plant. EMT models, such as EMTDCTM, can more accurately analyse power system behaviour. However, studies using these EMT models can take hours to complete. This redeveloped simulation tool using HYPERSIM will allow AEMO to conduct these studies in minutes (and also protect the privacy of other participants proprietary information) and thus allow AEMO operators to quickly analyse power system conditions.

Comment has been made by developers of renewable generation projects that they need access to system models to better inform their planning and risk assessments. Connection applicants currently provide data and models of their proposed generating plant to AEMO, and AEMO undertakes system modelling to determine impacts on the power system and any constraints and connection requirements. AEMO's system model contains confidential data and proprietary models of other generating units. Connection applicants undertake several iterations with AEMO to refine their project and complete the connection process.

In a joint initiative with ARENA, AEMO is developing a 'Connections Simulation Tool' which will provide access to wide-area models equivalent to those used by AEMO. Confidentiality of data and proprietary models of other generators will be maintained. This tool is to be available to connection applicants to use and through using a full power system model it will enable them to better design their generating system for specific grid locations. This will reduce the iterations required with AEMO. The project timeline is:

- Q3/4 2021 – Connections Simulation Tool Trials
- Q4 2021 – Connection Simulation Tool V1 Release. Simulation of network conditions using PSCAD™ available to a set of users
- Q1/2 2022 – Connections Simulation Tool V2. This is to include HYPERSIM as an alternative platform that applicants can utilise

AEMO is also working with UNSW Sydney and Solar Analytics on a three-year project funded by ARENA to provide insights into the optimal management of rooftop solar and other distributed energy resources on the broader electricity network.[87]

4.3.2 Future workforce

The energy sector is going through a rapid period of change, as demonstrated by the large body of work currently being undertaken to support the transformation of the NEM. The Panel was interested in stakeholder views on whether the industry will have access to all new skills required to cope with a more complex power system, including expertise in power engineering, data and analytics. The range of feedback is summarised below:

- Graduate quality has been high.
- There is concern about skill shortages from trade level through to higher skilled qualifications, including in power systems engineering.
- There are examples of electricity assets which are not being used to their full potential because of a lack of skill required.
- Access to overseas expertise through migration has been limited due to recent international travel restrictions, and due to a long-term reliance on skilled migration, time will now be required to build internal expertise.
- Cultivation of local talent will be beneficial, as solutions for the new grid are likely to be developed by us, rather than overseas.
- The sector is both a big data generator and consumer. Study of quantitative methods needs to be encouraged in order to achieve potential of using data for decision making.

[87] AEMO (1 June 2021), Modelling Distributed PV to improve Power System Security.

- Declining attractiveness of power engineering courses compared to newer fields such as quantum engineering and information technology. However, some of these areas such as artificial intelligence can be useful in certain analytical areas needed in the future (e.g., the abovementioned enhancement of situational awareness).[88]

Recognition of the volume and nature of workforce development required for the sector is reflected in an Opportunity Assessment[89] released by the Reliable, Affordable, Clean Energy (RACE) for 2030 Cooperative Research Centre (CRC) in October 2021. The report has proposed two Work Packages for the CRC in relation to workforce and skills development.

Work Package 1: Market size, workforce and employment

Findings from the report include the need to:

- Develop a methodology for quantification of energy sector workforce needs
- Perform an occupational breakdown and skills audit for several sub-sectors
- Conduct workforce projections for the energy sector
- Update standard classification codes for energy-related industries and occupations.

Work Package 2: New skills development

Findings from the report include the need to:

- Perform a stocktake and mapping exercise of existing tertiary education and training
- Identify future occupation and skills, mapped to align with net zero pathways
- Understand skills needs for fossil fuel workers
- Focus on industry attraction for graduates and other entrants
- Create pathways for developing cross-cutting skills
- Understand the digital skills uplift required in the sector.

Recommendations in the report address these findings, with projects established to progress the required work. Many of these are expected to complete by December 2022.

Other key relevant reports in the area of Australian energy sector workforce development include:

- Institute for Sustainable Futures report *Renewable Energy Jobs in Australia: Stage 1*[90]
- *Workforce Development Plan for the Tasmanian Energy Sector (Stage 1)*[91]
- Energy Skills Queensland Discussion Paper: *A Changing Electricity Industry, A Changing Workforce*[92]

It will be important for the NSW Government to ensure that appropriate workforce development, higher education and training policy, strategy and programs are in place to support the accelerating energy sector transition in NSW, through the Electricity Infrastructure Roadmap, Net Zero Plan and Hydrogen Strategy initiatives, and more broadly across the NEM.

[88] It can be argued that the skills in system modelling, dynamics and control which overcame the problems of wide-area interconnections in the 1960's (poor damping, self-excited oscillations needing stabilisers) might still be needed as we face a similar situation with new dynamics, now faster and more granular down to households; these skills were available as courses in those areas were popular then having helped put people on the moon for a start, but now student interest is less in those areas.
[89] RACE for 2030 (2021), E3 Opportunity Assessment: Developing the future energy workforce - Final Report 2021.
[90] Briggs, C., Rutovitz, J., Dominish, E., Nagrath, K. (2020), Renewable Energy Jobs in Australia – Stage 1. Prepared for the Clean Energy Council by the Institute for Sustainable Futures, University of Technology Sydney.
[91] Tasmanian Government (2020), Workforce Development Plan for the Tasmanian Energy Sector (Stage 1).
[92] EnergySkills Queensland (nd), A Changing Electricity Industry, A Changing Workforce: A Discussion Paper on the Future Skilling Implications of the Smart Grid.

Acronyms

Acronym	Complete Term
AEMO	Australian Energy Market Operator
AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
ARENA	Australian Renewable Energy Agency
ATS	Automatic transfer switch
BOM	Bureau of Metrology
CCGT	Combined cycle gas turbine
COVID-19	Coronavirus Disease 2019
CSE	NSW Chief Scientist & Engineer
DER	Distributed Energy Resources
DNSP	Distribution Network Service Provider
DPIE	Department of Planning, Industry and Environment
EAAP	Energy Adequacy Assessment Projection
ENCRC	Energy National Cabinet Reform Committee
ESB	Energy Security Board
ESOO	Electricity Statement of Opportunities
ESV	Energy Safe Victoria
EUSFA	Energy and Utilities Services Functional Area
EUSFAC	Energy and Utilities Services Functional Area Coordinator
EV	Electric Vehicle
FCAS	Frequency Control Ancillary Services
FUM	Forecast Uncertainty Measure
GEAR	Government Energy Action Response
GW	Giga Watts
HSC	Higher School Certificate
JIMS	Joint Information Management System
JSSC	Jurisdictional System Security Coordinator
IRM	Interim Reliability Reserve
IPART	Independent Pricing and Regulatory Tribunal
ISP	Integrated System Plan
LGA	Local Government Area
LOR	Lack of Reserve
MT-PASA	Medium Term Projected Assessment of System Adequacy
MW	Mega Watts
NEM	National Electricity Market
NER	National Electricity Rules
NGESO	National Grid Electricity System Operator
NSPs	Network service Providers
NSW	New South Wales
OCSE	Office of the Chief Scientist & Engineer
POE	Probability of Exceedance
PSN	Public Safety Network
PV	Photovoltaics
QNI	Queensland to NSW Interconnector
RERT	Reliability and Emergency Reserve Trader
REZ	Renewable Energy Zone
SAPS	Stand Alone Power System
SCADA	Supervisory Control and Data Acquisition
ST-PASA	Short Term Projected Assessment of System Adequacy
TNSP	Transmission Network Service Provider
TELCOFAC	Telecommunications Services Functional Area Coordinator
USE	Unserved Energy
VDR	Voluntary Demand Response
VNI	Victoria to NSW Interconnector

VRE	Variable Renewable Energy

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 – Scope of Assessment 2021/22

2021-22 Summer Preparedness Assessment Scope Background

The NSW Government is seeking expert advice from the NSW Chief Scientist and Engineer (OCSE) on risks within the National Electricity Market (NEM), especially in relation to the 2021-22 summer period. This will build on the work of national bodies and focus on opportunities for the NSW Government to take further action to maintain the reliability of supply in the State.
In 2018, 2019 and 2020, the OCSE chaired a panel to assess the adequacy of NSW's summer preparedness in relation to the energy market and associated emergency management functions. The panel considered the risks, responsibilities, controls and coordination arrangements the NSW Government had within the energy market and emergency management functions. The 2018, 2019 and 2020 OCSE panels concluded that NSW was well prepared for the approaching summer periods.

In conducting its summer preparedness assessment, the OCSE consults with the Australian Bureau of Meteorology, the Australian Energy Market Operator (AEMO), the Australian Energy Market Commission (AEMC), Australian Energy Regulator (AER), Energy Security Board (ESB), network operators and generators.

Terms of Reference

The 2019 OCSE Summer Preparedness Assessment Terms of Reference (TOR) was developed in 2019 and was intentionally designed, reviewed and approved to be valid until 2023 to enable annual engagement of the OCSE for summer preparedness assessments. To maintain validity of the TOR until 2023, clause 2.c. as outlined below was designed into the 2019 TOR to enable any additional risks or scope of works to be included in annual engagements with OCSE:

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. *c. identifies any emerging risks for NSW and makes recommendations on actions to address any vulnerability identified.*

Scope of 2021-22 Summer Preparedness Assessment

OCSE will provide advice and recommendations to the NSW Government on risks within the NEM, especially in relation to the summer 2021-22 period. This will build on the work of national bodies and focus on opportunities for the NSW Government to take further action to maintain the reliability of supply in the State.

OCSE will synthesise work undertaken by 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.

OCSE will also consider national measures, ongoing work by AEMO and other market bodies, and current NSW Government actions, to address energy reliability and security risks. This assessment builds on previous OCSE 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.

OCSE will identify any emerging risks for the 2021-22 summer and make recommendations on actions to address any vulnerability identified. OCSE will also examine opportunities for enhanced working relationships between AEMO, TransGrid and the NSW Government regarding energy emergencies.

In addition, OCSE will account for market developments, ongoing monitoring and work from national bodies, including updates to AEMO's ISP and ESOO.

For the 2021-22 Summer Preparedness Report, the three risks below have been identified for consideration by OSCE which is enabled by the 2019 OCSE TOR under clause 2.c. and is outlined below:

1. COVID-19 impacts on the energy market, including AEMO demand forecasting through the summer period with more people potentially working from home and the preparedness of the NSW energy market with a shift in energy demand.

2. Transition from summer preparedness to situational preparedness, including year-round energy emergency preparedness and assessment of the energy system resilience to higher degrees of variability and evolving energy demand profiles.

3. Energy & Utility Services Functional Area (EUSFA) preparedness and response to AEMO Lack of Reserve (LOR) notifications including:
    a. Triggers for information flow between the Jurisdictional System Security Coordinator and EUSFA;
    b. Engagement between EUSFA and the AEMO Liaison Officer upon receiving LOR notifications (at a certain threshold – LOR 2 for example); and
    c. Time based guidelines with regards to preparedness and response measures upon receiving an LOR notification and the actual forecasted LOR period.

In undertaking this work, an expert Panel as well as staff selected by OCSE will consult with, and consider work being undertaken by, the NSW Government and other relevant organisations including TransGrid, AEMO, AER, AEMC and ESB.

The OCSE Panel is to provide the 2021-22 Summer Preparedness Assessment report by 31 October 2021.

Appendix 3 – Stakeholder Engagement

Table 10: List of stakeholders

Name/Organisation
AGL
Ausgrid
Australian Energy Market Commission (AEMC)
Australian Energy Market Operator (AEMO)
Australian Energy Regulator (AER)
Bureau of Meteorology (BOM)
CWP Renewables
Delta Electricity
Edify Energy
Endeavour Energy
Energy Security Board (ESB)
EnergyAustralia
Essential Energy
Independent Pricing and Regulatory Tribunal (IPART)
NSW Department of Planning, Industry and Environment NSW Energy and Utilities Functional Area (EUSFA) Energy Division NSW Electricity Infrastructure Roadmap team
NSW Fair Trading
NSW Health, Environmental Health Branch
NSW Telecommunications Authority
Origin Energy
Queensland Government
SafeWork NSW
Snowy Hydro
Tomago Aluminium Company
TransGrid
Victorian Government

Appendix 4 – Deeside Power Station: System Services

The Deeside Power Station is a 498 MW gas-fired combined cycle (CCGT) power station in Wales.[93] The station was been shut down and placed in preservation (mothballed) in March 2018.

The station originally consisted of:

- two gas turbines
- two heat recovery steam generators
- and a steam turbine

A schematic of a CCGT is shown in Figure 17.

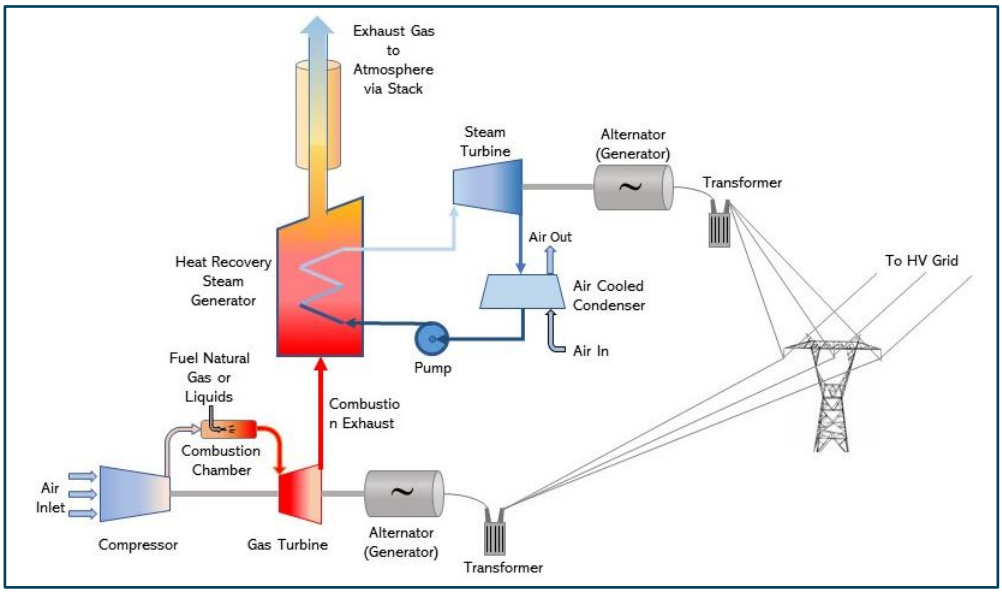


Figure 17: Schematic of a CCGT

Redevelopment work to repurpose the gas turbines (compressor and turbine) began in March 2020 with specialist new turbine blocks installed. A schematic of a repurposed CCGT is in Figure 18. The hatched area in a repurposed station could be put in mothballs or totally decommissioned.

[93] https://www.nationalgrideso.com/news/deeside-power-station-begins-world-first-power-system-stability-contract-national-grid-eso

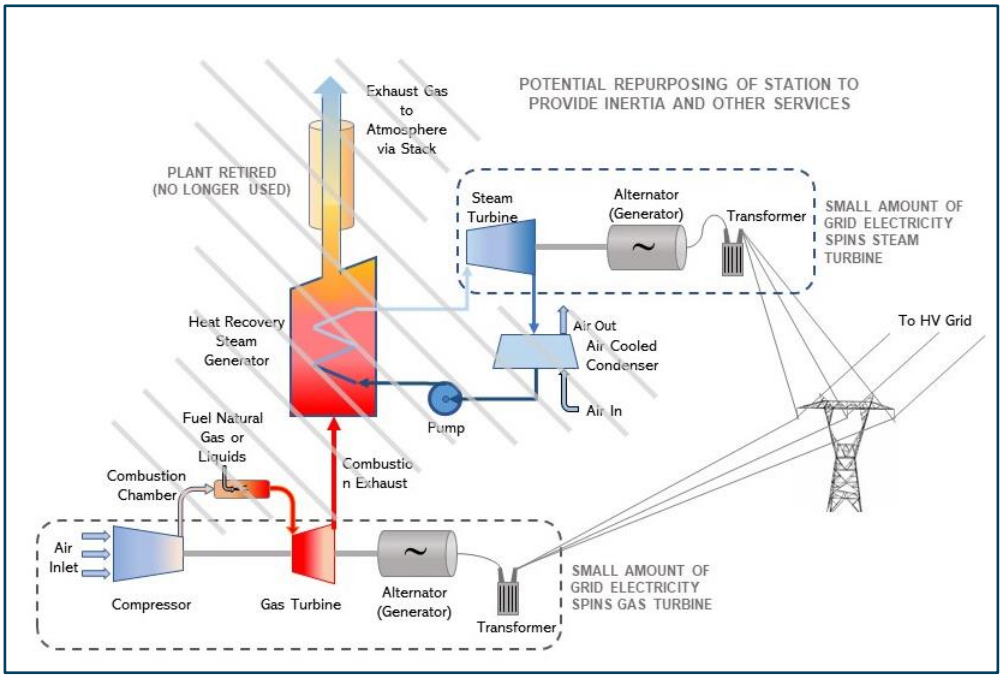


Figure 18: Schematic of the repurposed CCGT

At Deeside, a small amount of electricity is used from the grid to spin the rotors (compressor, gas turbine and alternator) to provide system support services including inertia and reactive power (to control voltage levels). These services were traditionally a by-product of the kinetic energy in the spinning parts of large traditional power stations.

On Friday 18 June 2021, the two gas turbines at the Deeside Power Station began providing inertia and reactive power under a six-year stability contract awarded in January 2020 by the National Grid Electricity System Operator (NGESO). Triton Power, the owners of the repurposed Deeside Power Station commented that it was satisfying to see the same assets reused in a way that enables the energy transition and can be considered recycling in its purest form. NGESO also commented that innovations, like that which occurred at Deeside, were cheaper and greener than the alternative of building new facilities to provide the services.[94]

The NGESO under its 'Stability Pathfinder'[95] has created a market for inertial and other stability services and has procured the equivalent of around five coal-fired power stations worth of inertia through a number of facilities including the Deeside repurposing, synchronous condensers, rotating stabiliser synchronous machines, hydro-electric pumped storage plant and rotating grid stabilisation technology.

[94] https://www.nationalgrideso.com/news/deeside-power-station-begins-world-first-power-system-stability-contract-national-grid-eso
[95] https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability

Appendix 5 – NSW Government Plans and Strategies

NSW Net Zero 2050 Plan

The NSW Government released its Net Zero Plan Stage 1: 2020-2030 in March 2020.[96] This Plan set outs the initial steps for NSW to reach its goal of net zero emissions by 2050 and covers several sectors including energy, electric vehicles, hydrogen, primary industries, organic waste and carbon financing. The Net Zero Plan complements the NSW Electricity Infrastructure Roadmap.

The Plan has four priorities:

1. *"drive the uptake of emissions reduction technologies that also support economic growth, or reduce cost of living or doing business*
2. *empower consumers and businesses to make sustainable choices*
3. *invest in the next wave of emissions reduction innovation to ensure economic prosperity from decarbonisation beyond 2030*
4. *ensure the NSW Government leads by example."*[97]

The Plan covers several sectors including the energy, electric vehicles, hydrogen, primary industries, organic waste and carbon financing. The Net Zero Plan complements the NSW Electricity Infrastructure Roadmap.

Since the announcement of the Plan there have been a number of programs and plans announced. These are summarised below.

- In March 2021, the NSW Government announced $750 million in funding for the Net Zero Industry and Innovation Program. The Program has a focus on opportunities to reduce emissions across NSW industry and businesses, these areas include:
    - Clean Technology Innovation – guided by the OCSE Decarbonisation Innovation Study[98] this focus has six streams of work[99]:
        - Clean technology research and development grants[100]
        - NSW Decarbonisation Innovation Hub[101]
        - Research development and commercialisation infrastructure grants
        - Grants for commercialisation and pilots
        - Low emissions standards
        - Unlocking sustainable finance
    - New Low Carbon Industry Foundations – including enabling infrastructure, increasing capability for supply chains and fostering clean manufacturing precincts through:
        - Clean manufacturing precincts decarbonisation roadmaps[102] – to help industry sectors shift to zero emissions
        - Developing hydrogen hubs for NSW
    - High Emitting Industries – funding for major plant and equipment upgrades to enable emission reductions.

[96] https://www.environment.nsw.gov.au/topics/climate-change/net-zero-plan
[97] DPIE (2020) Net Zero Plan Stage 1: 2020-2030
[98] https://www.chiefscientist.nsw.gov.au/independent-reports/decarbonisation
[99] https://www.energysaver.nsw.gov.au/reducing-emissions-nsw/net-zero-industry-and-innovation
[100] https://www.environment.nsw.gov.au/funding-and-support/nsw-environmental-trust/grants-available/clean-technology-research-and-development
[101] https://www.chiefscientist.nsw.gov.au/science-in-nsw/nsw-networks/decarbonisation-innovation-hub
[102] https://www.energysaver.nsw.gov.au/reducing-emissions-nsw/net-zero-industry-and-innovation/clean-manufacturing-precinct-decarbonisation-roadmaps

- In June 2021, the NSW Waste and Sustainable Materials Strategy 2041 – Stage 1: 2021-2027 was released.[103] The Strategy supports NSW transition to a circular economy reducing waste and emissions.
- In June 2021, the NSW Electric Vehicle Strategy was released.[104] The Strategy includes a range of incentives to support the uptake of EVs including changes to stamp duty for EVs, transitioning the NSW Government fleet and investment in charging stations.
- On 28 September 2021, the NSW Government released the Net Zero Plan Stage 1: 2020-2030 Implementation Update.[105] The update noted the outcomes to date and committed to a new emissions reduction target from 35% to 50% by 2030.

NSW Hydrogen Strategy

The NSW Hydrogen Strategy[106] was released in October 2021 with the aim of NSW rapidly increasing the scale and competitiveness of clean and green hydrogen to capitalise on the domestic and global opportunities. The NSW Government is providing approximately $3 billion in funding to support this emerging industry.

The Strategy highlights the opportunities that hydrogen could provide for the energy sector. This includes:

- a potential avenue for constrained renewable generation or spare capacity to generate hydrogen
- a fuel source for gas-fired power plants (either currently in a blend with natural gas or the future potential for 100% hydrogen power generation)
- energy storage
- electrolysers providing opportunities for flexible load management and frequency control services
- opportunities in the context of SAPs and microgrids
- providing fuel security for NSW.

The Strategy has specifically called out six electricity sector actions:

- *"Provide funding support for the Tallawarra B power plant to use 200,000 kg of green hydrogen per year from 2025 and support development of the Illawarra hydrogen hub.*
- *Enable innovative hydrogen storage and stationary energy deployment projects in regional NSW to apply for grant funding under our $750 million Net Zero Industry and Innovation Program*
- *Progress state-based regulatory reforms to enable operation of standalone power systems within NSW distribution networks and investigate opportunities for hydrogen energy storage with Distribution Network Service Providers.*
- *Investigate opportunities for hydrogen energy storage and backup power generation in government owned assets.*
- *Share knowledge and data from hydrogen hub deployment projects with National Electricity Market (NEM) regulators to support integration of electrolysers for flexible load management and frequency control services within existing and emerging markets under the NEM.*
- *Incorporate impact of large-scale hydrogen production and use into planning and development of the NSW Renewable Energy Zones."*[107]

[103] https://www.dpie.nsw.gov.au/our-work/environment-energy-and-science/waste-and-sustainable-materials-strategy
[104] https://www.nsw.gov.au/initiative/nsw-governments-electric-vehicle-strategy
[105] DPIE (2021) Net Zero Plan Stage 1: 2020-30 Implementation Update
[106] DPIE (2021) NSW Hydrogen Strategy
[107] DPIE (2021) NSW Hydrogen Strategy, pg. 63

Intrinsically tied to the production of hydrogen in NSW is the forecasted increase in renewable energy capacity, with the Strategy calling out the Electricity Infrastructure Roadmap and the 12 GW of renewables within the REZs as an enabling factor for the 2030 hydrogen targets. Further, the Strategy aims to examine mechanisms to feed into the planning and development of the REZs that will encourage hydrogen production.

EnergyAustralia's Tallawarra B represents one the of the first forays into the electricity generation space for hydrogen in NSW, with the announcement that the project has been given the 'green light' on 4 May 2021[108] as a peaking plant (300 MW) that will be capable of using a blend of natural and hydrogen gas. The proposed AGL gas plant at Kurri Kurri, funded by the Commonwealth Government, is also being designed to be 'hydrogen-ready', with the ability to use hydrogen blended gas and the capability for that capacity to be expanded as hydrogen availability increases.[109]

[108] Energy Australia (4 May 2021), EnergyAustralia gives green light to Australia's first net zero emissions, hydrogen/gas power plant.
[109] Snowy Hydro (2021). Hunter Power Project Response to Submissions.