Chief Scientist & Engineer

Initial Report from the Energy Security Taskforce

NSW Chief Scientist & Engineer

5 May 2017

The Hon Donald Harwin MLC
Minister for Resources
Minister for Energy and Utilities
Minister for the Arts
52 Martin Place
SYDNEY NSW 2000

Dear Minister,

Initial Report of the Energy Security Taskforce

In February 2017 you established the NSW Energy Security Taskforce to provide advice on how NSW manages energy security and resilience, including its readiness, planning, preparation and response capability to extreme events.

On behalf of the Taskforce, I am pleased to submit the initial report of this review. The first phase of this review focused primarily on analysing the security and reliability issues for NSW's electricity system and, consequently, identifying actions the NSW Government should take to ensure that we are well prepared for next summer (2017-18) if faced with similar prolonged hot conditions as seen earlier this year.

The initial report also recommends measures to ensure the state is well prepared in the event of an unlikely but possible emergency that may result in prolonged or widespread energy disruptions.

I would like to acknowledge particularly my Taskforce colleagues, Mr Dave Owens and Dr Brian Spalding; our secretariat; all those interviewed; and those who made submissions and provided information.

Yours sincerely,

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5 May 2017

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EXECUTIVE SUMMARY

The NSW Minister for Energy, the Hon Don Harwin MLC, established the Energy Security Taskforce (the Taskforce) chaired by the NSW Chief Scientist & Engineer to advise on the resilience of the NSW electricity system to changing conditions, particularly climate and extreme weather events, and to examine how well we manage energy emergencies in order to recommend any actions needed to address vulnerabilities.

Most of New South Wales operates within the National Electricity Market (NEM) which commenced in 1998 and which also supplies electricity to Queensland, the Australian Capital Territory, Victoria, South Australia and Tasmania. It generates around 200 terawatt hours of electricity annually, covering about 80% of Australia's electricity consumption (Commonwealth of Australia, 2016).

The electricity market works as a 'pool' where power supply and demand are matched in real time through a centrally coordinated process. The NEM comprises more than 300 generators producing electricity, and a transmission grid made up of five state-based networks and six cross-border interconnectors (AER, 2015).

There is widespread, but not universal, agreement that the NEM has generally worked well to date. However, rising retail electricity prices and several recent events, including the state-wide black out in South Australia on 28 September 2016[1], have intensified scrutiny of the NEM's capacity to adapt to climate change measures and to evolving technological, economic and weather conditions, in order to continue to meet the security, reliability and affordability expectations of the community.

There has been particular discussion about the impact of policies addressing climate change which seek to reduce emissions, such as the Renewable Energy Target. These have led to the technical challenges posed by increasing amounts of intermittent renewable energy sources entering the NEM (such as wind and solar), and the corresponding (and intended) trend towards withdrawal of traditional coal-fired generation which has the characteristics of supplying 'firm' and synchronous power, unlike most of the solar and wind renewable energy generation. These technical challenges can be addressed, the question is more one of price.

The first job of the Taskforce was to examine the nature of the risks to the NSW electricity system to determine if there is a problem. This became particularly urgent after the so called 'hot day' event of 10 February 2017 when, during a heatwave featuring unusually high daily maximum and minimum temperatures over consecutive days, available supply was unable to meet demand. This resulted in a direction being issued by the market operator (AEMO) for Tomago Aluminium smelter to curtail part of its operations to reduce demand during the peak and requests from the Minister for Energy to the public to conserve electricity use. The retirement on 1 April 2017 of the Hazelwood Power Station, which supplied 4% of 'firm capacity' to the NEM, provided further impetus for this examination.

After an initial scoping of the problem, the Taskforce determined that its most urgent task was to advise on issues that need to be planned for immediately to ensure that NSW is well prepared to deal with any possible energy incidents during the coming summer (2017-18). Accordingly, this report focuses on risks posed to the state's energy security by extreme events, and measures the government can take in the short to medium term to lessen the impacts of these.

[1] 80 to 90 % of load capable of being restored had been restored by midnight of 28 September. All customers had supply restored by 11 October 2016 (AEMO, 2017e). The extreme weather event associated with this incident lasted from 28 September to 5 October.

A second report, to be delivered by the end of 2017, will cover issues that need to be addressed to ensure longer-term resilience of the NSW electricity system as we face the challenge of promoting and enabling investment in new firm capacity as part of a major transition of the energy system to low emissions. This second report will also take into account the analysis and recommendations of the Independent Review into the Future Security of the National Electricity Market (the 'Finkel Review') which is expected in mid-2017.

The Taskforce examined a range of data, for example wholesale electricity prices, supply and demand trends, predicted changes in climate and weather conditions, the events of last September in South Australia and 10 February 2017 in NSW, the analyses of these events by the bodies managing and regulating the NEM, and the roles of NEM participants, to assess the resilience of the NSW electricity system in the short term.

In summary, the Taskforce concludes there are several important emerging issues.

There are indications that when demand is very high, generally during hot periods, at times the reliability of generation supply and thus system reserves may not be as high as expected. This leads the Taskforce to question if the market incentives that are supposed to drive reliable supply are operating effectively. In these circumstances in NSW the system can come close to or not be able to meet demand, risking reliability of supply to consumers. However, we note that AEMO is not forecasting that NSW will breach reliability standards.

One indicator of this is the trend in 'lack of reserve' notices. 'Lack of reserve' means that AEMO is predicting that under certain conditions, available supply may not be enough to meet demand. Records show that, since 2009, across the NEM there has been a general decline in the number of actual 'lack of reserve' notices (AEMC, 2017a). However, NSW had a high number of actual 'lack of reserve' notices in 2011 and then very few up to 2017. But already in 2017 a high number of notices have been issued, including the first instance of 'load shedding' directed by the market operator since 2004.

There are a number of things that happen on hot days which combine to create greater risk: demand is high, driven by air conditioning load; thermal generation plant may not be able to operate at full capacity with higher ambient temperatures than the normal temperature ranges for which the plant is designed; there may be limits to generation not usually encountered (for example, environmental limits on cooling water discharge temperatures); wind farm output can be low on hot, still days; and, due to typical increase in air conditioner use as the day progresses, demand is often highest late in the afternoon just when solar PV capacity drops off. In addition to these risks, unanticipated plant failures can occur for various reasons, as seen on 10 February when some expected generation capacity was not available.

It is also conceivable that the closing of Hazelwood will exacerbate this risk. While AEMO has flagged that this reduction in supply capacity in Victoria may lead to reliability standard breaches in Victoria and South Australia for this coming summer, in the absence of any market response (AEMO, 2016k), there are increased risks for NSW (and other states) as existing generators move to replace the supply coming from Hazelwood.

The Taskforce also reviewed predictions of likely changes in climate, in particular, changes in extreme events. Notably, heatwaves are projected to occur more often and last longer. The South Australian blackout also highlighted the impact of hard-to-predict extreme weather conditions such as small tornadoes which pose a high risk to transmission infrastructure.

Another emerging issue relates to energy availability and the ability of generators to deliver more energy, as will be needed to manage the Hazelwood withdrawal (and later the withdrawal of other coal-fired generators; Liddell is slated for closure in 2022, for example).

As a result of the closure of Hazelwood, the approximately 10 TWh of energy that was produced from the station annually will need to picked up from mostly gas or remaining coal-fired plant, significantly testing these plants' capacity factors and fuel requirements. This increased 'strain' on that plant may also decrease the reliability of plant unless adequately planned for.

Although the current AEMO Energy Adequacy Assessment Projection report (AEMO, 2016b) does not indicate any issue in NSW, fuel availability is potentially a significant problem with widespread media coverage of concerns about domestic gas shortages. Coal availability has received less coverage but has been raised with the Taskforce by several generators and large users.

Taking these risks together, it is would appear that there could be a heightened risk associated with more frequent, hotter conditions, the changing generation mix and fuel availability within the NEM. Careful and prudent planning and management in the lead up to the coming summer will be important. The Taskforce is encouraged by AEMO's plans, as enunciated by its new CEO, to examine closely generation resources and reliability in the lead up to next summer.

In this context of possibly heightened risk, the Taskforce then examined how well NSW plans, prepares for, responds to and recovers from potential energy emergencies, including emergency management arrangements that would apply in the event of a widespread and/or prolonged black out. It also considered general risks associated with instantaneous disruptions to electricity supply, often caused by extreme weather events in a localised area. From the analysis to date, these risks appear to be well managed by distributors and emergency services under current arrangements and so are not covered extensively in this report.

The NSW Government, as a priority, should refine emergency management procedures to ensure that we are well prepared to respond to a major energy emergency (for example, a black out of Sydney, Australia's largest city; one covering multiple regions of NSW; or one covering the whole state). Because electricity emergencies are very rare (the last state-wide black out occurred in 1964), planning and response arrangements are less practised and, therefore, require urgent attention in the lead up to summer. This includes reviewing legislative provisions to ensure clear and appropriate powers can be exercised in an energy emergency in a timely manner, and ensuring the most effective governance, planning and communication arrangements are in place and are clearly understood and well-practised.

The NSW Government should lead by example in implementing innovative demand management procedures when high temperature and demand are forecast. The NSW Government can also take a more active role in helping the community and businesses understand how they can contribute to demand management responses when sustained hot conditions are forecast and also how they can be best prepared for a prolonged energy emergency.

RECOMMENDATIONS

The Taskforce makes seven recommendations, which focus on leadership in the COAG Energy Council; fuel availability; and prevention and preparedness for the short-term risks associated with peak demand periods. The Taskforce suggests these recommendations be implemented before the 2017-18 summer. The recommendations, including options for their implementation, are described in more detail in Chapter 4.

Recommendation 1
That the NSW Government, through the Premier and Minister, take a leadership role in COAG and the COAG Energy Council to encourage the states and Commonwealth to have a national policy approach to climate change and the integration of renewables within the National Electricity Market, to safeguard energy security and reliability.

Recommendation 2
That in producing its revised Energy Adequacy Assessment Projections (EAAP) in May-June 2017, AEMO pay particular attention to the generator fuel positions so that the market can see in aggregate if there is sufficient fuel in the system and can anticipate major changes. If the system is tight, this will be visible to participants, policy makers and market agencies, and may incentivise additional fuel contracting or investment in new generation.

Recommendation 3
That Government improve the speed and ease with which it can respond to an energy emergency, including revising legislative provisions where necessary.

Recommendation 4
That Government improve the structural processes underpinning the management of energy emergencies in NSW and ensure a stronger link between energy management and emergency management.

Recommendation 5
That Government improve procedures for operational communications during energy emergencies in NSW, including communication to the public, and ensure these procedures are well-practised.

Recommendation 6
That Government support industry and the community to prepare for, manage, and mitigate risks during energy emergencies, including providing guidance on how to reduce demand effectively during peak periods.

Recommendation 7
That Government establish a working group (including representatives of the Commonwealth and ACT Governments) to develop new protocols for agencies to reduce demand and increase behind-the-meter supply during periods of peak energy use (‘Code Warm’ protocol).

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1 INTRODUCTION

On 21 February 2017 the Minister for Resources and Minister for Energy and Utilities (referred to hereafter as the Minister for Energy) asked the Chief Scientist & Engineer to chair a NSW Energy Security Taskforce (the Taskforce). The Taskforce has been asked to advise the Minister on the resilience of the NSW electricity system in the face of changing conditions, in particular extreme weather events.

Other members of the Taskforce are Mr Dave Owens, former Deputy Commissioner of the NSW Police Force and former State Emergency Operations Controller, and Dr Brian Spalding, a Commissioner with the Australian Energy Market Commission and former Chief Executive Officer of the National Electricity Market Management Company (the predecessor of the Australian Energy Market Operator) and then Executive General Manager Operations of the Australian Energy Market Operator.

This review was requested in the context of events including the heatwave in NSW in February 2017 when available supply was unable to meet demand without curtailments, and the recent state-wide blackout in South Australia. Both of these events highlighted potential risks to energy reliability and security that may be emerging and the need to be well prepared for future energy events or possible emergencies flowing from widespread electricity supply disruption in NSW. Governments across Australia are addressing the challenge of maintaining a safe and reliable electricity market, while reducing emissions and maintaining electricity prices at reasonable levels.

The scope of the work undertaken by the Taskforce is to:

- assess the risks to and resilience of the NSW electricity system (including the transmission and distribution networks), from extreme weather events in the context of a changing climate
- review the adequacy of the State's management of electricity system security events including prevention, preparedness, response and recovery
- make recommendations on actions to address any vulnerabilities identified and/or opportunities for improvements in current practices

The full Terms of Reference for Taskforce are at Appendix 1.

This initial report of the Taskforce has a particular focus on issues that need to be addressed immediately to ensure that NSW is prepared for possible energy risks in the coming summer (2017-18). This brings a particular focus on actions that should prevent incidents from occurring, while ensuring that adequate structures and processes are in place if a major energy emergency was to occur.

The final report due at the end of 2017 will consider broader market issues relevant to the longer-term reliability and security of the electricity system in NSW.

1.1 CONTEXT

This section covers several matters that are part of the current context for issues examined by the Taskforce.

1.1.1 The NSW electricity system and the National Electricity Market (NEM)

Most electricity in NSW is supplied via the National Electricity Market (NEM). The NEM interconnects five jurisdiction-based regions - Queensland, New South Wales (including ACT), Victoria, South Australia and Tasmania (an interactive map is available from the AEMO website (AEMO, 2017b)). The NEM is the longest geographically connected power system in the world.

The NEM commenced in 1998 and generates around 200 terawatt hours (TWh) of electricity annually. It includes four major components – generation, transmission, distribution and users. Electricity is supplied by generators, transported via transmission lines to local electricity distributors or directly to large industrial energy users, and distributors deliver it to homes and businesses through arrangements with energy retailers. The NEM matches supply and demand in real time through a centrally coordinated process.

However, the NEM is evolving/transforming away from a completely centralised supply system to a system where there are increasing amounts of smaller, distributed generation and storage including ‘behind-the-meter’ generation, such as small-scale rooftop solar which within NEM regions now represents a combined capacity of approximately 4.5 gigawatts (GW) (APVI, 2017c). It is anticipated that small-scale distributed generation will be a significant component of the future energy supply.

The NEM is legislated by the National Electricity Law (NEL). The market and power system is operated by the Australian Energy Market Operator (AEMO). It is also responsible for managing power system security and reliability and maintaining key technical characteristics of the system. The NEM is overseen by the COAG Energy Council. The Australian Energy Market Commission (AEMC) provides policy advice and makes the rules and the Australian Energy Regulator (AER) monitors compliance and regulates the non-competitive sectors. A mixture of state-owned corporations and private companies participate in the NEM. In 2014-15 the NEM wholesale market turned over approximately $8.2 billion (AER, 2015).

The COAG Energy Council includes energy and resources ministers from every Australian state, the Northern Territory, the Australian Capital Territory and New Zealand. It is chaired by the Commonwealth Minister for the Environment and Energy. It is charged with overarching responsibility and policy leadership for Australian gas and electricity markets.

The gas market is separate but related to the electricity market in that there are gas-fired electricity generators. Australia’s gas market consists of three regions: the eastern, western and northern gas regions (AEMC, 2017e). AEMC makes and amends the National Gas Rules, which are applied to the northern and eastern gas markets to govern the wholesale gas market and facilitate the provision of gas (AEMC, 2017e). AEMO operates the wholesale gas markets and the physical gas system in Victoria. Separate arrangements are in place for the western market.

An important change to the nature of the NEM and its participants in NSW has been the privatisation of several generators and the recent long-term leasing of major parts of the state-owned transmission and distribution network. The NSW transmission network provider, TransGrid, was leased in 2015 on a 99-year lease. In 2016, 50.4% of the distribution network provider, Ausgrid, was leased on a 99-year lease and leasing of the distribution network provider Endeavour Energy, at 50.4% on a 99-year lease, is planned. Essential Energy remains government owned.

1.1.2 Electricity reliability and security

All aspects of the electricity supply chain need to be managed and maintained in real time to ensure that sufficient electricity is generated and transported to meet consumer demand at any given point in time.

There are two important and related terms that describe essential characteristics of the electricity system – security and reliability.

This report uses the definitions below for these concepts, adapted from the 'Finkel Review' preliminary report (Commonwealth of Australia, 2016):

- a **secure** power system is one that is able to continue operating within defined technical limits, even in the event of the disconnection of a major power system element such as an interconnector or large generator
- a **reliable** power system is one in which there is sufficient generation, transmission and distribution capacity to meet all grid demand. The National Electricity Rules include mechanisms to facilitate a reliable supply. These include a reliability standard that expects that no more than 0.002% (11 minutes in a year) of customer demand within a region goes unmet.

Or, in the definition used by the Department of Premier & Cabinet, energy security and reliability is about having systems in place to ensure that there is:

1. supply balance – physical supply can meet physical demand, including at peak times
2. technical stability – electricity supply is technically stable (e.g. constant frequency and current within narrow bounds)
3. contract certainty – a market that allows suppliers, retailers and consumers to access commercial contracts with price certainty over reasonable periods (2-5 years)
4. vulnerability assessment and emergency coordination - physical risks (especially from extreme weather events) are assessed and managed.

The operational definition of a reliable power system is captured in a 'reliability standard', which sets an expectation that is then used to set market parameters designed to drive investment and maintenance performance. The AEMC Reliability Panel sets the reliability standard which is incorporated into the National Electricity Rules and reviewed by the Panel every four years (AEMC, 2017c). As noted above, the standards for reliability are not set to be 100%. The current standard requires there be sufficient energy generated and/or obtained through the regional interconnectors to meet 99.998% of annual energy.[2] Since 2005 there have only been a few instances of unserved energy (insufficient generation and bulk transmission capacity to meet consumer demand); one incident in Victoria and one in South Australia in 2009 during a period of prolonged high temperatures (AEMC, 2017a). The AEMC (2017a) also notes that there was then another instance in South Australia in February 2017 and AEMO has advised that there was an unserved energy event in NSW on 10 February (AEMO pers comms, 2017, April 28).

The reliability standard does not include instances of demand not being met for security-related reasons or failures of transmission or distribution networks. The level of reliability of the transmission and distribution networks is set by each state and territory government (AEMC, 2017c). In NSW, the Independent Pricing and Regulatory Tribunal (IPART) regulates safety and reliability of transmission and distribution networks. However, the AER has a role in setting allowable rates of return and the amount for capital and operating expenditure for these networks to meet their reliability levels.

[2] "The reliability standard for generation and inter-regional transmission elements in the national electricity market is a maximum expected unserved energy (USE) in a region of 0.002% of the total energy demanded in that region for a given financial year" (NER Clause 3.9.3C).

1.1.3 Emission reduction policies and the challenge they pose in the NEM

The energy system is also influenced by emission reduction policies addressing climate change. These have been reviewed and changed frequently in recent years. There has been considerable discussion in the press about the consequences of uncertainty around the policy direction on emissions reduction in Australia. In this context the preliminary Finkel Review notes that "the lack of clarity about emissions reduction policy beyond 2020 has been a major contributor to the current investment uncertainty in the electricity sector" (Commonwealth of Australia, 2016). The need for certainty and integrated energy and climate policy is emphasised in the NSW Government submission to the Finkel Review (NSW Government, 2017).

Australia is a signatory to the Paris climate change agreement and the Australian Government has committed to reduce emissions 26-28% below 2005 levels by 2030 (Department of the Environment and Energy, 2016). One of the key policies to reduce emissions is the Renewable Energy Target (RET), which has been reviewed and changed several times since it commenced in 2001 (Clean Energy Regulator, 2017). The RET operates independently of the NEM and was established to provide incentives for the uptake of renewable energy and to reduce emissions of the electricity sector (Department of the Environment and Energy, 2015). There has been a range of other policies, bodies and schemes designed to incentivise the development of renewable energy sources and energy efficiency at both industrial scale and small business and residential scale including the NSW Climate Change Policy Framework, the Clean Energy Finance Corporation, the Australian Renewable Energy Agency (ARENA), the NSW Solar Bonus Scheme, the NSW Greenhouse Gas Abatement Scheme, and various national and state based energy efficiency programs.

These policies have driven an intended, significant trend away from coal-fired generators that provide 'firm' and synchronous[3] generation and an increase in variable renewable energy generation which is generally non-synchronous generation. It has also created a change in demand patterns, driven in part by the significant increase in roof-top solar.

These trends in supply and demand have implications for the future reliability and security of the NEM (AEMC, 2017a). In particular:

- **maintaining frequency**: Frequency needs to be maintained at a constant level, which involves matching supply and demand of electricity instantaneously. Imbalances in supply and demand change the frequency. 'Inertia' is needed in the system to manage rapid changes in frequency. Inertia is generally provided by spinning devices (for example, generators and motors) that are synchronised to the frequency of the system (50 Hz). Newer technologies such as solar and wind are generally not synchronised and generally do not contribute inertia, making it more difficult to maintain a secure operating state (AEMC, 2016b)
- **maintaining system strength**: System strength is a measure of the voltage stability of a power system under all reasonable possible loading conditions (AEMO, 2017f). Synchronous generators contribute more to system strength than non-synchronous generators.

[3] "Synchronous generation refers to generation whose operation is tightly 'synchronised' to the operating frequency of the power system. For example, in a power system operating at a normal frequency of exactly 50 Hertz (Hz), or 50 cycles per second, the rotating parts of most synchronous generating units (such as the turbine and rotor) connected to the power system will be spinning in step with the system frequency. Synchronous machines respond exactly in lock step to any changes to power system frequency." (AEMO, 2016d)

In short, the contributions to system stability provided by firm, synchronous generation have long been ‘free goods’. Firm, synchronous generation and its associated services have been plentiful, inherent to the system and not valued separately (although a Frequency Control Ancillary Services (FCAS) market was introduced in 2009); now they are becoming scarcer. The preliminary Finkel Review report notes that non-synchronous “variable renewable electricity generators do not inherently have the characteristics to support and stabilise our electricity system that we have long taken for granted” (Commonwealth of Australia, 2016).This has created a heightened focus on tapping into innovative ways to provide these services by other means.

Also, the increase in renewable energy generation, which is also cheap to dispatch to the market, means that traditional thermal plant is becoming less viable, raising reliability and security issues for the system. The further challenge of increasing levels of ‘behind-the-meter’ generation means that the market does not know how much is being contributed, or from where, except in aggregate and ‘revealed’ through reductions in demand for grid-supplied electricity (AEMO, 2017l).

These challenges are being scrutinised by various bodies, including the AEMC and AEMO through pieces of work focussed on system security, along with increasing discussion of technological solutions such as storage, including through pumped hydroelectric systems.

This report examines these issues and potential risks in the NSW context, where the NEM-wide trends of increasing intermittent generation and withdrawal or de-rating of traditional thermal plant are occurring. A complication in assessing the challenge that emissions reduction policies pose for the NEM is that the incentives within the NEM, apart from the period of the operation of the carbon price, do not directly take account of the externality associated with emissions.

1.1.4 Events of 10 February 2017

One of the drivers for this review was the events of 10 February 2017 in NSW, when eastern Australia experienced a heatwave and NSW experienced an energy supply shortage. Key features of the events of that day are:

- on Friday 10 February, southeast Australia was experiencing a heatwave that had begun around 31 January. One of the features of this heatwave (and others in early 2017) was “unusually high daily maximum and minimum temperatures for at least three consecutive days over large parts of the country” (BOM, 2017h)
- in the days leading up to Friday 10 February, AEMO had issued a series of market notices forecasting that supply may not be sufficient to meet the reliability standard on 10 February. The first of these forecast ‘lack of reserve’ notices was issued on 7 February at approximately 15.00 (AEST). There was a series of additional notices issued through to 10 February
- on 9 February the NSW Minister for Energy appealed to the public to reduce demand voluntarily
- demand peaked at 16.30 (AEST), 10 February at 14,181 MW. This was short of the previous peak demand, which was experienced in February 2011, at 14,744 MW
- actual temperatures were up to 2 °C higher than forecast, with no afternoon cool change
- peak demand coincided with several equipment failures and reduced wind and solar photovoltaic (PV) generation
- some generation that had been expected to be available, was not available when required due to equipment failures at the Tallawarra and Colongra power stations (removing 1008 MW of available generation). There was also reduced output at some coal generators

- after a trip of the Tallawarra generating unit, and the removal of 400 MW from the system, there was overloading of the NSW and Queensland interconnectors as well as the NSW and Victoria interconnector creating an insecure operating state
- following the Tallawarra trip, the system experienced approximately seven minutes of low frequency oscillations
- an actual LOR3 condition (where the actual supply was no longer sufficient to meet demand in a secure manner) occurred at 16.50 (AEST)[4] until 18.26 (AEST), following the Colongra power station failing to start. This was the first actual LOR3 condition in NSW since 2004
- AEMO informed the NSW Responsible Officer (in TransGrid) that it was declaring a Level 4 emergency under the Power System Emergency Management Plan (TransGrid, 2017b).
- AEMO issued a direction to TransGrid to shed load from Tomago aluminium smelter, after attempts to get other generation (Colongra) online failed. Load had already been reduced from Tomago Aluminium prior to this direction (not at AEMO's request), and the AEMO direction was in addition to load that had already been reduced through the retailer and Tomago
- the NSW dispatch price was set to the market price cap ($14,000/MWh) from 17.05 (AEST) until 18.10 (AEST) (AEMO, 2017i).

AEMO has powers of direction through which it can instruct generators to come on line if satisfied that the direction is necessary to maintain or re-establish a secure power system or reliability of supply. This was not seen to be necessary by AEMO on 10 February as its forecasts showed that the available generation combined with the choice of a large retailer to use commercial arrangements with the Tomago Aluminium smelter to reduce load was sufficient to manage power system security. AEMO reports that the acute situation was largely the result of the equipment failures at Tallawarra and Colongra (AEMO pers comms, 2017, April 19).

1.1.5 Related reviews

There are a number of other reviews underway or recently completed which are relevant to the work of the Taskforce. The Taskforce has designed its work program to complement and draw from these other processes, and avoid duplication.

Some of the processes and reviews of particular relevance are:

- the Independent Review into the Future Security of the NEM (Finkel Review). The NSW Taskforce Chair is also a member of the Expert Panel for the Finkel Review
- AEMO's Future Power System Security program
- the AEMC's System Security Market Frameworks review
- Commonwealth Select Committee into the resilience of electricity infrastructure in a warming world, released April 2017 (Commonwealth of Australia, 2017b).
- Commonwealth Standing Committee on the Environment and Energy: Inquiry into modernising Australia's electricity grid
- Commonwealth Senate Environment and Communications References Committee: Inquiry into the retirement of coal-fired power stations, released March 2017 (Commonwealth of Australia, 2017a)
- Commonwealth Climate Change Review 2017, due by the end of 2017
- ACCC Gas Market Transparency Measures Inquiry, announced 19 April 2017
- NSW 2017 State-Level Emergency Risk Assessment (a key input for the Emergency Risk Management Framework)

[4] All times in the report are given in Australian Eastern Standard Time (AEST) as opposed to Summer Time as this is what all AEMO reports use.

- Commonwealth Attorney-General's Department's 'Strengthening the national security of Australia's critical infrastructure' project (Critical Infrastructure Centre, 2017)
- ACCC inquiry into retail electricity pricing, announced 27 March 2017.

1.2 PROCESS OF THE REVIEW

The Taskforce to date has had 9 meetings and 38 stakeholder meetings. It has examined a range of data to assess the resilience of the NSW electricity system in the short-term, including:

- supply and demand trends, including records of forecast and actual 'lack of reserve' conditions, the changing mix of generation types in NSW and the data on generation capacity and dispatch
- wholesale electricity prices
- predicted changes in climate and weather conditions
- the events of 28 September 2016 in South Australia and 10 February 2017 in NSW
- emergency management arrangements in NSW as they relate to an energy emergency.

The Taskforce also examined the roles of NEM participants and recent reports and analyses by AEMO, AEMC and AER.

This initial report of the Taskforce (based on work from February-April 2017) provides advice on the risks that may be relevant in the short term, including the coming summer, and recommends a range of actions that should be prioritised to prevent energy events or emergencies in the near term.

The second report of this Taskforce will take a longer-term view to examine broader market issues relevant to the ongoing reliability of the NSW electricity system, including consideration of the analysis and recommendations from the Finkel Review (Commonwealth of Australia, 2016).

1.2.1 Consultation

To date, the Taskforce has consulted with a number of stakeholders including NEM bodies, generators, transmission network service providers (TNSPs), distribution network service providers (DNSPs), retailers, and relevant government agencies from several jurisdictions, emergency management specialists, Tomago Aluminium Corporation, the Finkel Review, TasNetworks, the Tasmanian Energy Security Taskforce, regulatory bodies, and researchers. A list of meetings undertaken to date is at Appendix 2.

Broader consultation will be undertaken to inform the analysis and recommendations of the final report.

1.2.2 Submissions

The Taskforce has invited interested stakeholders from across government, industry, business and community sectors to make submissions.

The submissions for the initial report were due by 21 April 2017, however additional input from the public after that date will continue to be welcomed. These submissions are being accepted through the website of the NSW Chief Scientist & Engineer.[5]

Sixteen submissions have been received to date.

[5] http://www.chiefscientist.nsw.gov.au/reports/nsw-energy-security-taskforce

Further submissions are welcome which may comment on the content of this report, or focus on issues that should be considered in the final report.

1.3 STRUCTURE OF THIS REPORT

The remainder of this report provides an analysis of the potential risks and vulnerabilities faced in the NSW electricity system, and a review of the arrangements in place for managing energy emergencies, followed by recommendations for priority actions for Government.

Chapter 2 analyses issues of reliability and security in the NSW electricity system, including examining supply and demand balance, the trends in generation sources in NSW, and the potential risks posed by changing climate and extreme weather events.

Chapter 3 reviews current arrangements for preparing for and responding to serious energy incidents, including the relationship between management of the electricity system and emergency management procedures.

Chapter 4 provides recommended priority actions that Government should implement immediately to ensure preparedness for potential risks in the coming summer.

2 CHARACTERISING AND ASSESSING RISKS: HOW RESILIENT IS THE NSW ELECTRICITY SYSTEM?

The Taskforce assessed risks to the resilience of the NSW electricity system in the face of changing conditions with a particular focus on extreme weather events in the context of a changing climate.

This requires examination of both reliability and security of the system, that is, the ability of the system to provide enough supply to meet demand and its ability to continue operating within defined technical limits even after a disturbance.

This chapter considers the trends emerging across the NEM in the NSW context and through the lens of security and reliability of supply in NSW. It examines supply and demand trends for electricity (and briefly discusses gas) in NSW, the generation of electricity in NSW and how that is changing over time, the transmission and distribution network, and the projections for extreme weather in a changing climate. It then examines the implications of these issues for both reliability and security of the system both immediately and in the longer term.

This analysis identifies some immediate issues that are posing some risk now and can be addressed by the NSW Government in collaboration with the market operator and others. In other cases, issues are emerging for the years ahead or are particularly complex and will be examined further by the Taskforce for its next report.

2.1 SUPPLY AND DEMAND IN NSW

NSW generally has sufficient electricity to meet demand, through electricity generated in the state or imported via interconnectors from other states.

The current maximum capacity of approximately 20,000 MW through generators and interconnectors is greater than the historic maximum demand of around 14,000 MW[6]. The amount of electricity dispatched in NSW is generally less than available capacity.

Capacity and demand levels constantly change. Capacity is affected by the status of the generators (e.g. offline for maintenance) and the availability of fuel (e.g. water, sun, wind, coal and gas), and local conditions such as heat which can affect the efficiency of generation. Demand for electricity changes with the time of day, season, temperature and amount of rooftop solar PV. Under certain circumstances there is the potential for supply and demand to be tight, as happened on 10 February 2017.

2.1.1 Generation capacity

In the NEM, NSW generators have ~16,000 MW of nameplate capacity. This generation capacity includes: 15,485 MW from the 24 existing and committed scheduled and semi-scheduled generators (these are generators with aggregate nameplate capacity of >30 MW which operate in the AEMO central dispatch process) and 815 MW from 65 non-scheduled generators (those that do not participate in central dispatch process, generally with aggregate nameplate capacity <30 MW) (AEMO, 2017h). Additionally, there is around 1,400 MW of capacity not traded in the NEM 'behind-the-meter', mainly through rooftop solar PV (956.4 MW from <10 kW systems, 231.7 MW from 10-100 kW systems and 224.7 MW from >100 kW systems) (APVI, 2017b). Based on scheduled, semi-scheduled, non-scheduled

[6] The 14,000 MW represents the required grid supply after behind-the-meter generation has reduced the total consumer load.

and solar roof top PV generation, NSW currently has a generation capacity of around 17,712 MW. This is the maximum capacity - the actual available capacity at any point in time may be less.

As noted above, available capacity in the system depends on a range of factors, including some generators being offline, fuel availability, and local conditions such as the operational temperature of the plant.

Supply and demand for electricity are matched in real time through a centrally coordinated dispatch process managed by AEMO. The generators offer to supply the market with specific amounts of electricity at specific prices, with offers submitted every five minutes. From all offers submitted, AEMO determines the generation required to meet demand most cost efficiently. AEMO then issues dispatch targets to these generators that are obligated to comply.

A mix of generation technologies is used to respond to the fluctuating demand for electricity (AER, 2015). Figure 2.1 shows different types of generation in NSW and the average proportion of registered capacity available for dispatch with the average proportion actually dispatched.

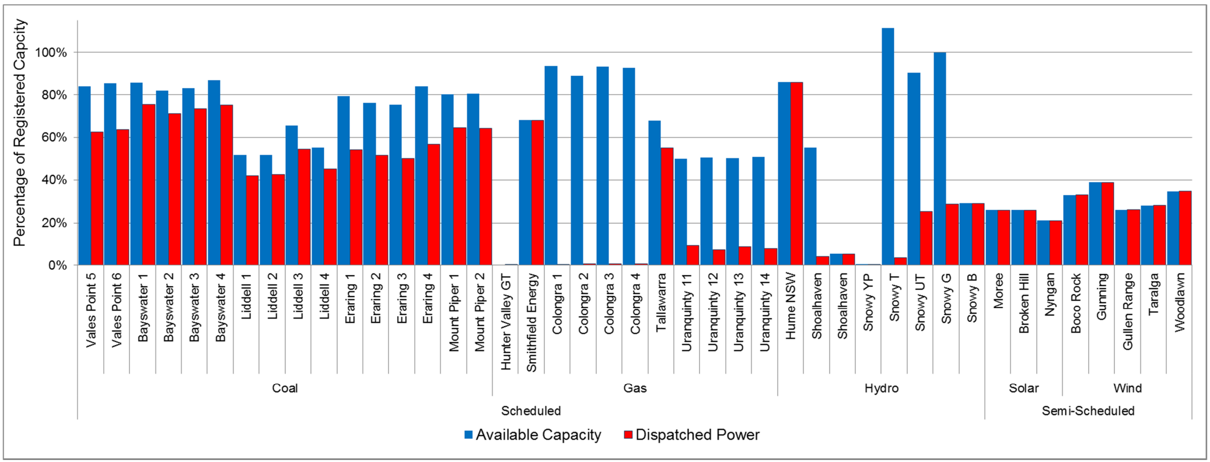

Figure 2.1: Percentage of registered capacity available and dispatched from scheduled and semi-scheduled generators in NSW between January 2013 – February 2017
Figure generated from data provided by AEMO pers comms (2017)

As shown in Figure 2.1, many generators do not generally dispatch all available capacity. However coal generators typically run continuously, due to the high start-up and shut-down costs. Gas and hydroelectric power generators often operate when demand and prices are high. Gas power generation has higher operating costs; however gas generators can quickly change output allowing them to respond quickly when prices are high. Conversely, hydro generation has low operating costs but is limited by the availability of water resources and competing priorities for water (e.g. environmental flows and agriculture), therefore generally only operates when prices are high (AER, 2015).

Intermittent generation, such as wind and solar, only operates with favourable weather conditions (AER, 2015). The low marginal cost of producing electricity with wind and solar, generally means that the capacity that is available is dispatched (Figure 2.1).

2.1.2 Interconnectors

NSW has been a net importer of electricity (Figure 2.2) accessing electricity from Queensland and Victoria through interconnectors. The nominal or rated capacity for import into NSW through the Victorian interconnector is 700-1600 MW; for the two Queensland interconnectors it is 210 MW (Terranora) and 1078 MW (NSW1-QLD1) (AEMO, 2015b).

There are six interconnectors within the NEM. The interconnectors are high-voltage transmission lines that enable the movement of electricity between different regions of the NEM (AEMO, 2017a). Electricity is imported into an adjacent region when demand is greater than can be met by local generators, or when the price of electricity is lower in a connected region to displace local supply (AEMO, 2017a). Figure 2.2 shows interregional trade across the NEM since it began in 1998.

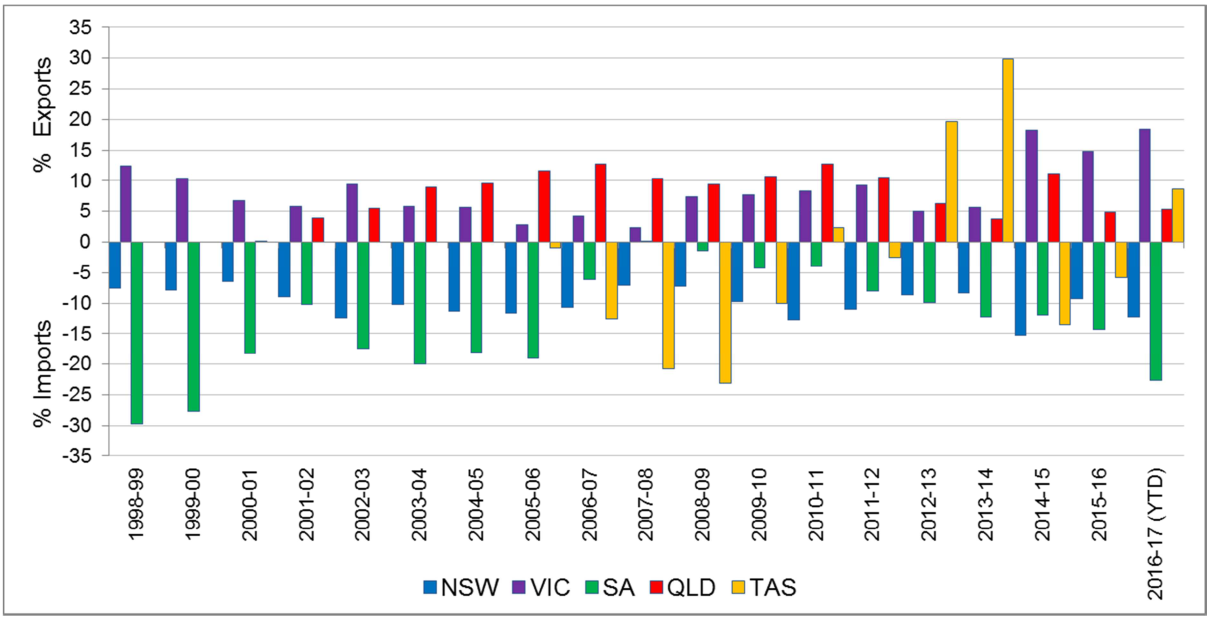

Figure 2.2: Net trading positions of the regions since the NEM commenced
Note: NSW and Victoria regions gained additional hydroelectric peaking capacity following the abolition of the Snowy Region Rule in July 2008. YTD data is current at 31 December 2016. Source: AER (2017a)

The interconnectors into NSW allow flow to and from Queensland and Victoria to match supply and demand across the regions. NSW has relatively high fuel costs, making it a net importer of electricity (Figure 2.2 and 2.3). During 2012-13 and 2013-14 (the years when a carbon price applied) Snowy Hydro significantly increased output, reducing the NSW region's reliance on imports (AER, 2015). AER reports that the abolition of carbon pricing made NSW the NEM's biggest net importer in 2014-15 (AER, 2015).

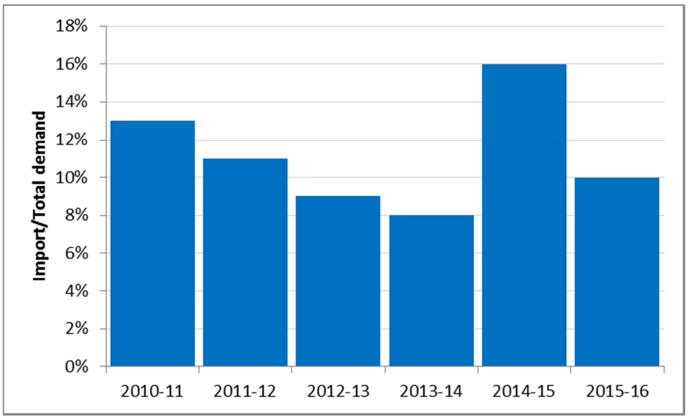

Figure 2.3: Net NSW import as percentage of total demand, through the three NSW interconnectors Terranora, NSW1-Qld1 and VIC1-NSW1.
Source: (AEC, 2016)

The ability of interconnectors to transport electricity is dependent on equipment limits, system stability and in turn on various generation and load levels. Interconnector flow may be limited by constraints within a region or between regions, as well as interactions with local generators and pricing effects (AEMO, 2016g). Physical limits such as network congestion and thermal limits for aspects of the transmission network may constrain the trading levels to below nominal capacity (AEMO, 2016g). The capacity of an interconnector is affected by electricity flow, and may be reduced if generation or load changes in a region (AER, 2012).

2.1.3 Dispatched capacity

Generally, many NSW generators are not operating to their full capacity because mostly there is more generation available than load to use it. Between 2013 and 2017 in NSW the average utilisation has been between 40-48%, and the maximum utilisation has been 65-80% of the generation capacity (Figure 2.4). This indicates that even when dispatch is high, approximately 20% of registered capacity is unused, and on average around 50% unused.

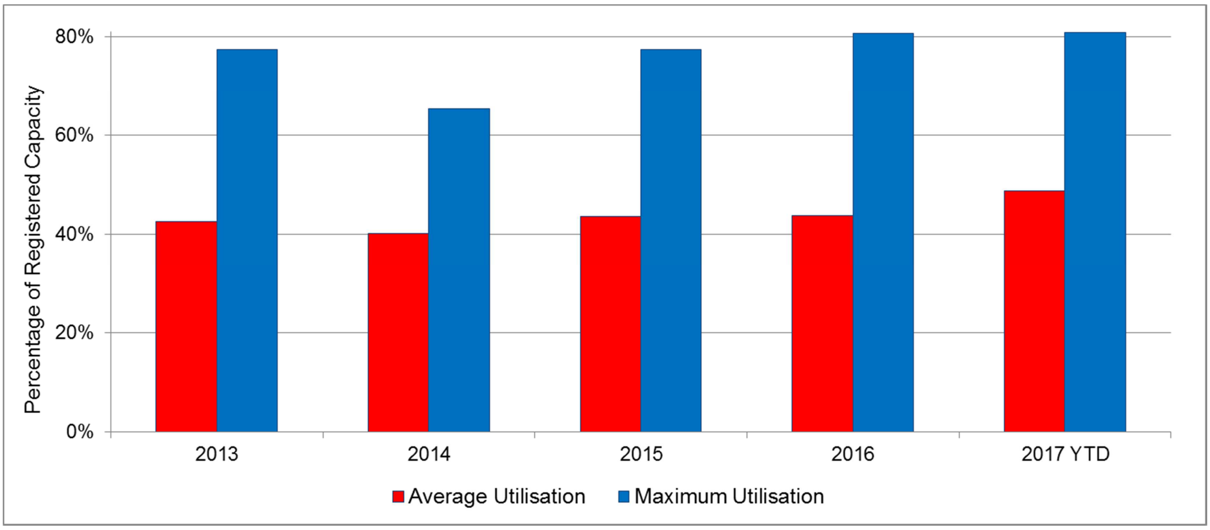

Figure 2.4: Average and maximum generator utilisation in NSW between 2013 – 2017
The utilisation is defined for any 5 min period as the dispatch level/registered capacity for the whole generator fleet. The average/maximum is taken over all the 5 min periods in the year.
Figure generated from data provided by AEMO (AEMO pers comms, 2017)

Figure 2.5 illustrates a comparison between the capacity of the generators at hand (registered generation capacity - average and maximum), the capacity of the generators bid into the market (available generation capacity - average and maximum) and the actual used power of that bid (dispatch (average and maximum)) over a particular year. This shows that average dispatch is generally *much* less than maximum dispatch, which is again generally lower than the maximum available generation capacity.

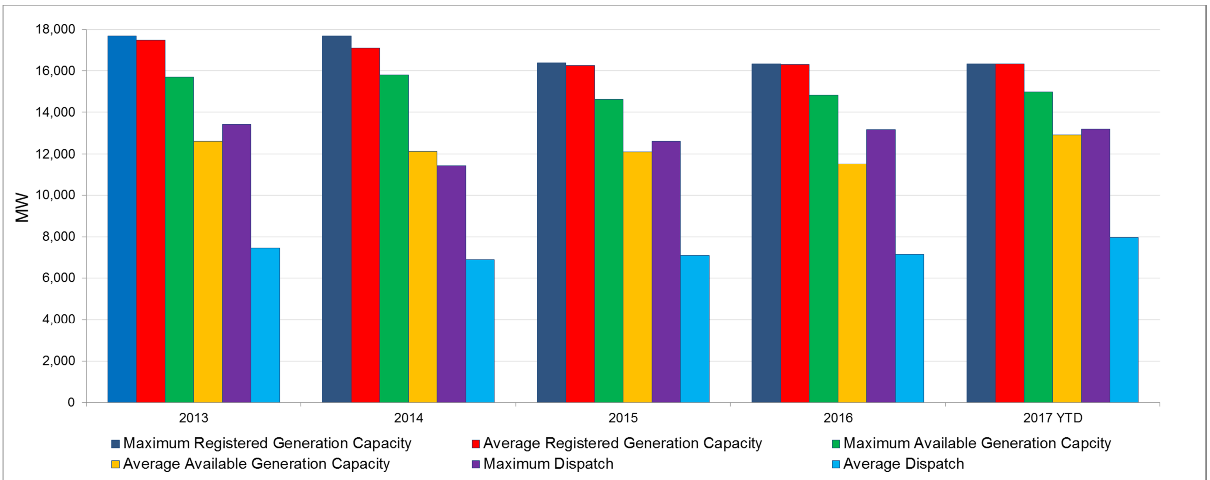

Figure 2.5: NSW generator dispatch and capacity over time
Figure generated from data provided by AEMO (AEMO pers comms, 2017)

These figures (2.4 and 2.5) do not take into account electricity supplied to NSW through interconnectors.

Nevertheless there are times when spare capacity (including from the interconnectors) can be low, where supply will not meet demand. Figure 2.6 considers the day and time in each year when the spare available generation and interconnector capacity was at its lowest, this is called the Minimum Spare Capacity Event. These events usually coincide with Lack of Reserve (LOR) events discussed in Section 2.3. During these times, the total available capacity that can be used to supply demand in NSW is separated into the available generator and interconnector components and plotted alongside the demand. It can be seen that the availability of both generation and interconnector capacity can play a role in ensuring supply is above demand.

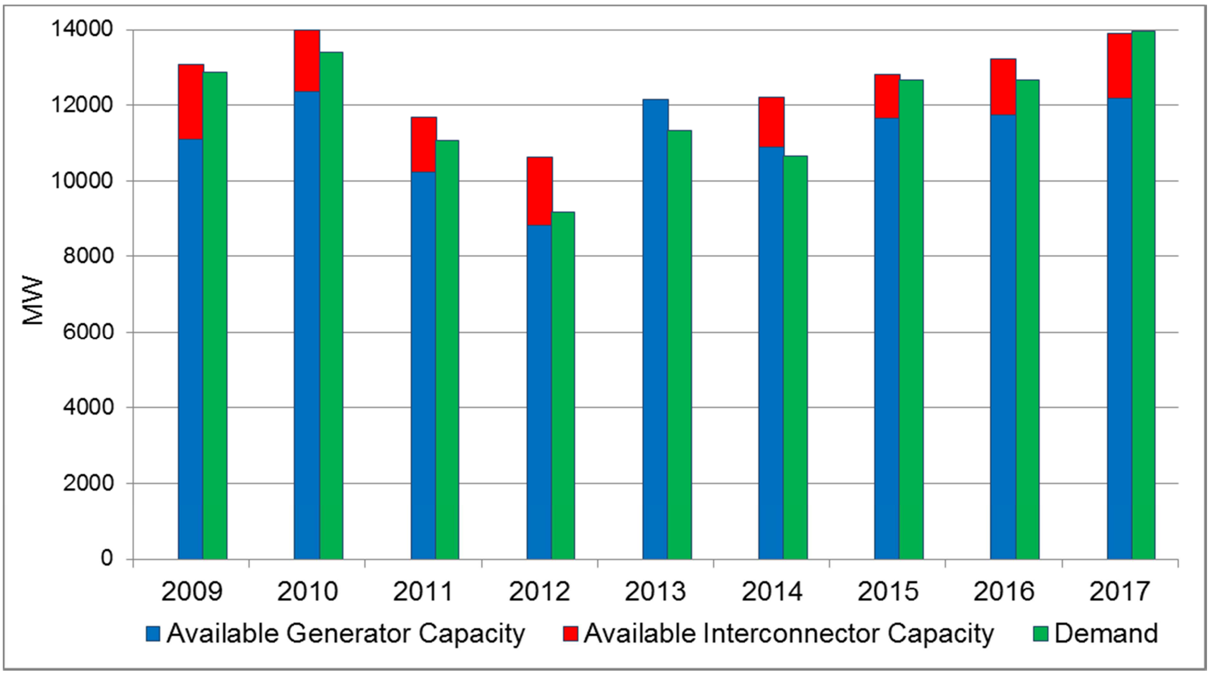

Figure 2.6: Minimum spare capacity events in NSW
The day and time (for each year 2009-2017) when spare available generation and interconnector capacity was at its lowest, compared with demand. The 2017 columns represent the LOR3 event on 10 February 2017.
Figure generated from data provided by AEMO (AEMO pers comms, 2017)

Analysis of the characteristics of the market on 10 February 2017, including by TransGrid, have shown a level of disconnect between the capacity that had been anticipated would be available and the level that was actually supplied into the market – both in terms of generators that did not come on line, and also generators that could not supply as much power as anticipated. It is understood that TransGrid and AEMO will be remodelling thermal limits and capacity levels in the system, given the age and maintenance needs of the generator fleet, and how these are having an impact on the capacity that generators can provide.

The '2017 columns' in Figure 2.6 correspond to the load shedding event (LOR3) that occurred on 10 February 2017. At that time the available capacity did not meet demand. Table 2.1 shows the supply mix during this event (the 5-minute dispatch interval ending at 17:00 AEST) prior to load shedding. Hydro was the only generation source producing to its installed capacity, in fact it contributed 94 MW more than registered capacity. The net import contribution was greater than the available capacity by 463 MW. The interconnectors being above limits led to the power system not being in a stable operating state (AEMO, 2017i), leading to a concern for system security.

Table 2.1: Generation contribution to demand in NSW 10 February 2017 at 17:00 AEST
(AEMO, 2017i; Snowy Hydro, 2017b)

Generation Source	Contribution to peak demand (MW) at 17:00 AEST	Available capacity (MW) at 17:00 AEST	Installed Capacity (MW)*	Capacity Factor (%)§
Net imports	1,745	1,282	2,888#	60.4%
Wind	284	284	651	43.6%
Large-scale solar	132	132	211	62.6%
Hydro	2,619	2,689	2,525	103.7%
Thermal	9,245	9,408	12,458	74.2%
Total	**14,025**	**13,795**	**18,733**	74.9%
Rooftop PV (estimated)	291	291	1,218	23.9%
Total including rooftop PV	**14,316**	**14,086**	**19,951**	71.8%

* Based on the registered capacity of each generating unit. Some generating units may operate above this value for short periods.
# Capacity is limited in practice by generating and loading levels
§ Contribution to peak demand/Installed capacity

Figure 2.7 shows the actual generation and import mix, including operational and underlying demand on 10 February 2017. The figure demonstrates the ramp up in hydro generation and the drop off of rooftop solar PV.

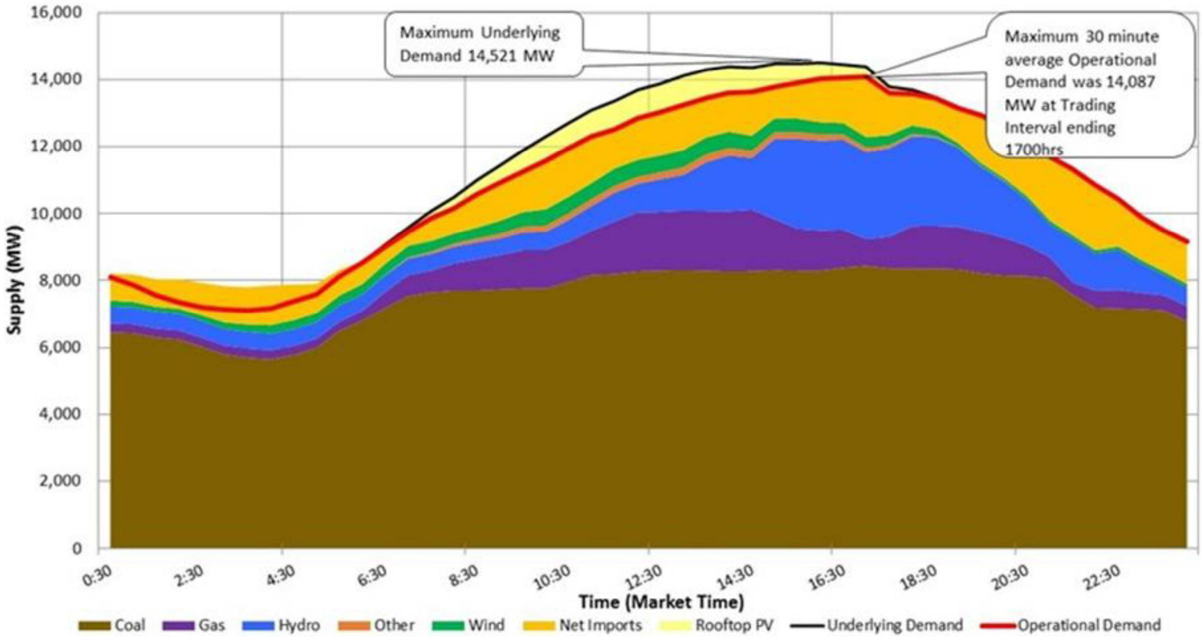

Figure 2.7: NSW electricity supply mix on 10 February 2017
This is based on average values for each 30-minute trading interval. Note: Maximum underlying demand includes all generation behind the meter, including but not only from rooftop PV
Source: (AEMO, 2017i)

Another way to view the generation data for 10 February is given in Figure 2.8 below. It illustrates generation at the time of the LOR3 notice. The large-scale and rooftop solar had dropped in the afternoon as would be expected on a sunny February day; there was little wind in the state so wind generation was low; hydro had ramped up to take advantage of the rising price; and there were unexpected outages on various thermal plants.

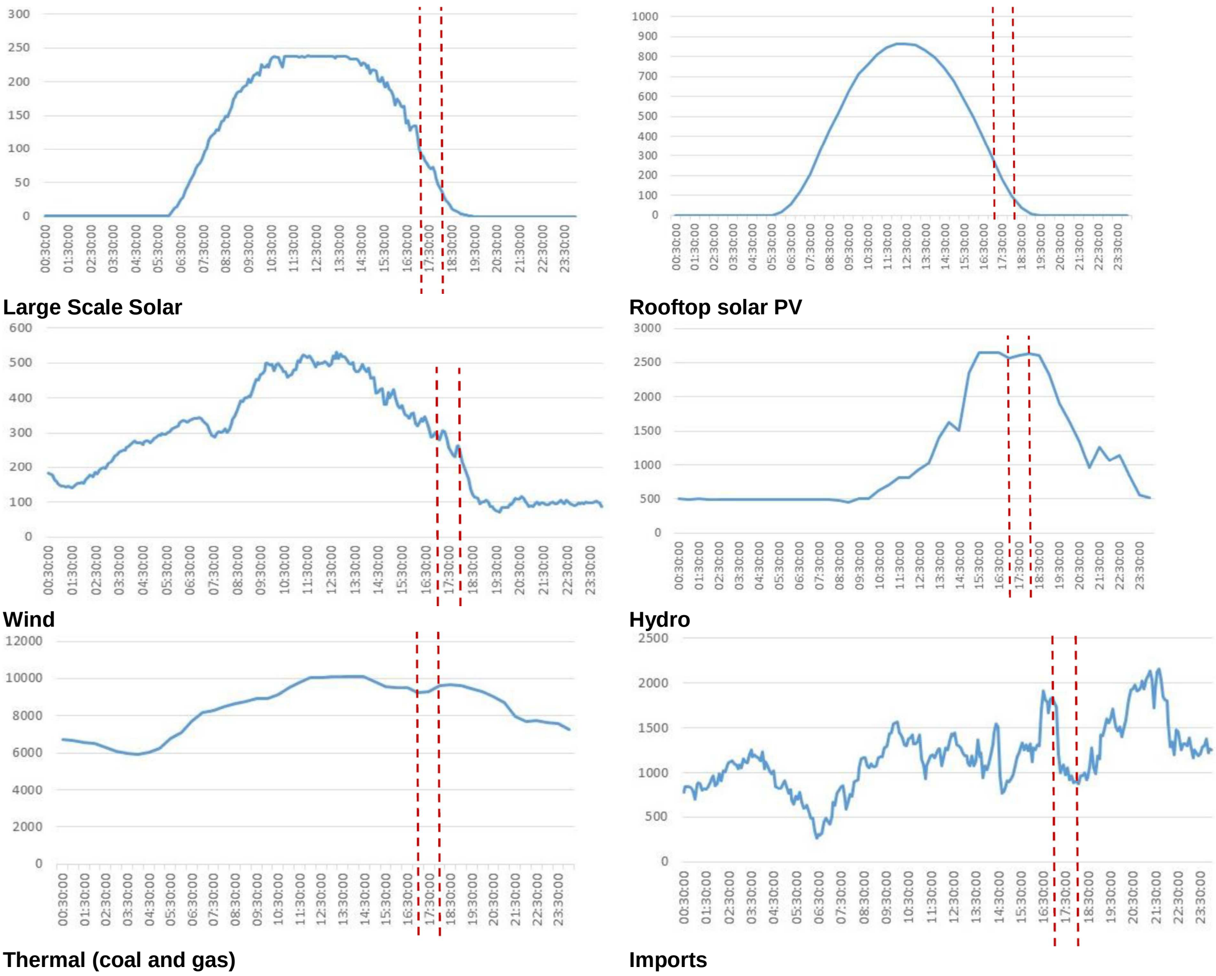

Figure 2.8: Source of supply through 10 February 2017 in NSW
The dotted lines represent the period of load shedding. Source: (AEMO, 2017i)

2.1.4 11 February – another eventful day

On 11 February, a Saturday, demand had reduced compared to a normal (hot) business day and a number of generators had repairs overnight, including Tallawarra Power Station. The combination of these two factors meant that lack of reserve levels were reasonable and no further load shedding was predicted without a major generator outage.

However, TransGrid has indicated that, due to the extreme weather there was an unusual number of coincident network events on 11 February. Namely, the collapse of two transmission towers in the Snowy Mountains as well as loss of a transmission structure in the Wagga Wagga region during a large storm on Saturday evening. The result of the collapsed structures in the Snowy Mountains meant transfer limits between NSW-Vic were reduced. An equipment fault at Muswellbrook substation Saturday morning meant that one 'leg' of the Qld-NSW interconnector was out of service. TransGrid initiated emergency repairs at Muswellbrook to avoid loss of the Qld-NSW interconnector in the event of a second contingency fault on the other leg of interconnector system. A second contingency loss would have led to system separation between Qld and NSW. A voltage reactor failed at Darlington Point meaning that system voltage control in the far western system was difficult and if exacerbated further may have led to transfer limitations in to the far west system.

2.1.5 Demand

The 2016 National Electricity Forecast Report (AEMO, 2016f) forecasts that despite predicted population growth, consumption of grid-supplied electricity across the NEM is to remain flat for the next 20 years (AEMO, 2016f).

The forecast is that in the next 20 years, the amount of consumption of grid-supplied electricity will not reach levels experienced during 2008-09 (AEMO, 2016f). Underlying demand for electricity is forecast to continue to grow but the increase would be managed through decentralised energy supply primarily through solar rooftop PV integrated with local battery storage and microgrids, and improvements through energy efficiency (AEMO, 2016f).

Peak, or maximum demand, is the maximum power requirement of the grid in any given time period (AEMO, 2016f). Maximum demand drives the overall capacity required in the system.

The demand for electricity varies over the day, due to seasons and temperature. Daily demand generally peaks in the early evening, while seasonal peaks occur in summer due to air conditioning and winter due to heating loads. The uptake of rooftop PV has also influenced daily load profiles (as illustrated by the so-called 'duck curve') (CAISO, 2016). To illustrate the seasonal variation of demand over time during the course of a day Figure 2.9 shows the 30-minute interval *average* demand load profiles of a selected month for each season in NSW from 2000-16. However note that the individual maximum peak demands are higher in all states in summer except in Tasmania (See Figure 2.10). Demand for electricity reaches its maximum on days of extreme temperatures, when air conditioning or heating loads are highest (AER, 2015).

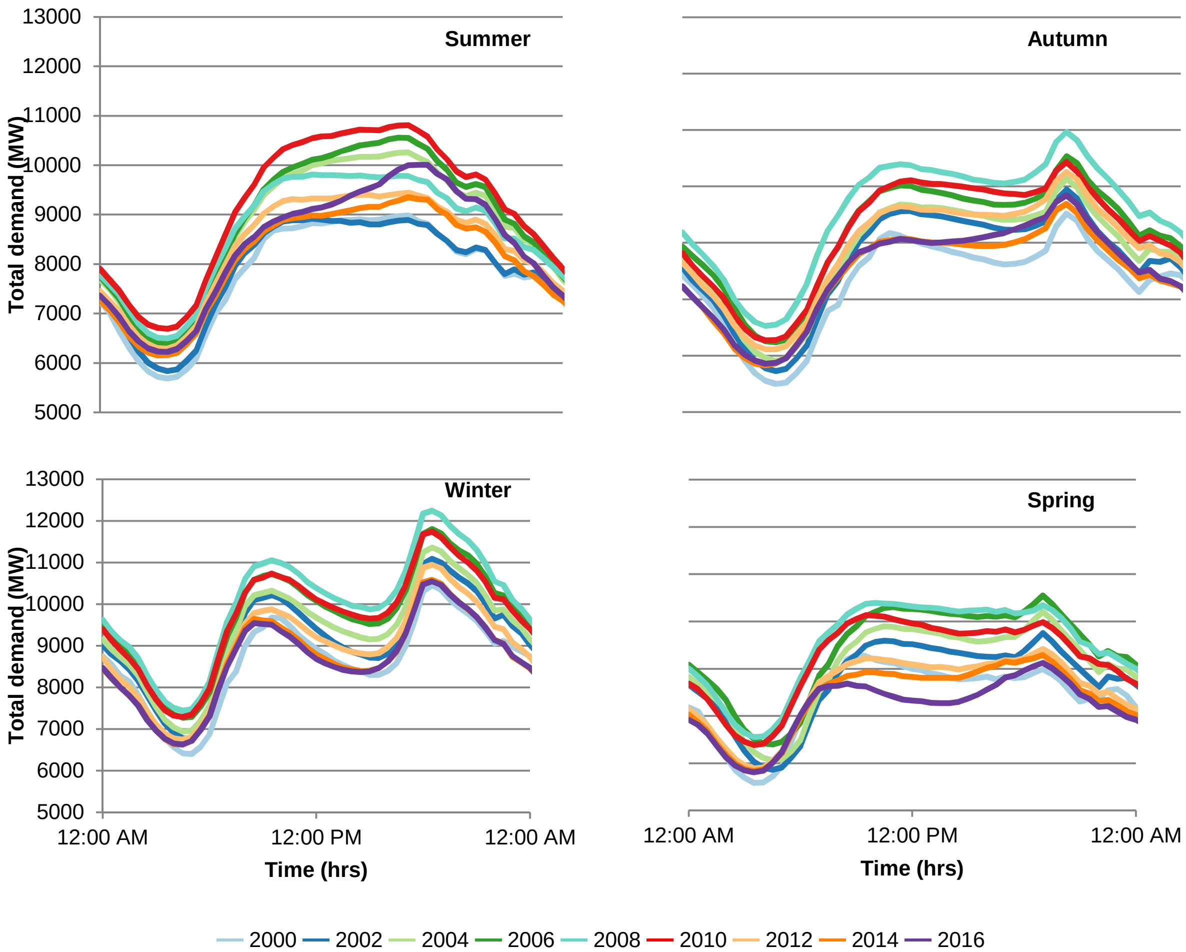

Figure 2.9: NSW seasonal variation of demand over time 2000-2016
Graphs derived from average of half hourly total demand data averaged over a month for each season. Graphs developed from data from (AEMO, 2017d)

The trends of summer and winter maximum demand have varied between regions in the NEM (Figure 2.10, (AER, 2017g)). In NSW, from 1998 until about 2010-11, summer maximum demand grew about 3% per year on average and winter maximum demand at about 1% per year. The maximum demand record for NSW was on 1 February 2011 at

14,744 MW (AEMO, 2017i). The maximum demand on 10 February 2017 was 14,181 MW at 16:30 (AEST) (AEMO, 2017i).

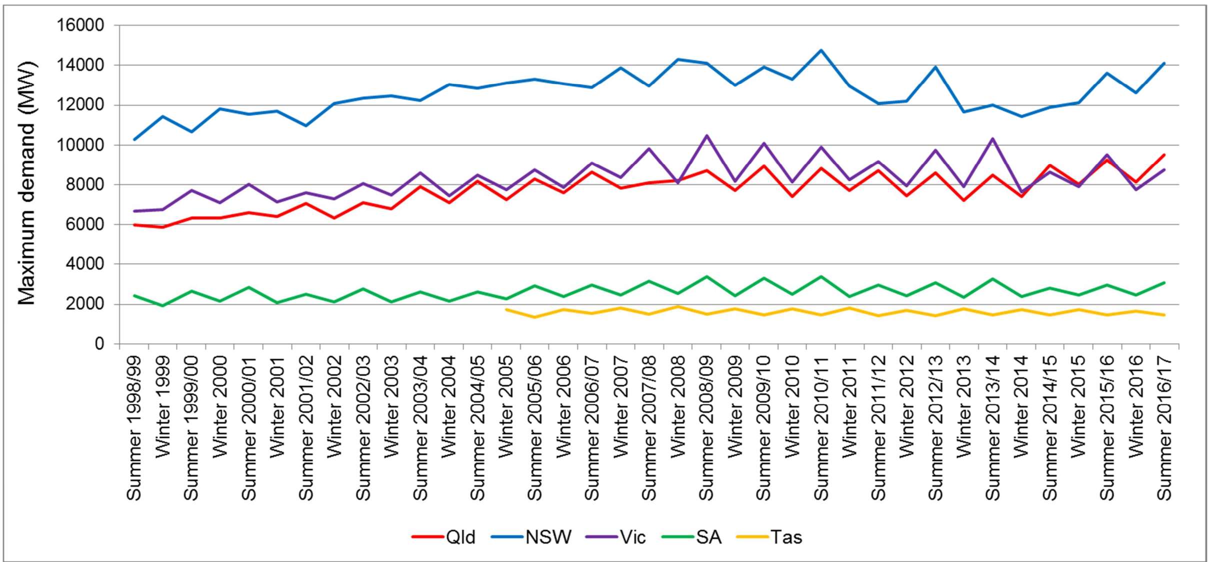

Figure 2.10: Summer and winter maximum demand by region since the commencement of the NEM
(AER, 2017h)

NSW maximum demand is projected to flatten and decline slightly (AEMO, 2016f). In NSW the summer maximum demand is driven by air conditioning loads (AEMO, 2016f). Although the use of air conditioning is expected to increase, the projected flattening of summer maximum demand is largely a result of a forecast increase in the energy efficiency of air conditioners, continued uptake of rooftop PV, and the forecast use of battery storage systems (AEMO, 2016f). Uptake of solar PV and battery storage is also forecast to move the time of summer maximum peak demand to later in the day and in the season (AEMO, 2016f).

AEMO has provided demand forecasts for the next 20 years based on the probability that the forecast demand would be met or exceeded. A 10% probability of exceedance (POE) means that the forecast demand for that season is expected to be met or exceeded one year in 10 (AEMO, 2016c) (see Table 2.2).

Winter peak demand is forecast to grow slightly, mainly driven by a shift from gas-fuelled towards electrified heating services (Table 2.2) (AEMO, 2016f; TransGrid, 2016b).

NSW is projected to see a reduction in minimum demand, and forecast shift in occurrence from the middle of the night to the middle of the day, due to the impact of uptake of solar PV (Table 2.2) (AEMO, 2016f).

Table 2.2: Projected maximum and minimum electricity demand for NSW in summer and winter
(AEMO, 2016f)

	Maximum demand (10% POE)		Minimum demand (90% POE)
Year	**Summer (GW)**	**Winter (GW)**	**(GW)**
2016-2017	14.2	12.3	4.9
2021-2022	14.1	12.5	5.0
2026-2027	14.0	12.8	4.3
2035-2036	14.1	13.2	2.9

Previously available demand response interventions (such as hot water system heating control) have been used for network management. This is increasingly not so due to market and technological changes. Previously, distributors deployed ripple control signals that turned on/off hot water systems, but now these have partly been replaced with timer controls. With these, distribution network system providers cannot actively intervene as before to change load.

2.2 RELIABILITY AND SECURITY RISKS

For the power system to function in a reliable manner, supply capacity must exceed demand at any given time. Despite NSW generally having sufficient generation there are some indications that there is a tightening of the supply and demand balance in certain circumstances, increasing reliability and security risks.

Forecasting for a range of time frames is conducted by AEMO to support efficient decision-making and long-term investment in the electricity market and infrastructure services (AEMO, 2016i). The forecasting allows AEMO to inform the market regularly and maintain power system security and reliability and manage demand now and into the future (AEMO, 2016f).

Forecasts are usually categorised as short-term, medium-term and long-term, depending on the time scale. Long-term load forecasting is important to allow the market to make decisions for investment such as in new generation facilities and in the development of transmission and distribution systems. Short-term forecasting provides essential information to determine the number of generators needed to meet demand at the lowest cost and for scheduling generators to be online (Fan & Hyndman, 2012). Accuracy of the forecast is important as overestimation of demand could cause excess investment in generation (and consequently unacceptably low prices for generators), whilst underestimation could cause instability in the grid or a lack of reserve condition (AEMO, 2016f). Forecasts are carried out by AEMO, investors and consultants.

2.2.1 Lack of reserve

To determine if supply will meet demand in the immediate future in a reliable manner AEMO does modelling known as the Short-term Projected Assessment of System Adequacy (ST-PASA). The “ST-PASA is published every 2 hours and provides detailed disclosure of short-term power-system supply/demand balance predictions for six days following the next trading day at a 30-minute resolution” (AEMO, 2016j).

If supply is projected not to meet demand and it is determined that reliability standards will not be met, AEMO, as part of its obligations through clause 4.8.4 of the NER, must inform NEM participants. It does this by issuing market notices which are intended to elicit a market response of increased generation capacity or a demand response.

These are known as ‘lack of reserve’ (LOR) notices. LOR events from least serious to most serious include:

- **Lack of Reserve level 1 (LOR1):** “If a credible contingency event with the most significant potential impact on the power system (such as the loss of the largest generating unit, or the loss of an interconnector) was to occur, there may be not enough capacity reserve to restore the contingency capacity reserve” e.g. not enough reserve to cover the loss of the largest two generators
- **Lack of Reserve level 2 (LOR2): “**If the most significant credible contingency event was to occur, it’s unlikely the amount of capacity in reserve would be enough to prevent involuntary load shedding” e.g. not enough reserve to cover the loss of the largest generator
- **Lack of Reserve level 3 (LOR3): “**Involuntary load shedding has commenced or is imminent to maintain or restore power system security” (AEMO, 2017i).

Should demand in a NEM region be projected to exceed supply, and all other means of meeting that consumption have been exhausted, through clause 4.8.9 of the NER (AEMC, 2017d), AEMO can instruct offline generators to come online and network service providers to interrupt temporarily the electricity supply to some customers, usually in NSW a large industrial customer.

If conditions change or a market response occurs and the projected lack of reserve condition is no longer forecast, AEMO will cancel the notice (AEMC, 2017a). There are numerous reasons why AEMO would cancel a forecast LOR notice, including a change in forecast demand or an increase in the expected available generation.

Since commencement of the NEM, there have been a total of 57 actual and 92 forecast LOR notices in NSW (excluding corrections and revisions to previous market notices) (Figure 2.11).

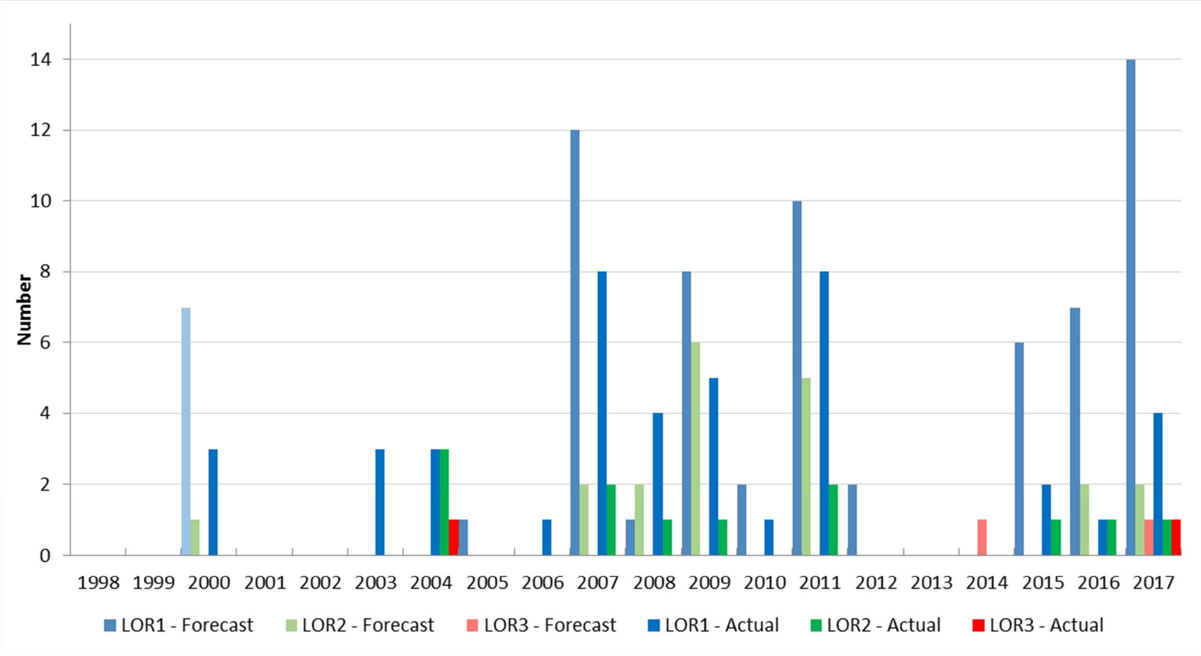

Figure 2.11: Number of forecast and actual LOR notices in NSW since commencement of the NEM
This figure was derived from market notice data provided by AEMO. Note that AEMO has advised that even after its best efforts to capture all the market notice data from 1998, there is no guarantee that all market notices have been captured due to changes in procedures, systems and database structure that have occurred over time. Figure generated from data provided by AEMO pers comms (2017).

There have been two actual LOR3 events in NSW since the start of the NEM, on 1 December 2004 and 10 February 2017. The 1 December 2004 incident led to the instruction that 200 MW of load be shed for one hour after a generator tripped (shut down) during a low reserve period (AER, 2007). The 10 February 2017 event was discussed in Chapter 1.

The larger number of LOR1 and 2 events in 2004, 2007, 2009, 2011 and 2017 appear to correspond to heatwave and/or drought conditions. Major heatwaves were experienced in 2004, 2009, 2011 and 2017, with 2007 associated with drought conditions. The duration of the 2017 high temperatures experienced in NSW was similar to that experienced in February 2004. The Bureau of Meteorology reports that "the February 2017 heatwave in NSW saw peak maximum temperatures higher than during the 2009 heatwave, and higher than during the 2004 event in all but one location (the New South Wales record highest daily maximum temperature set at Ivanhoe on 15 February 2004 of 48.5°C)" (BOM, 2017h). On 11 February 2017 new February maximum temperature records were set in NSW and southern Queensland (BOM, 2017h).

In 2011 there was a high number of actual LORs, the events generally coinciding with high temperatures (Figure 2.12). The highest recorded maximum demand in NSW occurred on 1 February 2011, which corresponds to a large number of LORs.

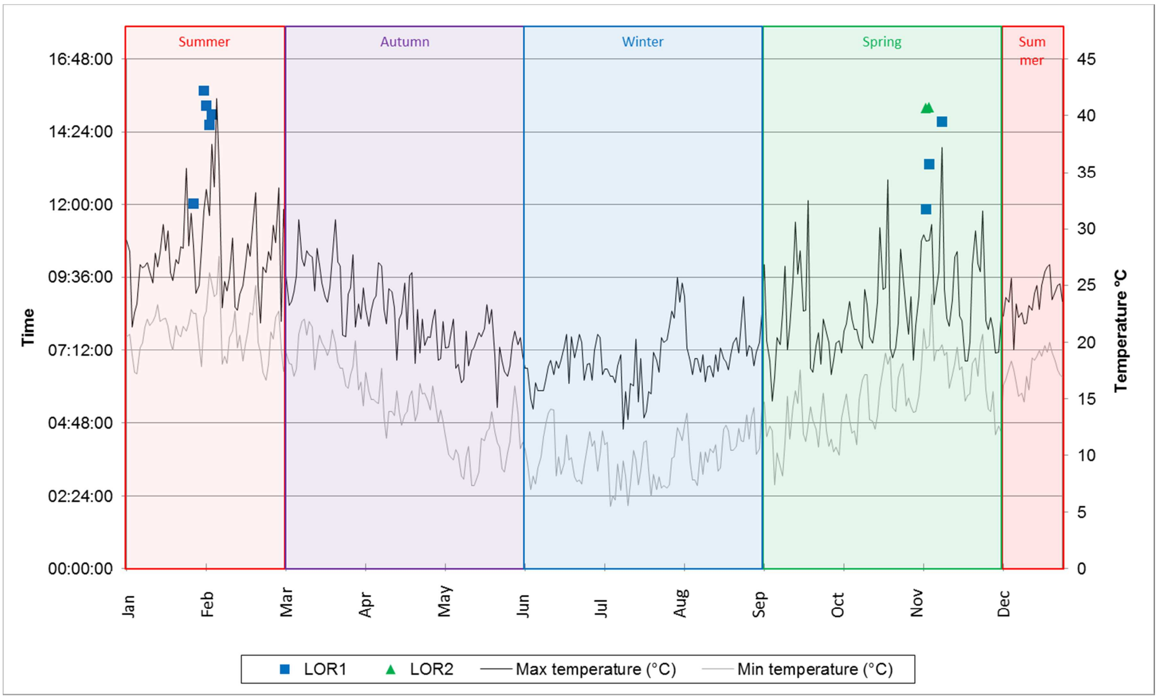

Figure 2.12: Lack of reserve events in NSW and temperatures during 2011
Figure generated from data provided by AEMO pers comms (2017) and data from Sydney Observatory (BOM, 2017c)

In 2017 to date there has already been a large number of LORs as a result of heatwave conditions. The increased number of LOR notices suggests there may be a tightening of supply and demand in NSW, especially during prolonged hot conditions.

2.2.2 Reliability standards

The NEM is required to operate to ensure reliability of supply. This reliability relates to “ensuring that there is enough capacity to generate and transport electricity to meet consumer demand” (AEMC, 2013). In the NEM this includes the “capacity of generation and bulk transmission sectors” (interregional capability).

The level of reliability depends on the generation and bulk supply sectors as well as the transmission and distribution networks. The ‘reliability standard’ referred to in Chapter 1 is the mechanism to set the market parameters of maximum price cap and the cumulative price threshold which in turn signal to the market to provide capacity to meet demand.

There has been a number of reviews of the standard but, so far, it has remained the same since it was established in 1998. The amount of unserved energy is a good indicator of the level of reliability (IPART, 2016). Unserved energy cannot be supplied because there is insufficient generation capacity, demand-side participation, or network capability to meet demand (AEMO, 2015a).

The AEMC Reliability Panel (2017a) found no unserved energy in the NEM during 2015-16 and reported that the NEM has performed well over the last decade in terms of reliability.

AEMO produces the Electricity Statement of Opportunities (ESOO) annually to provide a projected 10-year outlook of supply adequacy under a number of scenarios, including generation (AEMO, 2016a). The report looks for future possible breaches of the reliability standard.

The 2016 AEMO ESOO projected that “under a neutral economic and consumer outlook – and in the absence of new generation, network or non-network development – coal-fired generation withdrawals at the levels assumed may lead to reliability standard breaches…in New South Wales by 2025–26” (Figure 2.13, Table 2.3) (AEMO, 2016a). This projected breach relates to the withdrawal of 2,000 MW of generation from Liddell in March 2022. Projected breaches of the reliability standard for each region of the NEM under a range of scenarios are shown in Table 2.3.

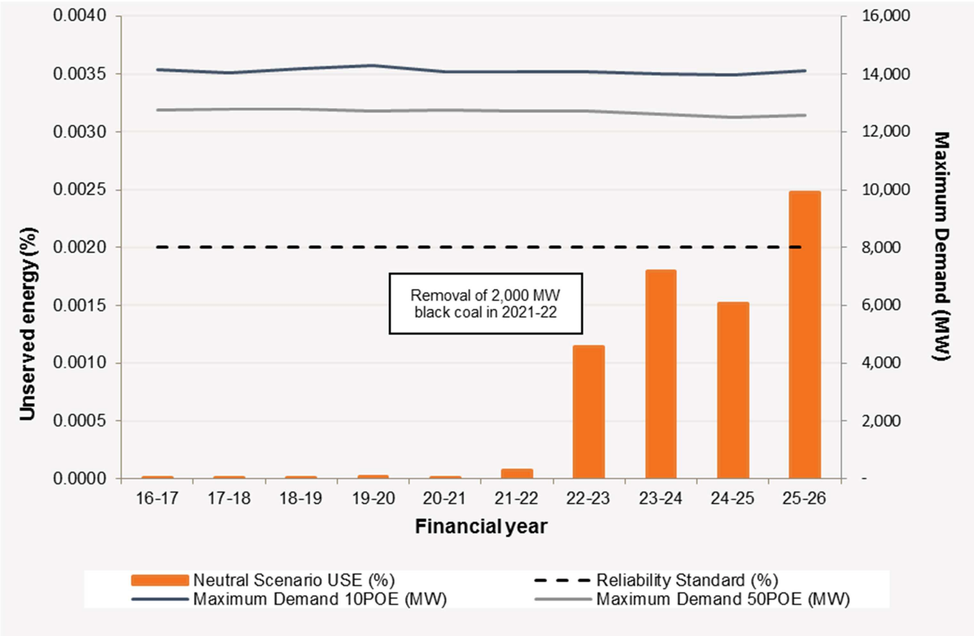

Figure 2.13: A projected outlook to 2025-26 of supply adequacy under a neutral scenario
From the 2016 AEMO ESOO for NSW (AEMO, 2016a)

Table 2.3: AEMO ESOO 2016 summary of projected supply adequacy shortfalls
(AEMO, 2016a)
Note: These projections were made before the closure of Hazelwood Power Station in Victoria. *Represents updated ESOO modelling by AEMO for Victoria and South Australia in relation to the closure of the Hazelwood Power Station (AEMO, 2016k)

Region	**Includes announced generation capacity withdrawals and additional modelled withdrawals based on COP21 commitment assumptions**						**Includes announced generation capacity withdrawals only**	
	Weak economic growth, with COP21		Neutral economic growth, with COP21		Strong economic growth, with COP21		Neutral economic growth	
	Timing	Shortfall	Timing	Shortfall	Timing	Shortfall	Timing	Shortfall
NSW	Beyond 2025-26	N/A	2025–26	0.0031%	2022–23	0.0095%	2025–26	0.0025%
QLD	Beyond 2025-26	N/A	Beyond 2025–26	N/A	2022–23	0.0029%	Beyond 2025–26	N/A
SA	2020-21	0.0021%	2019–20	0.0028%	2018–19	0.0029%	2017-18*	0.0042%*
TAS	Beyond 2025-26	N/A	Beyond 2025–26	N/A	Beyond 2025–26	N/A	Beyond 2025–26	N/A
VIC	Beyond 2025-26	N/A	2024–25	0.0021%	2023–24	0.0026%	2017–18*	0.0024%*

The future risk of load shedding is projected by AEMO to be greatest in the late afternoon (between 2.00 pm and 8.00 pm). This potential high risk could occur when high demand is associated with: low wind and solar generation, unplanned generator outages, and/or low levels of imports. AEMO notes that additional intermittent generation alone may not materially improve the reliability of the system. However, the risk of load shedding could be reduced with both network or non-network developments, including generation, storage, and demand side management services, if they can increase available supply or decrease demand at these times (AEMO, 2016a).

The 2016 AEMO ESOO highlights that "as intermittent generation (such as wind and rooftop PV generation) continues to increase, and thermal synchronous generation (such as coal and gas-fired generation) withdraws, total installed generation capacity alone becomes a less reliable indicator of supply adequacy". AEMO also notes that "availability of plant to supply energy when needed, and capability to provide ancillary services, are both key factors to consider when assessing opportunities related to secure operations and supply adequacy in the NEM" (AEMO, 2016a).

2.2.3 Generator and energy constraints

Significant commercial, weather, environmental, and regulatory events can have an impact on the electricity system through removing large generators from the network. Some of these are or could be predictable through appropriate modelling and monitoring of the generator, the upstream supply and the local environment. Others may be less predictable and not planned for.

Planning and environmental licencing can also have implications for generation under certain circumstances.

In NSW, Eraring Power Station (owned by Origin Energy) located in the Hunter Valley is being affected by rising groundwater that is discharging in the vicinity of the station, and which is understood to be coming from the Awaba underground coal mine (owned by Centennial Coal), which is no longer in operation. Origin Energy's Environment Protection Licence (EPL) 1429 for the Eraring Power station includes approval to undertake six months of groundwater pumping to manage the seepage of water. A more permanent solution to manage this seepage will be required and is being discussed by the companies and the NSW Government.

Mt Piper Power Station owned by Energy Australia is NSW newest coal fired generator (from 1992/93), located near Lithgow. The power station receives its coal from the nearby underground Springvale mine which is also operated by Centennial Coal. It is subject to conditions for mine water discharges, however, the company has requested a range of modifications to its development consent, including a modification known as Springvale Mine Extension Project MOD 2, which is seeking to extend the timeframe for release of water at the current quality levels due to delays in the development and installation of the water treatment technology. The Springvale mine owners are seeking to amend the consent conditions (SSD 5594) over the next two years to remove the interim water quality criteria.

The proposed modifications to Springvale mine include:

- Springvale Mine Extension Project MOD 1 – to increase annual production by 1 million tonnes, the stockpile and workforce – *approved on 20 April 2017*
- Springvale Mine Extension Project MOD 2 – to remove the intermediate requirement for salinity by 30 June 2017, and delay the requirement for toxicity until 30 June 2019 – *in assessment, not yet determined*
- Springvale Water Treatment Project – to develop new desalination water treatment plant at Mount Piper Power Station and holding reservoir for reuse in cooling Power Station – *in assessment, not yet determined.*

Should the Springvale Mine Extension Project MOD 2 amendment not be granted by 30 June 2017, Energy Australia indicates that groundwater pumping from the mine would need to cease in accordance with existing conditions of consent for the mine, which would lead to the closure of the mine and a possible cessation of generation at the power station once coal stock are exhausted.

Generators are also subject to licensing under the *Protection of the Environment Operations Act (1997)*. Environment protection licences are the primary means in NSW to control the localised, cumulative and acute impacts of pollution.

Licence conditions are aimed at preventing or minimising the environmental impacts from the licensed activity. The conditions could, for example, limit emissions from the licensed activity, or require monitoring of pollutants or ensure operating procedures are environmentally acceptable.

Environment protection licences can have the effect of limiting electricity generators' capability in certain circumstances, for example, there are limits on the cooling water outlet temperature for Vales Point and Eraring power stations that became important during the 10 February event.

It is understood that on 10 February some generators were operating below capacity due to EPL thermal limitations when temperatures in Lake Macquarie were high. This affected Origin Energy Eraring Pty Ltd (EPL No.1429) (630 MW) and Delta Electricity at Vales Point (EPL No.761) (201 MW).

Ahead of next summer, it would be prudent for the NSW Government (through the EPA) and generators to discuss what options are available to alter operations, or put in place technological interventions, to minimise potentially harmful environmental discharges and other impacts to ensure generation does not become unavailable due to EPL conditions under conditions when reserve levels are low.

2.2.4 System constraints

Just as individual generators operate within constraints that help ensure their safe operation and security, the system as a whole also operates within technical constraints such as operating frequency.

The electricity system is designed to operate at a frequency of 50.00 ± 0.15 Hz. As mentioned in Section 1.1.4, on 10 February when the Tallawarra power station tripped, there was a timeframe of 7 minutes where the system oscillated between 49.75 and 49.85 Hz with a period of ~22 seconds. This oscillation needs investigation and it is understood that AEMO is to hold a workshop to commence that process.

2.2.5 Wholesale electricity price volatility

Another indicator of tightening supply and demand in certain circumstances is volatility in wholesale electricity prices. When demand is high and there is limited supply, prices will rise. On 10 February 2017, wholesale prices reached the cap of $14,000/MWh due to lack of supply in the state.

Electricity generated in the NEM is sold in a wholesale spot market covering Queensland, New South Wales, Victoria, South Australia, Tasmania and the ACT. Generators and retailers often protect themselves from fluctuations in the spot price by entering into hedge contracts or by vertically integrating the retail and generation activities.

Figure 2.14 illustrates quarterly average wholesale spot prices for each of the NEM regions. It shows restrained prices from 2011 to 2015 along with volatility in the market during periods of unusual weather events. Note the impacts of the drought from 2007 to 2010, the volatility in South Australia, and the effect of the power shortage in Tasmania in 2015-16. The price for NSW displays a similar trend to Victoria with both apparently less volatile than the other states in recent years although this could be changing.

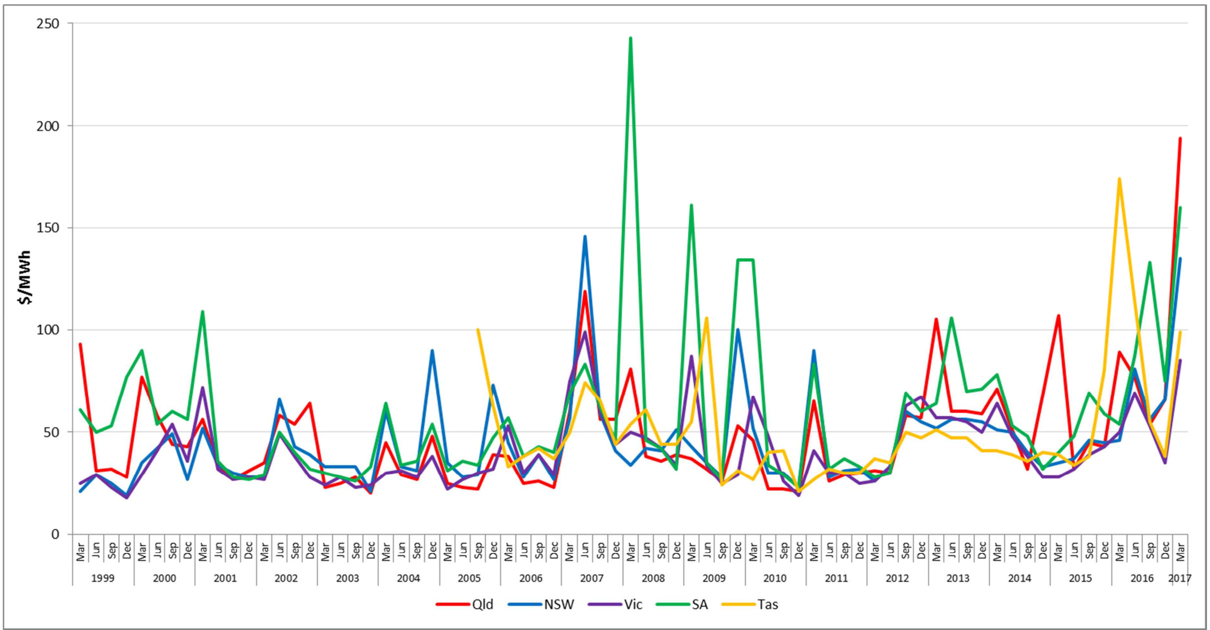

Figure 2.14: Quarterly volume weighted average wholesale spot prices 1999 to 2017
(AER, 2017h)

2.2.6 AER spot price reports

Recent AER reports provide other examples of the impact of tight supply/demand conditions.

Under the National Electricity Rules, when the electricity spot price exceeds $5000/MWh, the AER is required to produce a report on the exceedance. Three circumstances of exceedance were recorded in the immediate lead up to 10 February - in South Australia on 8 (AER, 2017c) and 9 February (AER, 2017d); and in NSW on 9 February (AER, 2017b). At the time of drafting, the AER report on the 10 February exceedance in NSW was not available.

In South Australia on 8 February, issues with both demand and generation capacity forecasts led to an underestimation of required demand and an overestimation of capacity available from wind generation (AER, 2017c). In response, higher-priced generation was brought on and load shedding was required. The AER report indicates that had these forecasts been more accurate, other less drastic interventions (such as sourcing additional generation) could have been possible with a longer lead time. The AER report indicates that AEMO is looking at mechanisms to improve demand forecasting (AER, 2017c).

The 9 February NSW situation was also in part due to forecasting issues and to events in South Australia (AER, 2017b). Demand for the NSW 5 pm trading internal was underestimated by about 800 MW and generator availability was approximately 560 MW below forecast (in combination 1360 MW), just short of the level for an LOR notice (AER, 2017b).

2.3 IMPLICATIONS OF A CHANGING GENERATION MIX

How electricity is generated in Australia and many places around the world is changing. Global agreements around climate change targets as well as national and local emission reduction targets are increasing the pace of this change. In the NEM there is trend away from traditional thermal generation to renewable energy, including solar, wind, hydro and geothermal. The use of coal and gas as a fuel for energy production is decreasing over time and renewables in many cases are taking their place. There is currently no new investment in coal power stations, with significant new, investment in areas such as wind and solar. The most recent baseload power added to the NEM in NSW came on line in 2009.

The transition to lower-emissions power generation has implications for energy security and reliability in Australia and NSW. Old synchronous coal power stations are leaving the market and being replaced mainly by non-synchronous, intermittent generation. This can reduce the strength of the system, its resilience and its ability to operate in a secure manner. There is an increase in the amount of distributed energy resources (DER) behind-the-meter, such as through rooftop solar PV, changing the demand for energy throughout the day. This 'invisible' source of energy can affect how demand is forecast and how supply is managed.

2.3.1 The changing generation mix

Currently coal provides ~ 50% of the generation capacity and ~76% of the generation output in the NEM (Figure 2.15) (note: this output number is pre-Hazelwood closure) (AEMO, 2017h; AER, 2017e).

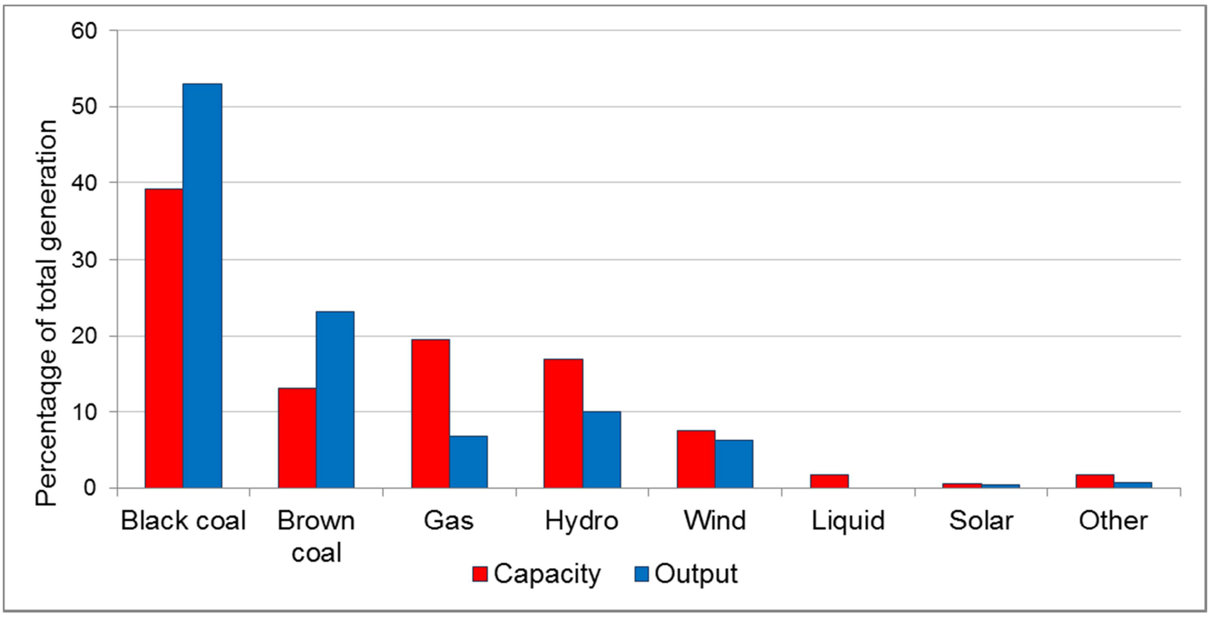

Figure 2.15: Percentage capacity each fuel type contributes to overall generation capacity in the NEM, and the percentage output each type of generation contributes to overall output, for the 2016/17 financial year
Source: AER (2017e)

NSW, Victoria and Queensland rely more on coal than do other regions in the NEM. However, reduced electricity demand across the NEM since 2008, and investments in renewable generation (which can dispatch electricity at low prices), has led to significant coal and gas powered generation plant being permanently or temporarily removed from the market (AER, 2015). Figure 2.16 shows the existing and currently proposed generation capacity in the NEM. Figure 2.16 shows the future withdrawal of around 2,000 MW of coal generation in NSW with the closure of the AGL Liddell Power Station in NSW in March 2022.

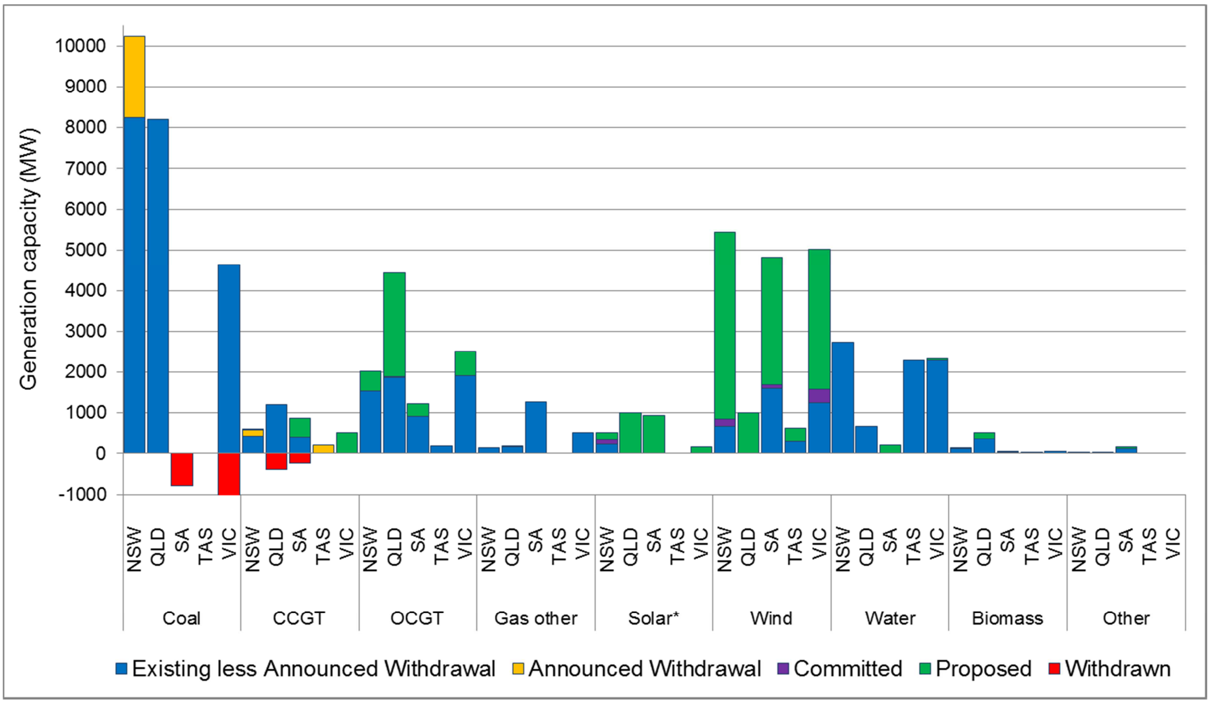

Figure 2.16: National Energy Market existing and potential new developments by generation type
Updated to include the withdrawal of Hazelwood power station in March 2017. Source: AEMO (2017h)
OCGT: Open Cycle Gas Turbine, CCGT: Combined Cycle Gas Turbine. * Solar excludes rooftop PV installations.

The shift away from coal thermal generation is further illustrated in Table 2.4, comparing the current and proposed future generation capacity in the NEM and NSW by fuel type (AEMO, 2017h).

Table 2.4: Current and potential generation types in the NEM overall and NSW
Calculated from (AEMO, 2017h)

Generation type	Current in NEM (%)	Current in NSW (%)	Future in NEM (%)*	Future in NSW (%)*
Coal	49	63	32	42
Gas	24	14	24	13
Hydro	17	17	13	14
Wind	8	4	26	28
Solar (excluding rooftop PV)	1	1	4	3

*Existing less announced withdrawal, committed and proposed

In line with national trends, NSW has increasing amounts of electricity from intermittent generation sources in the grid, but not as much proportionally as other regions. The committed and proposed generation projects are shown in Figure 2.16, none of these is in coal generation. The majority of new projects in NEM are for wind generation with 615 MW committed and 12,443 MW proposed (NSW: 175 MW committed and 4,596.4 MW proposed) (AEMO, 2017h). Further proposed generation in the NEM is for gas (Open Cycle Gas Turbine (OCGT) 3,965 MW proposed) and solar (111 MW committed and 2,293 MW proposed, excluding rooftop PV installations).

There is a trend of reduced reliance on coal across the NEM (Figure 2.17 showing data up to 2014-15). There are also changes occurring in the mix of renewables, with increases in wind generation in most jurisdictions.

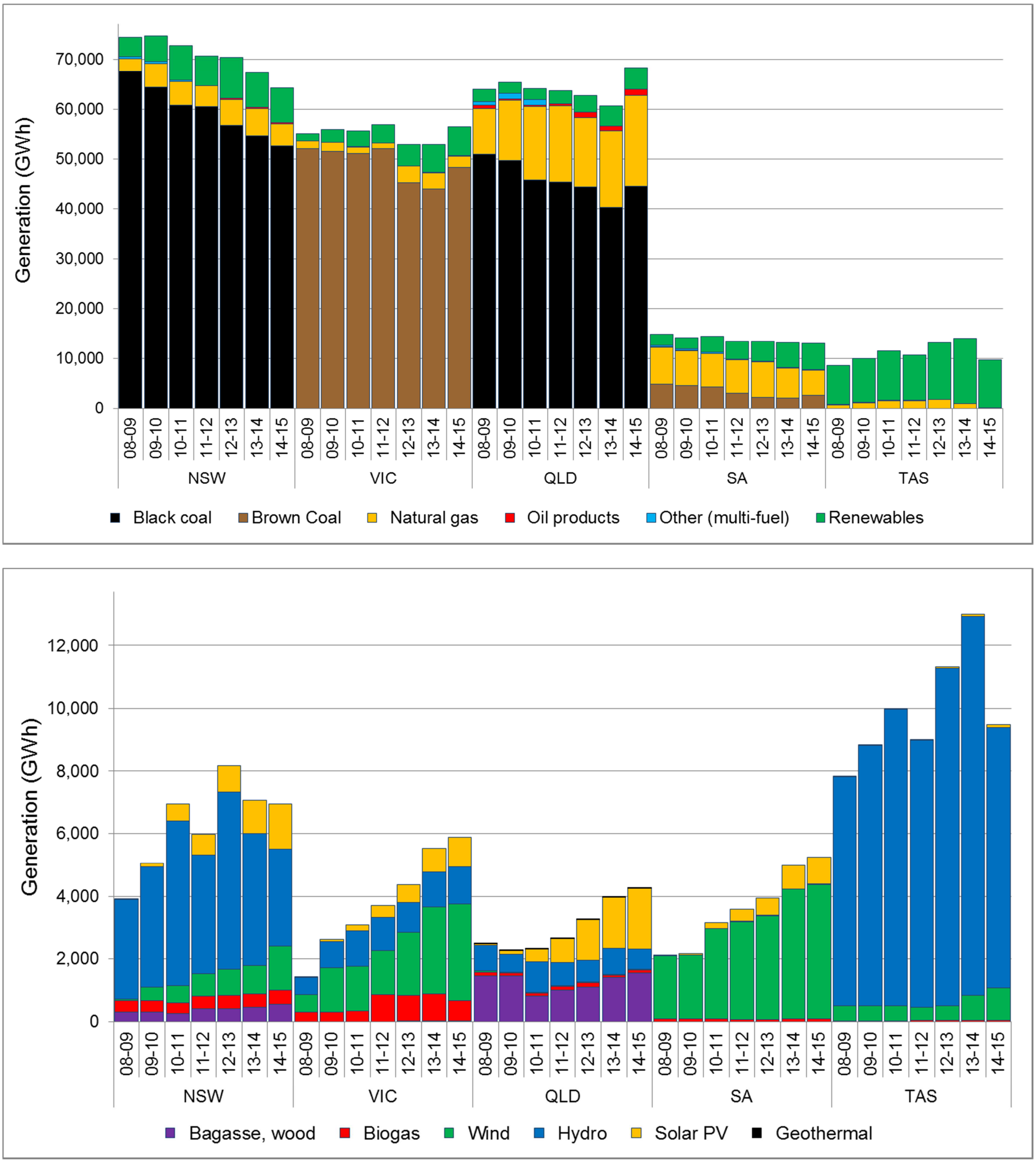

Figure 2.17: **Electricity generation by fuel type for each region of the NEM between 2008/09 – 2014/15**
Top: All fuel types, Bottom: Renewables. (OCE, 2016)

The changing energy mix in NSW without effective planning and management for the transition is likely to lead to technical issues in the future. The draft Reliability Panel report, AEMC (2017a) highlights emerging system security issues resulting from a reduction in the level of synchronous generation, including a decrease in available system inertia, resulting in increased challenges to maintain system frequency following disturbances and declining system strength. These issues are well described in the AEMC reports of the System Security Market Frameworks Review (AEMC, 2016b).

AEMO has also established the Future Power System Security (FPSS) Program to address these technical challenges (AEMO, 2016d).

In its final report the Taskforce will take account of any conclusions on this matter in the Finkel Report and will monitor progress on the implementation of the AEMO FPSS Program in NSW.

2.3.2 Withdrawal of coal generation

There are currently 19 coal generators in the NEM (24 in Australia) which range between 9 and 45 years old, many were commissioned in the 1960s (Australian Energy Council, 2017). Outside of the NEM Western Australia has the youngest coal generator in Australia at 6 years old, however this only has a small capacity at 208 MW. In NSW the youngest is 23 years old (Australian Energy Council, 2017).

Recently a number of power stations have closed, the most recent withdrawal being Hazelwood Power Station (1,600 MW) in March 2017 (Engie, 2016). The impact of this withdrawal is discussed below.

The oldest power stations may not necessarily close first. The life span of the power station is driven by economics and the time over which it is expected to be viable in the market with normal repairs and maintenance. The market provides price signals to allow owners to identify when and whether it is worth refurbishing a power station to maintain its operation, or when a power station should exit the market (Commonwealth of Australia, 2016).

Reduction in the synchronous generation that is supplied by coal will have a significant impact on the security and reliability of the power system unless new forms of FCAS services are provided. Possibilities for providing such services on wind generators are being trialled in South Australia at present with ARENA funding support (Parkinson, 2017a). Virtual power plant trials (e.g. as reported by the ABC News (Coleman, 2017)) are another area where innovations are likely to address this issue (Parkinson, 2017b).

The Senate Environment and Communications Committee completed an inquiry into the Retirement of coal fired power stations in February 2017. The recommendations of the committee noted the need for a transition plan in relation to the retirement of coal fired power stations (Commonwealth of Australia, 2017a). Stakeholders have raised with the Taskforce the desirability of a ‘no surprises’ rule where retirement of generators would need to be flagged years in advance. This could reduce accelerated, disorderly closures and aid investor confidence. This is a matter that has also been raised with the Finkel review.

2.3.2.1 Example: Hazelwood withdrawal

Hazelwood, a brown-coal power station located in the LaTrobe Valley, had eight generation units (combined 1,600 MW capacity) and accounted for 10,326 gigawatt hours (GWh), or approximately 22%, of Victorian operational supply in 2015/16 (AEMO, 2016e).

The first generation unit went online in 1964. The decision to retire the station on 31 March 2017 was announced on 3 November 2016 (Engie, 2016). The reasons cited for closure were the age of the plant, which has been operating for over 50 years, and the economic factors: the cost to ensure the viability and safety of continued operation in current and forecast market, and the prohibitive cost of retrofitting or revamping the plant (Engie, 2016).

AEMO has projected that the firm capacity of the NEM, which is of key importance to ongoing NEM reliability, will not be negatively impacted by the retirement of Hazelwood (AEMO, 2016k). It is assumed that the 4% of firm capacity that Hazelwood currently provided will be mostly covered (approximately 90%) by black coal generation in NSW and Queensland, noting that many plants do not currently operate at full capacity (AEMO, 2016e).

The primary issue, however, is the generation forecast for Victoria against average summer demand and extreme peaks. In these periods, there will be an increased demand for imports from NSW and Tasmania: this could lead to reliability breaches in the summer of 2017/18 for Victoria and South Australia in the absence of market response (AEMO, 2016k).

The AEMO ESOO November 2016, released as a result of the Hazelwood retirement, indicates that to combat this that there will need to be increased generation from the existing NEM generators and the potential return of short-term withdrawn plant (AEMO, 2016k).

In addition to the reduced firm capacity from Hazelwood, the approximately 10 TWh of energy that was produced from the station annually will need to be picked up from mostly gas or remaining coal-fired plant, significantly testing these plants' capacity factors. Fuel availability will also be an issue given the long-term forward contracting of coal into the export market. This increased 'strain' on plant may also decrease the reliability of plant unless adequately planned for.

2.3.3 Fuel availability

Issues of fuel supply into the future are of potential concern across a number of generation technologies, both renewable and fossil fuel based. Constraints on fuel supply can have implications for both electricity generation in terms of power, as well as electricity generation in terms of energy supply over time.

The focus of discussion within the report so far has been on supply of electricity balanced against consumer demand, in particular how electricity power capacity (nameplate, available, dispatched) of the system or generators addresses demand requirements such as on particularly hot or cold days, or in cases where plant are off line. An energy supply problem is somewhat different as it relates to the supply of electricity over time rather than at specific time points. This could be due to outages in transmission or outages in generation over time, or potentially reduced generation capacity over time due to a reduction in the availability of fuel.

In thinking about the energy requirements over a year (say) for the NEM, there needs to be sufficient energy from a combination of sources to run the generators at periods of high and low load across the year.

The patterns of drought and floods, as well as climate change, and requirements for environmental and agricultural water use mean that regular, predictable quantities year-to-year of water for hydroelectric generation may never be achievable. Measures such as cloud seeding and pumped hydro to increase the availability of water for energy generation are technologies in use and planning.

Wind and sunlight are not considered to be predictable short-term as energy sources, and generation from these sources is currently considered by the NEM as semi-scheduled or non-scheduled generation. Microgrids, synthetic FCAS, battery storage, pumped hydro storage, and hydrogen generation are a few of the technologies that can be used in combination with solar and wind generation to extend and schedule the energy from these generators.

2.3.3.1 Coal

An emerging issue is the availability of coal. Australian coal generators are fuelled by brown coal in Victoria and black coal in NSW and Queensland. Brown coal is lower quality in terms of energy content and more polluting in terms of emissions, and also has a propensity to combust in storage so does not tend to be stockpiled, nor exported. The higher quality of black coal and lower likelihood to combust means that black coal is exportable, indeed is one of NSW's top export commodities (NSW Department of Industry, 2017). Export contracts for coal have long lead times, and involve contracting for sale, coal wagons, coal rail line, export from the terminal – typically export contracts for coal are two years forward, which reduces the flexibility to source new coal fuel to address the Hazelwood closure.

Several operators of coal-fired power stations have raised with the Taskforce problems concerning future coal supply. This includes the challenges of obtaining reasonably priced forward contracts for coal so they can replace the capacity shortfall caused by the Hazelwood withdrawal at relatively short notice and the environmental challenges discussed in Section 2.2.3 above.

2.3.3.2 Gas

The gas and electricity markets are related. Gas is an important fuel for electricity generation especially in times of peak demand, while it can also provide 'firm', synchronous baseload. Gas is often talked about as a transition fuel in the move towards lower-emission electricity generation from renewables. Also, while maximum domestic gas demand is driven by cold weather and the requirement for heating, gas power generation demand in south-eastern Australia is driven more by conditions in the electricity market which consumes more gas in summer, during peak electricity demand (AEMO, 2017g).

In Victoria, gas is used for residential heating in winter, and for peaking gas turbines in summer months. The fuel for these activities is sourced day-to-day from the Iona Underground Gas Storage (Iona UGS) facility (AEMO, 2017k). This facility is replenished via the South West Pipeline, and takes several months to refill. Concern has been raised that with Hazelwood coming off line, if the gas is required to provide a greater contribution to generating base load electricity, as opposed to only peaking electricity, then there will not be enough gas to refill the storage, leading to supply disruptions next summer. The constraint does not appear to be one of price, rather the limitation is due to the capacity of the supply pipeline with AEMO unable to direct investment that would remove capacity limitations (AEMO, 2017k), while gas supply from Victoria to NSW is also expected to reduce more in winter due to the limitations of Iona UGS. In the Gas Statement of opportunities (AEMO, 2017g), AEMO projects that "declining gas supplies could result in electricity supply shortfalls between 2019 and 2021 of approximately 80 GWh to 363 GWh across South Australia, New South Wales, and Victoria". Shortfalls in supply may be seen as early as summer 2018 (AEMO, 2017g).

Now Australia has industrial-scale gas export facilities (at Gladstone), domestic gas supply issues have become particularly newsworthy especially over recent months with some industry players indicating that they are not able to purchase gas domestically, while others indicate that they can access it but the price is high. In 2014 the Chief Scientist & Engineer noted, in her review of coal seam gas in NSW, that increase in export capacity would lead Australian east coast gas prices to rise to meet the export price (CSE, 2014).

On 19 April 2017 the Australian Government announced that it had asked the ACCC to do an inquiry into the supply of and demand for wholesale gas in Australia, the Gas Market Transparency Measures Inquiry (ACCC, 2017). The Taskforce will follow this Inquiry closely.

2.3.3.3 Importance of the Energy Adequacy Assessment Projection

AEMO publishes an Energy Adequacy Assessment Projection (EAAP) at least annually (AEMO, 2016b). According to the NER (Clause 3.7C(a)), the purpose of the EAAP "is to make available to Market Participants and other interested persons an analysis that quantifies the impacts of energy constraints on energy availability over a 24 month period under a range of scenarios" (AEMC, 2017d). AEMO will publish an updated EAAP in May/June 2017, and has requested an update to energy limitations from the generators in response to recent developments in the electricity and gas markets, triggered by the additional constraints in relation to gas that have been identified.

The Taskforce believes this updated EAAP is a particularly critical document in light of concerns around availability including fuel supply issues for Mount Piper discussed in Section 2.2.3.

2.3.4 Visibility of distributed generation

Increasingly, residential and small-scale industrial consumers are choosing to manage how their demand for energy is met. This has been made possible through the introduction of small scale renewable technology, residential battery storage, home energy management and other IT systems (AEMO, 2017l). As of April 2017, there were over 1.66 million PV installations in Australia, with a combined capacity of over 5,920 MW (APVI, 2017a).

Any person who owns, controls, or operates a generating system connected to a transmission or distribution network must register with AEMO as a generator, except where they meet the exemption criteria (AEMO, 2016h). Exemptions may apply for certain generating systems with a nameplate rating under 5 MW, or under 30 MW with annual exports below 20 GWh (AEMO, 2016h). Distribution network service providers (DNSPs) are responsible for maintaining a public register of completed embedded generation projects.

Historically AEMO collects data to the transmission level of the electricity supply chain (AEMO, 2017l). AEMO forecasts demand and load profiles on a regional basis and at transmission connection points (AEMO, 2017l). In some weather conditions consumers show particular energy use behaviour, such as putting on air conditioners during hot days, so an increase in demand can be anticipated by AEMO through weather forecasting and modelling (AEMO, 2017l).

However, AEMO increasingly is lacking data regarding how DERs and consumer behaviour will influence load prediction and response (AEMO, 2017l). The significant uptake of DER through embedded generators has changed load profiles and the ability of AEMO to predict them (AEMO, 2017l).

As more DER that is not predictable and visible is installed behind the meter, it will reduce AEMO's ability to:

- *"Quantify how the power system is likely to behave and manage operations within the boundaries of the technical envelope.*
- *Manage the power system using the usual operational levers, because DER is managed by consumers or their agents.*
- *Develop, calibrate, and validate its technical or business models, meaning AEMO needs to assume how future trends will deviate from past trends.*
- *Predict variability in load due to DER, increasing regulation frequency control ancillary services (FCAS) requirements and costs.*
- *Predict load and its response to disturbances as accurately in the past.*
- *Have certainty in the effectiveness of emergency control schemes to manage power system frequency, if DER affected, for example, the volume of load available to be shed" (AEMO, 2017l).*

This lack of visibility will also affect the management of extreme power conditions and has the potential to make parts of the grid more vulnerable to failure (AEMO, 2017l). On the other hand, improved visibility of DER may aid in energy security.

2.4 TRANSMISSION AND DISTRIBUTION

Transmission and distribution lines in NSW form meshed networks that allow electricity to be supplied to end-users. The high voltage electricity transmission network is managed and operated by TransGrid in NSW and the ACT. The network consists of 99 bulk supply substations and more than 13,000 km of high voltage transmission lines and cables. The transmission network is interconnected to Queensland and Victoria allowing trading between the states. There are three electricity distributors in NSW that are responsible for different regions of the state. They are Endeavour Energy, Essential Energy and Ausgrid. These networks manage the electricity substations, small distribution substations, power poles and above and below ground electricity cables.

The transmission and distribution networks in NSW generally meet reliability standards. Most outages in the transmission and distribution network that customers experience are local and most likely to be weather or other random event related.

2.4.1 Reliability in the transmission network

The outage rate of the transmission network was better than target for the 2015-16 financial year (TransGrid, 2016a). During this period TransGrid implemented a large capital works program, including replacement of transformers, transmission lines and poles. Eight of TransGrid's 21 connected customers experienced loss of supply from unplanned outages (Table 2.5) (TransGrid, 2016a, 2016b). During 2015-16, there were no unplanned outages lasting more than a minute at interconnectors (TransGrid, 2016a).

TransGrid promotes non-network options for demand management by informing the market of constraints via the Transmission Annual Planning Report (TAPR), and other communications (IPART, 2016).

The NEM Constraint Report (AEMO, 2016g) examined trends relating to the time when a Transmission Network Service Provider (TNSP) submits a planned outage to AEMO's network outage schedule and the outage start time. AEMO found that compared to other TNSPs in the NEM, TransGrid submits a greater proportion of their planned outages with good notice (more than 30 days before the start time) (AEMO, 2016g)

Table 2.5: TransGrid transmission network performance and investment

	2011-12	2012-13	2013-14	2014-15	2015-16
Energy usage (GWh) [1]	72 357	68 740	67 104	68 405	68,919 (estimated)
Maximum summer peak demand (GW) [1]	11.662	13.392	11.708	11.714	13.192
Capital works program ($M) [2]	360	522	563	304	262
Circuit fault outage rate (%) trend: Transmission lines [objective = 17.86] Transformers [objective = 14.92] Reactive Plant [objective = 15.54] [2]	 11.33 13.02 12.83	 18.47 17.29 13.62	 16.21 14.21 14.37	 10.56 10.88 8.81	 12.80 14.76 11.67
Off supply event: >0.05 system minutes [objective = 3] >0.25 system minutes [objective = 1]	 2 0	 4 1	 5 0	 1 0	 4 3
Unplanned outage, resulting in loss of supply, average duration (minutes) [objective = 144] [2]	96	141	157	50	69

Source: [1]TransGrid, NSW Transmission Annual Planning Report 2016 (TransGrid, 2016b), and [2]Transgrid annual electricity network performance results 2015-6 (TransGrid, 2016a)

AER regulates the revenue of TransGrid through five-yearly determinations to adjust proposed capital expenditure and operational expenditure (AER, 2017f).

The IPART economic assessment of Electricity Transmission Reliability Standards (IPART, 2016) found that historically the NSW electricity transmission network has had a high level of reliability.

IPART has developed new reliability standards through an economic framework designed to provide the most value to customers, balancing the costs of customers experiencing outages and the costs of providing reliability, paid for by customers through electricity prices (IPART, 2016). As of 1 July 2018, TransGrid will be required to demonstrate compliance through simulation modelling at each bulk supply point. TransGrid must plan the network in order to meet the requirements set out in reliability standards (IPART, 2016). A planning rather than an outcomes-based network capability approach was recommended as, unlike distribution networks, transmission networks tend to have a low number of outages and there may be no signs of major vulnerabilities in the network until reliability is already badly affected (IPART, 2016).

IPART recommended a level of redundancy and an allowance for minutes of annual unserved energy (IPART, 2017). The level of redundancy required is in line with current standards and specifies the number of backup arrangements that must be in place to support continued supply of electricity in the event of failure in a part of the transmission network (IPART, 2017). The unserved energy allowance is a new addition to the standards. IPART recommended unserved energy allowances ranging from 0.6 minutes per year in Inner Sydney to 115 minutes in one area in NSW's west (IPART, 2017).

IPART did not recommend including obligations around the time to restore supply in the reliability standard (IPART, 2016). TransGrid will need to incorporate the expected time to restore supply in the event of a disruption to be able to model the level of expected unserved energy (IPART, 2016). Proposed changes in the redundancy requirement standards and around the expected amounts of unserved energy are designed to allow greater flexibility as to how standards are met in order to avoid creating a barrier to the uptake of new technologies (IPART, 2016).

Ageing assets may cause a reduction in rating, resulting in constraints in the system. TransGrid indicates that to relieve constraints new assets may be required. If the peak demand can be managed then constraints may be relieved through non-network options, such as demand management and increasing the amount of embedded or local generation (TransGrid, 2016a).

2.4.2 Reliability in the distribution network

The greatest proportion of unplanned outages in the electricity supply chain generally occur in the distribution network (AEMC, 2017b). The common reasons for electricity power outages are: weather, spikes, vehicle accidents, bushfires and animals. Distribution network providers communicate power outage information to customers through online maps and alerts.

Nevertheless, during 2015-16 all DNSPs met their system average interruption duration index (SAIDI) and system average interruption frequency index (SAIFI) targets (AEMC, 2017a). Details of DNSP's performance are published in annual reports against their Network Management Plans.

The AEMC rule change in December 2016 required DNSPs to publish information about expected system limitations (AEMC, 2016a). A licence compliance report against the reliability standards is also undertaken by IPART (AEMC, 2017a). In September 2016, IPART was given the role as the safety and reliability regulator. IPART monitors compliance of the DNSPs with reliability standards as part of their licence administration function.

Planned power outages are scheduled to allow maintenance or construction. AEMO lists these in the Outage Schedule, planned outages may be added to the schedule in response to an emergency or up to two years in advance (AEMO, 2017c). Unplanned outages occur when electricity is unexpectedly disconnected due to equipment failure.

2.5 EXTREME WEATHER IN A CHANGING CLIMATE

Weather has a significant impact on electricity and gas demand, and also creates risks to the physical distribution and transmission network.

Extreme events derived from temperature and precipitation include: heatwaves, heavy rainfall and wet spells, drought and dry spells, coastal inundation, cyclones and severe storms, earthquakes and conditions conducive to bushfires. Not all extreme events will lead to serious impacts, depending on the area they affect, for example, cyclones that don't make landfall.

Some climate events may not be extreme in themselves but their accumulation can lead to extreme conditions, such as reduced precipitation leading to droughts (IPCC, 2012). Changes in extremes can be related to changes in mean conditions, for example slight increases in mean air temperature increase the extreme maximum temperature experienced (IPCC, 2012).

To forecast energy demand in NSW, AEMO relies on forecasts modelled by WeatherZone and Telvent using Bureau of Meteorology (BOM) temperature data from stations at Bankstown, Canberra, Penrith, and Sydney Airport (AEMO, 2017i). Averages for each location are calculated, weighted and then used in AEMO's demand forecasting models (AEMO, 2017i).

2.5.1 NSW climate and weather

The NSW and ACT Regional Climate Modelling (NARCliM) Project is a research partnership between the NSW and ACT governments and the Climate Change Research Centre at the University of NSW.

The NARCliM project began in 2011 in response to the need by regional decision makers and impact assessment researchers for high resolution climate change projections (NSW OEH, 2017a; UNSW, 2017). Previously, climate change information had been at a scale that could not be used for localised decisions. Many climate extremes occur on a small scale and cannot be reliably estimated from global climate models, which are based on coarse resolution. NARCliM produces simulations at a finer resolution of 10 km for present conditions (1990-2009), near future (2020-2039) and far future (2060-2079) (Olson, Evans, Di Luca, & Argüeso, 2016).

The NARCLiM projections have been generated from four global climate models, dynamically downscaled by three regional climate models. These were run with multiple settings to capture a more realistic set of projections and more reliable information on rare, extreme weather events (NSW OEH, 2013). Extreme weather events and future climate forecasts from NARCLiM and other services are described in Table 2.6.

Of particular note, the NARCLiM modelling projects that heatwaves are projected to occur more often and last longer than currently across most of NSW. There will be more days over 40˚C, and by 2030 up to 10 more heatwave days per year. By 2070 it projects up to 33 more heatwave days per year in northern NSW (NSW OEH, 2014c; Argüeso, Di Luca, Evans, Parry, Gross, Alexander, Green, & Perkins, 2015). For Sydney, an increase in all temperature variables (average, maximum and minimum) is projected for the future. The average number of days with a daily maximum temperature of above 35˚C is projected to increase, with an additional four days by 2020 and 11 more days by 2060 (NSW OEH, 2014a). By 2060-2079, these temperature conditions will extend into Autumn (NSW OEH, 2014a).

The resolution of the NARCliM simulations (10 km) is not high enough to capture urban effects on local climates, such as the urban-heat effect (Argüeso et al., 2015). Almost 90% of the NSW population lives in urban areas. The Office of Environment & Heritage used the projections from NARCliM to provide information on the impact of development on urban heat in the near future (2036) (NSW OEH, 2017b). Change in land use has the potential to double the temperature increases caused by climate change in urban environments. Change in land use from grasslands to medium density has the greatest increase in heat (0.5°C –

0.9°C). For new urban developments, the greatest temperature increase is projected to occur in summer afternoons which coincides with the maximum energy use demand (NSW OEH, 2017b).

Table 2.6: Some NSW extreme weather events, their occurrence and forecast

Weather type	Definition	Seasonality	Forecast
Thunderstorm	Thunderstorms that produce any of the following: hailstones ≥2 cm diameter, wind gusts ≥90 km/h, flash flooding, tornadoes'[1,9]	Peak months December, January. Severe thunderstorm season September - March[1,9] The peak timing is between 2 – 6 pm[1,9], and the recorded frequency >100 per year in NSW and ACT[1,9]	Increase in hail frequency predicted[5], with an increase in the coastal regions by 2030, with hail risk days projected to increase by between 4 to 6 days per year[7,15]
Extreme rainfall and flood warning	Amount of precipitation of any type over a specified period of time, often associated with storms[1,11]	Varies regionally and related to the Southern Oscillation Index (SOI) – moderate to strongly negative conditions usually associated with below average rainfall for NSW (El Niño); moderate to strongly positive conditions usually associated with above average rainfall (La Niña)[14]	Rainfall intensity has increased over the past century, most regions are not projected to significantly increase in the near future (2020-2039)[3] By 2060-2079, significant increases in rainfall extremes are projected for some regions[3]
Heatwave	≥3 days of high maximum and minimum temperatures that are unusual for that location compared to the previous 30 days and 'normal' temperatures[1,10]	Exclusively November - March, with about 90% during December – February[2]	Heatwave intensity, duration and frequency trend is an increase across NSW in the near future[1,10] Across most of NSW there will be more days over 40˚C, by 2030 up to 10 more heatwave days per year, by 2070 up to 33 more in northern NSW[2,4]
High fire weather warning	Influenced by wind, temperature, humidity, rainfall and state of available fuels. NSW Rural Fire Service, NSW determines Fire Danger Rating[1,12]	Greater potential for dangerous fire situations from spring to mid-summer[1,13]	There has been an overall trend of increase in danger days and the fire season has lengthened since 1970s[6] By 2030 increase in the number of danger days, by 2060 greatest increases in the far west and north-west regions[8,16]

Source: [1]BoM severe weather services (BOM, 2017f), [2](Argüeso et al., 2015), [3](Evans, Argüeso, Olson, & Di Luca, 2014), [4](NSW OEH, 2014c), [5](Nicholls, 2008), [6](BOM, 2016b); [7](CSIRO & BOM, 2007); [8](CSIRO & BOM, 2015), [9](BOM, 2017a), [10](BOM, 2017b), [11](BOM, 2017e), [12](BOM, 2017d), [13](BOM, 2009), [14](BOM, 2005), [15](Stokes & Howden, 2010), [16](NSW OEH, 2014b)

The BOM's Heatwave Service operates between November and March: "Heatwaves are calculated using the forecast maximum and minimum temperatures over the next three days, comparing this to actual temperatures over the previous thirty days, and then comparing these same three days to the 'normal' temperatures expected for that particular location. This means that, in any one location, temperatures that meet the criteria for a heatwave at the end of summer will generally be hotter than the temperatures that meet the criteria for a heatwave at the beginning of summer" (BOM, 2017b).

The count of days that Sydney experienced summer heatwaves was high during 2016-17. Since 1958, the only other year with a higher count of heatwave days was 1990-91 (BOM, 2017h) (Figure 2.18).

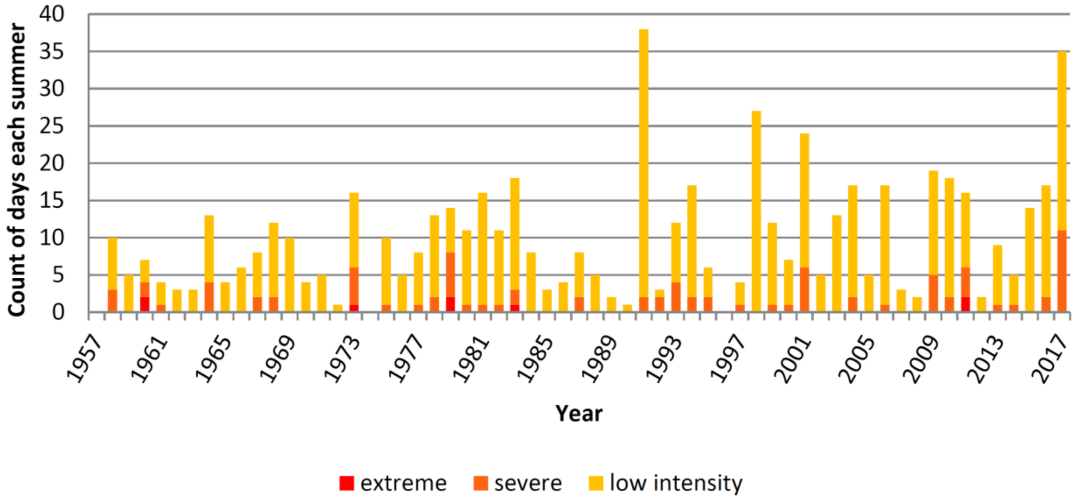

Figure 2.18: Count of days in which Sydney has been in a three-day heatwave during summer with heatwaves categorised into extreme, severe and low intensity
Source: (BOM, 2017h)

Overall, in Australia, the time between heat events is shortening. A series of prolonged or intense warm spells have affected Australia roughly every six weeks since the end of 2012. Temperature data for New South Wales shows that from late spring to early autumn, the frequency of warm events is increasing (BOM, 2017h).

The 2016-17 summer was the warmest on record for NSW with several widespread heatwaves (Figure 2.19). NSW also had a number of other meteorological records, including: record number of hot days and consecutive days of extreme heat, warmest night on record for any NSW weather station, and the second warmest day on record for the State as a whole (BOM, 2017g, 2017h). Rainfall was below average, though localised thunderstorms caused rain and wind damage (BOM, 2017g).

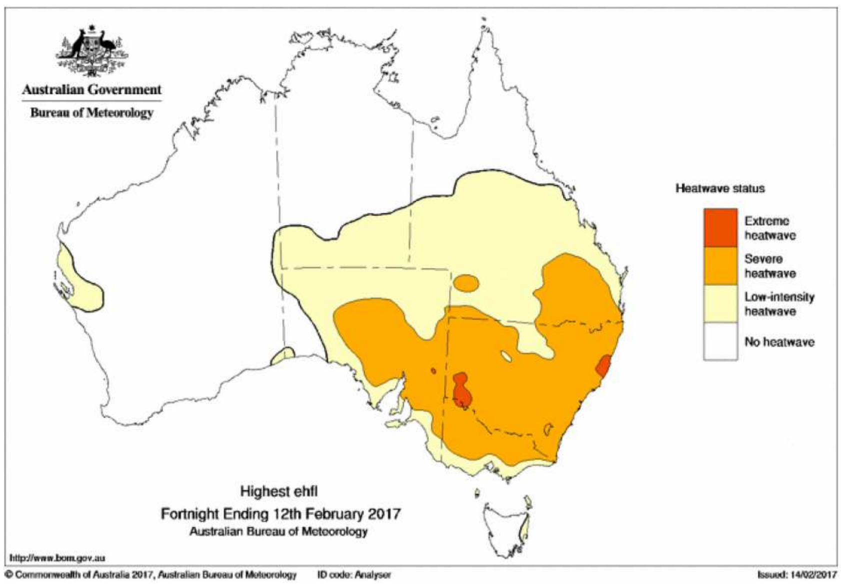

Figure 2.19: Highest three-day heatwave status observed from 30 January to 12 February 2017 (BOM, 2017h)

Differences between forecast and actual temperature during an extreme heat event can lead to inaccuracies in the energy demand forecast. This situation occurred in South Australia during last summer. On 7 February 2017 the BoM issued an extreme heat warning (BOM SA, 2017). The following day was the hottest on record for SA as a whole state (BOM, 2017h), and rolling blackouts occurred. In a report on the event, AEMO highlights errors in the temperature forecasts supplied by independent forecasters, which were 3-4˚C lower than actual temperatures, stating “errors in the temperature forecasts led to errors in the demand forecast” (AEMO, 2017j).

In addition to the general trend of extreme heat events increasing in duration, frequency and intensity (BOM, 2016b), the Taskforce also considered the question of whether heat events are likely to occur across major population centres in the National Electricity Market at the same time (for example, in Brisbane, Sydney and Melbourne concurrently), which could present demand challenges for the electricity network.

Preliminary analysis by the Bureau of Meteorology suggests that it would be rare to experience a single day of extreme heat in Brisbane, Sydney and Melbourne at the same time. It is more common to see extreme heat in south-east SA, Victoria, Tasmania, southern NSW and ACT in one 24 hour period, then in NSW over the next 24 hours, and then in SE Queensland for the next 24 hours.

When considering multiple days and nights of extreme heat consecutively (i.e. three days of combined, high day and night temperatures in a row), there have been historical instances of heat waves affecting Adelaide, Hobart, Melbourne, Canberra, Sydney and Brisbane at the same time, however, these were at the lower end of the intensity scale.

In general, there does not appear to be a clear trend in geographical extent of extreme days across major population centres and modelled projections would be needed for an assessment of likely future conditions (BOM pers comms, 2017, May 2).

2.5.2 Implications for energy supply and demand

While many extreme weather events have minimal or localised impacts on power security, the potential for weather to have significant impacts on energy supply might be increased during:

- certain times of the year with the greatest concentration of extreme weather events
- a widespread weather event, such as a heatwave, impacting multiple generators and the capacity of other jurisdictions to supply energy through interconnectors
- conditions when the timing of the extreme weather event coincides with peak energy demand (Orme & Swansson, 2014).

The threat that extreme weather poses to power security includes physical impacts resulting in damage and loss of infrastructure and disruption to energy supply chain, resulting in low reserves and unserved energy.

An increased number and severity of extreme weather events will have an impact on fuel supply, power generation and the reliability of pipelines and electricity grids. Energy generators that are driven by the weather, such as hydro, wind and solar could be positively or negatively impacted by changing weather patterns (University of Cambridge & World Energy Council, 2014).

Precipitation in the Snowy Hydro Scheme catchment area and the implications for energy supply has been the subject of some research. The University of Queensland has been working with Snowy Hydro Ltd to develop models to forecast precipitation between one and five years into the future (UQ, 2017). Previous research collaborations with other universities have included examination of precipitation enhancement, reconstructing the drought history to inform about future drought conditions, and understanding the processes that result in snow melt runoff (UWA, 2015).

In the last 110 years of data collection, the amount of water coming into the region covered by the Snowy Hydro Scheme has ranged from 683 gigalitres (GL) in the 2006/07 drought, to 5761 GL in 1917. The long term average is just below 2800 GL (Figure 2.20). About half the inflow is from snow melt and rain during spring. During 2015-16 the inflow was below average, 1650 GL. This will further increase the time it will take for storages to return to long-term average levels (Snowy Hydro, 2017a).

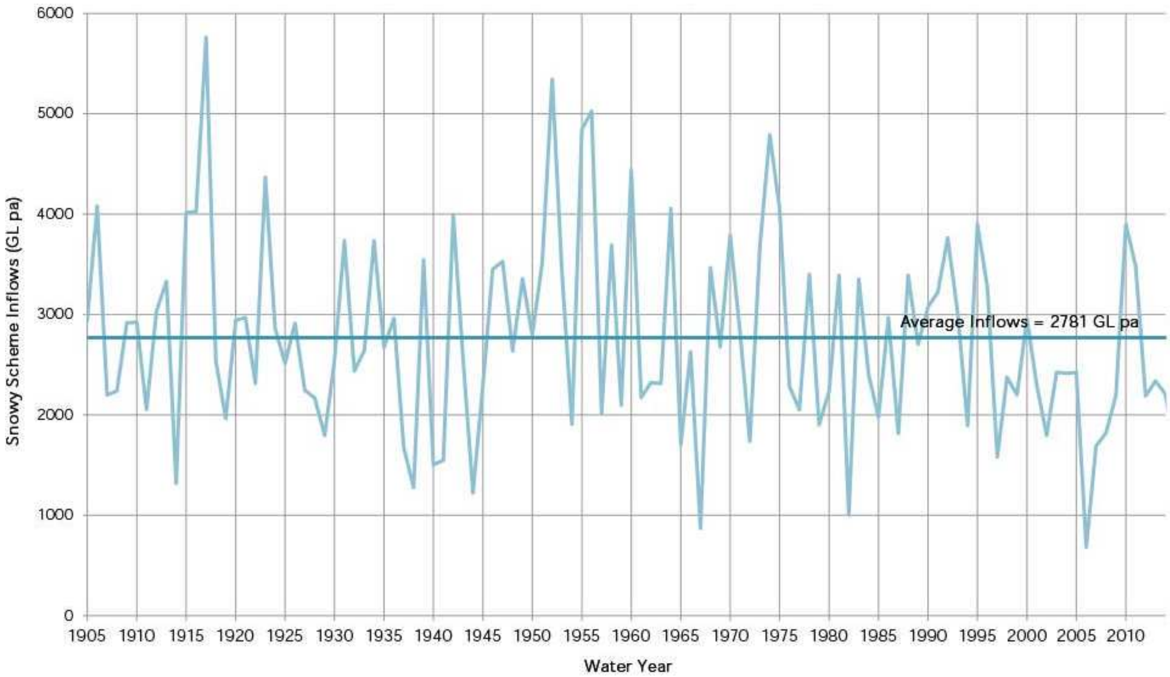

Figure 2.20: Snowy Hydro Scheme water inflows from May 1905 to April 2016
The long-term average inflow is shown as a darker line (Snowy Hydro, 2017a).

Small tornados are examples of extreme weather events which are typically difficult to predict (as they are hard to spot using satellite data) but have potential to damage infrastructure. A recent example is the period 28 September to 5 October 2016 when large areas of South Australia experienced multiple supercell thunderstorms producing at least seven tornados, damaging to destructive wind gusts, very large hailstones and locally intense rainfall. Thunderstorms developed in the morning and by the afternoon electricity supply was lost across the state (black system event). The BOM continued to issue severe thunderstorm warnings throughout the day. Five faults led to the black system event, four of these occurred due to the impact of supercell thunderstorms and tornados on three transmission lines (BOM, 2016a).

The wind gust speed associated with collapsed metal truss transmission line towers is 187-266 km/h. A tornado damage assessment estimated the wind speeds based on the extent of damage. The three-second wind gust speed of three of the tornados was estimated at 190-260 km/h, and one at 127-189 km/h (BOM, 2016a).

The threat that extreme weather poses to power security extends to flow-on effects such as the affordability and competiveness of the market, increased wholesale market costs and costs to consumers, higher insurance premium and reinsurance costs, and an increase in other operating and maintenance costs to suppliers and retailers (Orme & Swansson, 2014).

Table 2.7 summarises some of the key potential impacts of climate and climate extremes on different parts of the electricity supply system.

Table 2.7: The influence of climatic extremes on components of the energy supply chain and operations

	System component	Mean and maximum temperature increase, heatwave events	Precipitation changes: dry spells, flood and drought	Other severe weather: tornado, cyclone, thunderstorm, tsunami, wind, bushfire
Demand	Annual and seasonal energy use	Increased temperatures and heatwaves create higher demand in summer through air-conditioner use[1]	Increased variability, more energy may be needed for water treatment[1]	Increased variability in demand
	Regional maximum demand	High maximum demand through air-conditioner use[1]	Longer dry spells exacerbate high temperatures[1] resulting in increased energy demand	Increased variability in demand
	Load duration curves	Energy demand increasing in the afternoon due to residential air-conditioner use	Energy demand of water supply system might change timing of load[1]	
Supply	Transmission and distribution equipment capacity/lifetime	• Shorter transfer capacity and increased rate of equipment ageing[1], equipment operating close to technical limits [3] • Conditions that cause high demand result in congestions/ constraints on key interconnectors[3] • Heatwaves may be widespread and have the potential to impact larger areas and multiple NEM jurisdictions, limiting amount of energy that can be supplied across the entire NEM[3]	Dry spells and low humidity increase bush fire risk and voltage faults in distributor network, increasing risk of bushfire ignition[4]	• Pipelines at risk from coastal flooding and inundation • Power lines and substations at risk from all severe weather events, particularly strong wind conditions[2] • Tornados and wind gusts associated with storms can damage infrastructure, particularly power lines[12] • Potential for cumulative impacts e.g. heatwave conditions associated with lightning and bushfires[3]
	Coal, oil or gas mines and thermal power plant production	• Decrease in efficiency of generators could lead to reduced capacity or temporary shutdowns[1,2], water temperature of natural reservoirs required to stay within prescribed range to avoid irreparable environmental harm[1] • Warming of water temperatures reduce cooling effect on power plant and can reduce generation efficiency[7]	• Under heavy rainfall, open coal pits impacted by floods and landslides[2] • Decreased amount of water available for cooling result in reduced capacity or temporary shutdowns[2]	• Offshore platforms impacted by cyclones and onshore infrastructure by other severe weather leading to production interruptions[2] • Severe weather impacting rail and shipping transportation of fuel to power plants[7]
	Hydropower production	Increased evaporation from reservoirs[1], water required to maintain environmental flows[1]	Increased variability, lower summer flows result in decreased production[9], water is required to maintain environmental flows[1], water shortages lead to competition for water supply with other industry and utility groups[9]	Infrastructure may be damaged
	Solar energy production	Performs well -max efficiency of some rooftop PV may be limited by the max power temperature coefficient[5]	Efficiency of some rooftop PV may be limited by cloud shading[6]	Infrastructure may be damaged
	Wind energy production	Temperature increases can lead to an increase in peak wind speeds in some areas, which may increase performance of production[11]		• High wind gusts have potential to damage turbines[8] • Areas of highest wind energy in NSW are in exposed areas (Great Dividing Range and the coast)[10] increasing vulnerability to extreme weather such as storms
	Bioenergy/ Biomass production	Temperate climates could increase agriculture yields[2] and the amount of gases generated from waste sources[9]	Decreased amount of water available reduce agriculture yields[7]	Destroyed agriculture crops reduces production[2]

Source:[1](Coughlin & Goldman, 2008), [2](University of Cambridge & World Energy Council, 2014), [3](Orme & Swansson, 2014), [4](Jacobs, 2014), [5](Sino Voltaics, 2016), [6](Sathyanarayana, Ballal, L.P.S, & Kumar, 2015), [7](US EPA, 2017), [8](Dvorak, 2015), [9](Commonwealth of Australia, 2010), [10](Geoscience Australia, 2017), [11](Fant, Schlosser, & Strzepek, 2016), [12](BOM, 2016a)

2.6 SUMMARY - RESILIENCE OF THE SYSTEM TO CHANGING RISKS

Overall, the Taskforce finds that the NSW electricity system is relatively well placed from an electricity security and reliability point of view under average conditions, where the generation capacity is more than sufficient. NSW has the benefit of interconnectors with Queensland and Victoria, and NSW currently has a lower proportion of intermittent power sources compared with some other regions, and a greater proportion of dispatchable baseload renewables in hydroelectricity.

However, as demonstrated by the events of 10 February, during an extreme weather event and with a number of coincident factors (e.g. peak demand coinciding with solar generation dropping off at the end of the day, one or more unexpected equipment failure and decreased output from thermal generators) the reliability and security of supply in NSW can be compromised.

The events of this day were managed so that the system maintained its integrity, however, directed load shedding was not avoided. It has also been argued that there was a near miss with the seven minute oscillation event that could have resulted in further load shedding. Furthermore, there is an indication that if the following day, 11 February, had been a weekday rather than a weekend (with reduced demand), further load shedding may have been required on that day as well. There is every chance that similar conditions could occur again in the near future, as heatwaves are already increasing and will continue to increase in duration, intensity and frequency.

While demand for grid-supplied electricity is declining generally, partly due to uptake of rooftop solar and increased energy efficiency, the peak demand events, largely driven by air conditioner load, are less predictable and have been more volatile over time. As described by Sandiford (2017) this poses the general challenge of maintaining capacity for peak load while general consumption falls.

The energy supply mix in NSW is changing, following the NEM-wide trend of increasing use of renewables and the withdrawal of conventional thermal plant, including the planned closure of Liddell in 2022. It is not yet clear how the market will respond to this, and AEMO is already indicating that without a market response, this will lead to energy shortfalls for NSW. The Taskforce will examine this issue in more detail for its next report.

There are some unknowns and emerging risks. Emerging risks include fuel availability in tightening gas and coal markets, the overall impact of intermittent generation on the system and some indications that generators might operate less well in hotter conditions. A major unknown is what technology innovations will emerge to manage the shift to providing secure and reliable electricity supply associated with intermittent power sources.

The best available predictions about changes to extreme weather in a changing climate are clearly pointing to hotter summers - heatwaves are likely to increase in frequency, duration and intensity.

Therefore, there are real risks to electricity security and reliability that require prudent and proactive planning, from both a generation/supply and peak demand-management perspective. Detailed recommendations for addressing these issues are described as a package in Chapter 4.

2.7 MATTERS FOR THE FINAL REPORT

Many of the issues that have been highlighted since 10 February are still being studied and their potential impacts on capacity and energy are still being assessed.

One technical matter that has been raised several times with the Taskforce is the challenge associated with recovering from a system black event. Stakeholders have generally indicated that they consider a black system event in NSW to be highly unlikely. However, many have raised concerns about current black start arrangements and the time that a full system restart might take to see electricity restored to major population centres and time-sensitive industrial users. This issue will be covered in the next report.

There have also been issues raised about whether the market appropriately incentivises maintenance of ageing plant, and whether there are anti-competitive behaviours leading to supply constraints at time of peak demand and high price. These matters will also be covered in the next report.

In the next report, the Taskforce will also examine the following issues further:

- cybersecurity and the resilience of the electricity system to security challenges
- the adequacy of licence conditions on system owners and operators covering responsibilities and requirements in emergency situations and how they were incorporated in contracts during leasing
- climate-related risks to NSW energy infrastructure
- cost and benefit considerations.

This next report will also address any relevant issues that emerge from the Finkel Review and other studies underway.

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3 MANAGEMENT OF ENERGY INCIDENTS: HOW WELL DO WE PREPARE FOR AND RESPOND TO INCIDENTS?

Following consideration of the nature of the risks to the NSW electricity system, the Taskforce identified the need to examine how well NSW prevents, prepares for, responds to and recovers from energy incidents. The management of energy incidents in NSW has two distinct components:

- energy emergency management procedures (which provides guidance on managing electricity system security)
- state emergency management procedures (which provides guidance on responding to specific hazards to protect the safety of the community).

Effective functioning and interaction of both components is critical to ensuring that the State is able to prepare for and respond to energy incidents effectively. To understand how well this is done, this chapter analyses the two components separately and then looks at how effectively the two procedures work together in an energy emergency.

3.1 TERMINOLOGY

The term 'emergency management' has different meanings within the electricity and emergency management sectors. The electricity sector uses the term when responding to power system incidents (AEMO, 2015f). These incidents range from a local potential or actual loss of power which can effectively be managed by an electricity distributor and resolved relatively quickly, through to an incident which may result in wide power interruptions for an extended period and may need some level of involvement or action by the Governor of New South Wales.

Within broader state emergency management, an emergency is defined by the *State Emergency and Rescue Management Act (1989)* as being:

> "*an emergency due to an actual or imminent occurrence (such as fire, flood, storm, earthquake, explosion, terrorist act, accident, epidemic or warlike action) which:*
>
> *(a) endangers, or threatens to endanger, the safety or health of persons or animals in the State, or*
>
> *(b) destroys or damages, or threatens to destroy or damage, property in the State, being an emergency which requires a significant and co-ordinated response.*
>
> *(2) For the purposes of the definition of emergency, property in the State includes any part of the environment of the State. Accordingly, a reference in this Act to:*
>
> *(a) threats or danger to property includes a reference to threats or danger to the environment, and*
>
> *(b) the protection of property includes a reference to the protection of the environment*".

This dual meaning of emergency management creates confusion. For the purposes of this report, the term 'emergency' will be used to refer to large scale power interruption which cannot be avoided; is imminent; or power has been lost. For all other situations, the term 'incident' will be used.

3.2 TYPES OF ENERGY INCIDENTS AND THEIR CONSEQUENCES

Power system incidents and emergencies can vary in terms of timing, geography, impact and extent of the consequences. Power disruptions can be caused by external events such as floods or heatwaves or by technical issues and supply/demand imbalances within the power system. As the causes and consequences of power system disruptions vary, so too do the appropriate responses to address them. To understand the most effective ways to prevent, prepare for, respond to, and recover from power system incidents, it is important to differentiate the incidents. In what follows, the different nature of energy incidents is described and then the plans that exist to respond to and manage them. This in turn is followed by an analysis of the adequacy of these plans, both in theory and in practice.

There are four distinct electrical system security incidents that can cause disruption to supply that are considered in this report:

- major damage incident
- automatic load shedding
- short-term notice of a power supply shortage
- longer-term notice of a power supply shortage.

These incidents can result in a disruption of power supply, either abruptly or through energy management options, like voluntary reductions, mandatory restrictions or load shedding.

The way in which these energy incidents are responded to and managed is tightly connected to AEMO's Power System Emergency Management Plan (PSEMP) and the power system emergency response levels which range from 1 to 5. These levels are used by AEMO, jurisdictions and other NEM players to categorise the required response procedures by NEM participants to energy incidents such as those outlined above. "The power system emergency response levels have no relationship to the 'lack of reserve' levels as defined in the NEM Rules. Lack of reserve levels are only a signal to the electricity market and do not constitute an emergency situation" (AEMO, 2015f). Table 3.1 and the analysis below explains these power system emergency response levels in greater detail. The situation that occurred on 10 February 2017 was a level 4 event.

Table 3.1: Operational responses to power system emergency response levels

Power System EM Response Level	Description	Operational response/responsible parties
1	Operational incident – local/limited impact	• NEM participant (e.g. TNSP or DNSP) manages response through local resources without additional assistance • manual load shedding possible to local area, if required to restore supply • voluntary reductions possible, but unlikely
2	Local emergency – external impact limited	• NEM participant (e.g. TNSP or DNSP) manages response through local resources • potential support from emergency services to NEM participant • manual load shedding possible to local area, if required to restore supply • voluntary reductions possible, but unlikely
3	Widespread emergency – moderate to severe impact affecting more than NEM participant	• NEM participant mobilises emergency response plans. Support from emergency services. Could be localised power outages • jurisdiction may initiate voluntary reductions • manual load shedding, depending upon circumstances
4	AEMO coordinated cross jurisdictional response – overall system integrity impacted	• all parties participate • NEM participants carry out repairs • AEMO initiates load shedding, if required, and restoration by the networks; focuses on overall system stabilisation • jurisdiction may initiate voluntary reduction instructions, carry out emergency management functions, direct rotational load shedding as required
5	Jurisdictional direction – impact escalates so jurisdiction intervenes	• all parties participate • jurisdiction exercises emergency powers to impose mandatory restrictions • voluntary reductions and manual load shedding, depending upon circumstance

3.2.1 Major damage incident

A major damage incident can cause unexpected or abrupt loss of power supply. Examples include a cyclone that damages many transmission towers and interrupts supply to a large area, lightning strikes, explosions, fires, bushfires, floods and heatwaves. These events are generally not anticipated except for potential warnings through weather forecasts.

A major damage incident is classified according to the consequences of the incident. Such an incident can have localised or far reaching impacts affecting the whole jurisdiction or the whole of the NEM depending upon the nature of the incident and where it occurs within the system.

A major damage incident with local impacts is classified as a Level 1 or 2 power system emergency response. The response is managed using local resources and AEMO doesn't engage in the response. At Level 2, NSW officers liaise with each other and other players as required. While the incident may cause damage, the extent is usually geographically contained unless it escalates.

When the impact of a damaging incident is broader, the incident can be classified as a Level 3, 4 or 5 power system emergency response and a coordinated response may be needed. These levels involve activating energy emergency response plans and generally engagement by AEMO with the relevant jurisdictions to manage the response. While a Level 3 power system emergency response involves the affected participant activating an energy emergency response plan, a Level 4 power system emergency response level requires AEMO to mobilise a response team, as a Level 4 affects more than one jurisdiction.

As well as requiring activation of the energy emergency management response procedures, an incident may also require coordination through the state emergency management procedures. Hazards like floods, bushfires, heatwaves, etc., are dealt with through state emergency management procedures to reduce the threat to life and property. In many cases both procedures rely on each other and the two responses need to work together to achieve their complementary goals.

3.2.2 Automatic load shedding

Automatic load shedding is a specific loss-of-power situation that occurs automatically and quickly. It can be caused by major damage incidents like those described above. Automatic load shedding is a consequence of the network protecting itself from damage or to prevent low frequency causing instability in the power system. It can occur when there is either sudden generation deficiency or from events like unexpected network equipment failure. When events of this nature occur, detection equipment in the grid will automatically switch off parts of the system to protect the network.

3.2.3 Short-term supply shortages

When short-term energy supply and demand issues that last a day or two are not resolved by the market by adding additional generation or reducing load, this can result in manual load shedding or voluntary restrictions. AEMO is responsible for managing Lack of Reserve notices that signal to the market where reserves are low or where supply is forecast or is actually not meeting demand. The preferred response to predicted low reserves is for the market to respond by increasing generation. If this doesn't occur and short-term supply shortages are imminent, voluntary reductions can be used to address the shortfall in supply. Voluntary reductions are used when demand does not greatly exceed supply. In these instances the jurisdiction makes a request to the public to reduce energy consumption to balance supply and demand. Such a request has no enforcement power (AEMO, 2015c). Where voluntary reductions are insufficient, mandated rotational load shedding would be required.

According to the NSW Power Supply Emergency Guidelines, voluntary reductions are generally implemented if required for a power system emergency response Level 3 or 4, but could also carry into a Level 5 response as required (NSW Government, 2015).

If further demand reductions are required or a quick response is needed, manual load shedding may be the necessary response. Load shedding is the deliberate interruption of electricity supply that arises from a capacity shortfall through transmission or generation. Manual load shedding is instructed by AEMO in accordance with the NSW Jurisdictional Load Shedding Guidelines. The Guidelines cover priority of loads and equitable load shedding principles. Accordingly, manual load shedding usually occurs in rotation around parts of the grid when demand increases to a level above available generation and AEMO has to direct networks to reduce load and rebalance supply and demand in the grid (NSW Government, 2015). While manual load shedding could occur at all response levels depending upon the circumstances, it is most likely to be instructed AEMO when the emergency hits a Level 3 or 4 (JSSC pers comms, 2017, April 19).

How the load is shed depends upon the urgency and the time available to respond. AEMO has different protocols that are used if less than 5 minutes' notice is given versus more than 5 minutes' notice. This short-term distinction determines whether the load is shed by the transmission network (TransGrid) when there is less than 5 minutes' notice by AEMO, or by the distribution network (Ausgrid, Endeavour Energy, Essential Energy and Actew AGL) when there is greater than 5 minutes' notice. If more than 5 minutes' notice is given by AEMO, then the distributors will undertake load shedding as directed in accordance with their proportional share of the Network (see Table 3.2 below) (NSW Government, 2015). In these instances AEMO will provide participants advice on the volume, location and duration of the load to be shed as required.

Table 3.2: NSW proportional sharing of load shedding by Distribution Network Services Providers (DNSPs) in NSW (>5 mins)

Distribution Authority	Load shedding required by DNSPs
Ausgrid	47%
Endeavour Energy	29%
Essential Energy	20%
Actew AGL	4%

3.2.4 Longer-term supply shortages

A longer-term energy supply shortage occurs when the market is notified several days in advance about the forecast shortage or alternatively the shortage is expected to last for several days or more. For example, AEMO forecasts low reserve conditions for several days and issues notices to the market to respond with increased generation. Another condition that could cause a longer-term supply shortage is the loss of major generating capacity for an extended period.

As is the case for a short-term supply incident, load shedding under the same procedures described in the previous section can be used to manage the imbalance in supply during longer-term energy supply shortages.

A longer-term energy supply shortage occurred in NSW during the heatwave which led up to the hot day of 10 February 2017 when AEMO issued a series of forecast and actual Lack of Reserve notices (LOR1, LOR2 and LOR3) from 7 February onward. Forecast and actual shortfall throughout this period ranged from around 20 MW to 675 MW compared with a peak demand of 14,181 MW (AEMO, 2017i). Demand was forecast to be high and the market wasn't responding to market notices to provide additional generation as the heatwave continued. A Level 4 power system emergency response was activated at 9 am on 10 February by the AEMO NEM Responsible Officer (AEMO pers comms, 2017, April 19). Several key triggers led to a Level 4 activation, including that it was the third day of a heatwave that caused load shedding in SA; multiple regions were affected; and there were gas supply concerns (AEMO pers comms, 2017, April 19). Several responses were applied. Voluntary reductions were implemented when the NSW Minister for Energy requested that the public, amongst other measures, reduce use of air conditioning units where possible or, if using them, operate them at 26°C. While the total reduction in demand cannot be quantified precisely, it was estimated by AEMO in their 10 February incident report that this request resulted in a reduction in demand of around 200 MW (AEMO, 2017i). Load on the system was also reduced during the peak demand period on 10 February when an LOR3 Actual was in place by shedding a potline at the Tomago aluminium smelter for approximately one hour to shed 290 MW of load and stabilise the system. AEMO issued the direction (Market Notice 57397) to the NSW Responsible Officer (located at TransGrid) to do this at 16:58hrs AEST (AEMO, 2017i). Figure 3.1 below illustrates the manual load shedding procedures used in this incident.

The incident on 10 February in NSW did not escalate to a Level 5 and further load shedding was not required. If an incident does become a Level 5 power system emergency response, the NSW Government could have intervened and directed mandatory restrictions under Part 6 of the *Energy and Utilities Administration Act (1987)*. Mandatory restrictions can be utilised following proclamation by the NSW Governor to activate emergency powers. This enables the NSW Government to direct the use and supply of electricity within the State. If this situation were to occur, the Jurisdictional System Security Coordinator (JSSC) would develop a mandatory restriction schedule in accordance with protocols, including the Qld/NSW Inter-jurisdictional Power System Emergency Management Protocol for managing voluntary reductions/mandatory restrictions across all or part of the both states (AEMO, 2015e). The time to invoke mandatory restrictions would typically be 2-4 days and until this was achieved involuntary load shedding would most likely be required.

A summary of the prevention, preparation, response and recovery strategies for each of the above incidents is given below in Table 3.3.

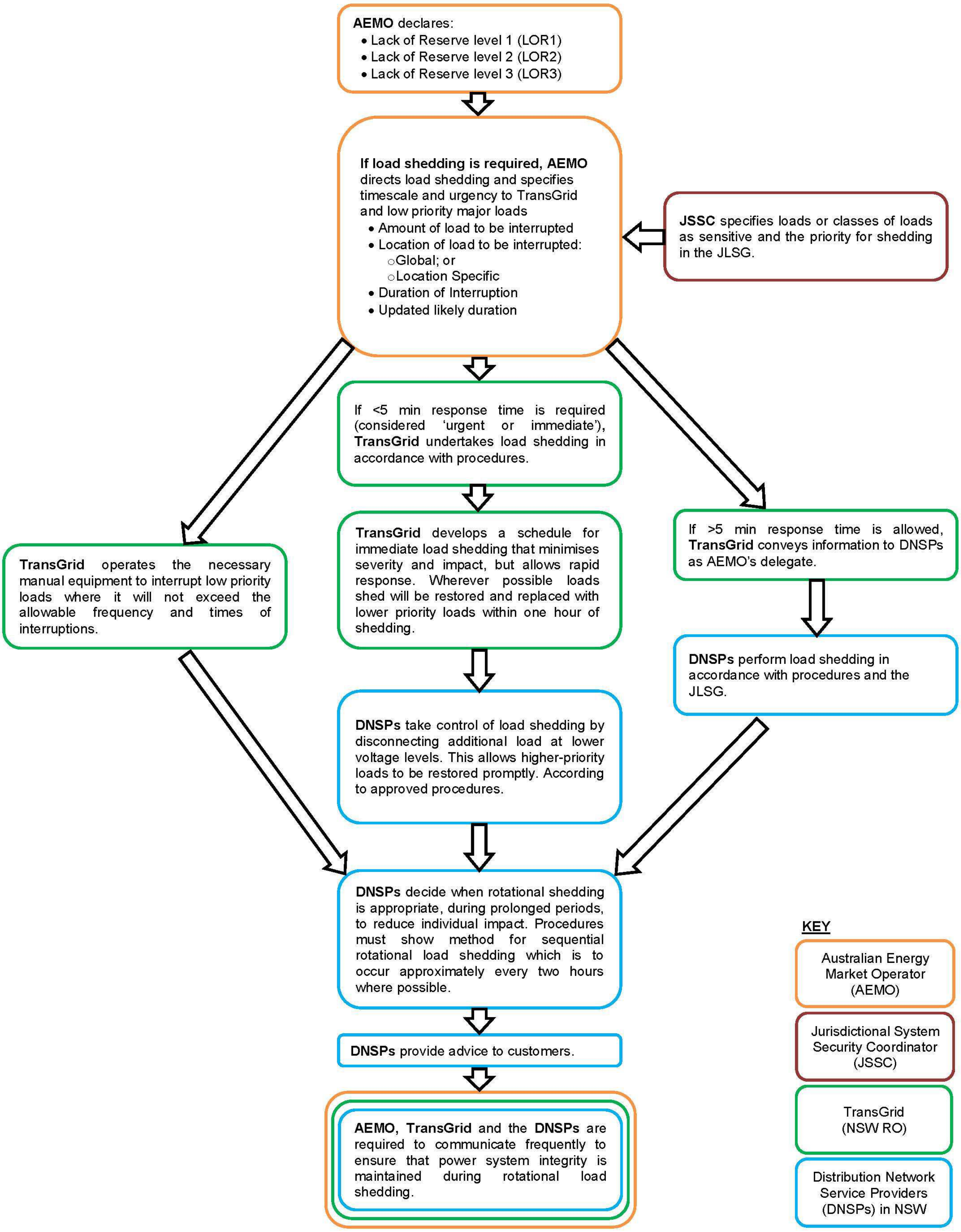

Figure 3.1: NSW manual load shedding procedures
(NSW Government, 2015)

Table 3.3: Management of electricity system security events

Incident Type	Major damage incident (e.g. bushfire)	Automatic load shedding (e.g. technical failure)	Short-term notice supply shortage (~1-2 days)	Longer-term notice supply shortage (> 2 days)
Stage				
Prevention	• equipment design • reliability standards	• equipment design • reliability standards	• ability to lift plant restrictions • generation comes online • voluntary reductions	• ability to lift plant restrictions • generation comes online • voluntary reductions
Preparation	• State Emergency Management Plans • TNSP and DNSP emergency plans • Emergency Management and power system exercises	• TransGrid maintains operating manual for automatic under frequency load shedding for NSW • NSW develops protocols for the priority and order for load shedding • AEMO Power System Security Guidelines load restoration	• AEMO power system emergency management plan and exercises • PASA/LOR market notices • NSW load shedding guidelines • voluntary restrictions • TransGrid emergency management plan • Responsible officer effectiveness • TransGrid and DNSP manual load shedding plans	• AEMO power system emergency management plan and exercises • PASA/LOR market notices • NSW load shedding guidelines • Responsible officer effectiveness • mandatory restrictions ready and understood • legal instruments and role clear to enact essential services legislation • call centre ready
Response	• emergency services • back-up power systems • information provision/media management • plant/equipment repair • power system restoration	• emergency services • backup power systems • ministerial briefing material • information provision/media management • plant/equipment repair • power system restoration	• LOR market notices • Responsible officer (TransGrid)/ AEMO processes • JSSC processes • voluntary or mandatory restrictions • information provision/media management	• LOR market notices • Responsible officer/AEMO processes • JSSC processes • voluntary restrictions • mandatory restrictions pricing schedules • information provision/media management
Recovery	• black start plans by TNSP, DNSPs, Generators, AEMO • DNSP and TNSP restoration plans	• black start plans • DNSP and TNSP restoration plans	• review processes	• review processes

3.3 EMERGENCY MANAGEMENT PROVISIONS AND OPERATIONS: PREVENTION, PREPAREDNESS, RESPONSE AND RECOVERY

3.3.1 Energy emergency management provisions

There are two main statutory and procedural frameworks that deal with power system incidents and general state emergencies where power is affected. The frameworks underpinning these two streams are illustrated below in Figure 3.2.

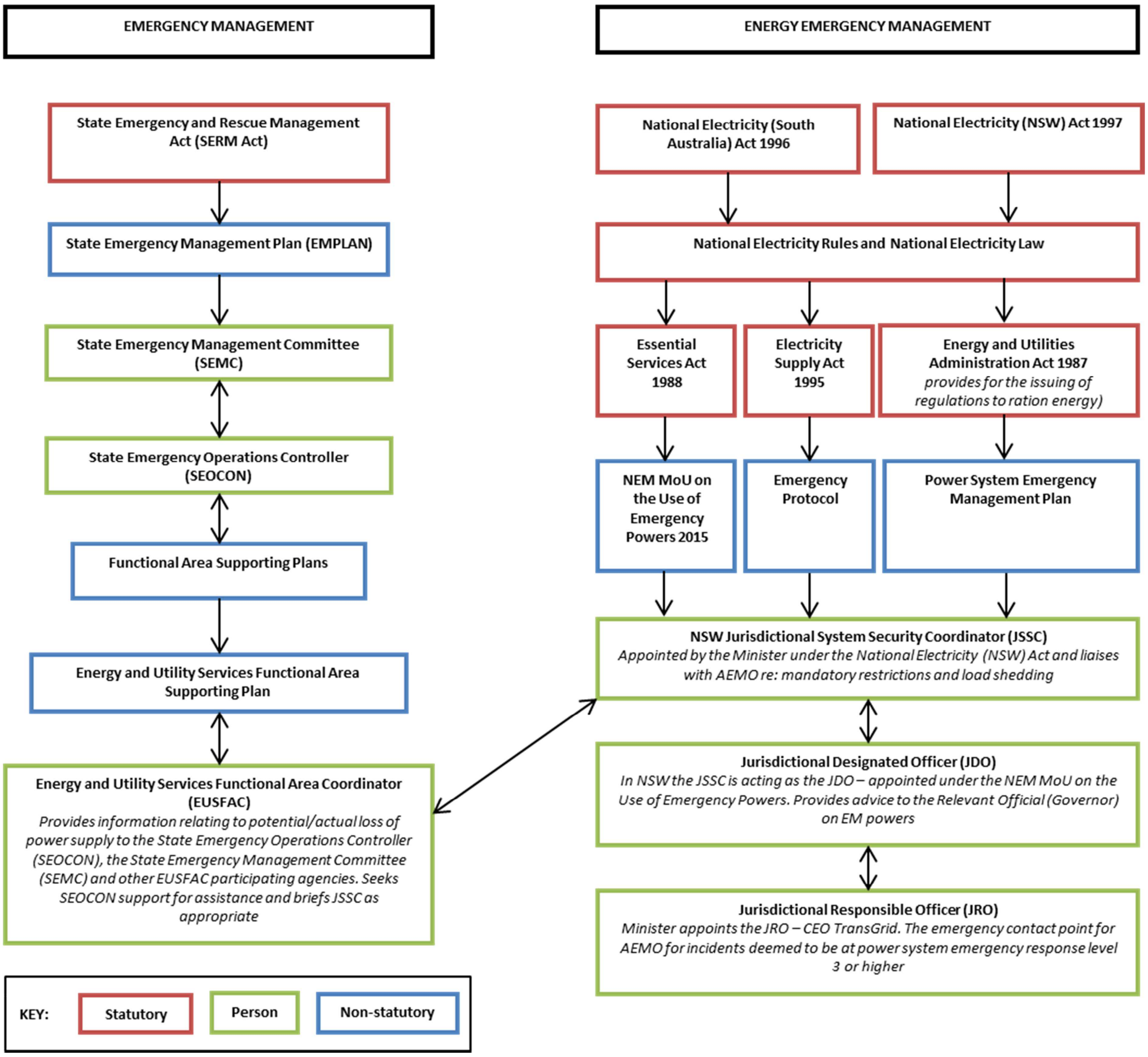

Figure 3.2: Emergency management and energy emergency management processes
(NSW Government, 2016b)

As illustrated in Figure 3.2 energy emergency management is dealt with under the National Electricity Rules and National Electricity Law (NEL) which is contained in a Schedule to the *National Electricity (South Australia) Act 1996.* The NEL (which is a national law, not a Commonwealth Act) is applied as law in each participating jurisdiction of the NEM by application statutes (AEMC, 2017f). In NSW this is reflected in the *National Electricity (NSW) Act 1997* which operates alongside the *Essential Services Act 1988*, the *Electricity Supply*

Act 1995 and the *Energy and Utilities Administration Act 1987* which regulate various aspects of the supply and management of energy in NSW.

Sitting below the NEL is a range of non-statutory instruments such as the AEMO PSEMP (AEMO, 2015f), the National Electricity Market Jurisdictional Load Shedding Guidelines for NSW (NSW Government, 2015), the National Electricity Market Power Supply Emergency Guidelines for NSW (NSW Government, 2016b), the National Electricity Market MoU on the Use of Emergency Powers (AEMO, 2015d) and the National Electricity Market Emergency Protocol (AEMO, 2015e), that together govern power system emergency response procedures which are carried out by market participants within the NEM such as AEMO, the network service providers and the relevant jurisdictional roles (see Table 3.4).

3.3.2 Use of State Emergency Powers for Electricity

As explained above, the *National Electricity Act (NSW) 1997*, the *Essential Services Act 1988*, the *Electricity Supply Act 1995* and the *Energy and Utilities Administration Act 1987* regulate various aspects of the supply and management of energy in NSW. They enable the Minister to use electricity specific emergency powers under certain circumstances (AEMC, 2017f).

Sections 24 and 25 of Part 6 of the *Energy and Utilities Administration Act 1987* enable the Governor to exercise electricity specific emergency powers "whenever it appears to the Governor that from any cause the available supply of any form of energy or energy resources is or is likely to become less than is sufficient for the reasonable requirements of the community"[7]. In such a circumstance the Governor can make a regulation by proclamation to "control, direct, restrict or prohibit the sale, supply, use or consumption of the proclaimed form of energy"[8] and can authorise the Secretary or person specified in the regulation "to specify the terms and conditions"[9] and "direct a person who extracts, provides, supplies, transports or distributes the proclaimed form of energy to extract it for or provide, supply, transport or distribute it to a person specified in the regulation"[10]. Such a proclamation under the Act will remain in force for 30 days unless amended, varied or revoked. Ten penalty units apply for offences under section 25 of the Act[11] which equates to $1,100, a relatively small amount. These emergency powers are derived from section 26 of the Act which enables the Governor to declare a state of emergency in relation to the supply of 'energy or energy resources other than gas or electricity'[12].

In order for a proclamation to be made and a regulation developed, the following processes need to be completed as described in the Department of Premier and Cabinet requirements (NSW DPC, 2017):

- an Explanatory note drafted by the Jurisdictional Designated Officer (JDO) to provide the Executive Council with an explanation of the advice for recommendation to make a proclamation
- an Executive Council Minute drafted which recommends that the Governor, with the advice of Executive Council, make the proclamation under section 24 of the Act
- a Proclamation drafted by the Parliamentary Counsel and signed by the Governor and the Minister to enable the making of a regulation (NSW Government, 2016b)
- a regulation drafted and published to provide for the use and supply of energy and to give directions to energy authorities and consumers. In emergencies, the regulation is made and published at the same time as the making and publication of the

[7] *Energy and Utilities Administration Act (1987): s24(1)*
[8] *s25(1)(a)*
[9] *s25(1)(b)(iii)*
[10] *s25(1)(b)(ii)*
[11] *s29*
[12] *s26(1)*

Proclamation to authorise the regulation (Parliamentary Counsel pers comms, 2017, May 2).

3.3.2.1 When is it appropriate to use these emergency powers?

The National Electricity Market Memorandum of Understanding on the Use of Emergency Powers 1998 and the National Electricity Market Emergency Protocol between AEMO and NEM participating jurisdictions outline the circumstances around which state emergency powers should be used in relation to electricity supply shortages in the NEM. Feedback from AEMO indicates that the use of state emergency powers can be very helpful in the management of an energy supply emergency where AEMO does not have powers or functions to take certain steps that would alleviate a situation, or when AEMO's powers are not otherwise clear (AEMO pers comms, 2017, April 19). For example, directions from the state under emergency powers can facilitate rationing of available supply or directly require action by a person who is not a registered participant, both of which AEMO is not able to do. Jurisdictional emergency management legislation can also provide additional protection or sanctions for directed persons or organisations (AEMO pers comms, 2017, April 19).

3.3.2.2 Problems and risks associated with the current process

Consultation with the NSW Parliamentary Counsel highlighted the fact that the *Energy and Utilities Administration Act 1987* was drafted during the 1980s, well before the NEM started, at a time when the energy industry and the energy system were structured in a very different way. The current legislative process seems unnecessarily convoluted and does not reflect the complex energy system that exists today. A simpler trigger is needed to enable a fast and very clear response to a sudden energy emergency. For example, as in most contemporary Acts, it would be more appropriate for the Minister rather than the Governor to enact the energy emergency powers, with provisions included to enable the Minister to delegate these powers to the Secretary or other appropriate officers within the Department as necessary. As far as possible the Premier should be involved in the decision to invoke the energy emergency response, so the exercise of energy emergency powers by the Minister could be subject to consultation with the Premier.

This presents an opportunity to develop a new, simplified Act which would replace Part 6 of the *Energy and Utilities Administration Act 1987* and would specifically be targeted at energy management in an emergency. It would take into account the current complexities of the system. Such an Act would give the NSW Government the same energy emergency management powers as currently exists regarding the control, direction, restriction or prohibition of the sale, supply, use or consumption of energy. And it would not affect the operation of the NEL or alter the existing procedures which exist within the NEM MoU on the Use of Emergency Powers or the NEM Emergency Protocol on when or how state emergency powers can be used. However the new Act could provide a simplified trigger for these powers to be enacted and would more clearly articulate how these powers fit within the existing NEM energy emergency management procedures and the State emergency management procedures under the *State Emergency and Rescue Management Act (1989)* (the SERM Act) and the State Emergency Management Plan (EMPLAN) (NSW Government, 2012). As well, the Act could identify clearly all the relevant roles and responsibilities under the Act. At present, there is no one document which articulates how energy emergency management is managed in NSW both from an energy *and* an emergency management perspective.

3.3.3 Roles and responsibilities of NSW energy emergency management personnel

The key officials in NSW in an energy related emergency are determined under the NEM Emergency Protocol. These include:

- AEMO NEM Responsible Officer, which in NSW is held by a representative within AEMO
- Jurisdictional Responsible Officer (JRO), which in NSW is held by a designated person in TransGrid
- JSSC which sits within the Department of Planning & Environment, Division of Energy, Water, Regulation & Portfolio Strategy (hereafter referred to as Department of Planning & Environment) and is responsible for communicating with AEMO about sensitive loads and requirements for NSW in relation to shedding and restoration of loads.

The technical and operational aspects of load shedding are undertaken through AEMO and either TransGrid or the distributors, with the JSSC in frequent communication. Table 3.4 below gives an overview of these roles and responsibilities.

Table 3.4: Roles and responsibilities of NSW energy emergency management personnel

Title	Emergency System	Roles/responsibilities
AEMO NEM Responsible Officer (NEM RO)	Electricity Market Emergency Management	AEMO fills this role. Under the NEM MoU on the Use of Emergency Powers and corresponding Protocol, the NEM RO acts as the emergency contact point for jurisdictions during a power system emergency response of level 4 or higher (AEMO, 2015f).
Jurisdictional Responsible Officer (JRO)	Electricity Market Emergency Management	In NSW, a designated person in TransGrid holds this role. This role is responsible for implementing the Emergency Protocol. The JRO, otherwise referred to as JRO is the main point of contact for AEMO during a power system emergency response of level 3 or higher. Much of this role relies on procedures produced before an event takes place, and the JRO is responsible for implementing direction from AEMO in relation to switching loads and liaising with the distributors around load reduction. The JRO must act in accordance with directions from AEMO and the Jurisdictional Load Shedding Guidelines.
Relevant Official (RO)	Electricity Market Emergency Management	The RO is the person with the authority to exercise emergency powers within the jurisdiction. In NSW, the Governor has the authority to proclaim a special regulation (lasts 30 days) to cover responsibilities for mandatory restrictions under the emergency.
Jurisdictional System Security Coordinator (JSSC)	Electricity Market Emergency Management	This role is currently filled within the Department of Planning & Environment. The JSSC is responsible for the preparation and maintenance of the jurisdictional load shedding guidelines and corresponding procedures. During an emergency, the JSSC liaises with AEMO and other jurisdictions' JSSCs in relation to voluntary or mandatory restrictions. The JSSC is responsible for approving mandatory restriction schedules. The JSSC will coordinate the declaration of emergency powers by the NSW Governor, as needed (NSW Government, 2016b).
Jurisdictional Designated Officer (JDO)	Electricity Market Emergency Management	Currently the same person acting as the JSSC. Under the MoU on the Use of Emergency Powers and corresponding protocol, the JDO provides advice to the RO in relation to exercising emergency powers and restrictions. The JDO is also responsible for developing and reviewing the NEM Emergency Protocol (AEMO, 2015f).
Department of Planning & Environment media team	Electricity Market Emergency Management	The Department of Planning & Environment's media team is responsible for managing all public information and media releases that relate to a power supply incident or emergency and for ensuring that consistent messages are relayed between the transmission network, distributors, AEMO and the Minister's Office (NSW Government, 2016b).

The division of roles and responsibilities of energy emergency management personnel under the NEM Emergency Protocol are fulfilled by staff from different organisations in each jurisdiction in the NEM. This is illustrated in Table 3.5 below.

Table 3.5: NEM Emergency Protocol roles and responsibilities across jurisdictions

	Jurisdictional Responsible Officer	Jurisdictional System Security Coordinator	Jurisdictional Designated Officer
QLD	Powerlink	Powerlink	QLD Department of Energy and Water Supply
ACT	ActewAGL	ACT Environment and Planning Directorate	ACT Environment and Planning Directorate
NSW	TransGrid	NSW Department of Planning & Environment	NSW Department of Planning & Environment
VIC	AEMO	AEMO	VIC Department of Environment, Land, Water and Planning
SA	SA Department of State Development	SA Department of State Development	SA Department of State Development
TAS	TasNetworks	TAS Department of State Growth - TAS	TAS Department of State Growth

Figure 3.3 illustrates how the communication channels are intended to operate between energy management personnel in the instance of an energy emergency.

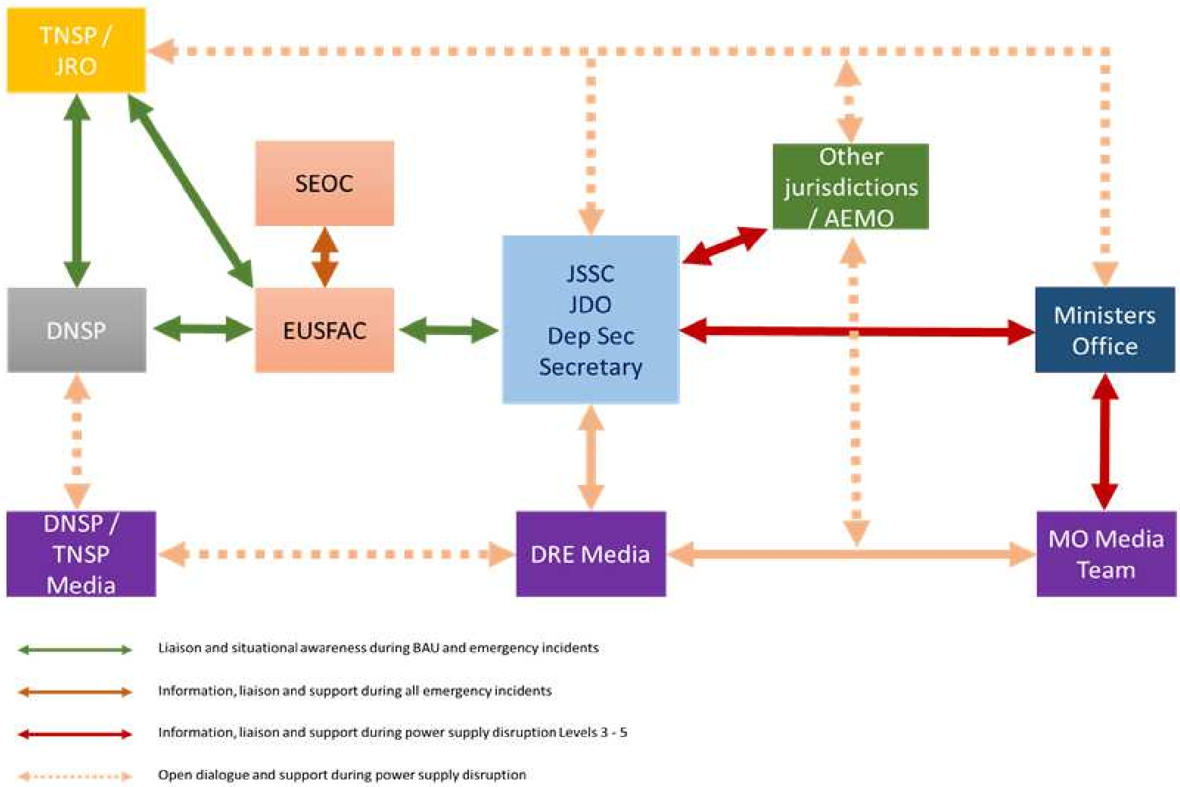

Figure 3.3: Energy emergency management communication flow chart
(NSW Government, 2016b)

3.3.4 Emergency management provisions

Alongside the energy emergency management framework is the state emergency management framework which stems from the *State Emergency and Rescue Management Act 1989* (SERM Act) and EMPLAN. This framework is reviewed in detail to highlight how it interacts with the energy emergency management procedures and to identify any gaps between the two frameworks.

The state emergency management system deals with emergencies due to an actual or imminent event (i.e. fire, flood, storm, terrorist attack, etc.) which endanger life or destroy or threaten property (NSW Government, 1989). The State Emergency Management Committee

(SEMC), the State Emergency Operations Controller (SEOCON) and the State Emergency Recovery Controller (SERCON) all play critical roles in the overarching management of emergencies. The Energy and Utility Services Functional Area Coordinator (EUSFAC) in the Department of Planning & Environment, Division of Resources and Mining (formerly the Department of Industry, Division of Resources and Energy) leads the coordination of information and advice during energy, gas or fuel incidents or emergencies between combat agencies, the SEOCON, the JSSC and functional area participants, as required. The roles of the main officers in the state emergency management system are given in more detail in Table 3.6 below.

The Energy and Utility Services Functional Area operates under a Supporting Plan. The existing Energy and Utility Services Functional Area Supporting Plan (EUSPLAN) (State Emergency Management Committee, 2004) is a supporting plan to the NSW Disaster Plan (DISPLAN), now EMPLAN (NSW Government, 2012) to co-ordinate the management of disruptions to energy and utility supply within NSW from the state emergency framework. Sections 3.3.6.1 and 3.3.6.2 in this report go into further detail about supporting and sub plans, including analysis of the current EUSPLAN.

Table 3.6: Roles and responsibilities of emergency management personnel

Title	Emergency System	Roles/responsibilities
State Emergency Management Committee (SEMC)	State Emergency Management	The SEMC is established under the SERM Act 1989 to assure NSW has a robust system in place to deal with hazards that can become emergencies. Membership on the SEMC includes the SEOCON, the SERCON and functional area coordinators. Some of the SEMC's responsibilities include providing advice to the Minister in relation to emergency management (EM), reviewing the adequacy of the EMPLAN, endorsing sub plans and supporting plans, and facilitating cooperation and information sharing across agencies involved in EM (Emergency NSW, 2017a).
State Emergency Operations Controller (SEOCON)	State Emergency Management	When an emergency occurs that is not under the designated control of a Combat Agency according to the EMPLAN, the SEOCON assumes control. In this situation, the SEOCON is responsible for: controlling and coordinating the emergency response operations (at the state level); establishing and controlling a State Emergency Operations Centre (SEOC) who support the SEOCON with the necessary staff and communications equipment; providing advice to the Minster for Police and Emergency Services regarding possible 'State of Emergency' declarations (NSW Government, 2012; Emergency NSW, 2017b). If a combat agency has control of an emergency situation, the SEOCON (and the SEOC) supports them and if required, takes control.
State Emergency Recovery Controller (SERCON)	State Emergency Management	The SERM Act requires the appointment of the SERCON. The SERCON is responsible for: oversight of the preparation and maintenance of NSW recovery plans, including policies and arrangements, unless already established in hazard specific plans; liaising with the SEOCON; coordinating comprehensive assessments and the need for recovery operations; providing oversight and support to regional/state level Recovery Coordinators (NSW Government, 2012).
Energy and Utilities Services Functional Area Coordinator (EUSFAC)	State Emergency Management	Cabinet nominated representative on the SEMC. The EUSFAC coordinates the Energy and Utilities Services Functional Area for the provision of energy and utilities support and resources for emergency planning, preparation, response and recovery operations. The EUSFAC coordinates information and advice between combat agencies, the SEOCON, the JSSC and functional area participants, depending upon the event type. The EUSFAC may respond to electricity incidents while also responding to gas or fuel incidents during the same emergency.
Public Information Functional Area Coordinator (PIFAC)	State Emergency Management	PIFAC integrates public information and messages to provide a 'single source of truth' to the public in the event of an emergency. The PIFAC may require the EUSFAC to source public messages related to energy and utilities from the participating organisations as appropriate.

3.3.5 The broader relevance of energy emergency management

Energy security and emergency management are linked. While the aim in managing an energy emergency is to minimise possible disruption to power, when disruption to power is unavoidable it has the potential to have an impact on all aspects of society, with potential for loss of life and disruption to day-to-day activities. Accordingly, it is important that the emergency management sector and those involved in essential services or services provided to vulnerable people, have an understanding of how they will respond to power interruptions. This may include:

- health services – hospitals (public and private), aged care facilities, home care
- food – food production and community access to food
- water and other utilities such as sewage and telecommunications
- transport
- education
- data.

The South Australian energy incident in September 2016 highlighted the importance of energy emergency management procedures to broader portfolio areas. Of particular importance were the emergency management arrangements that these portfolio areas had in place to respond to and manage power outages. For example, health services as a portfolio was significantly affected during the South Australian power outage. Accordingly the Taskforce decided to review the emergency management procedures that are in place in a range of portfolio areas in NSW, paying particular attention to health services.

3.3.5.1 Health services

Within NSW Health, emergency management is managed by the State Health Services Functional Area Coordinator (State HSFAC) which sits within the Ambulance Service of NSW. While the State HSFAC sits within the Ambulance Service, the role is responsible to the Minister for Health and performs the emergency management functions on behalf of the NSW Ministry of Health and reports emergency management information through to the Chief Health Officer. The State HSFAC takes responsibility for the NSW Health Services Functional Area Supporting Plan (NSW HEALTHPLAN) (NSW Health, 2013). The NSW HEALTHPLAN describes the arrangements for the coordination of health resources during a State-level health emergency or an emergency where a State response is coordinated under the EMPLAN (NSW Government, 2012). Further, the State HSFAC takes a proactive role in ensuring health services are prepared and can respond to emergencies situations, including loss of power.

NSW Health has 15 Local Health Districts (LHDs) and three Specialty Networks covering NSW. Through performance agreements with each of the LHDs, the Deputy Secretary for System Purchasing and Performance in the Ministry of Health can issue directives to the LHDs requiring them to comply with policies and guidelines. The State HSFAC uses these systems to communicate requirements for emergency management. Each of the LHDs has a similar emergency management structure to the Office of the State HSFAC whereby each LHD has a Local Health District Health Services Functional Area Coordinator (LHD HSFAC) who is responsible for responding to emergencies within their area. The LHD HSFAC is appointed by the LHD Chief Executive, however is accountable to the State HSFAC. Each LHD has a governing board, which is responsible for the strategic direction and operational efficiency of the LHD. However, in accordance with NSW Health's Corporate Governance and Accountability Compendium, these boards have no formal responsibility in the operational response to emergencies under the NSW Health Plan. This responsibility rests with the LHD HSFAC working to the State HSFAC. Where an energy incident is small scale (e.g. power interruption to part of a hospital), the LHD HSFAC manages the response with communications back to the State HSFAC. For larger energy incidents (e.g. loss of power to a suburb) the State HSFAC would get involved by acting as a conduit for information between the relevant emergency functional area and the LHD HSFAC.

While the paragraph above outlines the emergency response framework for LHDs, a similar framework exists across other health services including pharmaceuticals and blood supply services which feed into the State HSFAC. The Director of the Office of the State HSFAC meets quarterly with the functional area coordinators across the health services (including the LHD HSFACs) to discuss emergency management including issues management, recent events, preventative measures and policy endorsement. The State HSFAC is required to undertake an emergency management exercise at least annually which may include the LHD HSFACs.

Hospitals

NSW Health has informed the Taskforce of a number of measures in place to safeguard electricity supply during power outages. All public hospitals are equipped with Uninterruptible Power Supply (UPS) units and back-up generators. When the electricity supply is interrupted, the UPS units theoretically provide power for up to 8 hours, during which time power is switched over to generators. The Director of the Office of the State HSFAC advises LHD HSFACs that back-up generators should be checked monthly to ensure they start, are serviced annually and that diesel fuel is replaced regularly given the fuel has a shelf life of between 12 and 18 months (NOSEC, 2009). For some hospitals, double feeds from different distribution systems have also been installed so that if one distribution system is interrupted, power is still supplied to the hospital. These arrangements have been implemented across the public hospital system and where private hospitals are on the same campus, these are included in the emergency power arrangements. While the arrangements do not extend to private hospitals, the Australasian Health Facility Guidelines requires facilities to consider the need for UPS units and standby power. NSW Health requires private health facilities to comply with these Guidelines. During discussions with the Taskforce, the Director of the Office of the State HSFAC indicated they were confident that private hospitals have alternate power arrangements.

Further feedback from the Director of the Office of the State HSFAC indicated that issues have been experienced regarding UPS units being unable to last for more than one hour. Back-up generators are tested, but there is no existing process in place to test either the generators or the UPS units under load (with the exception of the commissioning of new hospitals when the facility is put into total shutdown and a ‘load test’ is undertaken). Testing under load once a hospital is operational presents significant challenges, therefore appropriate testing mechanisms should be considered for the future. Further, unless the UPS units are used frequently, the battery life may be less than anticipated due to battery deterioration. Thus checking the batteries needs to be done on a regular basis.

Another issue identified by the Director of the Office of the State HSFAC is the presence of fixed windows in hospitals which increases hospitals’ reliance on air-conditioning for ventilation. Where air-conditioning systems are not connected to back-up power, both air-conditioning and ventilation will stop during power outages. In addition to this, during the summer periods room temperatures will naturally increase.

Through their performance agreements, LHDs are required to report to the Ministry of Health on their performance relating to areas such as performance information, service delivery, clinical services and financial performance. There is no requirement for the LHD to report on the operational aspects of power back-up systems including maintenance records and results from system testing. Some type of formal reporting requirement may assist with ensuring power back-up systems are adequately managed so that they are operational during emergency incidents. As mentioned above, LHD boards have no responsibility for emergency management and their roles and accountabilities do not extend to business continuity (NSW Health, 2012a). This may need to be addressed to allow for formal reporting of operational aspects of power back-up systems.

The South Australian energy incident in 2016 highlighted an additional pressure on hospitals during power outages. That is that medical practices in general do not have back-up power arrangements and as a result, people needing medical assistance during the power outage were referred to hospitals. This increased the pressures placed on the hospitals in South Australia that were already under strain.

Figure 3.4 (taken from the HEALTHPLAN (2013)) provides an overview of the Emergency Management Committees and arrangements within NSW Health. Within the diagram, minimum occurrence has been interpreted as minimum meeting frequency.

Aged care facilities

Aged care facilities are vulnerable health facilities requiring action plans during power interruptions. The Commonwealth Department of Health has overall responsibility for regulation of aged care facilities. All aged care facilities are required to conform with accreditation standards. These standards are outcomes based measures and include the need for facilities to prepare plans to manage risks such as fire, security and other emergencies (AACQA, 2017a). Generally, aged care facilities are managed by non-government and private organisations, with third-party bodies assessing facilities against the standards and reporting these outcomes back to the Commonwealth Department of Health (AACQA, 2017b). In general, management under board oversight in aged care facilities is responsible for meeting their accreditation standards. The Australasian Health Facilities Guidelines exist to assist with the development of these emergency plans and protocols. NSW Health also provides assistance and advice to aged care facilities on emergency plans (NSW Health, 2012b; NSW Government, 2016a).

During discussions with the Director of the Office of the State HSFAC it was noted that evacuation in an energy emergency may not be in the best interest of the aged care residents with the risk of loss of life occurring during the evacuation. Accordingly, for some aged care facilities where evacuation can be avoided, management plans should consider actions that address resilience, which in the case of power interruptions would be alternative power sources. Aged care facilities are advised to have access to generators, either already on-site or alternative pre-existing arrangements with a generator hire company.

Home care

There are an increasing number of people living independently in the community who require medical equipment to survive. There is a high level of concern by the Director of the Office of the State HSFAC that many of these people may not have action plans in place for power outages. In the event of a power outage, NSW Health is able assist those participating in the Hospital in the Home Program. Further, the NSW Government has implemented a Life Support Rebate Program (NSW Resources & Energy, 2017b; Energy Australia) which provides support for people who require intensive life support equipment at home and also provides for a mechanism to register with the local energy distributor which can provide advice on what to do during a power interruption and an emergency contact number to call during a power outage.

Concerns were also raised by the Director of the Office of the State HSFAC that these two programs may not capture all home care patients who are at risk during energy incidents. A mechanism could be explored to ensure all people living independently in the community, who are reliant on electricity for health reasons, have plans for how to respond to power interruptions. It was suggested by the Director of the Office of the State HSFAC that the National Disability Insurance Scheme and the ‘My Aged Care’ services may be able to assist with the provision of information, however privacy issues will need to be considered.

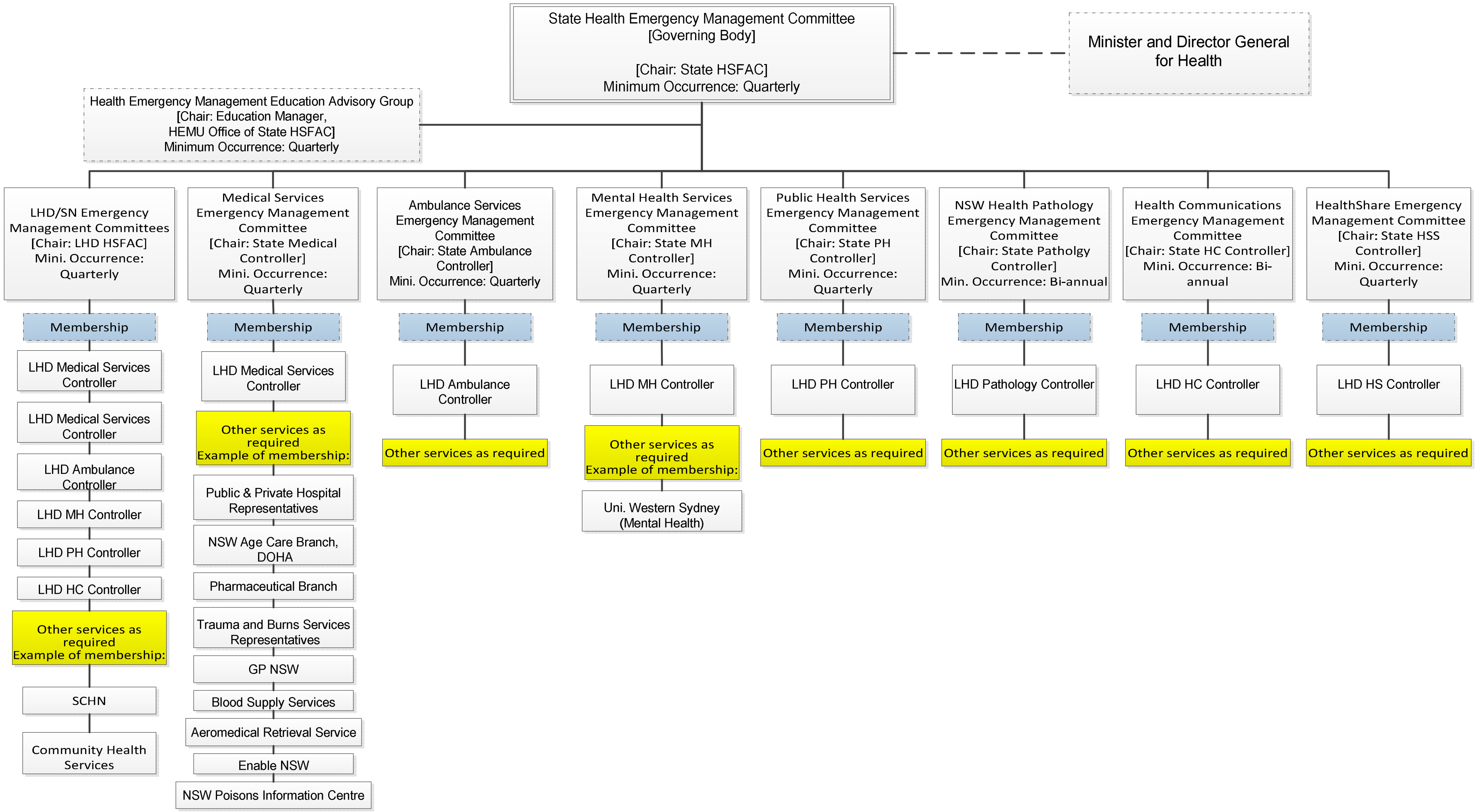

Figure 3.4: Health Emergency Management Committees (NSW Health, 2013)

3.3.5.2 NSW Health summary

Overall NSW Health has good emergency management arrangements in place which are well developed and are coordinated and managed by the Office of the State HSFAC. In discussions with the Director of the Office of the State HSFAC it was agreed that there is a need to consider succession planning for the Director, Office of the State HSFAC, and State HSFAC roles. Given the critical nature of the NSW Health emergency management system there is a need to ensure it continues to be well resourced and led into the future. This could include examining more closely matters identified by the Office of the State HSFAC and issues such as responsibilities for testing back-up systems, and reporting on and audit of emergency management arrangements in health facilities. Since the Taskforce's initial discussions with the Director of the Office of the State HSFAC, the Taskforce understands that agencies within NSW Health are working collaboratively to identify opportunities to build more robust systems and develop procedures to manage energy emergency management issues better.

3.3.5.3 Food

The NSW Food Authority (Food Authority) is responsible for the Food Industry Sub Plan (FISP) under the EMPLAN (NSW Government, 2009). The FISP describes the arrangements for the coordination of food resources during an emergency which has the potential to have an impact on food safety and/or food supply. During a state response under the EMPLAN, the Food Authority can also provide support through the State Agriculture and Animal Services Functional Area (AASFA) Supporting Plan (NSW Government, 2011).

The Food Authority has some general food safety advice for both businesses and consumers on being prepared for and responding to emergencies, including power interruptions (NSW Food Authority, 2009). It also provides consumer information prepared by the food and grocery sector for preparing for an emergency, including how to develop a 14-day pantry supply for emergencies (AFGC, 2015). Aside from the pantry list, the advice would only be relevant for incidents or emergencies of less than 24 hours. Much of the information sourced from the Food Authority relates to responding to food safety during an incident or emergency and not the provision of food. Within the FISP, many industry groups and organisations are listed as supporting agencies and can be called upon to assist with the supply of food.

As with other sectors, many food businesses have developed and implemented Business Continuity Plans (BCPs) to manage power interruptions. The presence of BCPs would be more common in larger food businesses that have the resources to develop these plans such as large manufacturers, larger retailers and fast food chains. BCPs however would be less common in small businesses, especially family owned operations, where resourcing is limited for responding to emergencies and as such is more likely to be reactive rather than proactive.

The Food Industry Emergency Sub Plan makes no mention of responding to power interruptions. Food processors are mentioned as medium priority loads within the load shedding guidelines. Electricity distributors may consider manual load shedding where it is expected that these businesses can sustain short-term interruptions.

In summary energy emergency management as it relates to the food sector principally rests with the business community. As such the sector's ability to respond to power outages relies primarily on individual businesses and the available resources they have at hand to prepare for and respond to power outages. The NSW Government could play a greater role in assisting businesses, particularly small businesses, to have the necessary arrangements in place. This assistance would be of equal benefit to consumers.

3.3.5.4 Water and other Utilities

The supply of water is an essential service that needs to be managed during an interruption to power. There are a number of water utilities across NSW including Mid-Coast Water, Shoalhaven Water and regional councils, with Sydney Water and Hunter Water providing services to a large proportion of the NSW population (Sydney Water pers comms, 2017, May 2). Emergency management for drinking water and wastewater falls within the EUSPLAN so the EUSFAC has a coordination role during both energy and water emergencies.

Sydney Water

Sydney Water is a state-owned corporation responsible for providing water, wastewater and some stormwater services across the Greater Sydney, Blue Mountains and Illawarra regions (Sydney Water, 2017b). The Taskforce held preliminary discussions with Sydney Water to understand how it responds to power interruptions. Sydney Water is dependent on both the electricity and telecommunications networks to operate its assets, which presents a significant vulnerability. It operates 827 pumping stations, 243 reservoirs and 35 treatment facilities. In addition there are 6 other treatment facilities owned and operated by external companies.

Sydney Water has incident management procedures and plans in place that reflect the NSW State Emergency Management arrangements. It keeps in regular contact with the Energy & Utilities Functional Area Coordinator (EUSFAC). It has generators and containment equipment which can be deployed in the event of a power disruption. It also has contractual arrangements with major generator hire companies and water and wastewater tanker companies across Greater Sydney and the Illawarra for use when needed during power outages.

Sydney Water has agreements with energy suppliers to pump water during off-peak hours, reducing the load during peak electricity use. During the heatwave of February 2017, Sydney Water was proactive - filling its reservoirs overnight and deploying generators to help reduce daytime electricity load. Proactive deployment of generators to critical facilities enables contingency plans to be initiated quickly (Sydney Water pers comms, 2017, May 2).

Sydney Water maintains relationships with energy distributors and provides them with a list of its critical assets so that they can prioritise these assets in the event of a power disruption, working together to use contingency arrangements effectively.

Extreme weather events such as wind storms and east coast lows are usually localised, but can result in longer-term damage to both water and electricity infrastructure and potentially longer disruption. There is a significant amount of interconnection between water systems with usually enough storage in system to sustain water supply during these types of events. Contingency is therefore usually concentrated on wastewater facilities.

The Commonwealth Attorney-General's Department sponsors a Critical Infrastructure Program for Modelling and Analysis (CIPMA). The CIPMA modelling and analysis helps Sydney Water to prevent, prepare for, respond to, and recover from natural and human caused disruptions to critical infrastructure. Sydney Water has collaborated with CIPMA to understand its vulnerabilities and determine appropriate mitigation programs.

Through its own energy efficiency and renewable energy programs, Sydney Water is generating a considerable amount of its own energy. In 2015-16, Sydney Water generated 21% of its total energy requirements from biogas, hydroelectricity and solar energy (Sydney Water, 2017a). Through these programs Sydney Water has been able to maintain energy use at 1998 levels despite population growth and increased development. In the future Sydney Water hopes to be able to generate more power from its wastewater facilities than it uses, which will be helpful for future emergencies.

Hunter Water

Hunter Water is also a state-owned corporation and is responsible for providing water and wastewater services to the lower Hunter region (Hunter Water, 2017). Feedback from Hunter Water indicates that both the water and wastewater systems are able to manage during short-term outages, with stored drinking water still able to be distributed and wastewater systems able to remove waste from customers to storage facilities until power is restored. For longer localised power outages, systems are in place to allow drinking water to be safely tankered in and wastewater to be safely tankered out. Due to the infrequent nature of longer-term, large-scale power outages, Hunter Water takes an incident-response approach, sourcing generators and equipment as required. Given recent power outages in the area have largely been a result of major damage incidents, such as the 2007 and 2015 floods caused by east coast lows which affected more than just power supply, Hunter Water's incident-response approach has generally been considered acceptable to customers. It was acknowledged however that the community may be less accepting of a loss of water supply and wastewater services if the outage is due to a lack of energy supply alone. Should these events become more frequent, Hunter Water has indicated that there may be a need to consider additional capital investment on infrastructure such as standby generators to allow Hunter Water to respond in a manner expected by its customers and required by environmental regulation.

The major damage incidents experienced in the Hunter region in the last decade, in 2007 and 2015, both caused considerable damage including flooding, power loss, and loss of life. In these situations, Hunter Water responds in cooperation with other energy and utility service providers, other emergency management functional areas and emergency services more generally. Hunter Water believes that these major damage incidents are best managed at a regional level with direct communications occurring between those able to assist restoring services. Hunter Water also stressed the need for all personnel involved in responding to power outages, both in the private and public sector, to understand the essential nature of the role that utilities such as Hunter Water play in ensuring the reliable provision of safe drinking water and the management of wastewater to maintain the health and wellbeing of the community.

While the scope of the EUSPLAN does include the possibility of disruptions to the provision of water services, the EUSPLAN makes no mention of how other utilities such as water services should respond to power outages. The draft EUSPLAN merely lists water utilities, including Hunter Water and Sydney Water, as being "supporting organisations". In instances where power outages may be of concern due to tight energy supply and AEMO determines that load needs to be shed manually, advance notice from the EUSFAC to water utilities regarding the intended location of the load shedding would allow water utilities to respond proactively to ensure interruptions to water supply are kept to a minimum. During the 10 February 2017 incident the EUSFAC provided energy supply shortage updates to the water utilities.

During the 10 February 2017 energy incident, the Minister for Energy contacted Hunter Water to seek assistance in managing power consumption to reduce demand on the energy system. Between 4pm and 6pm (AEDT)[13] on 10 February Hunter Water was able to reduce its energy consumption by half (4600 kW) by adjusting its wastewater treatment facilities and water pump stations in its water distribution network.

In summary water utilities are important users of electricity and have systems in place to assist managing power outages. It is clear however that where practicable, advanced warning would assist water utilities to respond to and manage power outages. Water utilities

13 AEDT refers to Australian Eastern Daylight Time. Sydney was on AEDT in February 2017. Times reported by AEMO are in AEST.

also play an important role for the government in demand side management which needs to be appropriately planned for given there are no pre-existing arrangements so that this mechanism can be utilised where possible to manage energy supply shortages.

3.3.5.5 Transport Services

Electricity is essential for transport services. Widespread loss of power has the potential to cause significant disruption to the road and train systems. Within the emergency management framework, the Transport Services Functional Area Supporting Plan details the support that transport services will provide to the SEOC, combat agency, emergencies services organisations or other Functional Areas when responding to an emergency situation (Ministry of Transport, 2008).

While power interruption is not mentioned in the Transport Services Functional Area Supporting Plan, transport services have considered this in their business-as-usual and emergency/incident response systems and procedures. Many of the critical facilities including the Transport Management Centre (TMC) and the Rail Management Centre have the ability to switch to back-up generators during a loss of power. In addition, alternative facilities are available should there be the need to evacuate. Control centres for motorways and the Harbour Bridge all have generators.

Road tunnels have generators available for essential services only allowing time to remove vehicles from inside the tunnel. Following this, tunnels would be closed as the generators are not designed or intended to continue full operations. 35 traffic lights within the Sydney CDB have UPS units and the TMC with assistance from Roads and Maritime Services (RMS) has access to approximately 40 generators for use at significant intersections in the greater Sydney Metropolitan area. Most of these back-up systems can operate for at least 24 hours.

RMS and Ausgrid have arrangements in place through the TMC to provide appropriate notice, where possible, to deploy generators for key traffic lights in areas that are expected to be affected by load shedding.

The electrified rail network has its own high-voltage transmission system separate to the electricity distributor’s network. Because of this, rail services can continue even when there are local power outages.

Small localised power outages can be managed as rail sub-stations having dual feeds which allow power to be redirected from other areas if needed. While the high-voltage transmission system is able to manage localised power outages as described above, major widespread outages affecting the greater metropolitan Sydney, while very rare, would cause the rail system to stop operating. Ventilation in train tunnels is maintained by natural flow of air in platforms and tunnels through momentum of trains passing through the tunnels. As such, during longer term power outages when trains are no longer able to operate, ventilation will be compromised.

Rail emergency response procedures for widespread outages

During widespread power outages an emergency or incident management response would be required. In these situations the Transport Management Centre has the ability to deploy extra crew and staff, with assistance also provided by NSW Fire & Rescue and NSW Police Force. Staff would be deployed to assist evacuating passengers from trains, including those in tunnels, to the nearest station. Where rail services are not available, buses would be used as a limited alternative mode of transport. Depending on the time of the outage, deploying buses during emergency situations could take a number of hours. The buses would have a reduced capacity compared to the train system. In the event of a widespread power outage, it is likely that the time taken to have replacement buses could be longer due to potential traffic congestion and the available capacity could be further stretched. The TMC, the RMS and the Transport Services Functional Area also have access to the government radio network to coordinate emergency responses.

Given the importance of the transport system, transport services remain in a state of readiness to respond to emergencies. Where the incident or emergency can be prepared for, such as a flood or fire emergencies, the Transport Services Functional Area Coordinator (TSFAC) is in contact with other Functional Area Coordinators to enable early response. This occurred during the 10 February 2017 power system event where the EUSFAC provided regular situation reports to the SEOC and other Functional Area Coordinators. Should a loss of power due to manual load shedding have occurred, the Transport Services Functional Area would not have been given advance notice of the area to be shed and any response would be reactive and a reduce opportunity to manage potential service disruptions. The TSFAC advised that greater warning regarding manual load shedding locations would assist in response preparations and decrease interruptions to transport services.

3.3.5.6 Education

The NSW Department of Education has no formal published policy regarding what actions schools should take during power interruptions. During the 10 February incident, schools remained open. The Department of Education notes that schools are only closed during extreme events including fire, flood and for health and safety reasons (Paterson, McDougall, & Godfrey, 2017). Schools are not specifically mentioned in the load shedding guidelines. They are likely to be considered as low priority load, and depending on the circumstances, may be part of the general community to lose power during manual load shedding.

Universities have a range of services and infrastructure, some of which would be critically affected by a power disruption. Accordingly NSW universities have developed strategies to minimise disruption to staff and students in the event of power outages. Many of these strategies are not designed to maintain business as usual, but rather to manage and prioritise resources to critical infrastructure and assets, such as laboratories with ongoing research requirements (where specific conditions must be maintained, such as fridges, freezers, etc.) and security (including restricted access facilities), over lower-risk infrastructure, such as lecture rooms.

3.3.5.7 Government Data Centres

The maintenance of data, including NSW Government data, is paramount and any loss of power has the potential to have an impact on data integrity. The NSW Government recognises this and has developed an overarching Government Data Centre Reform Strategy (DFSI, 2016). A key feature of this Strategy is the relocation of over 130 NSW government data centres to two purpose built data centres, one in metropolitan Sydney and the other in the Illawarra region (NSW Government, 2014).

The NSW Government Data Centres are Uptime Institute Tier III[14] certified in design and operation. The facilities have multiple generation and battery back-up facilities on site, and a number of contractual obligations exist to ensure that liquid fuel supply is able to be provisioned in the event of a delayed electrical outage from the grid. The facilities can be independently powered for 72 hours through on site generation and back-up fuel supplies. Both facilities are regularly tested through a combination of warm starts of generators and full black starts at least every 6 months (GovDC pers comms, 2017, May 3).

[14] 'Uptime Institute Tier III' is a certification standard for data centres. It indicates that the data centre has: dedicated space for IT systems with UPS, dedicated cooling 24/7 and generators to protect against power interruptions (Tier I); redundant critical power and cooling systems (Tier II); ability to undertake equipment replacement and maintenance without impacting on the operation of the facility (Tier III) (Uptime Institute, 2017).

The NSW Government Data Centres currently have no formal involvement in energy emergency management procedures despite the fact that the Centres provide government data centre management services for all government clusters including health services, hospitals, education and transport. Further, while these portfolios are considered when manual electricity load shedding is required, no consideration is currently being given to the sensitivity of the load associated with the Government's Data Centres, and in turn, the data services they provide to each of these portfolios.

The NSW Government Data Centres are committed to using leading technologies and processes which are best practice nationally. As such the opportunity exists for other portfolios to learn from and consider implementing similar energy emergency management procedures in their organisations.

3.3.6 Adequacy of plans

3.3.6.1 Adequacy of the Energy and Utilities Supporting Plan

As explained previously, the Energy and Utilities Functional Area operates under a Supporting Plan, the EUSPLAN, which co-ordinates the management of disruptions to energy and utility supply within the state emergency framework (NSW Resources & Energy, 2017a).

The existing EUSPLAN that is publically available on the website is outdated having been written in 2004 and is very high level. While the Taskforce was made aware that there is an updated internal Concept of Operations (ConOps) from October 2015 which is in use by the EUSFAC, the Taskforce also understands that the 2004 EUSPLAN is the latest formally approved version. While there are sections in the EUSPLAN on preparation, planning, response, recovery, communication, roles and responsibilities, the EUSPLAN doesn't mention or link to the energy emergency management system, including EUSFAC communications with the JSSC in the event of a power system incident or lack of reserve issues. The EUSPLAN lists the participating and supporting organisations in the event of severe and sudden disruption to energy and utility services supply, but specific roles and remits for these organisations are not outlined. AEMO is also not mentioned in the EUSPLAN.

An updated Draft EUSPLAN has been developed by the Energy Division (NSW Resources & Energy, 2017a). This draft plan was provided to the Taskforce for review. While the document is not yet finalised, the Taskforce notes that the draft is much improved on the 2004 version, particularly around the planning, preparation, response and recovery (PPRR) principles and linking state emergency management processes with energy emergency management.

The draft EUSPLAN appears to amend the division of the responsibilities of roles by combining the EUSFAC and the JSSC roles. It specifically states that the EUSFAC may undertake the role of the JSSC during high-level incidents, including advising on voluntary reductions, load shedding and mandatory restrictions. While the Taskforce sees great benefit in bringing the EUSFAC and JSSC roles into the same unit of the Department of Planning & Environment to improve communications, the Taskforce strongly recommends that the roles be managed by two different people. This is critical due to the different skill set required for the EUSFAC role (planning, coordination, communication) compared with the JSSC role (technical knowledge, industry experience and subject matter expert with power engineering qualifications and a deep practical knowledge of the NEM or similar organisation). For example, several of those consulted noted that the skill and experience of the current acting JSSC was paramount on 10 February and essential to the incident being appropriately managed. In addition, during an incident or emergency, the JSSC and the

EUSFAC physically may be required to be in two locations; with the EUSFAC potentially required to be at the SEOC (NSW Resources & Energy, 2017a).

The JSSC is currently a part-time role within the Department of Planning & Environment. In NSW the JSSC also undertakes the JDO role as well. The Taskforce recommends that the JSSC and EUSFAC roles both need to be appropriately graded given their interaction with other functional area coordinators and energy emergency management personnel and adequately resourced given the critical nature of their roles in the event of an energy emergency. In order to get the appropriate skills and experience into the roles, both positions need to be at an appropriate grade and seniority.

3.3.6.2 The changing nature of energy: the need for a Sub Plan?

According to the EMPLAN

> *"A Sub Plan … is an action plan required for a specific hazard, critical task or special event. It is prepared when the management arrangements necessary to deal with the effects of the hazard, or the critical task or special event differ from the general coordination arrangements set out in the main or supporting plans for the area (NSW Government, 2012).*
>
> *A Supporting Plan … is a plan prepared by an agency/organisation or functional area, which describes the support which is to be provided to the controlling or coordinating authority during emergency operations. It is an action plan which describes how the agency / organisation or functional area is to be coordinated in order to fulfil the roles and responsibilities allocated" (NSW Government, 2012).*

The state's emergency management arrangements are to allocate roles and responsibilities across the various stakeholders and agencies so all are clear about their respective roles and tasks, including communication. The arrangements give clarity as to which is the lead agency in any particular situation and what the parties' roles are to support that agency during the PPRR phases for an event.

As explained, the Energy & Utilities Functional Area operates under a Supporting Plan. A supporting plan, as noted above, doesn't address a specific hazard or identify a combat agency. Instead, it describes how the functional area will support emergencies under other specific sub plans. Where no combat agency is identified, it is more likely that the planning and preparation phases of emergency response will not receive the resourcing and attention to ensure they function as well as they can during an emergency situation. In addition, without a designated combat agency identified, the role defaults to the NSW Police which presents a challenge given the NSW Police are not experts in energy related matters.

There is a changing view that energy is not only something that is affected by other emergencies, like floods, storms etc. but rather that lack of power is a hazard in its own right. Many of the emergency responses like CBD evacuations and hospital services rely on electricity. Multiple stakeholders expressed the view that in the past a supporting plan has been sufficient to manage the Energy & Utilities Functional Area with widespread electricity outages being relatively rare and those that have occurred have been geographically contained. However due to the community's increasing reliance on electrical devices and the potential increased future risk of a widespread electricity disruption, there is merit in consideration being given to the creation of an Energy Sub Plan.

An Energy Sub Plan would serve several purposes. It would:

- identify a combat agency for the specific hazard of widespread power disruptions and the support roles across PPRR and how they need to be managed between state, regional and local levels (NSW Government, 2012)
- clearly and more prescriptively list and articulate the roles and responsibilities for each of the relevant functional areas (including utilities) that would be affected by or need to respond to a widespread loss of power

- ensure that appropriate resourcing and exercises are regularly conducted with both energy emergency management and emergency management personnel to ensure that the responsible parties undertake the full spectrum of PPRR in preparation for an energy related emergency
- clearly explain how the Sub Plan relates to the established energy response procedures managed by AEMO, the transmission and distribution providers and the State
- support the need for an Energy & Utilities Supporting Plan to support other hazards.

The creation of an Energy Sub Plan would enable the NSW Government to improve the structural processes underpinning the management of energy emergencies in NSW and ensure a stronger link between energy management and emergency management which does not currently exist. The Taskforce recommends such a Sub Plan be developed.

3.3.7 Communications

Good internal and external arrangements for communications are imperative during any incident or emergency response including those related to power. In energy emergencies, communication procedures exist for both the energy emergency management and emergency management more generally. When responding to power issues, there are formal communication channels between AEMO, TransGrid, DNSPs, government departments and Ministers for both operational and external communication matters. Likewise within the emergency management area there are similar arrangements.

In preparing this report, the Taskforce held discussions with a number of stakeholders who are involved in responding to power supply issues. Most stakeholders agreed that they understood their roles and responsibilities and in the past have responded appropriately.

Exercising the plans and processes assist people to understand their roles and responsibilities. AEMO annually undertakes exercises with energy stakeholders and under emergency management plans exercises are also required. While energy emergency management personnel and state emergency management personnel undertake their own exercises, historically there have been no joint exercises conducted between the energy and emergency management personnel, although the EUSFAC acted as an observer in the AEMO national exercises in September 2016. Joint exercises would assist the two areas to understand each other's roles and responsibilities better and allow them to understand how they need to collaborate during energy incidents.

During the recent energy incident on 10 February 2017 there was considerable communication between electricity stakeholders, including communications with the public and other electricity users. Leading up to the day and on the day:

- AEMO held Responsible Officer teleconferences with participants from the various NEM jurisdictions (AEMO, 2017i)
- AEMO's media team communicated with the network businesses' media teams
- TransGrid (as the NSW Responsible Officer) liaised with government agencies
- AEMO issued regular media statements regarding the potential undersupply of power
- Government also issued a media release urging electricity users to minimise usage as much as possible, with the Minister for Energy requesting households reduce their energy usage.

Information from various Taskforce interviews indicates that for the 10 February 2017 incident:

- the regular teleconferences provided clear information
- the community appeared to respond to the call to reduce power usage, however TransGrid advises that the response was not uniform across the state. The level of

voluntary load reductions in the Sydney CBD and eastern Sydney wasn't commensurate with the greater load reductions in western Sydney and regional NSW
- the role associated with the JSSC was vacant at the time and had an officer acting in the role who had a strong background and appropriate experience. More formal back-up arrangements to manage staff absences could be implemented to ensure all staff are adequately trained and fully briefed
- numerous staff in the Department were on leave at the time (not unusual for this time of the year), so there were staff acting in roles where they may not have been fully aware of all the required procedures and the location of document templates and policies
- there was a high demand for information from the Minister's office and from the Department
- limited resources and a high staff workload made keeping up with the fast moving information difficult
- involvement of the Departmental communications team in all AEMO teleconferences would have enabled a more efficient transfer of information from the Department to the Minister's office.

The creation of an Energy Sub Plan would enable the NSW Government to improve operational communications during emergencies in NSW, including communications to the public and would ensure that they are well practised.

3.3.8 Implementation and operational issues

The Taskforce notes that the way operational plans are drafted in theory and the way they are implemented in practice can differ. There is a critical need for plans to be as clear as possible, to be tightly linked to all relevant associated plans, and to be adhered to.

Plans also need to take account of all the stakeholders involved. From the Taskforce's consultation with the parties involved in the 10 February 2017 power system incident, it is apparent that the communications that were needed during the incident were much more complicated than those suggested in existing plans (as highlighted earlier in Figure 3.3, included again at Figure 3.5b). The Taskforce examined the actual communications that occurred during the energy incident on 10 February. Figure 3.5a gives some idea of the complexity of the communications that actually occurred, illustrating several important points:

- many more communications were required on 10 February with stakeholders that hadn't been planned for or anticipated
- communications between energy emergency management and emergency management needed to be tighter
- planned communications procedures did not adequately reflect or take into account all the communications that needed to occur to respond to the energy emergency incident, for example communications with major government energy users to reduce their energy consumption had not been planned for
- personnel involved in the response procedures were then confused due to a lack of awareness about who was leading communications for relevant response procedures that needed to occur.

In many instances the 'right' communication procedures need considerable discussion between relevant stakeholders, ahead of future energy outages. For example, communications between the EPA and generators need to be refined and improved in order to set parameters for variations to generators' Environment Protection Licence conditions during energy supply shortages. Similarly communications with the public need to be tightly scripted in order to ensure clear and consistent messaging is used to provide guidance on how the public should reduce their energy consumption during energy supply shortages.

Both of these are examples of communications that were not adequately taken into account in existing policy and planning procedures as mapped out in Figure 3.5b below.

The diagram depicting communications during 10 February incident differs from the business as usual EUSPLAN diagram; there are some key points to note:

- during the incident there was considerable communication between AEMO and TransGrid with generators – this is not reflected in the EUSPLAN diagram which doesn't factor in communications with generators
- communications within the Department were more complex than presented in the EUSPLAN – comments from those involved suggested that due to staff being on leave and people acting in roles, staff were not fully aware of who was responsible for what and some roles were not as extensively involved in response procedures as expected
- communication with the public formed an important risk management strategy for reducing power usage and demand. A lot of media information was requested directly from the (already busy) JSSC. Media personnel were not as involved as might be expected
- communication and interaction outside the energy and emergency management sectors was necessary to manage supply (e.g. varying EPA license conditions for generators) and demand (requesting other government users to reduce usage) – these communications were conducted by a number of different personnel as pre-determined procedures were not in place
- all Function Area Coordinators across the Emergency Management Sector were aware of the incident through situation reports from the EUSFAC via the State Emergency Operations Centre.

An analysis of communications on 10 February 2017 highlights the need for improved communications between AEMO, generators, the Department and the EPA regarding generator's obligations and restrictions under Environment Protection Licences. Similarly there is a need for all parties to understand relevant roles and responsibilities better and a need for increased clarity regarding the interplay between potential environment and energy security risks. The EPA put forward the suggestion that a directive mechanism from AEMO to the EPA which does not have a price impact on the market should be given consideration.

While, the 10 February incident did not result in a significant loss of power, the complex communications during the event demonstrate that there is a need to ensure all parties are factored into communications planning for responding to energy incidents and that all parties are aware of their roles and responsibilities and have the knowledge and experience to undertake their roles.

A prepared media pack with all the relevant policies, procedures, briefings, media releases and legislative materials needs to be held by the Minister's office and all relevant personnel in the department so that pre-determined messages to the public can be efficiently and consistently provided to the public.

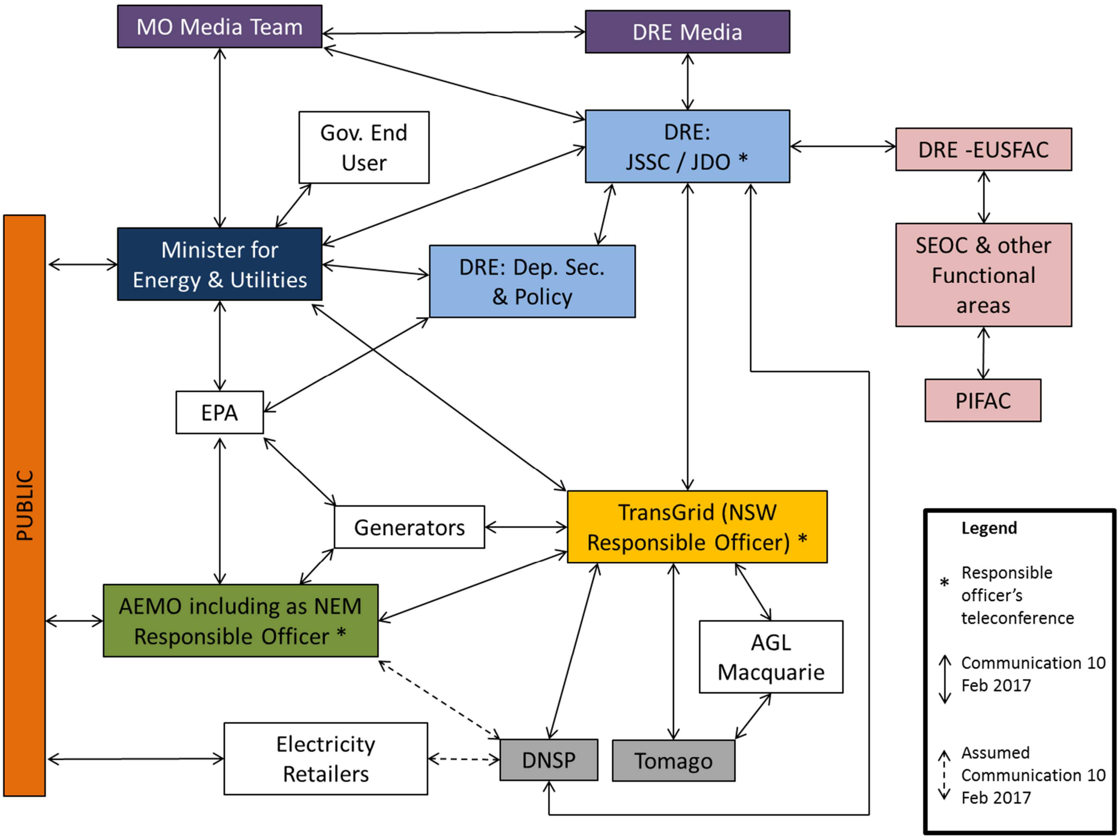

Figure 3.5a: Energy emergency communications on 10 February 2017

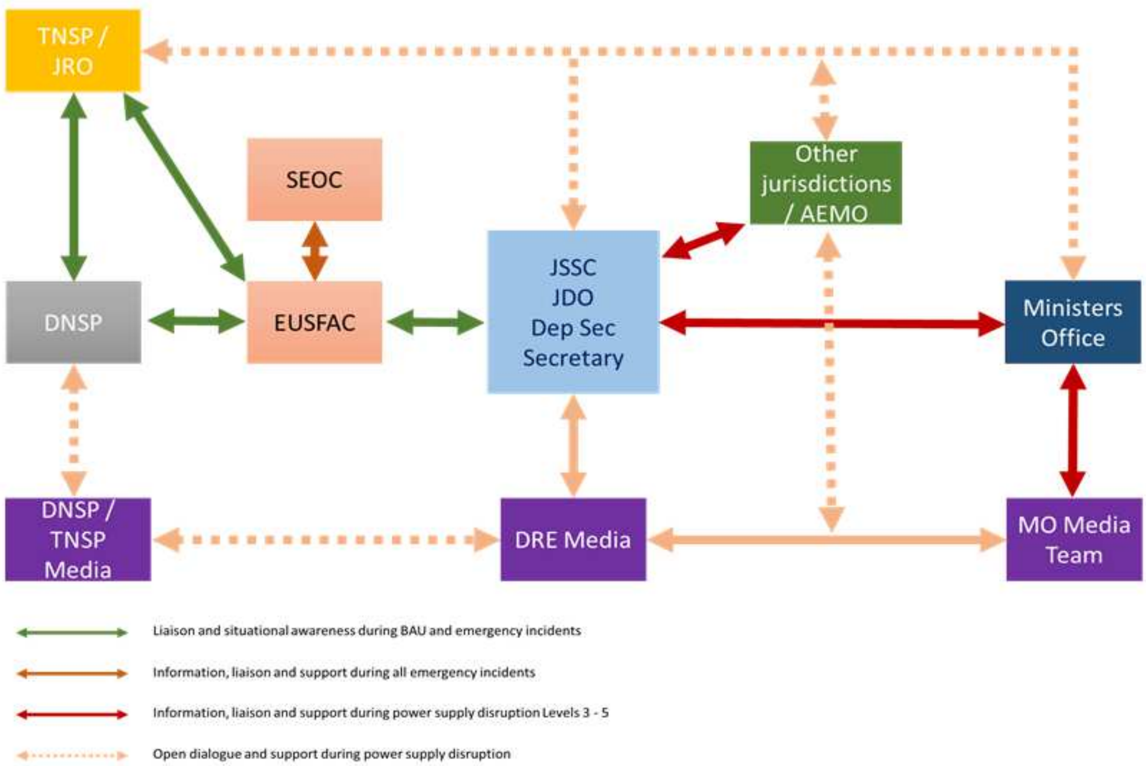

Figure 3.5b: Energy emergency management communication flow chart
(NSW Government, 2016b)

3.3.8.1 Use of the Public Information Services Functional Area Supporting Plan

During consultations, stakeholders commented on the fact that the Public Information Services Functional Area Supporting Plan (PIFASP) could be better leveraged during energy emergencies. The PIFASP provides details of the coordination of public information in a non-terrorist related emergency controlled by the SEOCON or where assistance has been requested by another agency during an emergency (NSW Government, 2005). The procedures within the PIFASP are used to ensure consistent messaging is used by government agencies during an emergency and to ensure communication is provided to the public in a timely and coordinated manner.

The PIFASP is the responsibility of the Public Information Area Coordinator (PIFAC) within the Public Affairs Branch of NSW Police. Any request from another agency to assist or coordinate public information during an emergency needs to be approved by the SEOCON.

The PIFASP is always active as the Public Information Functional Area Coordinator (PIFAC) constantly monitors situations which may develop into an emergency which may require public information (NSW Government, 2005). The PIFASP becomes operational at the direction of the PIFAC at which stage various actions occur including activating the Public Information Coordination Centre (including staffing) and notifying participating and supporting organisations and advising media organisations.

Due to the potential widespread nature of energy emergencies, the PIFASP has the potential to enhance public messaging on behalf of the EUSPLAN. While many localised power interruptions can easily be managed by local energy retailers and/or distributors, widespread or state-wide power interruptions have the potential to impact on essential services and as such may require a more rapid response. Further, during some power interruptions, electricity users' methods of communication could be limited due to the loss of power. Accordingly, PIFASP may be able to assist delivering public information effectively during a power interruption, especially during longer-term power outages. The PIFAC is accustomed to undertaking public messaging through various social media formats and historically does this role well during emergency events. This experience can be tapped into on behalf of energy incidents or emergencies.

3.3.8.2 The importance of strong personal networks as well as formal procedures

Figures 3.5a and 3.5b illustrate the complexity of the communications channels that are required to manage energy emergency situations. During stakeholder discussions, it became evident that the communications are more efficient and effective when the relevant personnel know each other, understand each other's roles and responsibilities, and had a level of familiarity with each other.

The Taskforce heard comments that with workforce changes, such as through retirements of long serving staff, or changeovers as electricity market operators were sold or moved location, the strengths of these personal networks has declined, which could have implications for the effectiveness of the communications in an emergency. The changed status of privatised organisations means that personnel who were once closer to government operations and closely involved in policy and operational procedures, are now further removed from government decision making.

Communication in emergency situations is typically more effective when people know each other, for example, through participation in exercises before an event. Relevant organisational leaders and officers could be encouraged to meet on a regular basis in forums or workshops to build and maintain such personal networks.

Other cultural and organisational elements that could be addressed to ensure that the right people with the right knowledge and skills are in place at times of emergency include:

- ensuring staff who are acting for colleagues on leave (as happens a lot in the summer months) are fully trained in energy emergency response procedures
- having technical or industry experts on recruitment panels for officers (including in government) who may be recruited to exercise “management or oversight roles during an energy emergency” would help ensure that the right skills mix is recruited
- involving both designated officers and their deputies in exercises and networking events would assist to ensure that there is suitable level of experience should an officer be absent, or an event occurs over a prolonged period requiring relief for staff.

3.3.9 Community engagement around energy

Information for the community on how to respond to power outages is provided by a number of groups. Electricity retailers have general information on what to do during a power outage and also provide specific information for those in the community who need electricity for life-support equipment. A number of government agencies also have information on power outages, although a lot of this information is included in more general information on how to respond to emergency situations such as floods and fire.

There are a considerable number of websites with information on energy efficiency and power outages and while the information appears consistent, there is no single source of information to guide consumers and businesses on how to prepare for and respond to energy shortages. Further, there appears to be little information on how to reduce power usage during periods of low power supply, except when this information is provided at the time of the low power supply.

3.3.9.1 Community call for action on 10 February

On 10 and 11 February when the heatwave was forecast to continue, the Department of Industry’s Division of Resources & Energy released two media statements to the public, which were widely broadcast as a request from the Minister for Energy to reduce energy consumption on 10 and 11 February by:

- turning air conditioners to 26°C
- turning air conditioners off in unused spaces
- adjusting fridge temperatures
- switching off unused appliances and turning off lights
- switching off pool pumps (NSW Resources and Energy, 2017b, 2017a).

The Minister then released a media statement on 12 February thanking the public for their assistance in curbing power use and helping to avoid black outs. The media statement noted that demand peaked on the Saturday around 300 MW less than forecast (Harwin, 2017). AEMO also estimated the voluntary load reductions on the Friday resulted in around a 200 MW reduction (AEMO, 2017i).

While a 200 MW public voluntary reduction may have only been a fraction of the peak demand (~13,000-14,000 MW), it represented a significant portion of the forecast supply deficit during the peak periods of 10 and 11 February. This deficit varied as the situation progressed, but ranged between around 20 MW and 675 MW (AEMO, 2017i).

While requests for voluntary reductions are a common tool for reducing demand in peak periods, the Taskforce understands that the decision to make the public call in February was made quickly and without pre-arranged media statements and materials to facilitate the process.

As summer heatwaves are projected to continue and potentially intensify, these situations are likely to arise again. The role for public voluntary reductions is important given their potential to take the ‘edge’ off a stressed power system. There is an opportunity to pre-empt the situation for the summer of 2017/18 and develop a proactive community communication and engagement strategy to make sure the public is aware and ready to do its part when the situation arises again. This could be modelled on other effective NSW Government campaigns to reduce consumption, such as the award-winning Water Wise program in NSW that provides clear guidance to the public on reducing water use.

3.3.10 Innovative approaches to securing supply and demand

The actions taken by the energy and emergency management sectors in response to electricity incidents are on the whole a reactive approach to managing supply and demand issues as they arise. This approach is appropriate, but could be improved using proactive approaches to managing supply and demand in a more sustained way.

One such proactive approach is the current TransGrid and Ausgrid initiative – Powering Sydney's Future Project (TransGrid, 2017a). The project aims to secure the future electricity supply for inner Sydney noting that the current inner Sydney electricity system is ageing and requires significant maintenance. This coupled with the catastrophic effect a multi-day power outage in Sydney, Australia's largest city and commercial capital, would have on the Australian economy, has led TransGrid and Ausgrid to engage with stakeholders to find solutions to improving the current network. The project is scoping both network (expansions or replacement) and non-network solutions including generation, storage and demand management. Non-network solutions are being proposed for use during and after implementation of the expansion or replacement of the network.

To gather input from stakeholders, a workshop was held in late 2016 which was attended by government, energy suppliers and regulators, large power users, industry and others. Some non-network solutions proposed at the workshop included:

- embedded generation, including solar generation
- energy power storage
- voluntary curtailment of load
- energy efficiency measures

While the solutions are predominately being proposed to deal with the current issues with the network, they are also likely to provide alternative power options for supply and demand management and are a very good example of the private sector taking a proactive approach to demand management. Ausgrid and TransGrid called for expressions of interest for demand side reduction and are still working through the commercial arrangements and identifying where identified demand reductions are firm or where they are potential reductions (that can't necessarily be depended on).

New technologies are emerging that provide increased opportunities for demand management and load shifting (to different times of the day), e.g. the CoolSaver trial initiative of Ausgrid that can manage the demand of residential air conditioners in the system. There may be cases, however, where new technologies being deployed can lead to less resilience in the market, with hot water coolers moving away from ripple control, to timer control, meaning that retailers are less able to centrally change the time that hot water heaters come on. Precooling of buildings and the increasing use of battery system technologies are other examples of technological approaches to reduce demand or change the supply curve for residences.

3.4 GOVERNMENT ENERGY USAGE AND GOVERNMENT'S ROLE DURING ENERGY EMERGENCIES

3.4.1 Policies for government to reduce energy usage during energy shortages

No policies or procedures currently exist within the NSW Government to manage the reduction in energy usage by government agencies or government-controlled assets during energy shortages in a coordinated way. Given the substantial energy footprint of the NSW Government agencies (NSW OEH, 2014d), there is a significant opportunity for the NSW Government to manage energy demand during energy supply shortages more proactively by developing principles and procedures for reducing energy consumption across government's largest energy users.

A Whole-of-NSW Government protocol should be developed which maps out the NSW Government's top 10, say, largest energy users and determines what energy consumption is able to be shed by each of these users – an internal load shedding schedule for government's largest energy users. Such a protocol could be called upon by the Energy Minister to manage the NSW Government's energy consumption proactively during energy supply shortages. This protocol would list the order in which government energy users may be asked to reduce their energy consumption and would calculate the cumulative total of load that could be reduced. The protocol would highlight any operational risks that need to be managed and the associated costs and benefits that need to be taken into consideration. These risks would in turn dictate how much energy demand can be reduced. Such a protocol would effectively be the inverse of the priority sensitive loads prepared by the JSSC for the Jurisdictional Load Shedding Guidelines.

During the 10 February 2017 energy incident, the Minister for Energy contacted Sydney Water and Hunter Water among others to seek assistance in managing load. Both organisations responded promptly, reducing demand by adjusting their wastewater treatment facilities and water pump stations in their water distribution network. During this energy supply shortage Sydney Water was also able to contribute electricity to the grid from North Head wastewater treatment plant to supplement supply at 10 MW and reduce demand at the Bondi wastewater plant by using power from Sydney Water's cogeneration plant (Sydney Water pers comms, 2017, May 2). Both organisations have indicated they would be willing to assist further if possible.

On 9 February Property NSW released a circular to all NSW Government agencies and building owners requesting that all "building managers and occupants implement measures to conserve energy and reduce the risk of unplanned outages" (Property NSW pers comms, 2017, February 9). Recommended immediate actions to government agencies included:

- "consider allowing staff to work from home on Friday 10 February
- for those in the office, consider staff leaving earlier to alleviate the anticipated peak between 4:30pm and 6:30pm (AEDT)
- adjust air conditioning set points to 26 °C
- shut down air conditioning zones if practical
- avoid after hours air conditioning and use of units that are supplementary to base building
- ensure all exterior windows and doors are closed, with blinds lowered to reduce solar gain
- adjust fridge and freezer temperatures to maximum where practical
- switch off unused electrical appliances such as microwave ovens and other items that use energy even when turned off or in sleep mode
- turn off lights where it's safe to do so and in unoccupied spaces

- when absent for more than 30 minutes, turn off computers, monitors, copiers, and printers whenever possible
- use stairs instead of elevators when possible" (Property NSW pers comms, 2017, February 9).

In light of these examples, there would be merit in Government developing a protocol which establishes a set of processes and principles and maps out which large government energy users can shed load or augment their energy consumption from other sources. This protocol would need to spell out how this can be done, and at what times of the day; any associated risks; and how these risks should be managed.

3.4.1.1 Code Warm procedures

In addition to the NSW Government playing a proactive role in reducing the energy consumption of its largest energy users during energy supply shortages, there is also an opportunity for the NSW Government to develop a 'Code Warm' protocol that government agencies more generally can follow in these instances. Code Warm could be mandated through a Direction circulated by each cluster Secretary in the instance of an energy supply shortage. Such a protocol would provide clear guidance to staff on what actions need to be taken and changes implemented in the workplace if deemed appropriate. This could include things a simple as pulling the blinds down, changing air conditioning settings, turning off non-essential office equipment, staff travelling home during off-peak periods etc.

While the reduction in energy consumption may be modest when considering one government user or one government agency in isolation, the cumulative total across government is likely to be significant. These proactive measures have the potential to alleviate supply shortfalls and could prevent energy emergencies from occurring and causing any subsequent detrimental impact on industry and the community more broadly.

3.4.2 Setting up government energy purchasing contacts to take account of energy emergencies

As well, Australian governments at all levels (and related public sector entities) can contribute to energy reliability in potential and actual emergencies by using their leveraging power as a large energy purchasers to negotiate contracts with retailers which include well-articulated and practiced load-shedding and load-reduction possibilities.

This leveraging power is considerable. For example, NSW Government agencies own and operate facilities and infrastructure that use more than 1,800 GWh of electricity each year or around 2.6% of NSW electricity sales. In 2012–13, the Government spent more than $390 million on electricity (NSW OEH, 2014d).

For electricity purposes the ACT is managed as part of NSW so there are leveraging possibilities through the Commonwealth and ACT Governments as well as local governments across the State.

3.5 MORE COULD BE DONE TO RESPOND TO ENERGY INCIDENTS EFFECTIVELY

Overall the Taskforce finds that policies and procedures are in place for energy emergency management and emergency management personnel to respond to energy incidents. To date however there appears to have been a disconnect between how closely the two operational streams have worked together. This is particularly apparent with regard to exercises and emergency simulations that have been conducted by the two operational streams in isolation of one another.

In addition to the above, the Taskforce has found that the arrangements surrounding responses to energy emergencies are very complex. How these arrangements operate in practice is contained in numerous different statutes, policies, procedures and documents which are administered by various agencies and organisations across state and Commonwealth jurisdictions. As such it is very difficult to identify a 'single source of truth' regarding all the relevant roles, responsibilities and procedures that are involved when responding to an energy emergency. Consequently the Taskforce believes that the development of an Energy Sub Plan under the EMPLAN that is endorsed by the State Emergency Management Committee would assist in ensuring that all personnel involved in an energy emergency response clearly understand all relevant roles and responsibilities. In addition to this, the development of a new simplified Act to manage energy-related emergencies would directly link the energy emergency management procedures in the new Act to relevant emergency management procedures under the State Emergency and Rescue Management Act to ensure that it is very clear how the two operational streams work together.

While energy emergency communications procedures are currently in place, the Taskforce has observed that the existing procedures on the whole do not adequately reflect or take into account all the communications that need to occur to respond to an energy emergency incident. This presents challenges for the personnel involved in the response procedures due to a lack of awareness regarding who is leading aspects of the communications and relevant response procedures that need to occur. Therefore the Taskforce recommends that the Government improve procedures for operational communications during energy emergencies in NSW, including communications to the public.

Another key finding was the need for energy operators to provide advanced warning where possible about load shedding to essential service providers that are reliant on electricity for the delivery of their services. While it is acknowledged that in some instances this is not practically possible, where time does permit, advanced notice would enable essential service providers to plan for these outages so that disruption to the public can be minimised. As a result it would be productive for the Government to develop memoranda of understanding with the relevant energy operators to establish the scope and terms for information sharing arrangements.

Following analysing the existing response procedures, it is very clear that there is a lot more that the Government can do to manage the energy consumption of the Government's largest energy users proactively during energy supply shortages. Through the development of a protocol and internal government load reduction procedures, the Government would be in a position to be much more proactive in demand-side management and may be able to assist in preventing energy emergencies from eventuating during energy supply shortages. Similarly the introduction of Code Warm procedures within government agencies would ensure that staff are able to take steps to reduce energy usage within their workplaces.

4 RECOMMENDATIONS FOR PRIORITY ACTION

Overall, the Taskforce finds that NSW is reasonably well placed from an electricity security and reliability point of view under normal conditions. However, there are signs of emerging reliability and security risks to the NEM overall, and in NSW specifically, particularly under prolonged hot conditions and over time more generally with the Liddell power station closing in 2022.

There are signs that the system can (and is more often) becoming stressed through reserves being limited during prolonged hot conditions. On 10 February not enough generation was available to avoid load shedding.

Following the introduction (from 2001 onwards) of various national and state policies to deal with climate change, NSW is experiencing the same NEM-wide trends of general declining average demand (due to increased energy efficiency and to increased behind-the-meter generation); retirement of traditional thermal plant, and increased uptake of renewable energy generation sources.

However, on 10 February 2017 NSW experienced the highest peak in demand for electricity since 2011. Some stakeholders have indicated that NSW was lucky this energy incident happened on a Friday, because had it occurred earlier in the week, the stresses on the system would have been greater. In this instance, the hot conditions continued into the weekend when demand is generally lower.

In future years, heatwaves are likely to increase in frequency, duration and intensity. In fact, this trend is already being experienced.

Therefore, risks to reliability and security of NSW electricity system are real and require prudent and proactive planning.

A key priority, also identified by AEMO, is to work with generators that are not currently operating to full capacity to ensure plans are in place to ensure reliability this coming summer, for example, by minimising maintenance planned for the summer period and understanding constraints better.

The Government can also take a proactive role in managing peak demands during periods of high stress, and encourage innovation for the longer term so new generators add to the reliability and security of the grid, for example, by encouraging generators using intermittent sources to have FCAS services and storage integrated with them.

However, in addition to preventative measures, Government should also prepare for the worst - from another heatwave like was experienced in February through to a widespread and/or prolonged black out - given the substantial social, economic and public safety impacts of a potential emergency.

Therefore, key priorities for Government in the lead up to next summer are to:

- through the Premier and the Minister, take a leadership role in COAG and the COAG Energy Council to have a national policy approach to climate change and the technology and market implications of these policies, to safeguard energy security and reliability
- take measures to manage peak demand proactively, and through engaging community and industry support, with the Government to lead by example in this through development of a ‘Code Warm’ protocol
- if preventative measures fail and load shedding is required, make sure the processes are optimised and effectively communicated

- improve the links between emergency management and the energy system, and make sure provisions, procedures and communications are refined and well-practised – this includes considering cultural issues post-privatisation of parts of the system so that good formal processes are in place as well as effective personal networks.

The Taskforce makes seven recommendations aligned with these priorities. As well as providing recommendations, the Taskforce offers a range of suggestions for assisting with the implementation of Recommendations 3 to 7. While all of these suggestions are important, in addressing the recommendations, there are many more things that could also be done to implement the recommendations that have not been discussed in this Report.

Recommendation 1
That the NSW Government, through the Premier and Minister, take a leadership role in COAG and the COAG Energy Council to encourage the states and Commonwealth to have a national policy approach to climate change and the integration of renewables within the National Electricity Market, to safeguard energy security and reliability.

Recommendation 2
That in producing its revised Energy Adequacy Assessment Projections (EAAP) in May-June 2017, AEMO pay particular attention to the generator fuel positions so that the market can see in aggregate if there is sufficient fuel in the system and can anticipate major changes. If the system is tight, this will be visible to participants, policy makers and market agencies, and may incentivise additional fuel contracting or investment in new generation.

Recommendation 3
That Government improve the speed and ease with which it can respond to an energy emergency, including revising legislative provisions where necessary.

An important part of implementing Recommendation 3 would be giving consideration to drafting a new, simplified Act to manage energy-related emergencies to replace Part 6 of the *Energy and Utilities Administration Act 1987.* Ideally this would:

a. remove the requirement for proclamation by the Governor to trigger emergency powers and allow the Minister to exercise emergency powers subject to consultation with the Premier. These powers could then be delegated to a nominated departmental official as appropriate
b. contemporise the penalty regime for non-compliance with emergency mandatory restrictions.
c. directly link the energy emergency management procedures in the new Act to relevant emergency management procedures under the *State Emergency and Rescue Management Act 1989*.

Recommendation 4
That Government improve the structural processes underpinning the management of energy emergencies in NSW and ensure a stronger link between energy management and emergency management.

Some important issues to cover when implementing Recommendation 4 would involve the following:

a. creating an Energy Sub Plan under the EMPLAN to manage energy-related emergencies which is endorsed by the State Emergency Management Committee (SEMC)
b. bringing the EUSFAC and the NSW JSSC into the one team to improve PPRR procedures
c. ensuring energy emergency management exercises are conducted biannually with the involvement of both emergency management and energy personnel

d. creating a fact sheet for inclusion in the Energy Sub Plan which clearly outlines the roles and responsibilities of the Minister for Energy and Utilities, JSSC, JDO, JRO, EUSFAC, and AEMO and explains how each role is appointed and under what instrument.

Recommendation 5
That Government improve procedures for operational communications during energy emergencies in NSW, including communication to the public, and ensure these procedures are well-practised.

Implementation of Recommendation 5 should include consideration of the following procedural changes:

a. where practicable, ensuring that load shedding information is provided to the SEOCON via effective communication between the EUSFAC, JSSC and NSPs to enable appropriate emergency management planning and response to occur
b. ensuring that a NSW Government media and communications representative is involved in every AEMO power system emergency response teleconference with the JSSC, EUSFAC and PIFAC
c. preparing a media pack which includes template media releases and key messages for use by the Minister categorised by energy event type. Copies to be held by the JSSC, EUSFAC and Minister
d. ensuring that prepared messaging is agreed to by all parties who will be communicating to the public in an energy emergency, including AEMO, BOM, RFS and the PIFAC so that consistent messaging is used
e. leveraging the Public Information Functional Area to communicate energy-related emergency messages to the community.
f. convening regular and structured workshops which include simulated energy emergency management exercises and procedures for the leadership and operational staff in key private and public energy organisations which are involved with energy emergency management to encourage development of strong personal networks.

Recommendation 6
That Government support industry and the community to prepare for, manage, and mitigate risks during energy emergencies, including providing guidance on how to reduce demand effectively during peak periods.

Key initiatives to be considered when implementing Recommendation 6 include:

a. Government (through the EPA) and generators discussing what options are available to alter operations or put in place technological interventions to minimise potentially harmful environmental discharges to ensure generation does not become unavailable due to EPL requirements under conditions when reserve levels are low
b. developing an awareness campaign for industry and the community which includes a set of guiding principles for energy demand management. This campaign can build on Sydney Water's success in its WaterWise campaign
c. establishing systems to ensure that community including vulnerable individuals, households and small businesses are adequately prepared for energy emergencies and that appropriate arrangements are in place for extreme circumstances.

Recommendation 7
That Government establish a working group (including representatives of the Commonwealth and ACT Governments) to develop new protocols for agencies to reduce demand and increase behind-the-meter supply during periods of peak energy use ('Code Warm' protocol).

Implementing Recommendation 7 should include the following:

:

a. developing a policy which outlines the measures that NSW, ACT and Commonwealth Government agencies (located in NSW/ACT) should implement in an energy emergency
b. developing a schedule and set of principles within the above policy to determine the order in which the largest energy users reduce their energy usage
c. creating a register of the governments' available back-up fuel sources and generators which can be deployed in an energy emergency
d. developing a set of procedures that agencies will follow in an energy emergency to reduce energy usage of their staff by adjusting air conditioning, lighting, use of public transport etc. to an agreed set of standards
e. using governments' leverage as a large energy users to negotiate contracts with distributors that include well-structured provisions for automatic load shedding and load adjustment during Code Warm periods.

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Acronyms

Acronym	Definition
AEMO	Australian Energy Market Operator
ACCC	Australian Competition and Consumer Commission
AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
AEST	Australian Eastern Standard Time
ARENA	Australian Renewable Energy Agency
BAU	Business as usual
BCP	Business Continuity Plans
BOM	Bureau of Meteorology
COAG	Council of Australian Governments
ConOps	Concept of Operations
COP21	2015 United Nations Climate Change Conference: Conference of the Parties (21st session)
DER	Distributed energy resources
DNSP	Distribution Network Service Providers
EAAP	Energy Adequacy Assessment Projection
EMPLAN	State Emergency Management Plan
EPL	Environment Protection Licence
ESOO	Electricity Statement of Opportunities
EUSFAC	Energy and Utility Services Functional Area Coordinator
EUSPLAN	Energy and Utility Services Functional Area Supporting Plan
FCAS	Frequency Control Ancillary Services
FISP	Food Industry Sub Plan
FPSS	Future Power System Security
GL	Gigalitres
GW	Gigawatt
GWh	Gigawatt hours
IPART	Independent Pricing and Regulatory Tribunal
JDO	Jurisdictional Designated Officer
JRO	Jurisdictional Responsible Officer
JSSC	Jurisdictional System Security Coordinator
kW	Kilowatt
LHD HSFAC	Local Health District Heath Services Functional Area Coordinator
LHD	Local Health Districts
LOR	Lack of Reserve
MoU	Memorandum of Understanding
MW	Megawatt
MWh	Megawatt hours

NARCLiM	NSW and ACT Regional Climate Modelling
NEL	National Electricity Law
NEM	National Electricity Market
NEM RO	NEM Responsible Officer (AEMO)
NSW HEALTHPLAN	NSW Health Services Functional Area Supporting Plan
PASA	Projected Assessment of System Adequacy
PIFAC	Public Information Functional Area Coordinator
PIFASP	Public Information Services Functional Area Supporting Plan
POE	Probability of Exceedance
PPRR	Planning, preparation, response and recovery
PSEMP	Power System Emergency Management Plan
PV	Photovoltaics
RFS	Rural Fire Service
RET	Renewable Energy Target
RO	Relevant Official
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SEMC	State Emergency Management Committee
SEOC	State Emergency Operations Centre
SEOCON	State Emergency Operations Controller
SERCON	State Emergency Recovery Controller
SERM ACT	State Emergency and Rescue Management Act
State HSFAC	State Health Services Functional Area Coordinator
ST-PASA	Short-term Projected Assessment of System Adequacy
TNSP	Transmission Network Service Provider
TWh	Terawatt hours
UGS	Underground gas storage
UPS	Uninterruptible power supply
US EPA	United States Environmental Protection Agency
USE	Unserved energy
YTD	Year to date

APPENDICES

APPENDIX 1 TERMS OF REFERENCE ENERGY SECURITY TASKFORCE

Extreme weather events, such as the heatwave conditions across NSW over January and February 2017, place significant demands on the State's electricity infrastructure. They highlight the need for best practice long term planning, as well as the need to ensure that the State is well placed to prevent, respond and recover from events when they occur.

The planning and management for extreme weather events is complex. There is the interaction between national and State energy regulatory frameworks and responsibilities, as well as the need to ensure coordination across all elements of the supply chain – market operator, transmission and distribution networks, retailers and customers. The complexity of arrangements for managing high risk events across the national electricity market, networks and jurisdictions has been highlighted by the Reliability Panel in its recent Review of the System Restart Standard.

Energy plays a key role in NSW's State Emergency Management framework. The Review will need to complement work taking place in this area.

Scope of review
The review will:

- assess the risks to and resilience of the NSW electricity system (including the transmission and distribution networks), from extreme weather events in the context of a changing climate
- review the adequacy of the State's management of electricity system security events including prevention, preparedness, response and recovery
- make recommendations on actions to address any vulnerabilities identified and/or opportunities for improvements in current practices

In undertaking this work, the Taskforce will have regard to NSW and ACT Regional Climate Modelling projections. The Taskforce will consider the costs and benefits of any recommendations.

Process
The review is to provide a draft report by the first half of 2017 and a final report by the end of 2017. The review should complement any broader emergency management work being undertaken across the NSW Government.

There is significant work being undertaken by the COAG Energy Council, Australian Energy Market Commission, Australian Energy Market Operator and Australian Energy Regulator. The Taskforce draw on this work and focus on areas particularly related to NSW which are not the remit of these other work programs.

The Taskforce should draw on the expertise of a wide range of stakeholders including the NSW transmission and distribution network businesses, AEMO (Australian Energy Market Operator), AEMC (Australian Energy Market Commission), and other National Electricity Market state and territory regulators.

APPENDIX 2 STAKEHOLDER MEETINGS AND SUBMISSIONS

Table A.1: Stakeholder meetings & teleconferences

Date	Stakeholder Group/s
22/02/2017	TasNetworks
24/02/2017	Water NSW
24/02/2017	Sydney Water
27/02/2017	Professor Paul Simshauser, Director General Queensland Department of Energy & Water Supply
28/02/2017	TransGrid
1/03/2017	Energy Australia
1/03/2017	Department of Energy & Resources
7/03/2017	Dr Kerry Schott, Chair TransGrid
8/03/2017	Australian Energy Regulator
8/03/2017	Office of Emergency Management, Department of Justice
9/03/2017	Australian Energy Market Operator
9/03/2017	Briefing - Security of Critical Infrastructure - Critical Infrastructure Centre (Cth)
13/03/2017	AGL
13/03/2017	Professor Andy Pitman, Director ARC Centre of Excellence for Climate Extremes
14/03/2017	Sunset Power International t/as Delta Electricity
14/03/2017	Chair, Reliability Panel, and CEO, Australian Energy Market Commission
20/03/2017	NSW Parliamentary Counsel
21/03/2017	Sydney University
22/03/2017	Tasmanian Energy Security Taskforce
23/03/2017	Department of Planning & Environment (formerly the Division of Resources and Energy within the Department of Industry until 1 April 2017)
27/03/2017	SnowyHydro Ltd
27/03/2017	NSW Crown Solicitor
28/03/2017	Iain Macgill, UNSW Australia
30/03/2017	Department of Planning & Environment
30/03/2017	Bureau of Meteorology
5/04/2017	Department of Planning & Environment
5/04/2017	NSW Health
5/04/2017	Ms Audrey Zibelman, CEO AEMO
5/04/2017	Terry Effeney, formerly CEO of Energex in Qld and a member of the Expert Panel for the Finkel Review
11/04/2017	Trevor Armstrong, Ausgrid
11/04/2017	Department of Premier & Cabinet
12/04/2017	Transport for NSW
19/04/2017	Hunter Water
24/04/2017	TransGrid
26/04/2017	Helen Bennett, Office of Energy Security, Commonwealth Department of Environment
26/04/2017	Energy Australia
1/05/2017	Property NSW
3/05/2017	GovDC

Note: The Taskforce has been in ongoing discussions with a range of government agencies including the Department of Planning & Environment, the Department of Premier & Cabinet, NSW Health, Transport for NSW, Department of Justice, Sydney Water, Hunter Water, AEMO and AEMC throughout the development of the Initial Report.

Table A.2: Submissions

Ref:	Name	Organisation
SUB001	Mr Aden Ridgeway	Paradigm Resources
SUB002	J F Brett RFD ED	
SUB003	Professor John Quiggin, ARC Laureate Fellow	
SUB004	Mr Rob Murray-Leach	Energy Efficiency Council
SUB005	Mr Roger Whitby	Snowy Hydro Limited
SUB006	Mr Matt Howell	Tomago Aluminium
SUB007	Mr Kevin Ly	Snowy Hydro Limited
SUB008	Mr Rod Howard	Endeavour Energy
SUB009	Submission in confidence	
SUB010	Mr John Griffiths	Gas Energy Australia
SUB011	Mr John Cleland	Essential Energy
SUB012	Mr Warring Neilsen	Elgas
SUB013	Mr Shaun Reardon	Jemena
SUB014	Mr Craig Memery	Public Interest Advocacy Centre
SUB015	Dr Tim Nelson	AGL Energy
SUB016	Mr Rob Sindel	CSR Limited