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Power struggle: short-term responses in a climate of uncertainty

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Discussion paper

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This working paper was written by Tony Wood, David Blowers, and Kate Griffiths.

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Overview

Electricity reliability concerns are at an all-time high. We've seen a series of unfortunate events over the last 18 months, particularly in South Australia, with significant political and media attention on the issue of reliability. A fierce blame-game is playing out and there is pressure on politicians to respond. The independent review of reliability ('the Finkel review') is urgently needed.

Storms and technical issues were involved in recent events. While there's not much we can do about storms, technical issues suggest we need to improve market rules and governance. New generation capacity will be needed in the long-term but insufficient generation capacity has not been the problem to date. There are important changes to be made, but there is also a real danger of politicians over-reacting to recent events and making decisions that increase electricity prices and make the task of reducing Australia's emissions harder.

Government investment in new generation capacity would be a very expensive way to improve reliability. New investment will be needed over time, but we should give the market a chance to respond. We are beginning to see the high prices that provide a signal for new investment.

Climate change policy remains the big uncertainty for investors. The 2017 review of Australia's climate change policies must provide a credible plan for emissions reduction and clear direction for the electricity sector.

We already have a safety net in place to procure emergency reserves if capacity shortages do arise. But we will need to more conservatively account for risks in future (including extreme weather, variable generation, and changing demand) to ensure reserves are available when needed.

Despite the pressure to act, it is important we don't rush into expensive solutions or an overly-planned approach. Interconnectors and capacity markets are risky investments with uncertainty about future demand – they could hit electricity bills hard. We do not yet have all the technologies in the market that we will need in future. An overly-planned approach will not provide the flexibility we need to take advantage of new technologies and better solutions as they emerge.

The Finkel review should instead focus on cheaper, 'no regrets' moves that will address the short-term risks to our electricity system: reduce policy uncertainty, fix market basics and boost options for managing system security.

- Reducing policy uncertainty requires integrated energy and climate policy that is credible and stable to drive down emissions intensity and enable long-term investments.
- There are a few 'market basics' that should be fixed to deliver clearer price signals for all participants, giving the market a better chance of managing reliability on its own.
- New markets for ancillary services would give the market operator more flexibility in responding to increasing and changing system security needs.

But the review also needs to consider the long-term risks to the reliability of electricity supply. Continued uncertainty around climate change policy will make the market uninvestable. And new markets, rules and policies may be needed if the National Electricity Market is to cope with increasing levels of intermittent generation. Developing a blueprint that can plot a sensible future for the National Electricity Market while addressing the immediate issues is the challenge for the Finkel review.

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1 Why we need a review of reliability

On the 28 September 2016, South Australia experienced a state-wide blackout – the largest blackout in the National Electricity Market since it began operation in 1998. An emergency meeting of state and federal energy ministers was held and ministers announced a review of Australia's National Electricity Market, to be led by Australia's Chief Scientist Alan Finkel ('the Finkel review').[1]

Australia's National Electricity Market (NEM) is a wholesale market that facilitates the exchange of electricity between generators and retailers in the electrically-connected states and territories of eastern and southern Australia (QLD, NSW, ACT, VIC, SA and TAS).

The question at the heart of the Finkel review is: can the NEM continue to efficiently deliver a dependable electricity supply through the transition to a cleaner-energy future? Effectively, is the market broken? The secondary question for the Finkel review is: what should governments do? This working paper attempts to answer these questions and identify priority areas for the attention of the Finkel review.

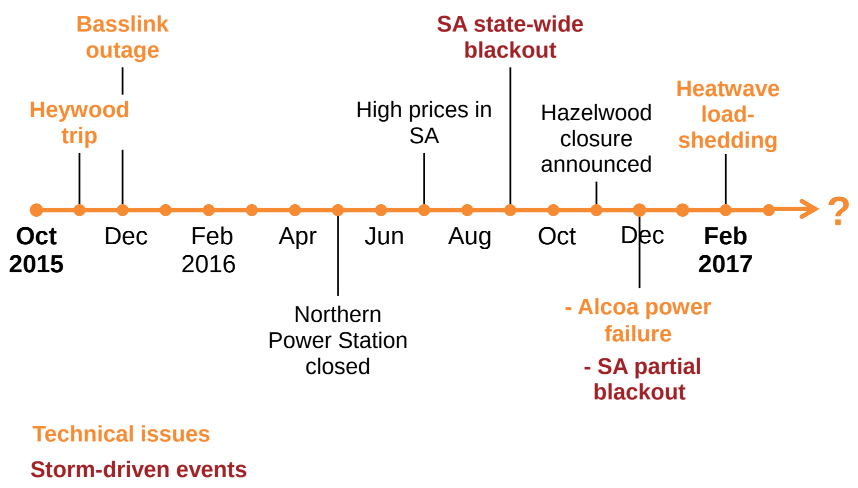
1.1 Recent events have triggered reliability concerns

South Australia's state-wide blackout in September was the trigger for the Finkel review, but other events in the last 18 months have also prompted concerns about the future reliability and security of the NEM (see Figure 1.1). Recent events include further power failures in South Australia, the retirement of major coal-fired generators, some very high wholesale prices, and outages of major transmission lines that link regions of the NEM.

The common themes across these events were storms, technical issues or both. Unusually violent storms were involved in both the 28

1. COAG Energy Council (2016a).

Figure 1.1: Recent events have triggered reliability concerns



Notes: Heywood is an interconnector linking South Australia to Victoria. Basslink links Tasmania to Victoria. Northern is a black coal-fired power station in South Australia. Hazelwood is a brown coal-fired power station in Victoria. Alcoa is an aluminium smelter in Victoria that lost power for the first time in the plant's 30-year history.

Source: Grattan analysis.

September and 28 December blackouts in South Australia, causing major network damage. The network damage in September triggered cascading technical issues until the whole state lost power.[2] The 28 December blackout was more contained, but around 20 per cent of South Australian households lost power (155,000 homes) and half of these lost power for more than 12 hours.[3]

During the February 2017 heatwave, power was cut to 90,000 homes in South Australia in a series of rolling 30-minute blackouts, even while generation capacity remained idle, raising questions about governance of the market.

On 1 December 2016, Alcoa's Portland aluminium smelter in Victoria lost power for the first time in its 30-year history. The outage was caused by a transmission failure and network repairs meant there was little reserve in the system at the time.[4] Aluminium in production at the time of the blackout solidified, reducing the plant's capacity to less than half. The full extent of the damage is still to be seen, with the company seeking state and federal assistance to keep the plant open.[5] The Heywood trip and Basslink outages in late 2015 were also driven by technical issues. Both resulted in high prices but grid stability was maintained and power was not lost.[6]

Any electricity system can be brought down by a severe storm; there is not much one can do about them. But technical issues suggest opportunities for improvement. Each of the recent events is discussed in detail at Appendix A. It is right that these events should prompt concern, the question is whether the National Electricity Market is at fault.

2. AEMO (2016a).
3. Holderhead et al. (2017).
4. AEMO (2016g).
5. Judd (2016); and Gordon (2017).
6. AEMO (2015b); and AEMO (2016f).

Box 1: Overview of this working paper

Chapter 1 introduces the challenges facing Australia's National Electricity Market (NEM) and argues that the Finkel review cannot solve everything – the review should focus on reliability risks.

Chapter 2 reviews the performance of the NEM on measures of capacity: are there signs of insufficient generation capacity?

Chapter 3 reviews the performance of the NEM on measures of security: can we maintain system security through the transition to avoid blackouts?

Chapter 4 identifies specific areas for improvement and key questions for the Finkel review to address.

An appendix summarises recent events that triggered reliability concerns.

1.2 Why the market needs reviewing

The NEM has served us well since 1998, but theoretical arguments have emerged in recent years that suggest the market might now (or soon) be unable to maintain a dependable electricity supply.

Arguments centre on the idea that the NEM has become "uninvestable"[7] either because it has been made so due to poor policy elsewhere (climate change) or its fundamental design makes it theoretically or practically impossible to deal with high levels of intermittency.

Investment uncertainty is on the rise. AGL Energy and BHP Billiton have raised concerns about investing in the market in recent years[8]

7. Macdonald-Smith (2016).
8. Stevens (2016); Macdonald-Smith (2014); and Macdonald-Smith (2016).

and uncertainty is also reported to be affecting investment in renewables.[9] Investment uncertainty risks have been acknowledged by the NEM rule-maker (the Australian Energy Market Commission, AEMC) since 2012.[10]

There are two main drivers of investment uncertainty.[11] First, climate change policy instability has meant the rules of the game keep changing and it is unclear which forms of generation will have a future in the market.[12] Second, potential investors are unsure if there will be sufficient revenue available in the market over time to recover their upfront costs.

The first is a policy failure that can and should be addressed as a matter of urgency. The second is a potential failure of the market that requires review.

This second argument is known as the 'missing money problem'. The NEM is an 'energy-only market' because generators are only paid for electricity that is consumed – they are not paid for having capacity available in case it is needed, only for energy generated when it is needed.[13] In energy-only markets like the NEM, the lowest marginal cost generation available is dispatched to meet demand, within reliability constraints. Those generators that provided the dispatched energy are paid the wholesale price (or 'spot price'), which can vary enormously through the day and throughout the year depending on the balance of supply and demand.

A common criticism of energy-only markets is that it is difficult for generators to recover their fixed costs because the wholesale price reflects marginal costs only (there is 'missing money' in the market design). The counter argument is that generators can recover their fixed costs during times of tight supply and high demand by pushing up the wholesale price. The 'missing money' problem is not new, and has not deterred investors in the past, but the rise of renewable energy has exacerbated it (see Box 2 on the next page).

1.3 Reliability encompasses both capacity and security

We have seen a series of events that point to security risks in the NEM. In parallel, investment uncertainty is on the rise pointing to potential capacity risks. A reliable electricity supply is one that has both *adequate capacity* to meet demand and *secure access* to this capacity.

In this paper we define reliability to mean a dependable supply of electricity, available on demand. This is what 'reliable electricity' means to the typical consumer. But we recognise that reliability also has a specific technical meaning that is narrower than our definition (see Box 3 on page 9).

A reliable electricity supply depends on all segments of the supply chain, including the available stock of generating units, the transmission network and the distribution network. Most interruptions to electricity supply occur in the distribution network. A tree might fall on a suburban power line, for example, cutting power to several homes in the area. Problems in the generation or transmission sectors affect many more people, but are rarer, generally accounting for less than 10 per cent of the duration of lost electricity supply to consumers.[14]

9. Puddy et al. (2016).
10. AEMC (2016d, p. 10).
11. Ibid. (p. 10).
12. *"The new investment that would normally be signalled by higher prices is stalled by a decade of policy uncertainty. No one knows what is going to happen next."* – Australian Energy Council's Chief Executive, Matthew Warren (representing electricity businesses. AEC (2016).)
13. In practice, the NEM is not just one market because the wholesale electricity market is supported by ancillary services markets and financial hedging markets, so generators do have other forms of revenue. The term 'energy-only market' is used to distinguish from capacity markets.
14. AEMC (2010).

Box 2: The Missing Money problem

Investors considering expanding or building new generation need to see enough revenue in the market to invest. The market has a 'missing money' problem if investment is needed but there is not enough revenue to encourage it.

In energy-only markets like the NEM, the wholesale price tends to reflect marginal costs of generation rather than the full cost. Generators rely on scarcity pricing – infrequent periods of tight supply and high prices – to recover their fixed costs.

A common criticism of energy-only markets like the NEM is that the market design makes it difficult for generators to recover their fixed costs. The Market Price Cap is the key regulatory mechanism for ensuring that prices can get high enough to attract new investment, but not so high as to hurt consumers (through abuse of market power in times of scarcity). If the price cap is set too low new investment may be deterred because generators may not be able to recover their fixed costs.

The 'missing money' problem is not new, and has not deterred investors in the past, but the rise of renewable energy has exacerbated it. When wind and solar are in the market, the wholesale price is pushed down because their energy (wind and sun) is free and renewable generators can rely on subsidies (under the Renewable Energy Target) to recover capital costs. While this has obvious benefits for affordability and emissions reduction, it poses a risk to system reliability if there is insufficient revenue available in the market for other forms of generation and storage that can operate when wind and sun are not available.

Increasing the periods of very low prices means that there needs to be an increase in periods of very high prices (and possibly a higher price cap) for other generators to recover their costs. The price cap in the NEM is currently set at $14,000 per megawatt hour. A 2016 study looked at what the price cap should be under an extreme scenario of 100 per cent renewables and no demand response. It estimated a price cap of between $60,000 to $80,000 per megawatt hour would be required to ensure sufficient revenue in the market, indicating that wholesale prices could oscillate between negative amounts to $80,000 per megawatt hour.[a]

Some argue the volatility created in pursuing high proportions of renewable energy in an energy-only market is likely to be unacceptable to investors, retailers, customers, and governments.[b] High volatility would likely increase hedging activity – deals between generators and retailers – which would minimise consumer exposure to high prices and offer generators a more steady income, but at a higher cost to consumers.

The 'missing money' problem is theoretical rather than demonstrated, but the uncertainty it creates could be sufficient to deter investment.

a. Riesz et al. (2016b).
b. Nelson et al. (2016).

In reviewing reliability, the full network must be considered, but network businesses do not participate in the NEM.[15] In this paper 'the NEM' refers to the wholesale electricity market operating in eastern and southern Australia,[16] while 'electricity system' refers to the full system for getting electricity to the user, including generation, transmission, and distribution.

1.4 There are many challenges but reliability should be Finkel's focus

Our electricity system is under significant pressure as Australia transitions to a cleaner energy future. There are strong policy imperatives for the transition to a low-carbon or net-zero emissions electricity system. What is not yet clear is how quickly the transition will be achieved and with what balance of costs between reliability, affordability and sustainability (and at what overall cost).

The 'energy trilemma' captures this challenge of balancing three different goals for our energy system: ensuring reliable supply of energy, without bills becoming unaffordable, and while reducing greenhouse gas emissions (see Box 4 on page 11).

Affordability and emissions reduction are big challenges. Electricity bills have been growing faster than inflation for a decade (see Figure 1.2 on the following page) and emissions intensity in the NEM has only come down slightly in the last five years (see Figure 1.3 on page 11). But these are not the problems the Finkel review needs to solve. Affordability challenges are not a new problem and emissions reduction

15. Market settings in the NEM only affect generation and major inter-regional transmission lines (known as interconnectors). Network businesses are regulated monopolies and do not participate in the wholesale market.
16. Including supporting markets: ancillary services markets and financial hedging markets.

Box 3: 'Reliability' has both broader and narrower meanings

This working paper uses the term 'reliability' in the broad sense: to mean a dependable supply of electricity, available on demand. The use of the term 'reliability' in the energy trilemma is also intended to have this broader meaning.

But 'reliability' is also a technical term with a much narrower definition: reliability events are those that occur when reserve capacity in the system has been exhausted (*i.e.* a loss of electricity because there is insufficient capacity in the system to meet demand). This contrasts with 'security events' which occur when reserve capacity is still available but cannot be accessed, for example because of equipment failure or shutdown.

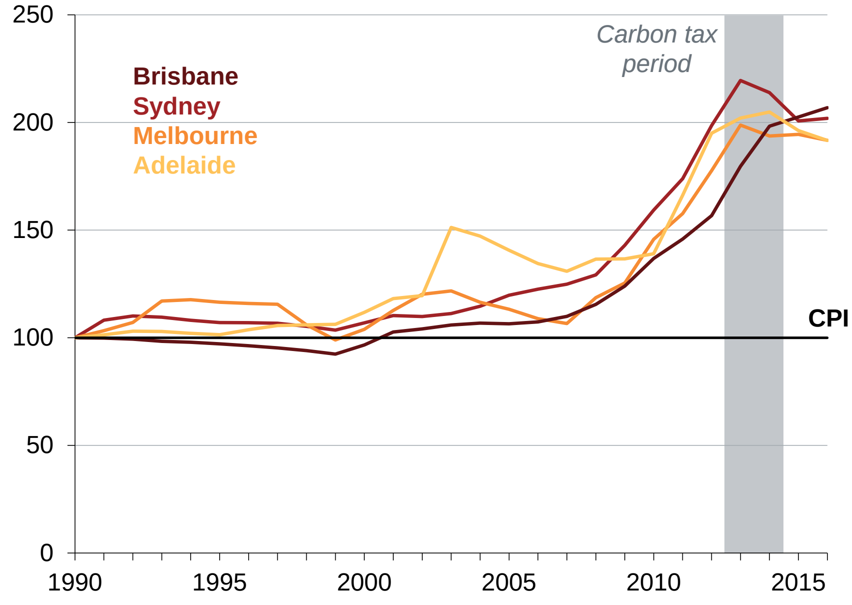
is the subject of another review – the 2017 review of Australia's climate change policies.[17]

The Finkel review should focus on risks to the reliability of our electricity supply, while recognising affordability and emissions reduction goals in weighing up potential solutions. This working paper reviews reliability risks in our electricity system, specifically asking:

- Are there signs of a capacity problem in the NEM? (Chapter 2)
- And can we maintain system security through the transition? (Chapter 3)

Figure 1.2: Electricity bills have been growing faster than inflation for a decade

Electricity index, four quarter average



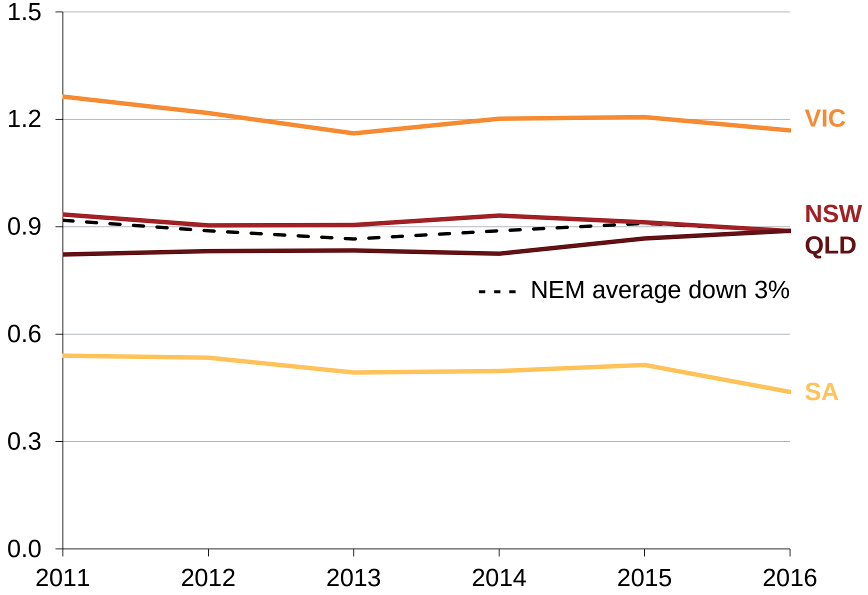
Notes: CPI = Consumer Price Index.

Source: Grattan analysis of ABS CPI data (6401.0, Sep 2016).

17. Department of the Environment and Energy (2016).

Figure 1.3: Emissions intensity has only come down slightly

Emissions intensity (annual emissions / annual energy delivered)



Notes: Emissions intensity in South Australia came down almost 20 per cent from 2011 to 2016 but other regions are lagging. Emissions intensity in Queensland rose 8 per cent.

Source: Grattan analysis of AEMO's CO2 Emissions Intensity Index by year, AEMO (2016b).

Box 4: Balancing the energy trilemma

The 'energy trilemma' captures the challenge of balancing three different goals for our energy system: ensuring reliable supply of energy, without bills becoming unaffordable, and while reducing greenhouse gas emissions.

There are naturally trade-offs between these goals – and different stakeholders will prioritise differently – but Energy Ministers tend to put reliability first.[a]

The energy system has long balanced reliability and affordability. Expectations for reliability are set through reliability standards and then least-cost solutions are sought to meet these expectations.

Emissions reduction is the new dimension, but it need not be complex to incorporate. With clear expectations for both emissions reduction and reliability, markets can resolve the least-cost solution.

a. COAG Energy Council (2016a).

2 Are there signs of a capacity problem?

Some argue that the NEM is broken – that the wholesale electricity market is no longer able to maintain sufficient generation capacity.[18] Two arguments imply that investment in generation capacity is at risk:

1. Climate change policy instability means investors are unsure of which types of generation have a future in the market and for how long; and
2. There may be insufficient revenue in the market to ensure a reliable system (see Box 2 on page 8).

Potential investors express several concerns, including demand for electricity in an oversupplied market, wholesale electricity prices, and the ability to secure Power Purchase Agreements (PPAs) that help to reduce financial risk.[19] Companies may be unwilling to sign long-term PPAs in the current investment climate.[20]

It is therefore appropriate to ask: are there signs of a capacity problem in the NEM?

2.1 Recent events did not reflect capacity issues

The 28 September and 28 December 2016 blackouts in South Australia were both driven by unexpectedly severe storms. It is unlikely that additional capacity would have helped had it been available in South Australia in September. Reserve capacity was available, but the storm was much more damaging than expected and the loss of critical transmission infrastructure triggered unknown protection features in some generation infrastructure, which reduced supply suddenly. The sudden loss of supply had a cascading effect that was too quick for emergency mechanisms to kick-in.[21] With hindsight, the problems could have been managed in ways that may have avoided the state-wide blackout.

In response to the September blackout, a new requirement for two synchronous generators to be running at all times was introduced to provide grid-stabilising services and back-up capacity.[22] But a partial blackout still occurred on 28 December when the network was hit by another violent storm. It is not clear if the additional capacity helped to reduce the impact of this second event, but it is clear that additional capacity cannot guarantee reliability.

Recent events did not reflect capacity issues, but more flexible, fast-response generation capacity and/or demand-response might have helped in responding to unexpected issues (see Appendix A).

2.2 Generation capacity problems are rare

Most blackouts are caused by security events (such as equipment failure or shutdown) preventing access to existing capacity rather than a lack of built generation capacity. One estimate suggests 88 per cent of electricity supply interruptions are security events.[23]

There have been very few instances in the past where generation capacity was insufficient to meet demand. The main reliability standard assesses the sufficiency of generator capacity to meet consumer demand (see Box 5 on page 14). Breaches of this standard are rare (see Figure 2.1 on the following page).

18. *e.g.* AGL Energy's Tim Nelson argues *"reconsideration of the NEM's energy-only market design appears inevitable"* (Nelson (2016)).
19. A 2015 survey of project proponents undertaken for the Electricity Generation Major Projects report, Office of the Chief Economist (2015, p. 16).
20. Ibid. (p. 20).
21. AEMO (2016a).
22. COAG Energy Council (2016b).
23. AEMC (2010).

Since 2001, Victoria and South Australia have each experienced only one year where electricity supply failed the reliability standard because of insufficient capacity. In other regions of the NEM, supply has never failed the standard. The reliability breaches in Victoria and South Australia occurred in January 2009, during the height of a heatwave and drought that also contributed to the Black Saturday bush fires in Victoria.

2.3 Future capacity risks

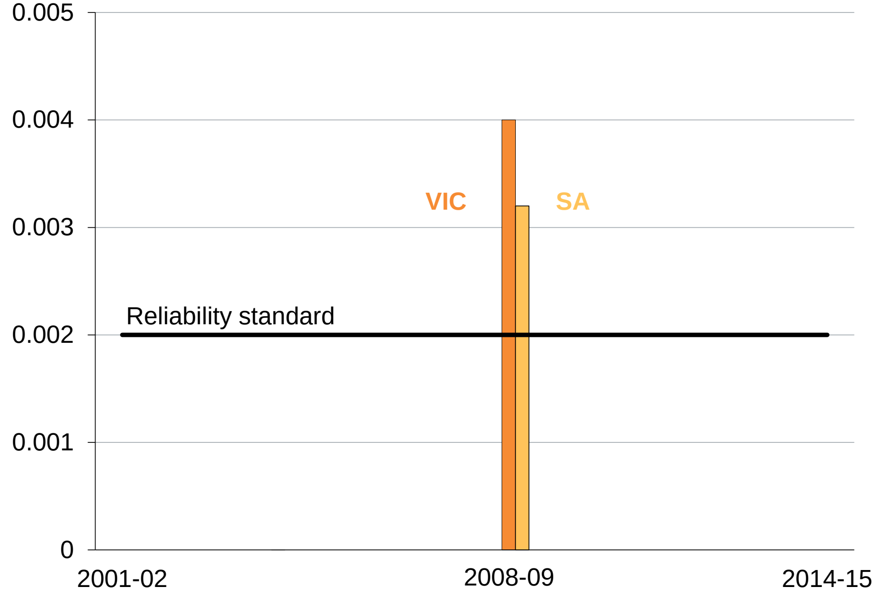
Over the last six years the NEM has had excess capacity,[24] but supply is now tightening in some regions.

All regions of the NEM have more built capacity than peak demand, most with at least a 10 per cent buffer (see Figure 2.2 on page 15). But when the intermittency of wind and solar is taken into account, both South Australia and Victoria (after Hazelwood closes) could need to import electricity from other regions of the NEM to manage peak summer periods of very high demand and low wind.

South Australia is the region most at risk of capacity shortage. At times of very high demand and low wind, South Australia is reliant on importing additional supply from Victoria. Existing interconnectors can provide this supply but South Australia is potentially vulnerable if islanded during high demand (cut-off from Victoria and the rest of the NEM).[25] The new reliance on imports and risks to system security have led to calls for additional interconnectors and/or new generation capacity in the state.

24. Demand for electricity has been falling since about 2010, resulting in overcapacity in the NEM, Office of the Chief Economist (2015).
25. If South Australia was islanded during peak summer demand, and wind capacity was less than 40 per cent, the state would not be able to meet demand and would need to resort to load-shedding. However system security is likely to be a bigger risk for blackouts than insufficient generation capacity if South Australia is islanded, see Chapter 3.

Figure 2.1: Only two breaches of the reliability standard since 2001
Unsupplied energy as a per cent of regional native consumption



Notes: Data not yet published for 2015-16. No breaches were projected for 2015-16.

Source: Grattan analysis of unsupplied energy reported in the AEMC's annual market performance reports, AEMC (2016b).

Supply will tighten in Victoria when Hazelwood closes in March. Victoria had significant excess capacity prior to the announced closure, but Hazelwood represents about 15 per cent of the state's total installed capacity, so its loss may mean Victoria needs to import electricity at times of peak summer demand.[26]

2.3.1 Potential shortfalls are projected for 2017-18

Both near-term and long-term capacity risks are currently projected (see Table 2.1 on page 17). Potential shortages are forecast for Victoria and South Australia next summer, due to the closure of Hazelwood, but can be managed through short-term market and/or operator responses (see Section 2.4 on page 16). Long-term projected shortfalls are a normal statement of opportunity for the market and should prompt new investment over time.

Two-year forecasts are published quarterly by the Australian Energy Market Operator (AEMO) to highlight potential future breaches of the reliability standard alongside various short-term responses available to the market (EAAP reports).[27] Annual long-term forecasts, known as the Electricity Statement of Opportunities (ESOO), highlight shortfalls over the next 10 years and are intended to prompt investment.[28]

Near-term potential shortfalls are less commonly projected than long-term shortfalls, but are still not unusual. Near-term risks for Victoria and

26. When Hazelwood closes, Victoria's excess capacity is about 4 per cent if the wind is blowing, and -8 per cent if not. However this does not factor in imports from other regions via interconnectors or potential market responses to the closure of Hazelwood. Victoria has many connections with other regions of the NEM to import additional supply.
27. The latest Energy Assessment Adequacy Projection was published in November 2016, AEMO (2016d).
28. AEMO (2016c). System adequacy projections are also published for short-term needs (next 6 days) and for medium-term needs (next 2 years). These only consider generation capacity available within 24 hours.

Box 5: Reliability standards

Reliability standards are used to determine the level of reliability we expect, and then investments in generation, transmission and distribution are made to meet these standards. Different standards for reliability apply in each segment of the supply chain and these standards are independently determined.

The main reliability standard (known as *the* reliability standard despite the existence of other standards) is used to evaluate whether sufficient investment in generation capacity is occurring to meet consumer demand. This standard applies primarily to generation, but also includes transmission between regions (interconnectors), to capture the benefits of generation across regional boundaries.

This reliability standard sets the expectation that demand will be met 99.998 per cent of the time in each region in the National Electricity Market. In practice this means that electricity supply can be at risk for only 11 minutes per year per region, on average, usually at times of peak demand.[a]

But this reliability standard only captures power failures that are caused by insufficient capacity in the system. Power failures caused by security events, such as equipment failure or shutdown, are not captured in this reliability standard.

a. Standards are established by the Australian Energy Market Commission's Reliability Panel and require that unserved energy per year for each region must not exceed 0.002 per cent of the total energy consumed in that region that year.

South Australia (in 2017-18) were projected in November 2016 in the wake of the announcement that Hazelwood would close. Before the November 2016 forecast, the last EAAP report to project a potential breach of the reliability standard was in June 2013, with a risk of shortfall forecast for South Australia and Victoria over the 2014-15 summer that did not eventuate.[29]

Investment uncertainty risk has been on the horizon for at least five years. Risk of shortfall driven by investment uncertainty was projected by AEMO in 2011 but did not eventuate.[30]

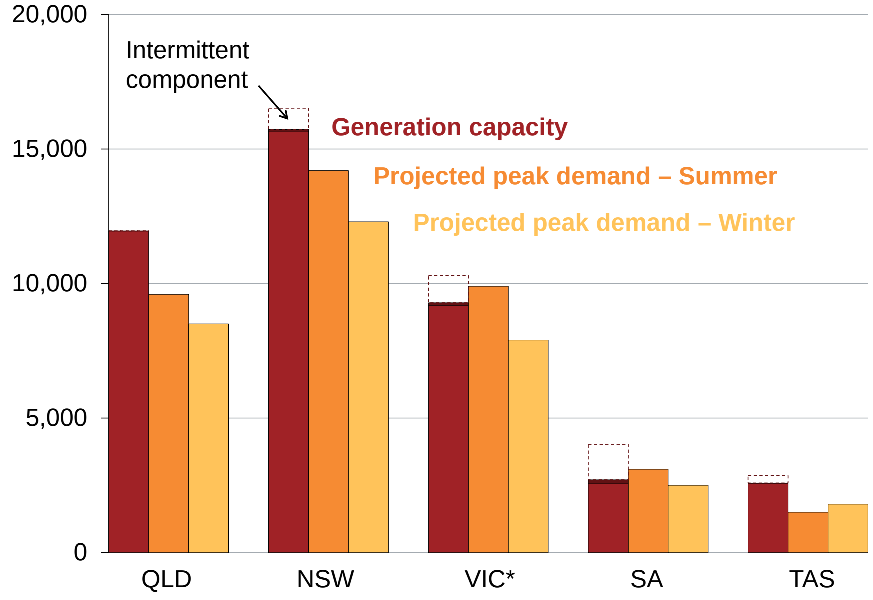
2.3.2 The investment pipeline is mostly intermittent renewables

Generation capacity withdrawals (capacity retired or mothballed) have exceeded new generation entry in recent years in response to overcapacity in the market.[31] But new investment will still be required in the next 10 years, with further withdrawals of non-intermittent generation capacity expected.[32] Aggregate demand has declined in recent years, but maximum demand is expected to hold steady.[33]

More clean energy will also be needed to meet the Renewable Energy Target (RET).[34] The existing RET seems likely to be left alone, with bi-

Figure 2.2: Sufficient capacity across the NEM but supply tight in South Australia and Victoria

Megawatts



*Notes: *Generation capacity as at 31 December 2016 except Hazelwood removed for Victoria. Intermittent component includes wind and solar, with a conservative 10 per cent capacity factor applied, as per AER (2015, p. 8). Distributed energy resources such as solar PV are not included. The peak demand forecast is for 2016-17.*

Source: Grattan analysis of registered generation capacity (AER (2016b)) and the latest demand forecasts (AEMO (2016h, p. 6)).

29. The risk of shortfall was revised in the following forecast because of a reduction in expected demand (AEMO (2013a) and AEMO (2013b)).
30. The 2011 ESOO projected reserve shortfalls in some NEM regions in 2013-14 or 2014-15, *"partly reflecting the impact of . . . uncertainty on investment in generation capacity"* (AEMO (2011)).
31. AER (2015, p. 7).
32. Office of the Chief Economist (2015).
33. Maximum demand occurs in summer for the mainland states (driven by air-conditioning) and summer maximum demand is forecast to occur later in the day and not grow over the next 20 years. Winter maximum demand is forecast to grow faster and become comparable to summer maximum demand from around 2030, AEMO (2016h).
34. Office of the Chief Economist (2015).

partisan support, but state and territory schemes could drive further investment in clean energy.

The pipeline for new investment is dominated by wind and solar (see Figure 2.3). More than 5000MW of new gas capacity has been publicly announced but not committed to.[35] Gas projects are reported to be unlikely to progress until domestic gas prices are more competitive.[36] Bucking the trend, expansion of a brown-coal power station in Victoria, Loy Yang B, was recently announced, with upgrades planned in 2019 and 2020.[37] The last major gas power station was completed in 2012 and the last new coal capacity in 2007.[38]

With most new capacity being wind and solar, there will be more intermittent generation in the market in future. Some non-intermittent renewable energy projects have been proposed for South Australia, including a couple of 100MW solar thermal and storage projects, but it is not yet clear if they will be feasible.[39]

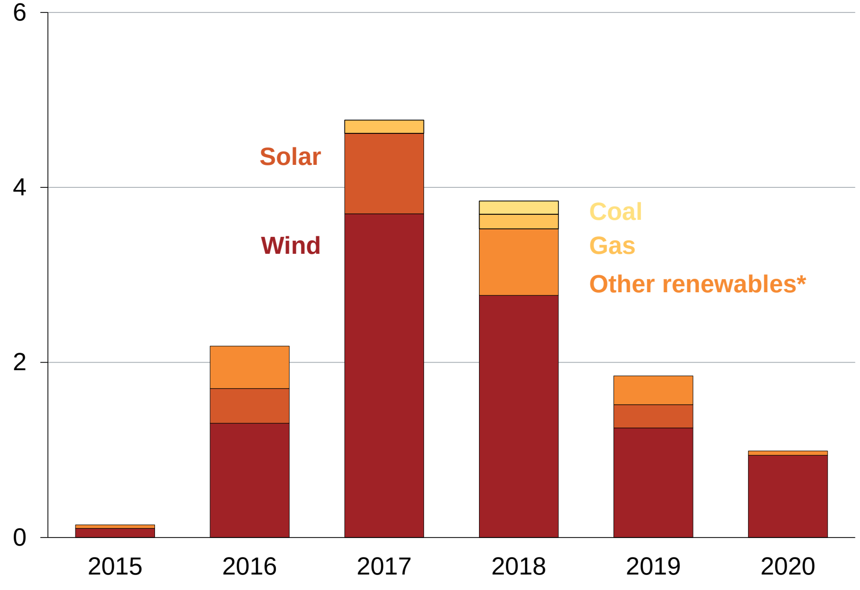
2.4 Managing future capacity risks

2.4.1 Short-term responses are available to the market

Short-term responses available to the market to meet potential shortfalls in 2017-18 include:[40]

- Bringing back withdrawn generation capacity (*e.g.* mothballed plants)

Figure 2.3: The investment pipeline is dominated by wind and solar
Gigawatts of new investment by year of expected start up and fuel type



*Notes: *Other renewables includes hydro, geothermal, ocean and biomass. The investment pipeline is as at October 2015.*

Source: Office of the Chief Economist (2015)).

35. Ibid.
36. Note the domestic gas price is pushed up by international gas markets, Office of the Chief Economist (ibid.).
37. But note announced projects are not necessarily committed, Puddy et al. (2017).
38. Mortlake open cycle gas-fired power station opened in August 2012 and Kogan Creek coal-fired power station opened in November 2007, AEMO (2012) and AEMO (2010).
39. Gage (2017); and AEMO (2017b).
40. AEMO (2016d).

- Demand reduction during vulnerable periods
- Advancing new generation projects that are already in the pipeline
- Increasing water storage now in advance of summer 2017-18 (to ensure more hydro power is available)

2.4.2 Emergency reserves can be contracted if needed

In the absence of a market response, and with a projected shortfall approaching, AEMO has the power to contract for emergency reserves. AEMO can contract for these additional reserves up to 10 weeks ahead under the Reliability and Emergency Reserve Trader (RERT) mechanism.[41] AEMO can then dispatch these additional reserves if they are needed to maintain power system reliability and security.[42] RERT contracts can be with supply or demand-side participants (such as a mothballed power plant or a large consumer willing to be paid to reduce their demand at vulnerable times).

Reserve capacity has only been contracted on three occasions since the commencement of the NEM – in 2005, 2006 and 2014.[43] In each case, reserve capacity was purchased for Victoria and South Australia, but did not need to be dispatched. The RERT mechanism was reviewed in 2016, and the AEMC decided to keep it with the specific purpose of addressing *"market uncertainty arising from a changing generation mix."*[44]

41. A rule change in 2016 reduced the period for activating the RERT from nine months in advance to 10 weeks in advance: AEMC (2016d).
42. Ibid.
43. In 2005 a total of 84MW of reserve capacity was contracted for the period 31 January to 4 March (33 days) at a cost of $1m; in 2006, a total of 375MW for the period 16 January to 10 March (54 days) at a cost of $4.4m; and in 2014, 650MW for the period 15-17 January (3 days).
44. AEMC (2016d).

Table 2.1: Medium and long-term risks projected for the NEM

Region	2-year outlook	10-year outlook
South Australia	Potential shortfall summer 2017-18	Shortfall 2019-20
Victoria	Potential shortfall summer 2017-18	Shortfall 2024-25
New South Wales	No shortfall	Shortfall 2025-26
Queensland	No shortfall	No shortfall
Tasmania	No shortfall	No shortfall

Notes: The 2-year outlook is the EAAP, November 2016 forecast, the 10-year outlook is the ESOO, August 2016 forecast.

Source: AEMO (2016d) and AEMO (2016c).

2.4.3 Prices are the signal for new investment

AEMO's 10-year outlook is intended to inform investment decisions, but prices in the NEM are the main signal for new investment. When supply tightens, prices increase, and there is greater incentive to invest in new generation capacity (see Figure 2.4 on the next page).

The Market Price Cap is set at $14,000 per megawatt hour. If the wholesale spot price is frequently hitting the Market Price Cap, then this is a risk for the market because prices may not be able to go high enough to attract new investment. The cap was hit several times during 2016 and early 2017, during separate five-minute dispatch intervals, particularly in Queensland and South Australia. But there is no trend to suggest significant growth in the frequency of high cost 30-minute intervals across the NEM over time (see Figure 2.5 on page 19).[45]

To attract new investment, prices need to go high enough, often enough, for generators to recover their fixed costs, but extreme volatility

45. The price paid for all electricity consumed during a 30-minute trading interval is the simple average of the six five-minute dispatch prices during the 30-minute period. AEMO issues a notice for each high price event, AEMO (2017c).

can make investors nervous because their returns depend on relatively few periods of very high prices. Figure 2.6 on page 20 shows the range of average weekly prices in South Australia increased in 2016, but the range was even larger between 2009 and 2011. Other regions of the NEM are also shown for comparison. Price volatility is certainly high, but this is not a substantially ‘new’ problem.[46]

Besides the wholesale price, another key source of revenue for generators are hedging contracts.[47] Base futures prices are increasing, particularly in South Australia (see Figure 2.7 on page 20). But there is no change to the overall volume of market activity (see Figure 2.8 on page 21).

Higher base futures prices signify that the market is now expecting higher wholesale prices over the next few years. Higher prices are the signal for new investment.

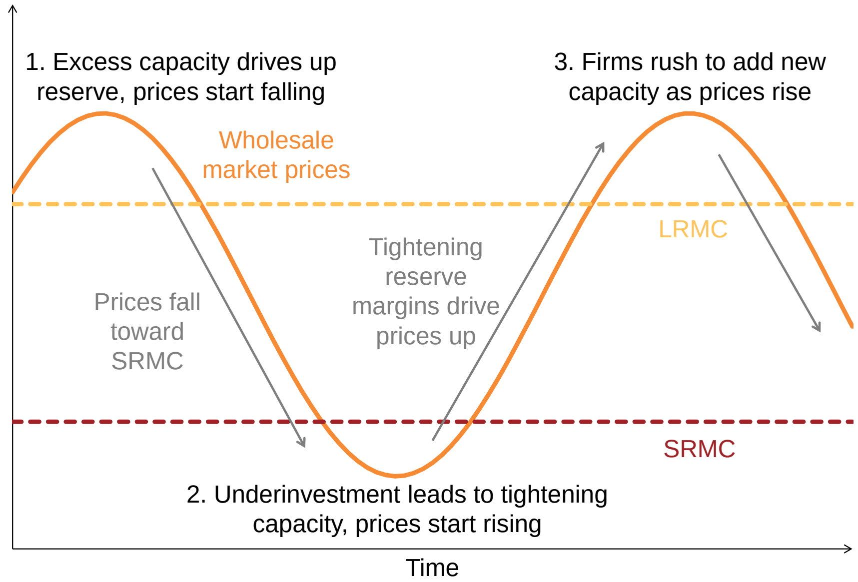
2.4.4 Government investment is an expensive way to go

Government investment in new generation capacity would be a very expensive approach to improving reliability, and would not on its own solve all the problems we have seen. It would also likely undermine private investment in the market.

After several years of overcapacity in the market and the subsequent withdrawal of generation capacity, supply has now tightened in some regions of the NEM, particularly South Australia and Victoria. The market is responding to this tightening of supply through higher wholesale prices, as it should. What is not yet clear is whether investors will respond and what kinds of capacity investments will be made.

46. Wholesale electricity prices are already highly volatile because both supply and demand fluctuate instantaneously.
47. Retailers can smooth their costs, and generators their revenues, by entering into hedging arrangements with each other.

Figure 2.4: The generation capacity cycle
Average wholesale market price



Notes: LMRC = Long-run Marginal Cost; SMRC = Short-run Marginal Cost.
Source: A reproduction of Steed et al. (2011) in McConnell et al. (2016)).

With significant political and media attention on reliability, there is a real risk that politicians will be looking for an 'announceable'. Government investment in new generation capacity is not the way to go. New investment will be needed over time, but we should give the market a chance to respond first.

2.5 Climate change policy is the big uncertainty

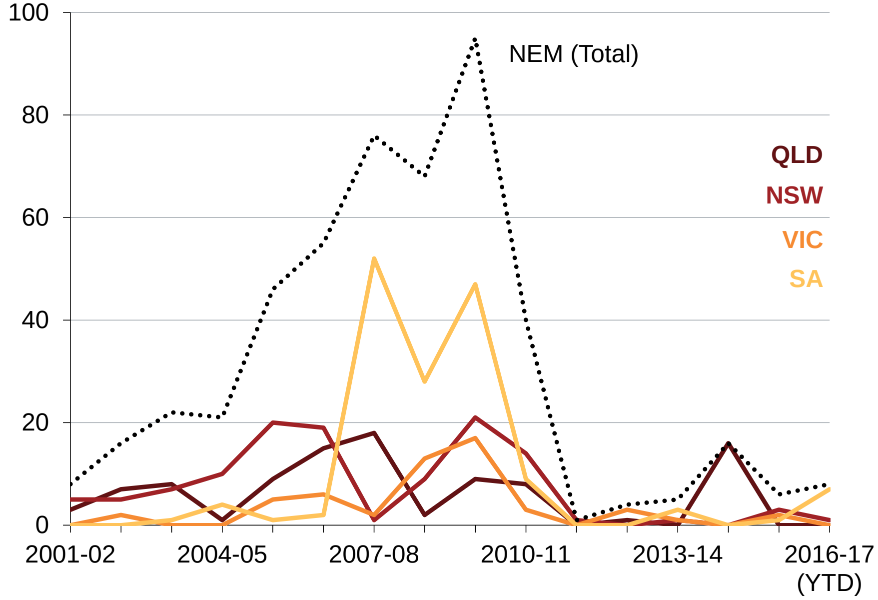
Climate change policy remains the big uncertainty for investors. Investments will need to be made in the coming years and government must ensure its energy and climate policy provides clear and stable signals for the market.

The current climate change policy vacuum is contributing to investment uncertainty. For example, it is not yet clear what will drive emissions reduction in the electricity sector after the RET ends in 2020 (see Box 6 on page 21).

The 2017 review of Australia's climate change policies must provide a credible plan for emissions reduction and clear direction for the electricity sector. The review should identify the electricity sector's contribution to Australia's overall emissions reduction targets, and the mechanism/s by which emissions reduction will be achieved. The mechanism should integrate with the NEM – a priority endorsed by the COAG Energy Council.

It is too early to tell if the market will become 'uninvestable'. But we should not rush into expensive solutions in fear of the unknown. There is still time to allow investors to respond and safety nets in place if they do not respond quickly enough.

Figure 2.5: No sign of major new challenges from high wholesale prices
Number of trading intervals above $5000 per megawatt hour

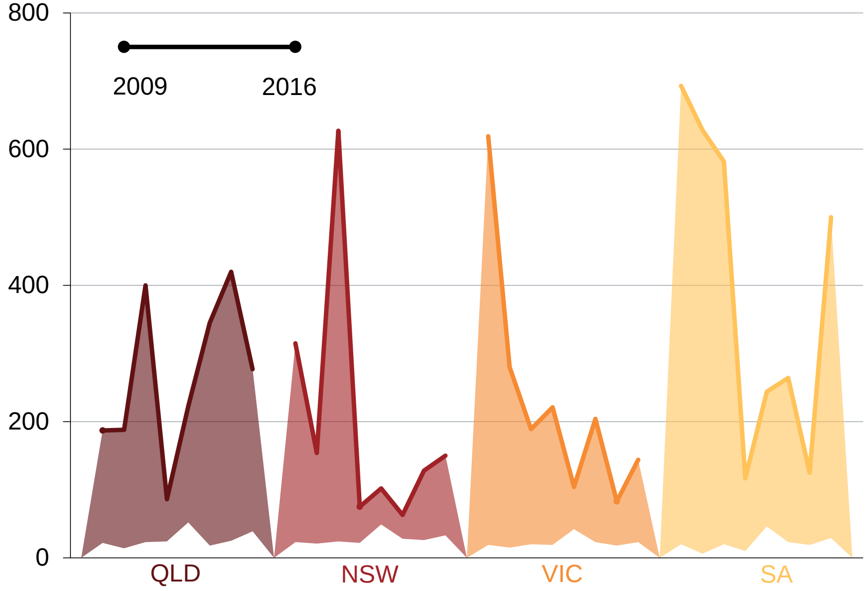


Notes: 2016-17 year to date is to 31 December 2016.

Source: Grattan analysis of AER wholesale statistics, AER (2016d).

Figure 2.6: Wholesale price volatility in South Australia picked up in 2016

$ per megawatt hour, weekly volume weighted average spot price

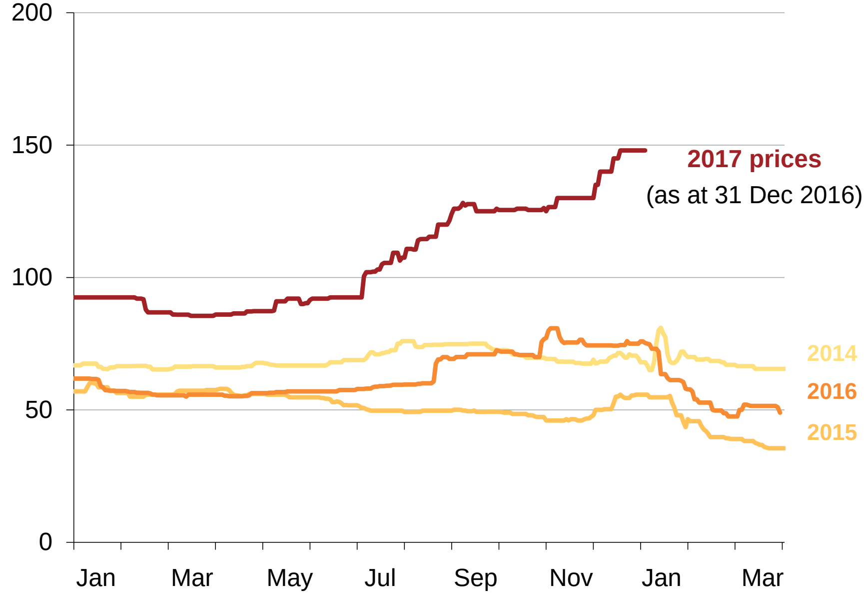


Notes: The range of weekly volume weighted average spot prices is shown for each region over time. The average for each week is weighted against demand for electricity. A log scale is used.

Source: AER (2016f).

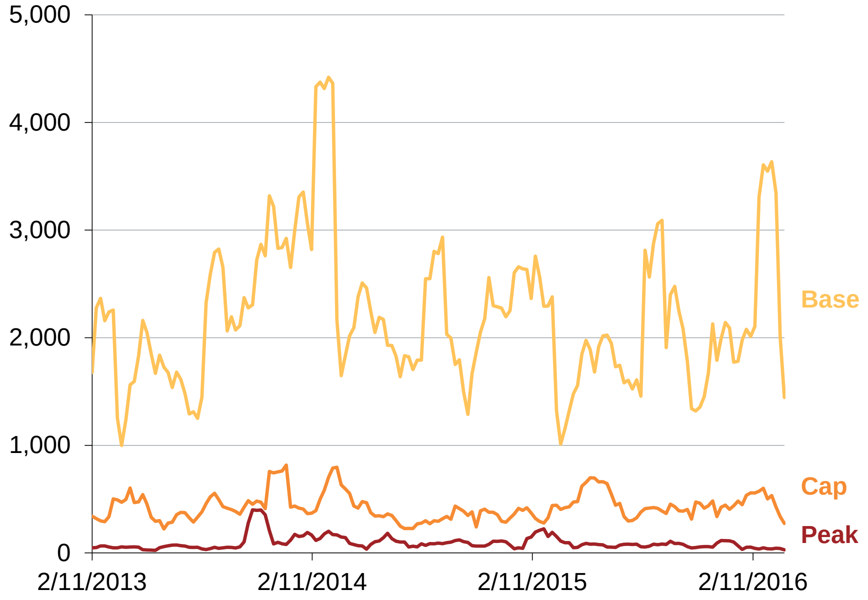
Figure 2.7: Contract prices for 2017 in South Australia are much higher than previous years

Daily base contract prices for the first quarter of 2014, 2015, 2016 and 2017, $ per megawatt hour



Source: AER (2016c).

Figure 2.8: No major changes in volume of market activity
Number of base, peak and cap contracts exchanged on the ASX, 5-week rolling average



Source: Grattan analysis of AER wholesale statistics, AER (2016a).

Box 6: The RET and investment uncertainty

It is not yet clear what will drive emissions reduction in the electricity sector after the Renewable Energy Target (RET) ends in 2020. This uncertainty is driving up spot prices for large-scale generation certificates. Higher prices should be a trigger for new investment, but with future climate change policies unclear, high prices may not be sufficiently attractive.

This could lead to a bad outcome for both emissions reduction and electricity affordability, because if the RET is not met there are financial penalties and consumers would ultimately foot the bill.[a]

a. Finkel (2016, p. 22).

3 Can we maintain system security through the transition?

System security is a serious and immediate challenge that has emerged in recent events.

A reliable electricity supply is one that has both *adequate capacity* to meet demand and *secure access* to this capacity. The power system is 'secure' when technical parameters such as power flows, voltage, and frequency are maintained within defined limits.[48]

Major disruptions to supply or demand (such as the loss of a generator or transmission line, or a sudden increase or decrease in demand) can drive rapid changes to technical parameters that need to be managed quickly to avoid blackouts. AEMO is responsible for balancing supply and demand of electricity on an instantaneous basis and maintaining these technical parameters within defined limits. A few key factors support the critical balancing process:

1. **System strength** helps to reduce the impact of disruptions on the system in the first place
2. **Inertia** helps to slow down changes in power system frequency, giving more time to respond
3. **Frequency response** returns frequency levels to normal

3.1 System strength is decreasing

When system strength is low, a major change in supply or demand means large changes in voltage. When system strength is high, the same change in supply or demand results in a lesser change in voltage. Voltage must be maintained within defined limits to avoid blackouts, and high system strength makes this easier.

48. AEMC (2016f).

The AEMC recently reported that *"system strength in some parts of the power system has been decreasing as the number of traditional synchronous generators are operating less or being decommissioned."*[49] Decreasing system strength will make voltage management more challenging and increase the risk of the sort of cascading outages that can lead to widespread blackout.[50]

3.2 Inertia is a potential risk for South Australia

Inertia is a property of the power system, determined by the nature of the generating units. Inertia is naturally provided by synchronous generators (generators that operate at the same frequency as the power system),[51] but other technologies can also provide inertia to the power system.[52]

When there is a major disruption in supply or demand, inertia helps to slow the subsequent changes in frequency. It does not stop the change in frequency or get it back to normal, but it buys time for other mechanisms to respond.

Historically, inertia in the system was plentiful because all generators were synchronous. With the rise of non-synchronous generators, such as wind, South Australia has seen a reduction in inertia. System inertia in South Australia has reduced each year since 2013.[53] When the Heywood interconnector is in service, South Australia can access inertia across the whole National Electricity Market, so the decline in inertia

49. Ibid. (p. x).
50. Ibid. (p. x).
51. Such as coal and gas-fired power stations and hydro plants.
52. *e.g.* synchronous condensers and synthetic inertia controllers, as noted in Finkel (2016, p. 29).
53. Ibid.

locally has no effect.[54] However, when islanded, South Australia's potential to manage sudden changes in frequency may be limited by the region's reduced inertia.

3.3 Frequency response needs are changing

The power system is designed to operate at a specific frequency, and deviations from normal result in blackout if they are not dealt with quickly.[55] Any imbalance in supply and demand causes the system frequency to change so AEMO procures Frequency Control Ancillary Services (FCAS) to return frequency levels to normal. FCAS are used to correct for minor deviations as well as in response to major events such as the loss of a transmission line.[56]

There is always a time-delay for frequency response so the system needs some inertia to slow the frequency change to provide time for FCAS to be activated.[57] Different FCAS markets exist for the provision of faster or slower services. The fastest FCAS markets are for six second response and this is usually provided by load-shedding or the closest synchronous generating unit/s.[58]

The AEMC have identified a need for even faster frequency response services, particularly as inertia declines. The AEMC and AEMO are working on a technical specification for a faster service to act somewhere in the range of half a second to two seconds.[59] This would likely be too quick for synchronous generators, but could potentially be provided by wind turbines, by energy storage devices and by demand-response schemes.[60]

3.4 The cost of managing system security is rising but still very small

System security needs are managed through ancillary service payments to providers. With the retirement of several coal-fired power stations, and more intermittent generation in the market, there are now fewer available providers of ancillary services.

With fewer suppliers of ancillary services and greater need, remaining providers will get a higher price for their services.[61] This higher price might attract investment in alternative ways of providing system security services, such as synchronous condensers, synthetic inertia controllers, and fast frequency response from battery storage.

Payments for ancillary services have indeed increased in recent months (see Figure 3.1 on the next page). Ancillary service payments more than doubled from 2014-15 to 2015-16 and are on track to more than double again in 2016-17. But ancillary service costs are still negligible at less than half of one per cent of wholesale costs.

3.5 Future risks to system security

The increasing penetration of intermittent generation is expected to challenge system security and impact operation of the power system.

54. AEMO notes that the decline in system inertia in South Australia does not affect the stable operation of the power system in South Australia as long as the Heywood Interconnector to Victoria remains in service, AEMO (2016e, p. 21).
55. The normal frequency level in the National Electricity Market is 50 Hertz. AEMO is charged with maintaining system frequency within the very narrow operational tolerance band of 49 to 51 Hertz.
56. AEMO (2015a).
57. AEMC (2016f).
58. The frequency deviation is detected locally and the generator governor reacts to the frequency deviation by opening or closing the turbine steam valve and altering the megawatt output accordingly.
59. AEMC (2016f, p. viii).
60. Ibid. (p. viii).
61. Synchronous generators such as coal and gas currently supply ancillary services, but it is possible for other generators to supply some ancillary services too with the aid of power conversion systems.

System security needs are changing and ancillary service markets will need to keep up to ensure new security needs can be managed. Recognising this, the AEMC is currently reviewing system security issues (see Box 7 on the following page).

3.5.1 Penetration of intermittent generation is the big uncertainty

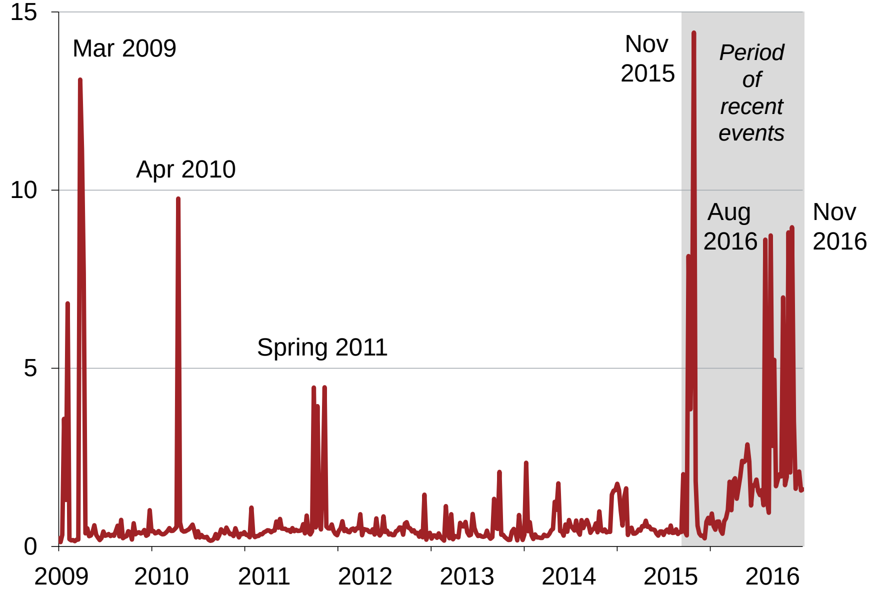
The increasing penetration of intermittent generation poses new challenges, particularly for system security. The challenge is that intermittent generation does not (currently) contribute to system security.

With increasing penetration of intermittent generation, there are fewer ancillary service providers and greater ancillary service needs. Higher penetration of distributed energy resources, such as solar panels on homes, also makes it more difficult for the operator to predict demand, which increases reliance on frequency control services to manage any imbalance that arises.[62] When system security issues arise, other forms of generation or new solutions are needed to manage them.

Most regions of the NEM get less than 10 per cent of their energy from wind and solar, so the impact of intermittency is small. But in South Australia wind supplied 38 per cent of electricity consumed in 2015-16 and has only increased since with wind supplying 50 per cent of electricity consumed so far this year (see Figure 3.2 on page 26). At times wind is supplying more than 75 per cent of South Australia's power.[63]

South Australia will likely be first in the world to see the effects of high levels of intermittent generation, and is particularly vulnerable if islanded. AEMO have looked at the risks for South Australia, if islanded, and estimate that almost a quarter of the time South Australia would be

Figure 3.1: Ancillary services payments have increased in recent months
Weekly cost (millions $)



Source: Grattan analysis of AER wholesale statistics AER (2016e).

62. AEMO (2017a).
63. AER (2015, p. 8).

unable to manage a major contingency event on its own (and most of the rest of the time it was 'uncertain' if the system could cope).[64]

AEMO is now trying to better understand what rates of frequency change the power system can withstand and where the limits lie.[65] System security needs are changing and it is important the operator has a range of options available to maintain system security. System strength and inertia are in decline, and while less of each may not be a problem, we need to know where the critical point lies.

While intermittent generation does not currently contribute to system security, it can contribute in future. Under causer-pays FCAS arrangements there is already an increasing incentive for wind farms in South Australia to add FCAS capability. Improvements to the market, proposed in Chapter 4, would further strengthen incentives for intermittent generation to invest in system security services.

3.5.2 Storm severity is a risk but not much we can do

Storm severity is expected to increase and this is likely to increase system security incidents.[66] Network infrastructure is particularly vulnerable to storms.

Network reliability has been consistent over time with no trends to suggest a growing problem in the performance of distribution or transmission networks (see Figure 3.3 on page 27). But we do not yet know how recent events will be assessed. The 28 September and 28 December 2016 storms led to major network damage. The latest data available on the performance of the NEM is 18 months behind (2014-15).[67]

64. AEMO (2016e, p. 23).
65. AEMO (2017a).
66. BOM and CSIRO (2016) and AEMC (2010): *"If the frequency and/or severity of extreme weather were to increase, this would likely impact mostly on the incidence of security events."*
67. AEMC (2016b).

Box 7: System security is under review

In July 2016, the AEMC initiated a review into system security *"to consider, develop and implement changes to market frameworks to allow the continued uptake of these new generating technologies while maintaining the security of the system."*[a]

An interim report in December 2016 identified two new system security services that are likely to be needed – inertia and fast frequency response – and suggest these services could be obtained through:

- Generator obligation;
- A competitive tender process;
- Direct provision of services by Transmission Network Service Providers; or
- Ancillary services incorporated into the dispatch process.

The final report is expected in mid-2017 and will propose policy changes and rule changes to improve system security for decision by the COAG Energy Council.

a. Ibid.

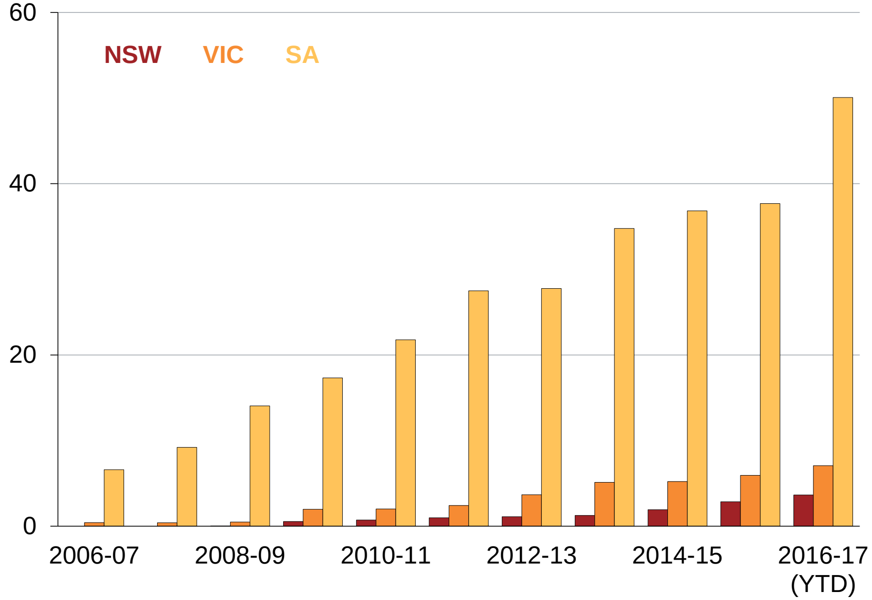
After the blackout on 28 December 2016, SA Power Networks reported that on average South Australians are without power for 168 minutes each year but that this storm alone would exceed that figure.[68]

Network improvements to increase the resilience of the system (*e.g.* more power lines, more regional interconnectors) or to protect the existing network (*e.g.* under-grounding of lines) are very costly and can never fully storm-proof the system. SA Power Networks pay compensation to those affected by significant power loss due to storms. They have reviewed alternatives to minimise storm impacts and found them to be much more costly than compensation. They estimate that under-grounding of lines would cost them $30-40 billion, and widespread tree clearances would not be acceptable to the community.[69]

Severe storms are a challenge for electricity systems around the world. No system can withstand every storm. But it helps to see a storm coming. The accuracy and precision of weather forecasting is important in managing system security risks.

More severe storms may mean more network infrastructure has to be upgraded or replaced. Consumers ultimately pay for network improvements so storms pose a risk to affordability too.

Figure 3.2: Wind energy is growing rapidly in South Australia
The percentage of output wind contributes to total output in each region



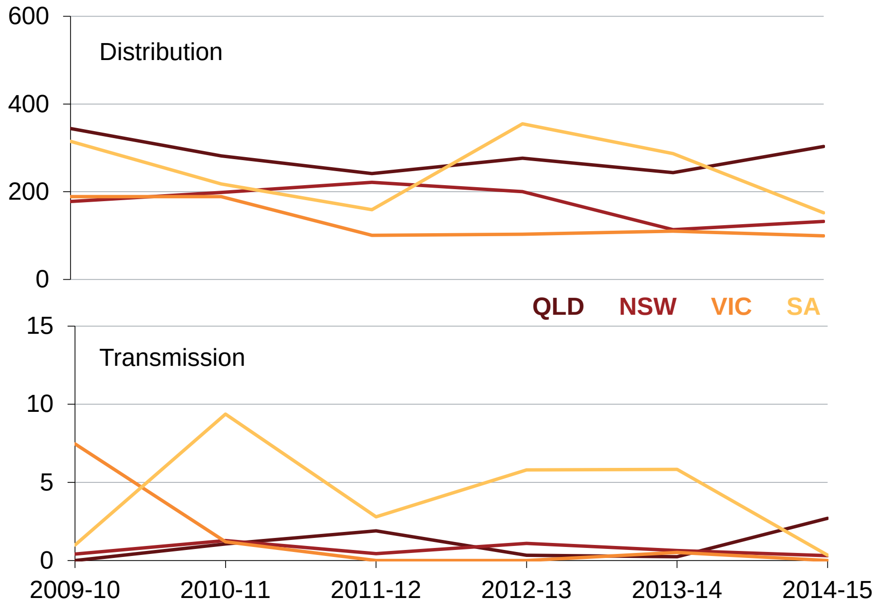
Notes: Queensland and Tasmania not shown. Queensland has barely any wind. Tasmania reached 10 per cent wind in 2015-16. South Australia is at 50 per cent wind in 2016-17 as at 31 December 2016.

Source: AER (2016g).

68. SA Power Networks (2017).
69. Ibid.

Figure 3.3: Network reliability has been consistent over time

Average unsupplied system minutes by NEM region



Notes: Unsupplied system minutes are measured in terms of the system average interruption duration index (SAIDI). SAIDI is defined as the sum of the duration of each sustained customer interruption, divided by the number of customers. It is calculated for different parts of each distribution network service provider's (DNSP) network and then averaged by region.

Source: AEMC (2016b).

4 Given future uncertainty, start with no regrets moves

4.1 The National Electricity Market is not broken yet

While there is room for improvement, the market is working by responding to greater uncertainty about generation investment and system security with higher prices. Recent high prices are the signal for new investment in generation and system security services.

Recent events point to system security as the main area for immediate improvement. Fixing technical issues and process failures is a top priority. New markets for ancillary services will be needed soon given the changing security needs of the system. We will also need to account more conservatively for risks in future – including extreme weather, variable generation, and demand coming on and off the grid through the day.

New investment will be needed over the medium to long-term. While an 'investability' problem is not yet apparent and is not implied by recent events, it could be a problem down the track. It is not clear if high prices will provide enough of a signal for the flexible and fast-response capacity and demand-response that will be needed in future. But there is still time for investors to respond and safety nets in place if they do not respond quickly enough (see Box 8).

Politicians can help by reducing policy uncertainty. Investors need credible and stable climate change policy that works with, not outside, the electricity market.

This chapter identifies 'no regrets' moves to improve market operations in the short-term. In parallel, we need to better understand how continuing policy uncertainty and higher levels of intermittent generation will affect investment in the NEM over the medium to long-term. These are questions the Finkel review should seek to answer.

Box 8: We already have a safety net in place – use this first

High prices are the signal for new investment. But even if investors are slow to respond to this signal we have a safety net in place that includes:

- Short-term responses available to the market, including bringing back mothballed capacity, demand response and water storage to increase hydro capacity.
- AEMO has an emergency reserve mechanism to procure additional generation capacity and/or demand-response up to 10 weeks before a projected shortfall if the market fails to respond.
- Ancillary service markets enable the operator to maintain system security. These markets will assume greater importance with fewer suppliers, which should promote investment in new ways of providing system security services.

We have a safety net, but it may be under-utilised. Reserves can only be procured if they already exist, so it will be important to monitor potential reserve facilities. To ensure emergency reserves are procured when needed AEMO should also account for risks more conservatively in its modelling and processes – including extreme weather, variable generation, and demand coming on and off the grid through the day. Greater use of emergency reserves will increase costs, but much less so than government investment in new capacity.

4.2 The NEM is facing large uncertainties

The NEM is facing large uncertainties. The transition to a low-carbon or net-zero emissions electricity system is already underway – and the expected scale of change required is unprecedented – but there is little visibility of the path ahead.[70]

It is unclear what the future generation mix will be, how much intermittent generation will be in the market, which new technologies will rise and when, what commercial investment decisions will be made and whether demand will continue to decline with consumers going off-grid for some of their demand or increase with the electrification of other industries, particularly transport. Box 9 captures a few of the big uncertainties the NEM is facing.

Given these uncertainties, it is important we do not rush into expensive solutions or an overly-planned approach. We do not yet have all the technologies in the market that we will need in future. Maintaining flexibility through the transition will ensure we can take advantage of the best solutions as they emerge.

We already have a safety net. The NEM has many mechanisms to manage issues with generation capacity, system security and network optimisation. Some of these are still yet to be put to the test. We should test and build on existing low-cost mechanisms before making major capital investments or redesigning the market.

4.3 We should resist rushing into major investments

One response to investment uncertainty and the increasing penetration of intermittent generation is to build more reserve capacity. More generation or network capacity increases system resilience. Greater connectivity between regions – via interconnectors – also provides this additional system resilience.

70. Energy Networks Australia and CSIRO (2016).

Box 9: The NEM is facing significant uncertainties

- **Policy uncertainty**: what mechanism will drive emissions reduction in the electricity sector? What will be the electricity sector's contribution to the 2030 targets?
- **Demand uncertainty**: will demand continue to decline with consumers going off-grid for some of their demand or increase with the electrification of other industries, particularly transport?
- **Intermittent generation**: how much intermittency can the NEM cope with? What levels of intermittency are likely?
- **Emerging technologies**: what will arise when and where? For example, when will large-scale storage become feasible?
- **Effects of climate change on reliability and security**: what frequency and severity of storms, droughts, floods and bushfire should we be planning for?
- **Investment uncertainty**: investors are weighing up these risks, what (if any) investments will be made?
- **Governance uncertainty**: will governance arrangements be flexible enough through the transition?

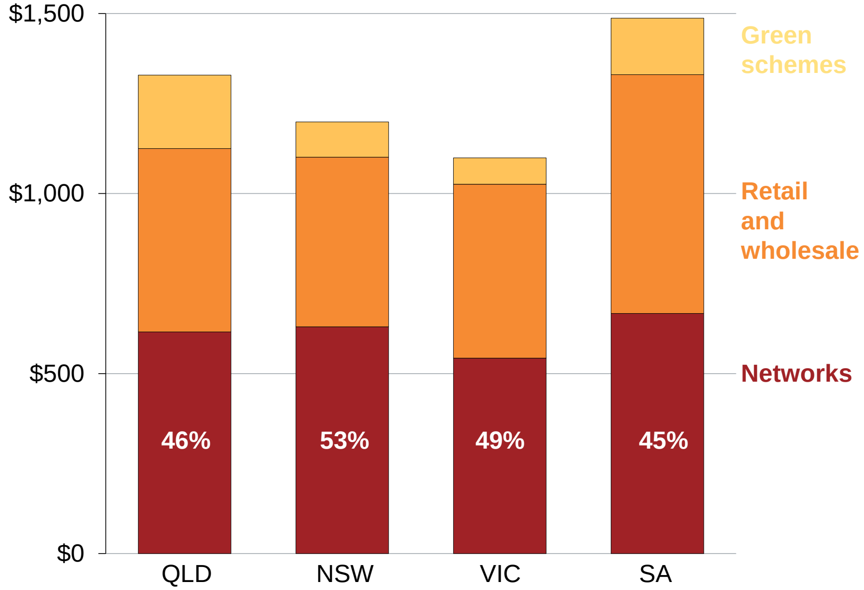
But these are big investments that will hike up electricity bills. They might buy peace of mind in the short-term, but can never guarantee reliability, and may lock in high costs (and potentially high emissions) for a long time to come. Overseas experience with pre-purchasing capacity has resulted in subsidies to existing generation and locked in high costs.[71]

Emissions reduction policies are central to the value of new capacity investments and these policies are still yet to be settled. In the meantime, there is already some reserve capacity in the system as well as a mechanism for procuring emergency reserves if required (see Section 2.4.2 on page 17).

Network costs are the largest component of electricity bills (see Figure 4.1). Demand uncertainty makes major network investments particularly risky for the consumer. If investments are made and then demand declines (as we have seen in recent years), increased costs are born by consumers with no added benefit. The last decade has seen $85 billion spent on our transmission and distribution networks, much of it justified by new demand that never came.[72] Consumers cannot afford this again.

The speed with which we move towards a more distributed electricity system is another key factor in whether major network investments such as interconnectors are needed. Generation at the point of consumption is much more secure than the current system but is not yet widely accessible. Critical services already have back-up power in case of blackout (for example, hospitals). Local generation and storage solutions may become attractive to a wider range of households and businesses over time, particularly as the costs of battery storage fall.[73]

Figure 4.1: Network costs are 40-50 per cent of residential electricity bills
Annual representative residential electricity bill across jurisdictions, 2015-16



Source: Grattan analysis of the AEMC's 2016 Price Trends data, AEMC (2016a).

71. e.g. The UK experience, see Orme (2016).
72. Garnaut (2016).
73. Energy Networks Australia and CSIRO (2016).

Some network investments will be required over time but politicians should not decide these. AEMO has suggested value in a more interconnected NEM.[74] Network businesses will consider these opportunities and may put forward proposals. As regulated monopolies, their revenue is secure so there is less risk in investment. But it will be up to the regulator if more interconnectors are in the best interests of consumers. Interconnectors may help, but not if the connection is with a state having its own capacity and security problems. Potential network improvements should be weighed against alternative non-network solutions with affordability, reliability and sustainability in mind.

Significant political and media attention on reliability issues is building pressure to act. But government investment in new generation and/or network capacity would be a very expensive way to improve reliability. There are cheaper alternatives that give us more flexibility and we should start with these 'no regrets' moves.

4.4 Start with 'no regrets' moves

Given the uncertainties facing the NEM, we recommend focusing on 'no regrets' moves as the first course of action. No regrets moves are the things that are likely to be needed whatever the future brings. They should be low cost, technology-neutral and enable new solutions to emerge over time.

No regrets moves for the NEM include:

1. Reduce policy uncertainty to provide clear signals for investment;
2. Fix market basics to enable clearer price signals for all participants; and
3. Boost options for managing system security to ensure the operator can procure a wider range of services as system needs change

74. AEMO (2016i).

4.4.1 Reduce policy uncertainty

Investments will need to be made in the coming years and government must ensure its energy and climate policy provides clear and stable signals for the market. There is currently no policy for driving down emissions from the electricity sector beyond 2020 (when the RET ends). This policy vacuum is contributing to investment uncertainty.

The COAG Energy Council has recognised concerns about investment uncertainty for a while, committing in 2014 to: *"reduce investment uncertainty where possible to enable the NEM to continue to efficiently deliver a reliable supply of electricity in an environment of policy and economic change."*[75]

The NEM needs clear signals for how future emissions reduction targets will be achieved and the expected contribution of the electricity sector over time. A market mechanism, and specifically a price on carbon is preferable. But whatever the mechanism, stable, credible and integrated energy and climate policy is urgently needed. A previous Grattan report, *Climate Phoenix*, shows how to get to a potentially bipartisan policy that ensures both environmental credibility and the predictability essential to enable long-term investments.[76]

4.4.2 Fix market basics

There are a few 'market basics' that should be fixed to give the market a better chance of managing reliability on its own:

- Dispatch and settlement periods should be aligned in the wholesale market to reward flexible generation and fast-response
- Consumers need clearer price signals to be able to demonstrate their preferences in the trade-off between reliability and affordability of electricity supply

75. AEMO (2015c).
76. Wood et al. (2016b).

- A greater variety of demand-response options are needed to enable the operator to better manage sudden changes in supply and demand, and to give consumers a stronger voice in the market

Align dispatch and settlement periods

Dispatch of energy in the wholesale market occurs in 5-minute windows while settlement (the price paid for energy dispatched) occurs over a 30-minute window.[77] This misalignment is for historical rather than strategic reasons. When the NEM was established in 1998 a short dispatch interval was chosen to reflect the dynamic nature of the power system, but a longer settlement interval was required because of limitations in the technology available at the time.[78]

Alignment of dispatch and settlement periods would reduce incentives to increase intermittency and increase incentives to respond to intermittency. The misalignment creates an unfortunate opportunity to 'game the system' by withdrawing supply during a 5-minute dispatch period to drive up the price paid for the 30-minute settlement period. If dispatch and settlement both occur over the same 5-minute window then a quick response to a supply deficit is rewarded with a higher price. This could provide incentives for quick ramp-up and balancing, as well as for energy storage.

Clearer price signals for consumers

Alignment of dispatch and settlement periods provides clearer price signals for generators and retailers. Clearer price signals are also needed for consumers to better understand consumer preferences.

Critical peak pricing and more cost-reflective network tariffs are the best place to start. Critical peak pricing (or rebates) would enable cost-sensitive households to reduce their demand (and their bill) in response to warnings of critical peak times.[79] This gives the consumer the opportunity to influence the trade-off between affordability and reliability.

Network tariffs should also be reformed so that they reflect higher costs for usage at peak times, because this is what is driving network build.[80] The current structure of electricity network tariffs has been a factor in encouraging an overbuild of the network, one of the main causes of higher power prices over the past decade.[81] The size and cost of the network is determined by peak demand, which occurs only once a summer in most states, but customers are charged on their year-round use of the network. More cost-reflective network pricing gives consumers the opportunity to demonstrate their preferences for network size and cost through their usage.

The AER recently approved a new tariff structure for ACT households and businesses that will include peak and off-peak pricing for electricity use. The new tariff structure will apply from December 2017 and is expected to encourage energy use at times of lower demand, and better reflect true usage costs during congested periods.[82]

More opportunity for demand-response

More opportunity for small, medium and large consumers to choose to participate in demand-response is needed to enable the operator to better manage sudden changes in supply and demand, and to give consumers a stronger voice in the market.

A 'Demand Response Mechanism' has been proposed to enable large energy users to opt out of power use at peak times and be paid for it.

77. The price paid for electricity is the average of the price of each five-minute dispatch in the 30-minute settlement period.
78. AEMC (2016c, p. 3).
79. Wood et al. (2014), see also Faruqui et al. (2010) and Herter (2007).
80. Wood et al. (2014).
81. Daley et al. (2016).
82. Dingwall (2017).

This could improve capacity management at peak times. It was originally proposed in 2012 to reduce barriers to demand-side participation in the wholesale market and to improve both affordability and reliability of electricity supply by providing a clear signal to participants to consider reducing demand during high peak price events.[83]

However, a Demand Response Mechanism is yet to progress, with the latest review determining that: *"Demand response can and already is happening in the NEM. There are no barriers to the continued proliferation of demand response that is currently underway."*[84]

While there may not be regulatory barriers preventing demand-side participation, accessibility is still an issue. Direct exposure to the wholesale market is highly risky for small to medium-sized consumers. Retailers claim to offer demand-response options to their customers, but there is also a conflict of interest here because retailers are unlikely to want to reduce demand given it supports their revenue.

Further work is needed to assess consumer interest in demand response and the value and accessibility of demand response options offered by retailers. The trade-offs between reliability, affordability and sustainability are largely being made centrally – consumers need more opportunities to influence these trade-offs and demonstrate their preferences through their electricity usage.

4.4.3 Boost options for managing system security

Technical and operational issues are being dealt with

Recent events have highlighted system security issues. Fixing the specific technical issues involved and identifying the gaps in processes that led to their emergence are important first steps to improving system security. The rule-maker (AEMC) and operator (AEMO) are already reviewing recent events and taking steps to identify and fix technical and operational issues.[85]

Areas identified for improvement include generator performance standards, performance of the system restart process and reducing the risk of islanding for the South Australian region.[86] These are urgent priorities.

Diversify markets for ancillary services

To reduce the risk of islanding and increase the likelihood that, if islanded, stability can still be maintained, the market operator can procure security services via competitive ancillary service markets. Diversifying markets for ancillary services would give the market operator more flexibility in responding to increasing and changing system security needs. New mechanisms should be investigated for procuring:

- Faster frequency response services;
- Inertia services;
- System strength services; and
- Demand response services.

Several markets for frequency response services already exist, but faster services are likely to be required in future, so this option should be developed now. The AEMC have identified a need for faster frequency response services and are working with AEMO on a technical specification. The faster service would likely be too quick for synchronous generators, but could potentially be provided by wind turbines, energy storage devices and demand-response schemes.[87]

83. AEMC (2012).
84. AEMC (2016e).
85. AEMO (2016a); and AEMC (2016f).
86. AEMO (2016a).
87. AEMC (2016f, p. viii).

Inertia services may only be needed rarely – when South Australia is at risk of islanding for example – but given no mechanism currently exists for procuring inertia and inertia in South Australia is in decline, it seems prudent to develop the option.[88] A new inertia ancillary mechanism was proposed by AGL in June and now looks to have the backing of the AEMC.[89]

System strength services have recently been procured in South Australia under the existing Network Support and Control Ancillary Services mechanism.[90] The details of this arrangement have not yet been made public so it is difficult to assess whether the existing mechanism is sufficient going forward. It is important to ensure that services are procured through a competitive process and that a variety of providers can participate – including new technologies that do not currently provide these services but could in future, such as battery storage and synchronous condensers.

Demand response is faster than other forms of response so ensuring ancillary service markets enable demand-side participation will give the operator more options in managing system security issues. A new rule introduced on 24 November 2016 now enables providers that coordinate and aggregate the demand of many customers to participate in ancillary services markets.[91] This is an important step forward.

88. According to the AEMC: *"there is currently no ability for AEMO or any other party to obtain additional inertia. In the past, inertia has been plentiful and so such a mechanism has not previously been required."* AEMC (2016f, p. vii).
89. *"The Commission has reached a preliminary view that the ability to maintain power system security in an efficient manner would be enhanced by the development and introduction of a mechanism to obtain inertia."* AEMC (ibid., p. vii).
90. The new requirement to have two synchronous generators operating at all times has been activated under NSCAS, see AEMO (2016i, p. 97).
91. *"More and greater diversity in providers of ancillary services would complement the increased penetration of intermittent and non-synchronous generation that is occurring in the NEM."* AEMC (2016e).

Diversifying market mechanisms for procuring ancillary services would strengthen the existing safety net and reduce system risk at low cost. The development of these mechanisms should be expedited. Market design (including how each service is obtained, conditions for provision of service, and penalties for non-delivery) need to be developed with trade-offs between affordability, reliability and sustainability in mind.

Voluntary participation in direct load control

Direct load control takes demand-response one step further, enabling the operator to directly manage industrial and/or residential demand to meet system security and capacity needs. For example, in the PeakSmart air-conditioning scheme run by Energex in south east Queensland, customers are paid an upfront fee of up to $500 to connect their air-conditioner to the scheme. During peak periods, Energex is able to remotely limit the amount of electricity used by the air-conditioners, reducing stress on the network. Similar schemes exist in other networks around the world, and for heating systems in the winter months.[92]

Many electricity markets have 'interruptible load schemes' for large industrial consumers. The National Electricity Market of Singapore has a well-established scheme where consumers are paid in return for having a pre-determined portion of their electricity supply on standby for temporary interruption. Interruptible load is traded in Singapore's Reserve Market.[93]

The NEM has emergency mechanisms that enable the operator to undertake load-shedding, but should expand options for voluntary participation in direct load control. It will take time to develop a residential scheme at scale so direct load control is probably a medium-term response to system security and capacity needs. Uptake of such

92. See Clearly Energy (2016) for a list.
93. Diamond Energy (2016).

schemes is not guaranteed so it will be important to consult with potential providers and gauge interest in residential and industrial participation in direct load control.[94]

Consider new technical solutions and storage in network planning

Our electricity system will need new ways of providing system strength, inertia and frequency response sooner or later. Recent reviews identify several options.[95] Battery storage is expected to be the dominant new source of energy balancing in a future net-zero emissions world.[96] New control systems could also be incorporated into the distribution network to provide ancillary services as synchronous generation is replaced.[97]

New markets for fast frequency response, inertia and/or system strength might expedite new technical solutions and storage. For example, wind farms may look to adopt synthetic inertia controllers to contribute to an inertia ancillary services market.

AEMO should also look at where new technical solutions or storage could strengthen the system as a whole, for example, the potential for battery storage solutions to strengthen weak points in the network. New technical solutions and storage should be considered in network planning.

4.4.4 No regrets moves will help buy time

No regrets moves will help buy time to resolve climate change policy and test the performance of the existing safety net – the mechanisms already in place to manage capacity and security issues.

94. For example, the electricity market operator in Texas has developed an ancillary service for 'controllable load resources', enabling the operator to smoothly curtail or increase load in times of need, but providers are yet to sign up (ERCOT (2016)).
95. Finkel (2016, p. 29); and Energy Networks Australia and CSIRO (2016, p. 56).
96. Energy Networks Australia and CSIRO (2016).
97. Ibid. (p. 56).

Climate change policy is under review in 2017. The hope is that the 2017 review and subsequent political decisions will provide credible, stable and integrated climate and energy policy. This is no easy task politically. But this is the leadership the electricity sector requires to enable least-cost investments and maintain a dependable electricity supply.

4.5 Over time we may need to do more

A dependable electricity supply requires both sufficient capacity and secure access to this capacity. Currently capacity is valued through wholesale price signals and system security services are valued through ancillary service markets. Expanding ancillary service markets is a first step, but over time we may need to do more to ensure system capacity and system security.

4.5.1 Options that place a greater value on reliability

To reduce security risks, intermittent generators could be required to contribute to system security. There are more secure forms of wind and solar than those currently operating in the grid. For example, technologies exist that enable wind turbines to contribute to inertia and fault ride-through specifications can also make a difference.[98] New markets for ancillary services may encourage intermittent generators to adopt these technologies. The potential impact of new requirements on emissions reduction efforts should also be considered.

New market structures may help to sure up system capacity. For example, a day-ahead market in addition to the current real-time market would mean capacity and security needs are scheduled further in advance. The risk of non-delivery is born by the generators but they also have a more stable income to manage risk. In practice, wind and solar

98. Finkel (2016).

may choose not to participate in a day-ahead market, but could still be dispatched in the real-time market.[99]

To promote long-term investment, some electricity markets have introduced auctions or payments for capacity. Payments are made to generators for being able to provide electricity, even if the electricity is ultimately not needed. Capacity markets are vulnerable to the accuracy of forecasts of future capacity needs. The same uncertainties that have provoked calls for a capacity market in the NEM, would likely ensure that significant overcapacity was procured. Consumers would pay the price and it could be very costly, particularly if demand declines.

Alternative market models such as these would be more expensive than the current model, so the potential benefits for reliability would need to be weighed against the impact on affordability. The attractiveness of alternative market models is also heavily dependent on what mechanism we choose for emissions reduction.

4.5.2 The market needs 'reliable renewables'

Reliable renewable generation or storage will be required sooner or later if the electricity market is to one day get to net-zero emissions. 100 per cent renewable generation looks to be technically feasible for Australia but will require at least some non-intermittent renewables, such as pumped hydro, concentrated solar thermal with storage, geothermal, biogas turbines and/or large-scale battery storage.[100]

The market currently has no mechanism that values the combination of reliable and renewable generation. The Renewable Energy Target (RET) incentivises least-cost renewables and currently the cheapest renewable energy is intermittent. Fast-response FCAS markets and alignment of dispatch and settlement periods in the wholesale market, as recommended here, would provide stronger incentives for reliable renewables and storage to provide flexible fast response. 'Reliable renewables' should also be a priority for the Australian Renewable Energy Agency (ARENA).

4.6 Two questions the Finkel review should seek to answer

The NEM is not broken yet but uncertainties remain that could pose threats to the market's successful operation over time. Two of the largest uncertainties are how should emissions reduction be valued in the market (climate change policy) and how should reliability be valued (given increasing intermittent generation).

In reviewing the NEM, the Finkel review should not try to design climate change policy, but instead look at how emissions reduction will affect reliability in the NEM, how the market would cope if policy uncertainty continues, and how to accommodate higher levels of intermittent generation in future.

Important questions for future work are therefore:

1. What will happen to investment in generation capacity if climate change policy is not resolved in the near term?
2. How will the NEM cope with higher levels of intermittent generation?

The Finkel review should seek to identify any alternative market structures or policies that allow for climate policy uncertainty and enable us to better manage intermittency.

99. As occurs in the Texas electricity market (ERCOT).
100. Riesz et al. (2016a).

Box 10: How will improving reliability affect affordability and emissions reduction?

- Electricity bills are expected to go up, whatever path we choose – but some options are more expensive than others[a]
- Greater use of ancillary services and emergency reserves to manage reliability will increase wholesale prices a little, but not a major impact on the bill (and less impact on affordability than alternatives such as capacity markets or interconnectors)
- Clearer price signals for consumers helps both reliability and affordability by giving consumers more choice and control over their demand and associated costs
- Stable and credible climate change policy helps both reliability and emissions reduction by providing clear signals for the market to enable clean energy investment

a. Energy Networks Australia and CSIRO (2016).

A A series of unfortunate events

This appendix provides a brief overview of what we know (so far) about the recent events that have triggered power failure concerns.

The main event of concern was the state-wide blackout in South Australia. We discuss what happened before, during and after this event to understand the likely causes. Six other significant events in the past 18 months are also discussed to identify any emerging patterns.

A.1 The South Australian blackout was 'a perfect storm'

On 28 September 2016, South Australia was hit by an unusually violent storm – described by the Bureau of Meteorology as a once-in-50-years event.[101] The storm brought down power lines, including major transmission lines, leading to a series of rapid system faults and voltage disturbances.

These rapid faults triggered the automatic protection mechanisms of many wind turbines simultaneously, resulting in the loss of 445 MW of wind generation across nine wind farms (about 10 per cent of South Australia's total registered capacity).

With this sudden loss of generation, flows on the Heywood Interconnector increased until its automatic protection mechanism was triggered and it disconnected too. Without the interconnector, and with limited remaining power supplies, the system could not meet demand.

System collapse was too rapid for other mechanisms, such as load-shedding – the deliberate shutdown of power to one part of the system to prevent the failure of the entire system – to kick-in. The speed of collapse was driven by the sudden and large deficit of supply when the interconnector disconnected (a loss of 900MW). The result was state-wide blackout. The blackout started at 4pm in the afternoon and lasted between three and eight hours. But even after eight hours some demand (approximately 10-20 per cent) could not be restored because of damaged transmission towers and lines. It was two weeks before all power requirements in the state, including large industrial demand, could be met again.[102]

In the event of a blackout, AEMO has contracts with generators to restart the system. Generators contracted to provide System Restart Ancillary Services (SRAS) must be able to restart without power from the grid. However, the two contracted SRAS generators in South Australia both experienced difficulties restarting.

The faults are still being investigated but AEMO's preliminary report points to an emergency diesel generator that failed and a circuit breaker that tripped, both requiring repairs that have since been carried out.

A.1.1 Three things clearly played a part

The final verdict on the event and its causes is not expected until March, but preliminary reports highlight many of the factors involved.[103] Three things clearly played a part:

1. The storm (and its unexpected severity) took out critical infrastructure;
2. The automatic protection systems of generation infrastructure reduced supply suddenly; and

101. Waldhuter (2016).
102. AEMO (2016j).
103. AEMO (2016a).

3. Failure to restart the system likely prolonged the blackout.

First, there is not much one can do to prevent a severe storm, but it helps to see it coming. The storm was forecast, but its severity may not have been known or recognised. Based on the severe weather forecast, AEMO recognised that there was an increased risk of power system failure due to lightning, but did not expect loss of transmission lines.

Second, AEMO is working with wind farm operators and turbine manufacturers to improve the settings on their automatic protection systems. Automatic protection systems are needed to prevent damage to infrastructure. However, there is some choice in the exact settings that trigger shutdown. For example, staggered settings might be preferable because if all systems have the same setting, then a large amount of supply can be lost simultaneously.

Third, AEMO is still investigating why system restart services did not perform as expected. It is not yet clear whether or not there will be penalties.

A.1.2 New requirements are already in place

Since the blackout, there is now a new requirement that two synchronous generators be running in South Australia at all times.[104] Synchronous generators can provide grid-stabilising services, helping to reduce the risk of system collapse. There are only a small number of gas generating units classified to provide these services in South Australia.

Two additional steps have been taken to improve the security of the system since the blackout. The Heywood interconnector is now under 'controlled operation' and AEMO is also taking a more conservative approach to maintaining system security by treating clusters of wind farms (or other generators) as a single group at risk of simultaneous failure.[105]

104. COAG Energy Council (2016b).

A.2 Other recent events

Six other major operating incidents have occurred in the National Electricity Market in the past 18 months, giving cause for concern when combined with a critical event like the state-wide blackout. Each event is briefly discussed, in chronological order.

A.2.1 November 2015 – Heywood trip

On 1 November 2015, the Heywood interconnector tripped resulting in 'synchronous separation' of South Australia from Victoria. There are two interconnectors between South Australia and Victoria but only the Heywood interconnector can provide grid-stabilising services.

When Heywood is out of action, South Australia must manage the stability of the grid on its own and the state has only a small number of gas generators to provide these services. With few providers, this drove up prices for Frequency Control Ancillary Services (FCAS). AEMO reported that: *"the cost of Regulating FCAS in the National Electricity Market (NEM) between 11 October and 10 November 2015 was approximately $27 million. Previously, the average cost of Regulating FCAS for a similar duration in 2015 would have been about $0.47 million."*[106]

The Heywood trip was costly, but grid stability was maintained and power was not lost. The technical problem that caused the original trip has since been fixed.[107]

105. Potter (2016); and COAG Energy Council (2016b).
106. AEMO (2015b).
107. The cause of the trip was a new sub-station relay that misinterpreted a routine test signal as a fault and tripped one of the two Heywood transmission lines. The

A.2.2 December 2015 – Basslink outage

The 'Basslink outage' was a technical problem that left Tasmania unable to import or export electricity for six months. On 20 December 2015, a fault in the Basslink cable between Tasmania and Victoria cut Tasmania off from the rest of the National Electricity Market.

Prices were elevated but the cable outage did not cause blackout.[108] The repair process took six months, with the cable returning to full operation in June 2016. A year later, international cable experts charged with investigating the fault determined it was "cause unknown" and reported as "a force majeure event".[109]

A.2.3 July 2016 – Price spikes in South Australia

On the night of 7 July 2016, the wind was hardly blowing in South Australia and the sun had gone down. Two coal plants in South Australia had closed earlier that year, and the Heywood interconnector to Victoria was effectively closed for upgrades. Gas was supplying nearly all the state's power needs. At 7.30pm, the wholesale price of electricity shot up to $8,900 per megawatt hour, a staggering sum when wholesale prices in the eastern states average about $50 per megawatt hour.

Price spikes are a fact of life in the electricity market. Far more troubling was South Australia's average wholesale price for the month of July – $229 per megawatt hour, more than three and a half times that of the eastern states. The news started a furious blame game. Some commentators attacked renewable energy as a vital power source for the state, others the operation of the electricity market, others the behaviour of gas generators. None of these narrow criticisms is fair. In fact, the market worked as it was meant to and the lights stayed on. Yet the incident exposed potential threats to the price and reliability of power in South Australia. A previous Grattan Institute report, *Keeping the lights on: lessons from South Australia's power shock*, discusses this event in more detail.[110]

A.2.4 December 2016 – Alcoa outage

On 1 December 2016, a transmission failure in western Victoria shutdown the Heywood interconnector. With reduced supply available, load-shedding was needed to balance the network in both Victoria and South Australia. Some industrial demand could not be met in Victoria for about 5 hours, while in South Australia power was restricted to around 200,000 properties between 1am and 2:30am.[111]

Alcoa's Portland aluminium smelter lost power for the first time in the plant's 30-year history. Aluminium in production at the time of the blackout solidified, reducing the plant's capacity to less than half. The full extent of the damage is still to be seen, with the company seeking state and federal assistance to keep the plant open. BHP Billiton's Olympic Dam mine in South Australia also experienced a five-hour power outage.[112]

The cause of the Victorian transmission failure is still to be determined but network repairs meant there was little reserve in the system at the time. AEMO have stressed that *"this event was not related to the Black System event in South Australia on 28 September 2016"*.[113]

other transmission line was out of service (while being upgraded to handle greater capacity). The problem relay has since been reprogrammed.

108. AEMO reports that at the time of the incident, four large industrial customers were disconnected to protect the broader Tasmanian network, but that power was restored within 30 minutes and there were no disruptions to residential or commercial customers. AEMO (2016f).
109. Basslink (2016).
110. Wood et al. (2016a).
111. Power restrictions are known as 'brownouts' – power is available but it is more limited.
112. Potter (2016); and COAG Energy Council (2016b).
113. AEMO (2016g).

A.2.5 December 2016 – Partial blackout in South Australia

On 28 December 2016, a severe storm brought down powerlines, with wind and trees causing extensive damage to the distribution network in South Australia. Around 20 per cent of all households lost power (155,000 homes). Half of these lost power for more than 12 hours, and around 1,000 were without power for four days.[114]

SA Power Networks, the operator of the South Australian electricity distribution network, is expected to pay out compensation totalling $20 million to households that lost power for more than 12 hours.[115]

A.2.6 February 2017 – Heatwave load-shedding

On 8 February 2017, power was cut to 90,000 South Australian homes in a series of rolling 30-minute blackouts initiated by AEMO. Unexpectedly high demand created a shortage because additional generation could not be brought online quickly enough. AEMO directed 100MW of load-shedding but approximately 300MW was interrupted, the reasons for which are still unclear.[116] Identifying causes and assigning responsibility for the problems quickly deteriorated into an ugly blame game.[117]

The heatwave across eastern Australia continued in the following days, raising concerns about power security in other states, particularly New South Wales. On 10 February, unexpected loss of supply coincided with peak demand in NSW and AEMO directed load-shedding in response, reducing supply to the Tomago aluminium smelter for one hour. Supply was limited because a 400MW gas generator experienced a fault and replacement generation of 600MW failed to start on request.[118]

114. Holderhead et al. (2017).
115. SA Power Networks (2017).
116. AEMO (2017e).
117. Wood (2017).
118. AEMO (2017d).

A.3 Storms and technical issues are to blame

The South Australian blackout and a number of other events in the last 18 months show our electricity system is not performing to the standards we are used to. The common themes across these events were storms, technical issues or both. There is not much one can do about storms, but technical issues suggest opportunities for improvement.

Technical issues were involved in many of the recent events. While specific issues have largely already been fixed, now is a good opportunity to review the technical settings of key infrastructure and ensure the overall market settings appropriately value the reliability and security of our electricity supply.

The Heywood interconnector has been a common bottleneck, reflecting its importance to both the security and capacity of the National Electricity Market. The importance of the Heywood interconnector has been recognised for many years, and upgrades began in 2013 to boost its capacity from 460 MW to 650 MW. The interconnector has had to operate at reduced capacity at certain times in recent years to enable the upgrades, and this was a factor in the recent price spikes in South Australia and in the Alcoa outage. However, the upgrade should ultimately relieve pressure on the interconnector when it is fully operational (expected by March 2017).

The rolling blackouts in February this year raised many questions about governance of the market, including the rules under which AEMO operates and how AEMO makes trade-offs between reliability and affordability in dispatching energy. There have clearly been issues with forecasting in recent events, suggesting AEMO's models will need to account more conservatively for the risks of storms, variable generation, and demand coming on and off the grid through the day. But there is also a need to clear up market rules, for example rules for accessing mothballed generation capacity and when to use the Reliability and Emergency Reserve Trader Mechanism to procure strategic reserves.

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