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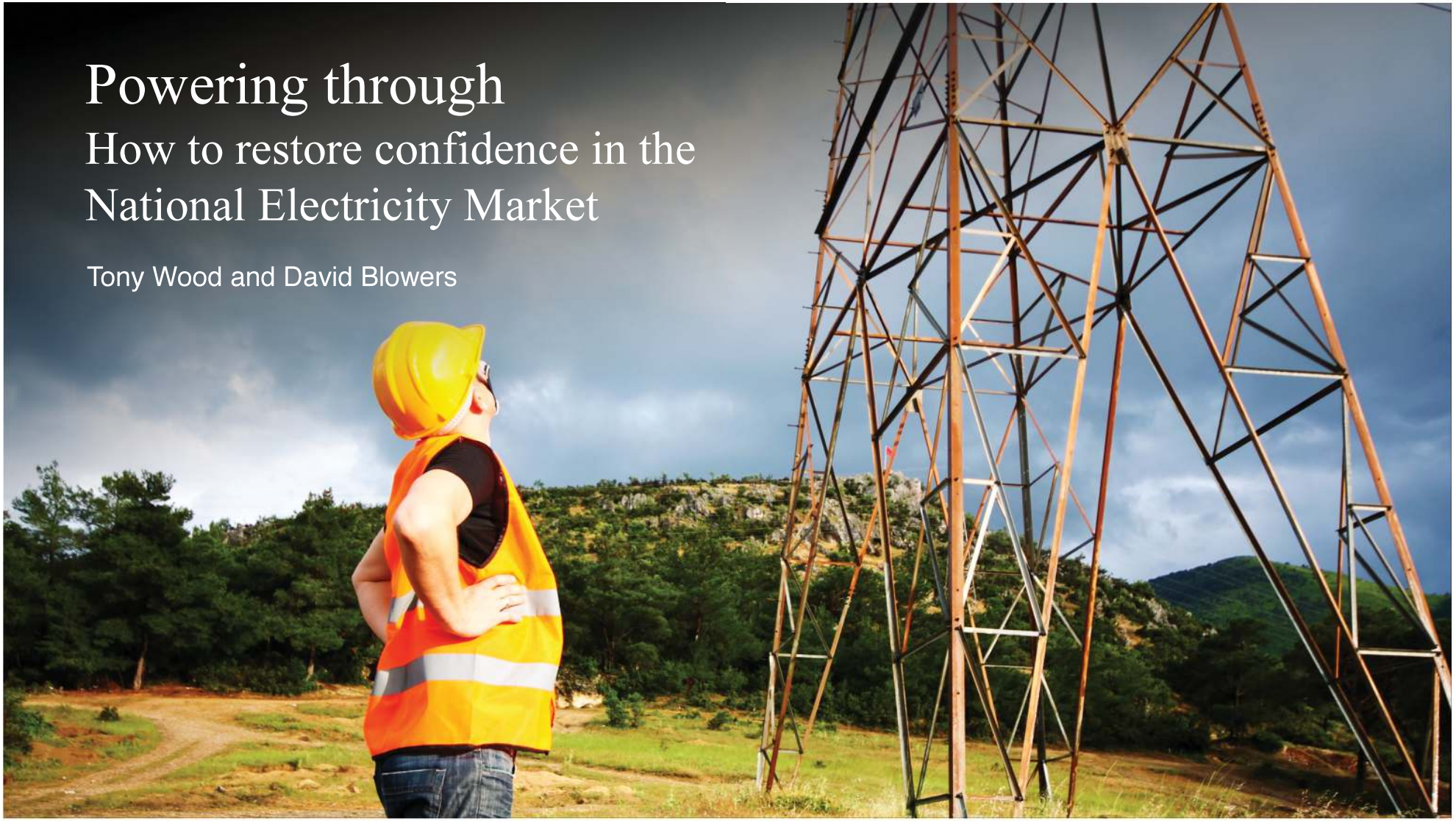
Powering through

How to restore confidence in the National Electricity Market

Tony Wood and David Blowers



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Overview

Australia's National Electricity Market (NEM) is at crisis point. Increasing prices for electricity have coincided with increasing concerns over whether the grid will break and whether there will be enough generation in future.

South Australia has become the epicentre of this debate, with its high share of wind and solar power. The closure of coal generators means gas generators are providing more power, at a time when gas prices are rising dramatically. A series of events, by no means with a single cause, saw blackouts, power restrictions and alarmingly high prices.

High price volatility, further growth in intermittent supply and reasonable expectations of some, yet unspecified, emissions constraint mean unmanageable risks for investments that would stabilise the market and reduce prices. Governments have responded with an escalating number of reviews and several disconnected and uncoordinated announcements. These may score political points but, in the absence of an integrated, national approach, could also make things worse.

The risk is that these pressures will destroy the NEM's capacity to be both an efficient spot market and drive the new investment and divestment decisions that Australia needs for low-cost, reliable and low-emissions electricity. If that happens, political posturing and blame shifting will mean that the NEM will be judged to have failed, when in fact it will have surely been systematically, if unintentionally, destroyed.

Continuing uncertainty, especially a lack of credible climate change policy, could prompt further government interventions in the energy market. Cascading government interventions would likely lead to a regulated, centrally-planned approach where investment risk and costs are transferred to consumers, prices are higher than necessary, security of supply is dependent on imperfect forecasts, and emissions reduction targets may still not be achieved.

There is a better way. First, policy makers need to address immediate concerns. Urgent action is needed to stabilise a physical system with increasing levels of wind and solar. This responsibility rests with the rule-maker and the market operator.

New markets are already being developed to ensure the stability of the NEM. Rule changes are needed to ensure there can be quick and efficient responses if there are shortages in generation. Power generators should be rewarded for being flexible and responding quickly. And more consumers should be offered a financial incentive to reduce their demand at peak times, thereby reducing pressure on the system.

A plan needs to be in place for the coming summer. Unlike last summer, the market operator should make full use of its range of powers. If there is the risk of a power shortage, all generation that can be made available should be made available.

Second, governments need to agree on a credible emissions reduction policy that integrates with the NEM. This should be the central result of the Federal Government's 2017 climate change policy review.

Third, the COAG Energy Council needs to identify and implement policies through the transition to ensure a dependable supply of electricity. This will require changes in governance arrangements for the NEM and is a focus of the Finkel review, due to report next month.

Change is on the horizon and the survival of the NEM cannot be assumed. It remains plausible that alternatives may be needed in the longer term. Decisions in 2017 will effectively choose between the ongoing primacy of markets, or central planning and regulation. At the very least, that choice should be consciously made.

Table of contents

1 Australia's energy crisis?

A series of events over the past year, particularly in South Australia, has led to political and media debate about the reliability of Australia's electricity system. Major coal-fired power stations in South Australia and Victoria have closed, wholesale prices have increased, and there are concerns about gas supply. Price volatility and policy uncertainty mean new investment is only likely when it is underpinned by government subsidies or contracts.

A fierce blame-game has begun, and politicians have responded to perceived failings by announcing a series of uncoordinated and potentially expensive government interventions in the electricity sector.

There is a better way. There are short-term reforms that would give the market a chance to respond, and buy time for policy-makers to develop and implement the best long-term solutions.

This report explains the challenges facing Australia's National Electricity Market (NEM) and identifies immediate actions to stabilise the NEM and longer-term actions to deliver secure, affordable and low-emissions electricity.

1.1 The electricity system is in transition

Australia's electricity system is changing, most dramatically in how we make electricity. Ten years ago almost all generation came from conventional fuel sources – coal, gas and hydro. Now wind and solar account for 7 per cent of electricity generated in Australia.[1] And in South Australia wind alone now accounts for almost 50 per cent of all electricity consumed.[2] About 15 per cent of Australian households now have solar panels on their roofs, compared to less than 1 per cent in 2007.[3]

The nature and function of many of the new technologies are different from the conventional fossil-fuel generators that have traditionally provided Australia with electricity. They can be intermittent, more widely distributed geographically and currently do not provide the same stability to the grid.

Australia has to make the transition from a fossil-fuel powered electricity grid to one powered by zero- or low-emissions technologies. But recent events show that Australia is not managing the transition well. The result is an electricity system that is less affordable, less reliable and may fail to deliver the required emissions reductions. Current emissions reduction policies are not sufficient to meet Australia's 2030 target.[4]

This report focuses on a major part of Australia's electricity system: the NEM. The NEM is a series of loosely connected wholesale electricity markets that facilitate the exchange of electricity between generators and consumers in eastern and southern Australia.[5] Prices in the NEM should drive appropriate investment and divestment in generation. There is a genuine question as to whether the NEM, as currently structured, can work as needed in the new energy world.

1. Department of Industry, Innovation and Science (2016, p. 19).
2. AER (2017a).
3. Clean Energy Council (2016).
4. Wood et al. (2016a).
5. The NEM has five regions with separate wholesale prices (south-east Queensland, NSW and the ACT, Victoria, South Australia and Tasmania) but electricity can be imported and exported between regions via long-distance transmission lines (known as 'interconnectors').

1.2 Is there a reliability problem?

In the past 18 months, new vulnerabilities in the NEM have emerged. The headline-grabber was the blackout in South Australia in September 2016 – the first state-wide blackout since the creation of the NEM in 1998. But there have been other smaller blackouts and incidents too (see Appendix A).

Tasmania's electricity interconnector to Victoria failed in December 2015, leaving the state unable to import or export electricity for six months. With insufficient water to run Tasmania's hydro power stations because of a drought, the state was forced to import diesel generators to keep the lights on. Even then some businesses had to cut their electricity use significantly.

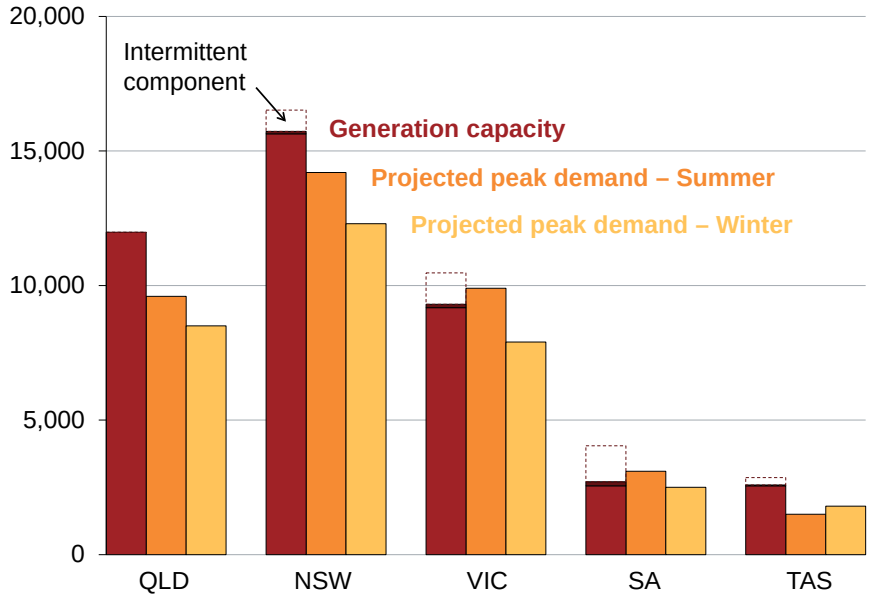
During the 2016-17 summer, it was feared there would not be enough electricity available to meet demand. In South Australia, despite there being sufficient generation capacity, power to some customers was deliberately cut off ('load-shedding') to ensure that supply met demand. Two days later, residents in New South Wales were asked to reduce electricity use during the busiest part of the day and power was cut to an aluminium smelter.

Now there are warnings there may be insufficient generation available to meet peak demand in South Australia and Victoria next summer.[6] Insufficient generation capacity has not been the problem to date, but supply is tightening in some regions. South Australia and Victoria may need to import additional energy from other regions of the NEM at times of peak demand if wind and solar are unavailable (see Figure 1.1).

Despite power stations closing and wholesale prices increasing, the market has been described as 'uninvestable'.[7] Without new investment

Figure 1.1: There is sufficient capacity across the NEM but supply is tight for some regions if islanded

Megawatts



Notes: Generation capacity is registered by region, but regions can import additional energy via interconnectors. Registered generation capacity is as at 31 March 2017, with Hazelwood removed for Victoria. The 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 for the grid is for 2016-17.

Source: Grattan analysis of registered generation capacity by region (AER (2017b)) and the latest demand forecasts (AEMO (2016c, p. 6)).

6. AEMO (2016a); and AEMO (2016b).
7. AEC (2017); and Macdonald-Smith (2016).

in generation, load-shedding during peak periods may become more frequent. All this has led to claims that the market is broken.[8]

1.3 Is there a price problem?

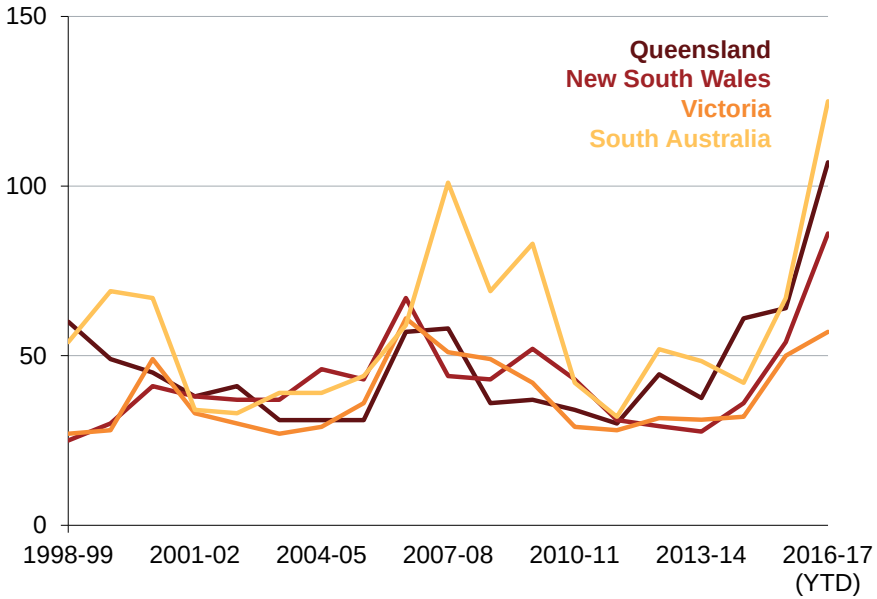
Wholesale prices have recently increased (see Figure 1.2).[9] But not so long ago, market participants were worried that wholesale prices in the NEM were too low for conventional generation to survive.[10] New wind and solar power was placing downward pressure on wholesale prices in the NEM, while receiving subsidies outside the NEM (under the Renewable Energy Target).

Falling demand for grid-based electricity, since about 2009, compounded the financial pressure on gas and coal. Some market participants and commentators suggested governments needed to look at ways to retire coal generation.[11]

But in the past two years, coal generation has been retired without government intervention, in particular Northern power station in South Australia and Hazelwood in Victoria. And major coal departures are set to continue, with the Liddell power plant in NSW expected to be shut by 2022.[12]

With the removal of supply, prices have risen dramatically. Figure 1.3 on the following page shows that during the 2016-17 summer, prices in all NEM states (except Tasmania) were twice as high as during the same period in the previous year.[13]

Figure 1.2: Wholesale electricity prices are now rising
Annual volume weighted average spot electricity prices in each region, $ per megawatt hour



Notes: The average is weighted against demand for electricity. YTD data current at 31 March 2017. Prices in 2012-13 and 2013-14 are adjusted by the estimated carbon price effect in AEMC price trends reports (2013 and 2014).

Source: AER (2017c), AEMC (2013) and AEMC (2014).

8. ABC (2017).
9. AEMC (2016a); and AER (2017c).
10. Nelson et al. (2015).
11. AGL (2016).
12. Robins (2016).
13. Wholesale prices in Tasmania were particularly high at the start of 2016 owing to the failure of the Basslink interconnector.

High wholesale prices are the signal to build new power generation. Until the market responds, high prices will flow through to consumers. Household bills in Sydney and Adelaide increased by around 10 per cent in 2016.[14] In Victoria, similar bill increases were announced at the start of 2017, with retailers blaming the closure of the Hazelwood power station.[15] These price increases come on top of a real 70 per cent increase in electricity bills across the NEM over the past decade.[16] The reasons for this are different in each state. Network investments have been a major contributor in NSW, Queensland and South Australia. The high price of gas has increased wholesale costs in Queensland and South Australia in recent years. Meanwhile in Victoria, the roll-out of smart meters and increases to the retail component of the bill are largely responsible.

1.4 Is there a gas problem?

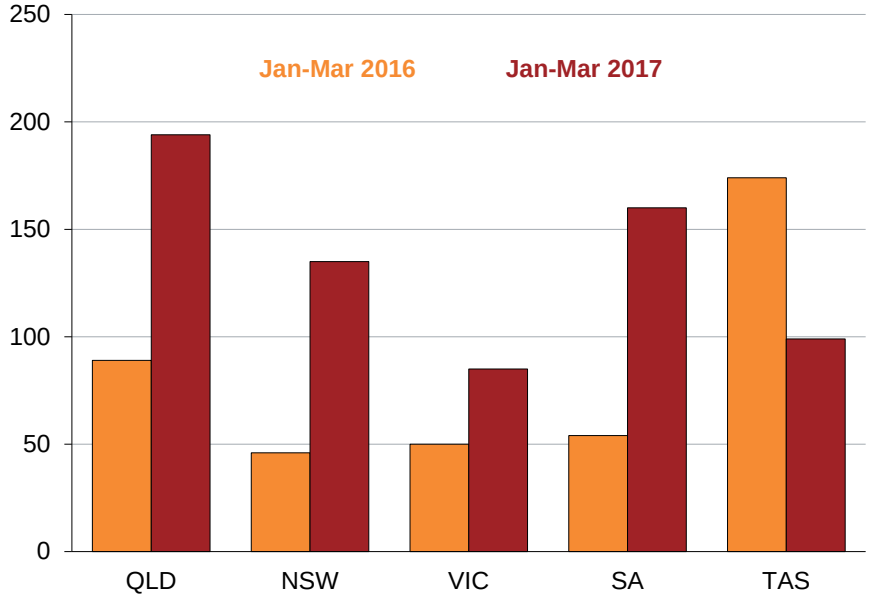
Recent increases in wholesale electricity prices are not solely due to a tightening of electricity supply. In the past 12 months gas prices increased rapidly, which fed through to the price of electricity.

With the advent of liquefied natural gas (LNG) export projects on Australia's east coast, the domestic price for gas has risen to compete with international prices. Bizarrely, there are reports that domestic gas prices in contracts are now even above export parity prices.[17]

Gas prices are now much higher than the historical $3 to $4 a gigajoule, as shown in Figure 1.4 on the next page. Origin Energy recently signed a contract with the South Australian power station, Pelican Point, to purchase gas for at least $8 a gigajoule (plus network costs).[18] Last

Figure 1.3: Summer prices were much higher this year compared to last year in most regions

Quarterly volume weighted average spot prices, $ per megawatt hour



Notes: The average is weighted against demand for electricity.

Source: AER (2017d).

14. ABS (2016).
15. Loussikian (2017).
16. Wood et al. (2017).
17. Stevens (2017).
18. Macdonald-Smith (2017a); and Stevens (2017).

winter, gas prices in the spot market reached $44 a gigajoule in Melbourne, $30 a gigajoule in Adelaide, $29 a gigajoule in Sydney and $19 a gigajoule in Brisbane.[19]

Gas now matters more in electricity generation than it used to. The exit of major coal-fired power stations – Northern and Hazelwood – means the NEM now relies more on gas-fired power when demand is high, or when there is little wind or sunshine. Increases in gas prices and an increased need for gas generation means higher wholesale electricity prices.

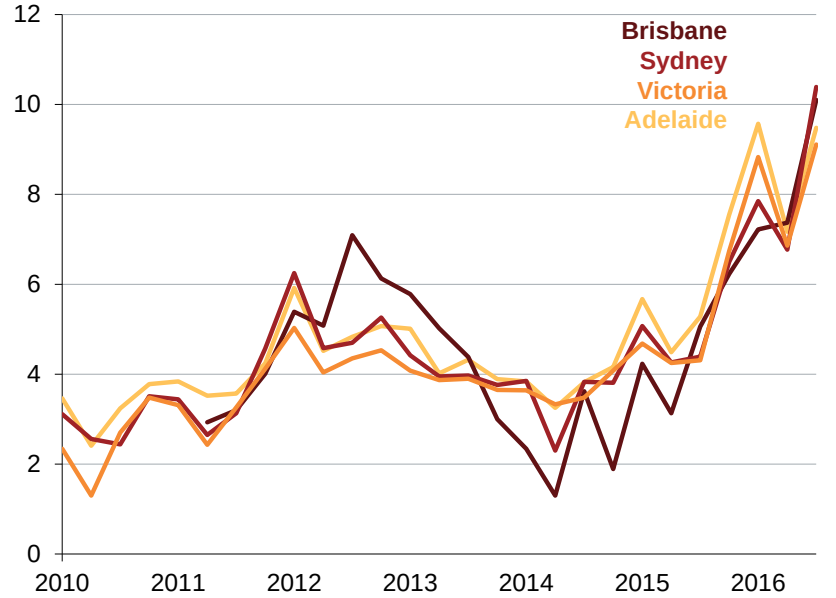
But high prices are not the only problem with gas. The Australian Energy Market Operator (AEMO) has warned of possible gas shortages as early as the summer of 2018-19 if action is not taken by the market or by government.[20] These potential shortages, and domestic prices reportedly higher than export prices, suggest possible failures in the domestic gas market.[21] The underlying issues are beyond the scope of this report but may be discussed in forthcoming Grattan Institute work.

1.5 Policy on the run: how governments have responded

The political blame-game over blackouts and security of supply is an unhelpful distraction at best. At worst, the risk is that governments make 'knee-jerk' policy decisions at great cost to the community.

The first response from politicians was through the Council of Australian Governments (COAG) Energy Council in October 2016. Federal and state energy ministers together announced an independent review of energy security in the NEM ('the Finkel review'), which will report by mid 2017. But four recent announcements seem to have pre-empted its findings.

Figure 1.4: Gas prices have risen substantially in recent years
Quarterly gas prices, $ per gigajoule



Notes: Victorian gas market average daily weighted prices by quarter are shown with the average daily ex ante gas prices by quarter for each Short Term Trading Market hub (Brisbane, Sydney and Adelaide).

Source: AER (2017e) and AER (2017f).

19. Spot prices in the short term trading markets (AEMO (2017a) and AEMO (2017b)) do not directly feed through to consumers.
20. AEMO (2017c).
21. Wood (2017a).

In March 2017, the South Australian Government announced its Energy Plan – a suite of government investments and new regulation to manage 'South Australian power for South Australians'.[22] In the same week, the Federal Government announced 'Snowy Hydro 2.0', a feasibility study into a major expansion of the Snowy Hydro scheme.[23] The third announcement, after a political deal between the government and Senator Nick Xenophon, provided a Commonwealth concessional loan of up to $110 million for a solar thermal plant in Port Augusta, South Australia.[24] The fourth announcement was a feasibility study into a major expansion of the Tasmanian hydro scheme.[25]

All four announcements appear to involve significant government investment in generation. These announcements are worrying because they may commit governments to investments prior to cost-benefit analysis. And if investments go ahead, they have the potential to undermine private investment in generation.

These decisions may further weaken the NEM and could lead to a spiral of government actions away from a reliance on market solutions and towards regulation and central government planning and control.

1.6 There is a better way

Cheaper and more effective solutions are available but depend on an integrated national approach.

National coordination of energy and climate change policy is necessary because Australia has a federal electricity system and national emissions reduction targets. National coordination is also likely to be cheaper for consumers because the most cost-effective ways to cut emissions and secure supplies will not be evenly distributed between states. Uncoordinated, unilateral state actions are likely to lead to higher prices and greater uncertainty about security of supply across the nation.

Recent announcements alone are at best band-aid solutions. Market reforms are still needed. Governments must solve the immediate problems, but also do more to identify and adapt for future risks:

- The Australian Energy Market Commission (AEMC) and AEMO must address the immediate problems by ensuring that all supply and demand options are in place to manage system security risks and the potential for shortages next summer (see Chapter 2).
- Governments need to address long-term capacity risks by rebuilding investor confidence in the NEM (see Chapter 3).
  - Investor confidence will depend on a credible emissions reduction policy that integrates with the NEM. This should be the central result of the Federal Government's current climate change policy review (see Chapter 4).
- The COAG Energy Council needs to identify and implement policies through the transition to ensure a dependable supply of electricity. This is the primary focus of the Finkel review and should be supported by more strategic and flexible governance arrangements (see Chapter 4).

22. South Australian Government (2017).
23. Massola (2017).
24. Belot and Gribbin (2017).
25. Turnbull and Hodgman (2017).

2 System security is the immediate challenge

A dependable electricity supply has both *adequate capacity* and *secure access* to this capacity. The NEM has very rarely run out of generation capacity.[26] Most blackouts arise when something in the system breaks.[27]

Recent events show that system security is a serious and immediate challenge. South Australia provides a telling example. By early 2016, concerns had been raised that South Australia could not maintain system security if unexpectedly cut-off from the NEM (see Box 1 on page 13). South Australia was unexpectedly cut-off during the statewide blackout in September 2016, and it almost happened again in March 2017.[28]

The power system is 'secure' when technical parameters such as power flows, voltage and frequency are maintained within defined limits.[29] 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 trigger rapid changes to technical parameters that need to be managed quickly to avoid blackouts.

AEMO is responsible for balancing the supply and demand of electricity on an instantaneous basis and maintaining these technical parameters within defined limits. Three factors support the critical balancing act:

- **System strength** helps to reduce the impact of disruptions on the system in the first place;[30]
- **Inertia** helps to slow down changes in power system frequency, giving the system more time to respond;[31]
- **Frequency response** returns frequency levels to normal.[32]

2.1 New problems with system security are emerging

The power system was built on the technical characteristics of traditional generators, such as coal, gas and hydro, which produce electricity through spinning turbines. The power system operates at the same frequency as these 'synchronous' generators, and these generators naturally have grid-stabilising properties such as system strength and inertia. Problems with system security have emerged because synchronous generators are operating less or being decommissioned.[33] Other technologies could provide grid-stabilising services ('ancillary services') in different ways, such as synchronous condensers, synthetic inertia controllers and large-scale battery storage, but these have not yet been adopted in Australia.[34]

26. AEMC (2016b).
27. AEMO (2017d).
28. AEMO (2017e).
29. AEMC (2016c).
30. System strength is a measure of the stability of the power system. Stronger power systems typically have higher fault current levels and are better able to control voltage in response to disturbances (changes in supply and demand). Voltage must be maintained within defined limits to avoid blackouts and damage to equipment. High system strength makes this easier, see AEMO (2016d).
31. 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), such as coal and gas-fired power stations and hydro plants. But other technologies can also provide inertia to the power system, such as synchronous condensers and synthetic inertia controllers, as noted in Finkel (2016, p. 29).
32. The power system is designed to operate at a specific frequency, and deviations result in blackout and equipment damage if they are not dealt with quickly. AEMO procures frequency response, also known as Frequency Control Ancillary Services (FCAS), to return frequency levels to normal, see AEMO (2015a).
33. AEMC (2016c, p. x).
34. As noted in Finkel (2016, p. 29).

As system strength declines and imbalances occur more often and more quickly, frequency response has to be much faster than before.[35] Yet the current market rules limit the ability of the operator to procure these services.

2.2 Rule changes are urgently needed

Three major reviews of system security are underway: the Finkel review, the AEMC's System Security Market Frameworks Review and AEMO's Future Power System Security Program.[36] These reviews have already delivered some rule changes to help manage system security.[37] They have also identified a need for:

1. New markets for ancillary services to give the market operator more flexibility in responding to increasing and changing system security needs

2. Aligning dispatch and settlement periods to reward flexible generation and fast-response

3. Demand-response mechanisms that enable the operator to better manage sudden changes in supply and demand, and encourage consumers to reduce their consumption at times of peak demand

It is critical that these new rules and further system security recommendations from the reviews are expedited by the COAG Energy Council.

35. The AEMC has identified a need for faster frequency response services, see AEMC (2016c).
36. All three reviews are expected to provide recommendations in mid-2017, see Finkel (2016), AEMO (2017f) and AEMC (2016c).
37. *e.g.* rule changes relating to emergency frequency control schemes and the introduction of protected events, see AEMC (2017a).

Rule change 1: New markets for ancillary services

New markets for fast frequency response, inertia and/or system strength would give the market operator more flexibility in responding to emerging problems.

Several markets for frequency response services already exist, but faster services are likely to be needed in future, so this option should be developed now. The AEMC and AEMO are taking action on fast frequency response[38] and should ensure options are available before next summer.

Procuring ancillary services through a competitive process, rather than regulation, is more likely to deliver a greater variety of providers and lower costs. New markets would be likely to expedite new technical solutions and storage. For example, wind farm owners may adopt synthetic inertia controllers to contribute to an inertia ancillary services market.

Rule change 2: Align dispatch and settlement

Dispatch of electricity in the wholesale market occurs in 5-minute intervals, while settlement (the price paid for energy dispatched) occurs over 30-minute intervals.[39] This misalignment is the result of historical rather than strategic factors. 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 limits to the technology available at the time.[40]

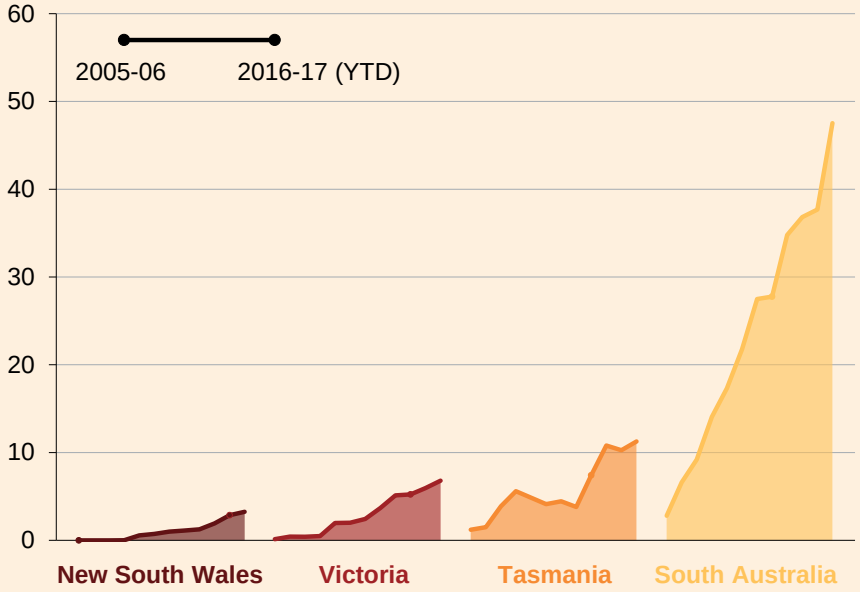
Aligning dispatch and settlement periods would reward flexible generation and fast-response, two things that are especially needed through

38. AEMO (2017g).
39. The price paid for electricity is the average of the price of each five-minute dispatch in the 30-minute settlement period.
40. AEMC (2016d, p. 3).

Box 1: South Australia is the canary in the coal mine

Most regions of the NEM get less than 10 per cent of their energy from wind and solar, so the impact of intermittent, non-synchronous generation is small. But in South Australia wind has supplied almost 50 per cent of the electricity consumed so far this year (see Figure 2.1). At times, wind is supplying more than 75 per cent of the state's power.[a]

Figure 2.1: Wind energy is growing rapidly in South Australia
The percentage of electricity generated from wind



Notes: Queensland has barely any wind energy (so not shown here). Tasmania reached 10 per cent wind in 2015-16. South Australia is at 48 per cent wind as at 31 March 2017. Source: AER (2017a).

a. AER (2015, p. 8).
b. AEMO (2017f).
c. AEMO (2016e, p. 23).
d. AEMO (2017f).

With more intermittent, non-synchronous generation, there are fewer ancillary service providers yet greater ancillary service needs. With generation spread more widely (not just a handful of power plants but thousands of homes with solar panels), it is more difficult for the operator to predict demand, which increases reliance on frequency control services to manage imbalances.[b]

South Australia has one of the highest levels of intermittent, non-synchronous electricity generation in the world, driven by the federal Renewable Energy Target (RET). The state is particularly vulnerable if the interconnector with Victoria fails and South Australia is unexpectedly cut-off from the NEM. AEMO estimates that almost a quarter of the time South Australia would be unable to cope if unexpectedly cut-off (and that for most of the rest of the time it is 'uncertain' if the system could cope).[c]

AEMO is trying to better understand what rates of frequency change the power system can withstand and where the limits lie.[d] It is vital that the operator has a range of options available to maintain system security. System strength and inertia are in decline and we need to know where the critical point lies.

Intermittent generation does not currently contribute to system security, but it can and should contribute in future. Under causer-pays Frequency Control Ancillary Services (FCAS) arrangements, there is already an increasing incentive for wind farms in South Australia to add FCAS capability. The market rule changes proposed in this report would further strengthen incentives for intermittent generators to contribute to ancillary services.

the transition.[41] If dispatch and settlement both occurred over the same 5-minute interval then a quick response to a supply shortfall would be rewarded with a higher price. This would provide incentives for quick ramp-up and balancing, as well as energy storage.

This rule change is currently underway, and the AEMC has formed a preliminary view backing it. Full implementation is likely to take at least three years.[42]

Rule change 3: Incentives to reduce demand

Consumers can help to manage system security and capacity problems by reducing their demand at peak times. Some large industrial consumers are already paid to do this, but not enough is done to encourage households and small businesses to do the same. Some electricity network businesses and retailers have developed demand-response options, but these are not yet widespread. Network businesses and retailers, seeking to maximise their profits, may be reluctant to develop, offer and promote options to reduce demand.

A new rule introduced on 24 November 2016 enables providers that coordinate and aggregate the demand of many customers to participate in ancillary services markets.[43] This is an important step forward, but the market also needs a mechanism to encourage demand-response at peak times.

A 'Demand Response Mechanism' was originally proposed in 2012 to enable energy users to opt out of power use at peak times and be paid for it. It was intended to reduce barriers to demand-side participation in the wholesale market.[44] The Demand Response Mechanism has not been implemented, 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.'*[45]

While there may be no regulatory barriers preventing demand-side participation, accessibility is still an issue. When security issues arise or supply is tight, market responses are still heavily on the supply-side. But demand-side responses may represent better value. While demand-response options are available to large consumers, it is not clear that they are being taken up, or that all businesses are aware of them.

Many households and small businesses may be willing to reduce demand at peak times, or respond quickly in emergency situations, to reduce their electricity bills. But these options are not yet widely available to small and medium consumers.

If the Demand Response Mechanism is not the best way to encourage greater demand-response, then something else is still needed. Policymakers and participants in the electricity sector need to revisit the subject of demand-response to identify other opportunities.

One example, that could become a model for households and small businesses, is the PeakSmart air-conditioning scheme run by Energex in south east Queensland. Under this scheme, customers are paid an

41. AEMC (2017b) notes that five minute settlement *'would promote productive, allocative and dynamically efficient outcomes by encouraging efficient operation in generation, use of energy services, and innovation and investment in an appropriate amount of flexible generation and demand response technologies. The result would be a more efficient mix of generation assets and demand response technologies over time leading to lower supply costs'*.
42. A final determination on the rule change is not expected until September 2017 and in a recent Directions Paper the AEMC notes that a transition period in the order of three years would be needed, see AEMC (ibid.).
43. *'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).
44. AEMC (2012).
45. AEMC (2016e).

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.

The NEM already has mechanisms that enable the operator to cut-off power to homes and businesses in emergencies ('load-shedding'), but voluntary schemes that reward individual consumers for load-shedding are likely to win broader support and should be implemented. Well-planned and communicated consultation with households and businesses will be critical here.[46]

Voluntary participation in such schemes gives consumers a choice in the trade-offs between affordability and reliability of electricity supply. Charging higher prices at peak times would also encourage consumers to reduce their use when the system is stretched.[47]

2.3 We need a plan for next summer

AEMO has a critical job to ensure capacity is available to avoid load-shedding in Victoria and South Australia next summer (see Table 2.1 on the following page).[48] It should also plan for the possibility of shortages in NSW (shortages are not forecast there, but the NSW system was also under pressure as recently as February 2017).

Short-term responses are available and market participants are already responding. Market participants can respond by increasing the output of existing capacity, reducing demand and/or bringing back mothballed generation capacity. AEMO suggested mothballed gas generation could be recalled to service within three months and that this *'would be sufficient to meet demand 99.998% of the time'.*[49] Origin Energy and Engie have since struck a deal that will enable the restart of the second turbine of the Pelican Point generator in South Australia.[50]

If market responses are insufficient, the operator has the power to sign contracts for emergency reserves (see Box 2 on the next page). AEMO did not use these mechanisms in 2017, even though events during 2016 suggested that there were real risks to the system. AEMO should monitor the availability of, and access to, mothballed generation capacity and be more prepared to use its existing powers, to ensure emergency reserves are available if needed. Using such reserves will increase wholesale prices, but could avoid the need for more costly public investment in new capacity.

Despite the availability of these options, the South Australian Government has taken matters into its own hands, funding 100 MW of battery storage and, through the local transmission and distribution companies, up to 200 MW of temporary generation, likely to be diesel.[51]

46. 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)).
47. For example, critical peak pricing (or rebates) during these times would enable cost-sensitive households to reduce their demand (and their bill) in response to warnings of critical peak times. Network tariff reform is also needed to better manage network congestion and minimise cost increases for consumers, see Wood et al. (2014).
48. AEMO (2016a); and AEMO (2016b).
49. AEMO (2016b) indicated that the Tamar Valley combined-cycle gas turbine in Tasmania, Swanbank E in Queensland and additional capacity at Pelican Point in South Australia could be recalled to service.
50. Macdonald-Smith (2017a).
51. South Australian Government (2017).

Table 2.1: The short and long-term risks state by state

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 Energy Adequacy Assessment Projection, November 2016 forecast. The 10-year outlook is the Electricity Statement Of Opportunities, August 2016 forecast. Long-term projected shortfalls are a normal statement of opportunity for the market and should prompt new investment over time.

Source: AEMO (2016a) and AEMO (2016b).

Box 2: Emergency reserves can be called on 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 sign contracts for reserves up to 10 weeks ahead under the Reliability and Emergency Reserve Trader (RERT) mechanism.[a] The operator can then dispatch these additional reserves if they are needed to maintain power system reliability and security.[b] 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).

During the heatwave in Australia in February 2017, the RERT mechanism was not used. Emergency reserves may have helped manage power problems, yet none were procured. Rules for when to use the mechanism to procure strategic reserves should be reviewed, taking account of changing patterns of demand and the increasing risks of extreme weather and intermittent generation.

Contracts for reserve capacity have been signed only three times since the NEM began in 1998 – in 2005, 2006 and 2014.[c] In each case, reserve capacity was purchased for both Victoria and South Australia but did not need to be dispatched.

a. A rule change in 2016 reduced the period for activating the RERT from nine months in advance to 10 weeks in advance, see AEMC (2016f). The RERT mechanism is available for the specific purpose of addressing *'market uncertainty arising from a changing generation mix'*, see AEMC (ibid.).
b. AEMC (2016f).
c. In 2005 a total of 84 MW 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 375 MW for the period 16 January to 10 March (54 days) at a cost of $4.4m; and in 2014, 650 MW for the period 15-17 January (3 days).

3 There are capacity risks ahead

There is enough built capacity for now, but there are capacity risks ahead. Generation capacity has been withdrawn (through plants being retired or mothballed) in recent years because of overcapacity in the market.[52] With further withdrawals expected, and new kinds of capacity needed through the transition, new investments will be required over the next decade.[53]

Despite high wholesale prices, questions have been raised about the 'investability' of the market.[54] The NEM is being blamed, but the primary failure here is climate change policy. A decade of toxic political debates, mixed messages and policy instability has prevented the emergence of credible climate change policy. Investment in electricity generation (including in renewables) is stalling as market participants await clear signals from government.[55]

3.1 New investment will be needed in the coming decade

Across the NEM there is enough built capacity to meet current and projected peak demand (see Figure 1.1 on page 6). But supply is tight in some regions, particularly South Australia. And further withdrawals of generation are expected in the coming years.[56]

Aggregate demand has declined in recent years, but maximum demand is expected to hold steady.[57] Over time, new investment in generation will be required, as well as more active demand-response, to continue to meet maximum demand as existing generation is retired.

New *kinds* of capacity will also be needed through the transition. The generation capacity currently in the market will not deliver sufficient emissions reductions to meet Australia's 2030 targets and longer-term ambitions. And new kinds of capacity are likely to be needed to balance the intermittency of wind and solar and ensure a secure energy system.

3.2 High prices are the signal for new investment

Wholesale prices in each region of the NEM are the main signal for new investment. When supply tightens, prices rise, and there is greater incentive to invest in new generation capacity (see Figure 3.1 on the next page).

To attract new investment, prices need to go high enough, often enough, for investors to recover the capital costs of new generation assets.

Wholesale prices are indeed rising (see Figure 1.2 on page 7). The wholesale spot price hit the Market Price Cap of $14,000 per megawatt hour several times during 2016 and early 2017, particularly in Queensland and South Australia.[58] The increase in wholesale prices over the

52. AER (2015, p. 7).
53. Office of the Chief Economist (2015).
54. Stevens (2016); Macdonald-Smith (2014); Macdonald-Smith (2016); and Puddy and Treloar (2016).
55. It seems many companies are unwilling to sign long-term Power Purchase Agreements that help to reduce financial risk in the current investment climate, see Office of the Chief Economist (2015, p. 20).
56. At least 2000 MW of coal-fired power in NSW is expected to be retired by 2022 when Liddell power station is shut, see Robins (2016).
57. 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, see AEMO (2016c).
58. But note that this was not the price paid. The Market Price Cap was hit during separate five-minute dispatch intervals. The price paid for electricity consumed is

past 12 months has also been reflected in the price of hedging contracts. Base contracts for the first quarter in 2017 have been noticeably higher than in the corresponding periods in previous years, particularly in South Australia (see Figure 3.2 on the next page).[59] And the market now expects much higher electricity prices in the future. As of June 2016, baseload futures for the following 2 years were at least $30 a megawatt hour higher than they were in June 2015.[60]

3.3 Investment has stalled

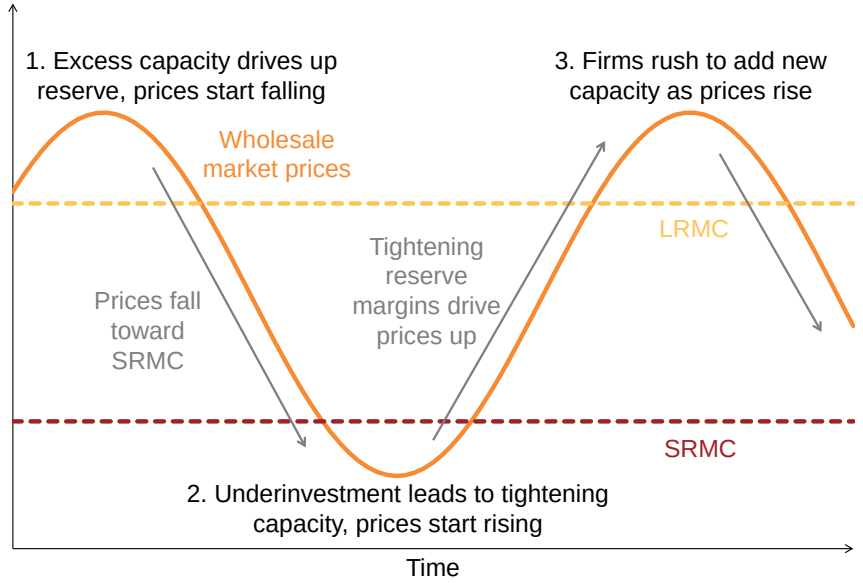
These price outcomes would normally attract new investment. Yet gas projects have stalled[61] and investors do not see a future for new coal generation.[62]

The federal Renewable Energy Target (RET) has driven investment in renewable energy. Subsidised wind and solar dominate the investment pipeline (see Figure 3.3 on page 20). But even investment in renewables has slowed as the RET's 2020 target approaches. It is not yet clear how states and territories will support renewable energy and how this might affect investment in the NEM.

3.4 The policy mess is weakening price signals

A lack of new investment has led some politicians and commentators to conclude that the market is broken.[63] But a mess of inadequate and

Figure 3.1: The generation capacity cycle
Average wholesale market price



Notes: LRMC = Long-Run Marginal Cost; SRMC = Short-Run Marginal Cost.

Source: A reproduction of Steed and Laybutt (2011) in McConnell and Sandiford (2016).

the average of the six five-minute dispatch prices in a 30-minute settlement period. AEMO issues a notice for each high price event, see AEMO (2017h).

59. Retailers can smooth their costs, and generators their revenues, by entering into hedging arrangements with each other.
60. AER (2017g).
61. More than 5000 MW of proposed gas projects were on hold as at October 2015, see Office of the Chief Economist (2015).
62. Priftakis (2017).
63. ABC (2017); Ludlow (2017); Nelson (2016); and Tingle (2017).

uncoordinated government policies makes it very difficult to tell whether or not the market can deliver new investment and divestment.

Wholesale prices in the NEM have never been a perfectly clear signal for investors. Hedging and ancillary services markets provide alternative revenue streams for generators. The RET subsidises renewables outside the wholesale market. And network investment decisions are made outside the wholesale market, but can have big consequences for generation investment decisions (particularly new interconnectors).[64]

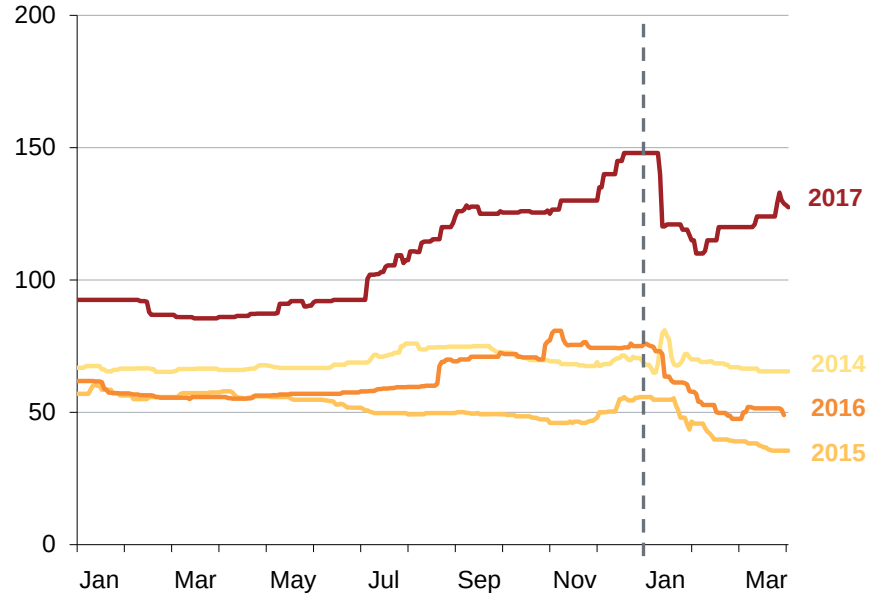
Uncertainty about future government policies further complicates an already complex market in several ways:

- Federal climate change policies are not yet adequate to ensure Australia can meet its 2030 emissions reduction targets;
- Different states have different targets over different time-frames;
- It is unclear what new federal and state government schemes might be introduced to reduce emissions;
- New government investments in generation have now been announced with the potential for further investments; and
- The South Australian Government has threatened direct intervention in the activities of the market operator.

It is too soon to give up on the market. But instead of providing clear policy direction and supporting market reforms, governments have stepped in with uncoordinated interventions themselves.

Figure 3.2: 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



Notes: The vertical dashed line signifies the start of the Q1 period for which the contracts are being purchased.

Source: AER (2017h).

64. New network investments are proposed by network businesses and must be approved by the Australian Energy Regulator as being in the long-term interests of consumers.

3.5 Government investment sets a risky precedent

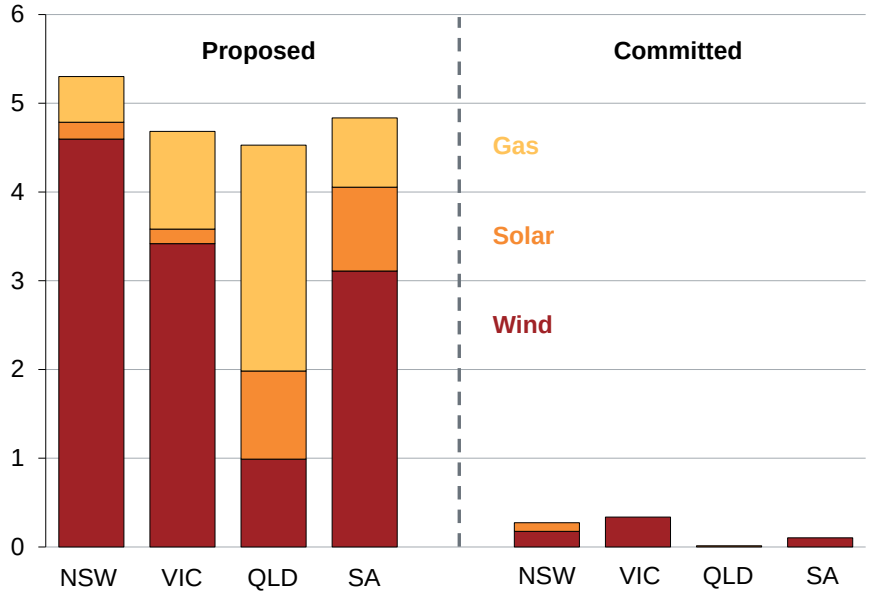
Recent announcements by the Federal and South Australian Governments were well-intended and make sense politically. But there is a risk that real and potential government investments in generation, and interventions in the market, will destroy the NEM's capacity to drive the new investment and divestment decisions needed for low-cost, reliable and low-emissions electricity.

The announcements suggest governments recognise that some investment in flexible generation or storage will be needed sooner or later. The Federal Government has announced feasibility studies for two pumped hydro projects, to provide up to 4500 MW of capacity on demand.[65] The South Australian Government has announced funding for a new gas facility and one or more large-scale battery storage facilities.[66]

If the intention behind these announcements was to test the competitiveness of new kinds of renewable capacity in the Australian market, then that is the role of the Australian Renewable Energy Agency (ARENA). Developing flexible renewables and storage should be a priority for ARENA, which operates at arms-length from government.

If the intention was to increase capacity in the NEM, then that should be the role of the market. The South Australian Government justified its decision to invest in a new gas facility by saying: *'The private sector is not building new generation. That is why government is stepping*

Figure 3.3: The investment pipeline is dominated by wind and solar
Gigawatts of potential new generation by fuel type and region



Notes: Potential new generation projects as at 27 February 2017. Proposed projects are those that have been publicly announced and may have completed initial feasibility studies, but have not yet received a Final Investment Decision (FID). Projects at the Committed stage of development have received a FID and have either started, or are expected to start, construction.

Source: AEMO (2017i)).

65. Pumped hydro acts as a form of storage, helping to balance out energy use by using energy from the grid when there is excess supply to pump water uphill and then releasing the water when supply is tight, to generate energy for the grid. Pumped hydro can be renewable if the energy used to pump the water uphill is renewable – so it can partner with wind turbines, for example, to provide reliable renewable energy.
66. South Australian Government (2017).

up and taking control of our energy future by investing in new generation.'[67] The Government sought to reassure the market that the new government-owned generator would be used only for emergencies. But AGL Energy labelled this 'wishful thinking' and has now shelved its own plans to build new generation.[68]

New government-owned generation sets a precedent and may deter private investors in future, which in turn could mean still more government investment is needed.

3.6 Governments need to rebuild investor confidence in the NEM

New capacity may not be needed for some years, but investments take time. Potential investors need clear signals now. It seems high prices are not sufficient to encourage new investment, because of the great uncertainty that surrounds future government policies and interventions.

The best way to reduce long-term capacity risks is to rebuild investor confidence in the NEM. Investor confidence depends on transparent markets, clear policy direction, and integrated climate and energy policy. The following chapter explains how to integrate climate and energy policies and improve market governance to rebuild investor confidence in the NEM.

67. Weatherill (2017).
68. Macdonald-Smith (2017b).

4 How to get out of this mess

The problems with Australia's energy system identified in this report are symptoms of the transition to a low-emissions electricity sector and a failure to properly integrate climate and energy policies.

Governments should implement short-term market reforms – many of which are already underway – to address the immediate challenges and buy themselves time to deal with the long-term issues (see Box 3).

Long-term issues are best addressed through credible climate change policy and governance reforms. But questions still remain about Australia's increasing reliance on gas and the long-term future of the NEM. The Finkel review and future Grattan work will address these questions.

4.1 Integrated energy and climate policy

The electricity sector contributes 35 per cent of Australia's total emissions and is expected to be a major contributor to emissions reduction (see Figure 4.1 on the following page). Yet current policies do not set any effective binding constraint on emissions in the power sector, and certainly not one linked to Australia's emissions reduction targets (see Figure 4.2 on the next page).

Australia needs a credible climate change policy that works with the electricity market: a plan with bipartisan support that can achieve current emissions reduction targets and expand over time to meet future targets (as agreed under the Paris agreement). Without such a credible plan, but with the expectation that some carbon constraint will be introduced sooner or later, there is enormous uncertainty for investors.

Some mechanisms for reducing emissions work better with the electricity market than others. Current policies, including purchasing emissions through the Emissions Reduction Fund and subsidising investment in renewable energy through the RET, create side-markets and

Box 3: Immediate priorities for policymakers

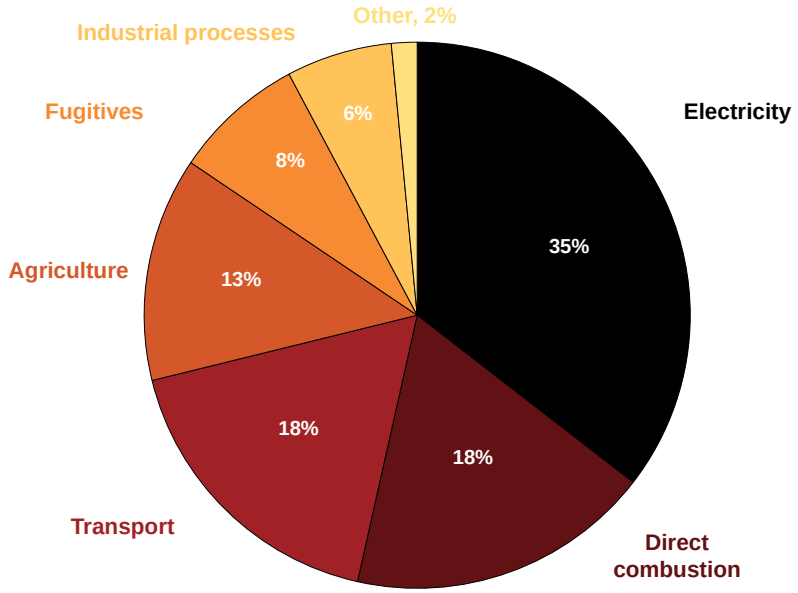
'No regrets' market reforms:

- Deliver a credible plan for emissions reduction with a clear price signal for the electricity sector
- Enable strategic and flexible governance through the transition
- Create new markets for ancillary services to manage emerging security challenges
- Align the dispatch and settlement periods to reward flexible generation and fast-response
- Encourage consumers to shift more of their consumption to off-peak periods
- Ensure emergency reserves are on hand for next summer to manage short-term risks of supply shortages

Long-term issues to be resolved:

- Australia's increasing reliance on gas
- Can the NEM, as currently structured, deliver appropriate investment and divestment in generation?

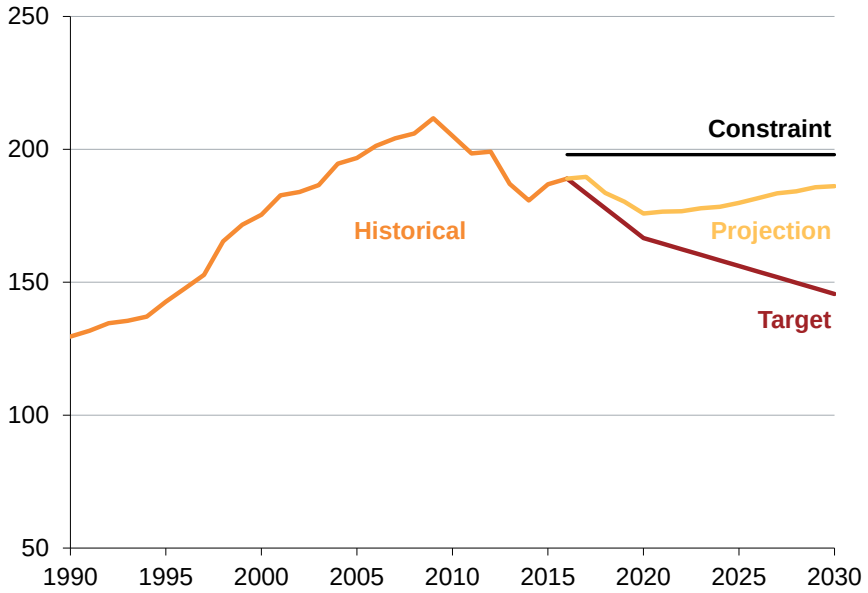
Figure 4.1: The electricity sector has a big role to play in reducing emissions
Emissions by sector in 2015



Notes: Direct combustion excludes fuels combusted for electricity generation or transport. Direct combustion includes generating heat, steam or pressure for major industrial operations, and using gas for household heating. Fugitives are emissions released in the extraction of fossil fuels. The 'other' category includes waste and land use, land use change & forestry (LULUCF).

Source: Department of the Environment and Energy (2016).

Figure 4.2: Current policies are unlikely to result in emissions in the electricity sector falling to meet their target
Emissions in the electricity sector, Mt CO2-e



Notes: The constraint refers to the baseline for the electricity sector, under the Safeguard Mechanism, which is set at 198 million tonnes CO2-e. The projection is the Department of the Environment and Energy's business-as-usual emissions projection for the sector. The target assumes emissions in the sector are reduced to 26 per cent below 2005 levels by 2030, in line with Australia's overall commitment under the Paris Agreement.

Source: Department of the Environment and Energy (ibid.).

new revenue streams that distort price signals in the NEM. There are cheaper ways to achieve emissions reduction.[69] The cheapest (and least-distorting) policy is an explicit carbon price – either set by government through a tax or, better still, set by the market through an emissions trading scheme (cap-and-trade or an emissions intensity scheme).

Our 2016 report, *Climate phoenix: a sustainable Australian climate policy*, proposed a solution. It showed how Australia's current suite of policies can be strengthened and expanded over time to achieve current and future emissions reduction targets. The report showed it is possible for Australia to make the transition from existing schemes to a more cost-effective emissions trading scheme.[70] A roadmap like this would give the energy sector the certainty it craves and, over time, create a clear price signal for investors.[71]

A credible climate change policy will require national coordination. Australia's emissions reduction targets are national and the NEM is a federal system. A national approach would enable all participants to invest in the cheapest ways to reduce emissions, whatever and wherever that may be. Separate approaches in each state would create inefficiencies and potentially contradictory policies. Ideally, federal and state governments will agree on a national approach. But if the federal government does not lead this effort, a second-best solution would be for the states to agree on a coordinated approach. That would be cheaper and more effective than each state going it alone, pursuing separate renewable energy targets.

69. Wood et al. (2015).
70. Wood et al. (2016a).
71. National emissions reduction policies for the energy sector are backed by generators and consumers alike, including the Australian Energy Council, AGL Energy, Origin Energy, and Energy Consumers Australia, among others, see Department of the Environment and Energy (2017).

If governments cannot successfully integrate climate and energy policies, Australia could conceivably fail on all three ambitions for energy supply – affordability, reliability and sustainability. If policy uncertainty deters private investors, then government is likely to step in – and ongoing intervention could be required, transferring investment risk and costs onto consumers.[72]

4.2 More strategic and flexible governance

The market reforms described in Chapter 2 are needed urgently. Many have been on the horizon for years (such as encouraging demand response). Yet there has been little progress. Likewise, clarity on climate change policy has been a high priority for the energy sector for years, but has not eventuated either. The lack of progress on priority issues points to problems with planning, decision-making and governance.

The Productivity Commission noted in 2013 that governance arrangements in the NEM are highly complex and *'are neither efficient nor effective in achieving good outcomes for consumers'*.[73]

A Review of Governance in 2015 identified *'a "strategic policy deficit" . . . which has led to diminished clarity and focus in roles, fragmentation and a diminished sense of common purpose'*.[74] The COAG Energy Council is responsible for driving effective market reforms. The review found that the Council and the Senior Committee of Officials were *'not providing effective and active policy leadership to the energy sector'.*[75]

72. The AEMC noted this risk in its submission to the Finkel review: *'Evidence from international markets suggests that if integration (that is, the maintenance of fundamental structures in the market that support investment and competition) does not occur, the impact on the efficacy of price mechanisms, together with uncertainty and policy risk, will likely require ongoing government intervention in otherwise well-functioning energy markets, transferring investment risk and costs onto consumers'*, see AEMC (2017c).
73. Productivity Commission (2013).
74. Vertigan et al. (2015).
75. Ibid.

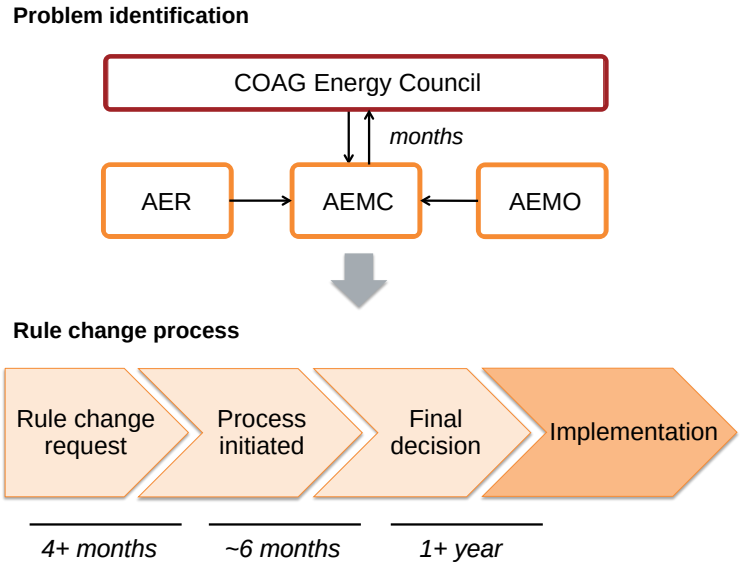
Recommendations from the Review of Governance are still being implemented. Meanwhile, the Finkel review will provide further recommendations to improve governance of the NEM through the transition.

Policy leadership will be critical through the transition. The COAG Energy Council needs to focus on the core strategic issues. It can get bogged down in process, and decisions can be compromised by state-specific political positions and conflicts of interest.[76] The AEMC has identified a long lag between when problems are identified and when they are considered by Ministers. This suggests the Council should meet more often, as it has in the past six months. Alternatively, a sub-Council could handle general business, freeing up Ministers to set policy direction.

Governance processes need to be streamlined and rule changes accelerated to ensure the energy system is prepared for next summer. The National Electricity Rules are highly specific. Changing a rule can take years (see Figure 4.3).[77] This may have been acceptable when the system was largely unchanging, but it is dangerous in today's rapidly evolving system. Many rule changes will be needed through the transition, and they will need to be made quickly if the system is to keep up. To speed up market improvements, new rules and programs could be piloted for a period prior to a formal rule change.

Energy institutions will need to get better at identifying and adapting for future risks. The COAG Energy Council has asked the AEMC to assess the strategic priorities of the energy market in 2017, and every three years thereafter with annual progress updates.[78] The AEMC should also monitor consumer preferences, including the value placed on reliability, affordability and sustainability of electricity supply, to better understand and respond to people's changing values and off-grid behaviour.

Figure 4.3: Governance arrangements are too reactive and too slow



Notes: The AEMC is not empowered to initiate rule changes. It provides market development advice to the COAG Energy Council, which can then request the AEMC to conduct a review or initiate a rule change. Any entity other than the AEMC can request a rule change, including the AER, AEMO, generators and consumers.

Source: Vertigan et al. (2015) and AEMO (2017d).

76. For example, decisions relating to network businesses, of which some states are owners.
77. AEMO (2017d).
78. COAG Energy Council (2016a).

On the technical side, AEMO should be identifying future security and reliability risks and testing solutions to better stabilise the grid.

4.3 The long-term outlook

Australia should start with the market reforms proposed in this report (see Box 3 on page 22). They are 'no regrets' moves that cost little and are likely to be needed whatever the future brings. But even with these improvements to the market, two long-term issues are left unsolved: Australia's increasing reliance on gas; and whether the NEM (as currently structured) can continue to deliver appropriate investment and divestment through the transition and beyond.

4.3.1 Australia's increasing reliance on gas

Electricity and gas supply have traditionally been managed separately, but they are becoming more interdependent.[79] Wholesale electricity costs are increasingly linked to gas prices, and gas is considered to be a critical fuel to enable the transition.[80]

Gas supply can ramp-up or ramp-down alongside intermittent renewables such as wind and solar, provide grid-stabilising services, and it is less emissions-intensive than coal.[81] But domestic gas prices have risen substantially in recent years with the creation of the LNG export industry and subsequent domestic market adjustments.[82]

Concerns about gas supply hit the headlines in March with the release of AEMO's Gas Statement of Opportunities 2017, which identified potential shortages from 2019. What was lost in the media panic was that the report is a normal statement of opportunity, designed to prompt market responses to increase supply. The report projects domestic gas shortfalls from 2019 to 2024 under the assumption that all international contract obligations are met before domestic market needs. But international contracts could also be met through international gas markets. The report recommended domestic gas production be increased or that supplies be reserved for domestic use.[83] The Prime Minister met with east coast gas companies to seek commitments to address the risk of domestic shortfalls. Unsatisfied with the response, he announced a new Domestic Gas Security Mechanism, which gives the Federal Government the power to impose export controls on companies when there is a shortfall of gas supply in the domestic market.[84]

In reality, how much Australian gas goes to domestic or international markets depends on price. And domestic prices have increased dramatically (see Figure 1.4 on page 9). With very high prices, gas may only be competitive to meet peak demand and balance intermittency until alternatives are developed. While gas is not about to run out, there are important questions about how Australia's domestic gas supply is managed and at what cost. Grattan will look at the role of gas in electricity generation in future work.

4.3.2 Can the NEM deliver new investment and divestment?

Many are questioning the NEM's ability to provide the right signals for new investment through the transition.[85] This is not just a question of ensuring *enough* capacity (in terms of volume), it is a question of having the *right kinds* of capacity that can respond to the changing needs of the market, and the *right balance* to meet reliability needs as well as emissions reduction targets at least-cost.

79. AEMO (2017c).
80. Finkel (2016), although this is contested, see Climate Council (2017).
81. However it is unclear exactly how polluting gas is when the entire supply chain of gas production is considered. Methane emissions from Australia's coal seam gas developments are largely unknown, see Climate Council (ibid.).
82. Finkel (2016).
83. AEMO (2017c).
84. Turnbull (2017).
85. Stevens (2016); Macdonald-Smith (2016); Nelson (2016); and Macdonald-Smith (2014).

By volume, there is sufficient capacity across the NEM for now. But over time, as further conventional generation retires, Australia will need more flexible, fast-response capacity and demand-response to balance the growing share of intermittent generation. Rule changes proposed in Chapter 2 will help create signals in the market for this kind of capacity in future.

It is not yet clear if the market reforms proposed in this report will be enough to deliver appropriate new investment and divestment through the transition. Australia may still have a long-term energy problem. But it is also too early to say the market can't work.

There are several possible futures for the NEM:

- The market could work, given clear policy direction and some adaptive measures through the transition;
- The market could fail to deliver new investment and divestment without a fundamental restructure; or
- Governments may give up on the market and take matters into their own hands.

A competitive market, with clear expectations for both emissions reduction and reliability, puts pressure on all forms of generation to cut costs, reduce emissions and improve availability. We do not yet know what technology mix we will need in the future. A competitive market enables better solutions to emerge over time – beyond those we can see now.

But if expectations for emissions reduction and reliability cannot be clearly established, then the market may require a fundamental restructure. Alternative market structures and policies may help to ensure system capacity and security through the transition. For example, in an effort to promote long-term investment, some electricity markets around the world now pay generators for being able to provide a promised amount of electricity, even if the electricity is ultimately not needed. Alternative market models such as these would be more expensive than the Australian model, so improved reliability would need to be weighed against the higher cost. The attractiveness of alternative models is also heavily dependent on what mechanism/s governments choose for emissions reduction. Future Grattan work will look at potential alternative market structures and policies for the NEM to ensure appropriate investment and divestment in the long-term.

There is also a third possibility: that governments choose a centrally-planned approach over a market-based approach. Consumers may take comfort in a centrally-planned program of investment and divestment, but it would be more expensive and may not improve reliability or achieve the emissions reductions required. A government-led program of investment, planning and coordination is likely to lock-in existing technologies at the expense of better solutions that may emerge in future. Investment risks and costs would be transferred to consumers and would be heavily reliant on forecasts (that are never quite right and often quite wrong). Over-investment would lead to higher costs, while under-investment would lead to supply shortfalls.

Australia is at a fork in the road. The decisions we make in 2017 may effectively be choices between the ongoing primacy of markets, or central planning and regulation. At the very least, our choices should be consciously made.

Appendix A: Recent events in the National Electricity Market

The headline-grabber was the state-wide blackout in South Australia in September 2016. But there have been other, smaller blackouts and incidents in the past 18 months. This appendix briefly discusses each event and seeks to identify any policy lessons.

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.[86] 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 too disconnected (a loss of 900 MW). Without the interconnector, and with limited remaining power supplies, the system could not meet demand.

The system collapsed too quickly for other mechanisms, such as load-shedding, to kick-in. The result was a state-wide blackout, which started at 4pm and lasted at least three hours. Even after eight hours, about 10-20 per cent of demand could not be met 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.[87]

AEMO has contracts with generators to restart the system in the event of a blackout. 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 had trouble restarting. One used a new start-up sequence that failed. The other appears to have been struck by lightning.[88] Repairs have since been carried out.

Three things clearly played a part

1. The storm took out critical infrastructure unexpectedly;
2. The automatic protection systems of generation infrastructure reduced supply suddenly; and
3. Failure to restart the system prolonged the blackout.

As a result of the blackout, AEMO is reviewing its risk assessment processes for extreme weather events. Based on the forecast of severe weather, AEMO recognised an increased risk of system failure due to lightning, but did not expect loss of transmission lines.[89]

AEMO is working with wind farm operators and turbine manufacturers to improve their automatic protection systems. Such systems are needed to prevent damage to infrastructure. However, there is some

86. Waldhuter (2016).

87. AEMO (2016f).
88. AEMO (2017j).
89. Ibid.

choice in the exact settings that trigger a shutdown.[90] 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.[91]

The Heywood interconnector is now under stricter centralised control, two synchronous generators are now required to be running in South Australia at all times, and AEMO is reviewing its system restart processes.[92]

A.2 Other recent events

Other smaller blackouts or incidents have occurred in the NEM in the past 18 months. They are 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. Yet it has only a small number of gas generators. With few providers, prices for Frequency Control Ancillary Services (FCAS) rose dramatically. AEMO reported that: *'The cost of Regulating FCAS in the National Electricity Market 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.'*[93]

The Heywood trip was costly, but grid stability was maintained and power was not lost. The technical problem that caused the trip has since been fixed.[94]

A.2.2 December 2015 – Basslink outage

On 20 December 2015, a fault in the Basslink cable between Tasmania and Victoria cut Tasmania off from the rest of the NEM. Tasmania was unable to import or export electricity for six months.

Prices were elevated but the cable outage did not cause a state blackout.[95] The repairs took six months, with the cable returned to full operation in June 2016. International cable experts charged with investigating the fault determined it was 'cause unknown' and reported the incident as 'a force majeure event'.[96]

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. Two of the state's coal plants had closed earlier in the 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 figure given that wholesale prices in the eastern states had been averaging about $50 per megawatt hour.

90. Ibid.
91. Potter (2016); and COAG Energy Council (2016b).
92. AEMO (2017j); and COAG Energy Council (2016b).
93. AEMO (2015b).
94. 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 other transmission line was out of service (while being upgraded to handle greater capacity). The problem relay has since been reprogrammed.
95. 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 (2016g).
96. Basslink (2016).

Perhaps more troubling still, South Australia's average wholesale price for the month of July was $229 per megawatt hour, more than three-and-a-half times that of the eastern states. These jumps started a furious blame game. Some commentators attacked renewable energy, 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 report, *Keeping the lights on: lessons from South Australia's power shock*, discusses this event in more detail.[97]

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 five hours, while in South Australia power was restricted to about 200,000 properties between 1am and 2.30am.[98] BHP Billiton's Olympic Dam mine in South Australia also experienced a five-hour power outage.[99]

Alcoa's Portland aluminium smelter lost power for the first time in its 30-year history. Aluminium in production at the time of the blackout solidified, reducing the plant's capacity by more 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.

Shutdown of the Heywood interconnector was an accepted risk at the time and load-shedding was the appropriate response. AEMO has stressed that *'this event was not related to the Black System event in South Australia on 28 September 2016'*.[100]

A.2.5 December 2016 – Partial blackout in South Australia

On 28 December 2016, a severe storm caused extensive damage to the distribution network in South Australia. About 20 per cent of households (155,000 homes) lost power. Half of these homes lost power for more than 12 hours, and about 1,000 were without power for four days.[101]

SA Power Networks, the operator of the South Australian electricity distribution network, is expected to pay $20 million in compensation to households that lost power for more than 12 hours.[102]

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 the market operator. Unexpectedly high demand had created a shortage because additional generation could not be brought online quickly enough. AEMO directed 100 MW of load-shedding but approximately 300 MW was interrupted, the reasons for which are still unclear.[103] Identifying causes and assigning responsibility for the problems quickly deteriorated into an ugly blame game.[104]

The heatwave across eastern Australia continued in the following days, raising concerns about power security in other states, particularly NSW. On 10 February, unexpected loss of supply coincided with peak demand in NSW. Supply was limited because a 400 MW gas generator

97. Wood et al. (2016b).
98. Power restrictions are known as 'brownouts' – power is available but it is more limited.
99. Potter (2016); and COAG Energy Council (2016b).
100. AEMO (2016h).
101. Holderhead and Langenberg (2017).
102. SA Power Networks (2017).
103. AEMO (2017k).
104. Wood (2017b).

experienced a fault and replacement generation of 600 MW failed to start on request. AEMO directed load-shedding in response, reducing supply to the Tomago aluminium smelter for one hour.[105]

A.2.7 March 2017 – South Australia not in a secure operating state

On 3 March 2017, South Australia's power system was at risk of black-out for 40 minutes. Faults at the Torrens Island switchyard resulted in a large and sudden loss of supply (610 MW). Power flows increased on the Heywood Interconnector to compensate, exceeding normal operating limits, but voltage levels were sufficient to avoid shut-down of the interconnector. *'AEMO believes this event came very close to tripping the Heywood Interconnector. This would have resulted in a black system in SA.'*[106] AEMO is still investigating exactly how a blackout was avoided but the automatic disconnection and reconnection of solar PV systems in response to the voltage disturbance may have helped.[107]

Previously, on 13 November 2016, South Australia's power system was not in a secure operating state for five hours. Fortunately, no problems arose that day.[108] AEMO responded quickly to the November 2016 incident by creating a new requirement for two synchronous generators to be on line at all times in South Australia. However even with this new requirement in place, multiple generating units were lost in the March 2017 incident.

A.3 Storms and technical issues are to blame

The South Australian blackout and other events in the past 18 months show our electricity system is not performing to the standards Australians are used to. These events were caused by storms, technical issues or both. There is not much one can do about storms, but technical problems suggest room for improvement.

The Heywood interconnector has been a common element in some of the incidents. Upgrades that began in 2013 boosted its capacity from 460 MW to 650 MW. During the upgrades it had to operate at reduced capacity, and this was a factor in the July 2016 price spikes in South Australia and in the December 2016 Alcoa outage. The upgrades are now done.

While specific technical issues involved in many of the recent events have now been fixed, governments and other market participants should take the opportunity to review the technical settings of key infrastructure.

The rolling blackouts in February this year raised many questions about governance of the market, including the rules under which AEMO operates and how it makes trade-offs between reliability and affordability in dispatching energy. There have clearly been problems with forecasting in recent incidents, suggesting AEMO should account more conservatively for the risks of storms, and variable generation and demand. Market rules and settings also need to be strengthened to help stabilise the grid.

105. AEMO (2017l).
106. AEMO (2017e).
107. Ibid.
108. AEMO (2017m).

Bibliography

ABC (2017). "SA won't be at the mercy of a national energy market or large power companies: Jay Weatherill". *Australian Broadcasting Commission*. http://www.abc.net.au/news/2017-03-15/sa-wont-be-at-the-mercy-of-a-national-energy/8355216.

ABS (2016). *Consumer Price Index*. Cat. 6401.0, December 2016 release. Australian Bureau of Statistics. http://www.abs.gov.au/ausstats/abs@.nsf/mf/6401.0.

AEC (2017). "Credible National Energy and Climate Policy Remains Solution". *Australian Energy Council online*. https://www.energycouncil.com.au/news/credible-national-and-climate-policy-remains-solution/.

AEMC (2012). *Power of choice review – giving consumers options in the way they use electricity*. Australian Energy Market Commission. http://www.aemc.gov.au/Media/docs/Final-report-1b158644-c634-48bf-bb3a-e3f204beda30-0.pdf.

_____ (2013). *2013 Residential Electricity Price Trends*. 13 December. Australian Energy Market Commission. http://www.aemc.gov.au/markets-reviews-advice/retail-electricity-price-trends-2013.

_____ (2014). *2014 Residential Electricity Price Trends*. 11 December. Australian Energy Market Commission. http://www.aemc.gov.au/Markets-Reviews-Advice/2014-Residential-Electricity-Price-Trends.

_____ (2016a). *2016 Residential Electricity Price Trends*. Data current as at 14 December 2016. Australian Energy Market Commission. http://www.aemc.gov.au/Markets-Reviews-Advice/2016-Residential-Electricity-Price-Trends#.

_____ (2016b). *Annual market performance review 2015, published September 2016*. Australian Energy Market Commission. http://www.aemc.gov.au/Markets-Reviews-Advice/Annual-Market-Performance-Review-2015.

_____ (2016c). *System Security Market Frameworks Review, Interim Report, December 2016*. Australian Energy Market Commission. http://www.aemc.gov.au/Markets-Reviews-Advice/System-Security-Market-Frameworks-Review.

_____ (2016d). *Consultation Paper – National Electricity Amendment (Five Minute Settlement) Rule 2016*. Australian Energy Market Commission. http://www.aemc.gov.au/getattachment/967daf48-28db-454b-841b-6e3397b3a0aa/Consultation-Paper.aspx.

_____ (2016e). *National Electricity Amendment (Demand Response Mechanism and Ancillary Services Unbundling) Rule 2016*. Australian Energy Market Commission. http://www.aemc.gov.au/getattachment/68cb8114-113d-4d96-91dc-5cb4b0f9e0ae/Final-determination.aspx.

_____ (2016f). *Extension of the Reliability and Emergency Reserve Trader - Final Determination*. Australian Energy Market Commission. http://www.aemc.gov.au/Rule-Changes/Extension-of-the-Reliability-and-Emergency-Reserve.

_____ (2017a). *Emergency frequency control schemes, 6 April 2017*. Australian Energy Market Commission. http://www.aemc.gov.au/Rule-Changes/Emergency-frequency-control-schemes-for-excess-gen#.

_____ (2017b). *Directions Paper: Five Minute Settlement, 11 April 2017*. Australian Energy Market Commission. http://www.aemc.gov.au/getattachment/fa4b80a5-e212-48a0-98dc-7478a370ab72/Directions-paper.aspx.

AEMC (2017c). *Submission to the Independent Review into the Future Security of the National Electricity Market*. Australian Energy Market Commission. http://www.environment.gov.au/energy/national-electricity-market-review/submissions.

AEMO (2015a). *Guide to Ancillary Services in the National Electricity Market, April 2015*. Australian Energy Market Operator. https://www.aemo.com.au/-/media/Files/PDF/Guide-to-Ancillary-Services-in-the-National-Electricity-Market.ashx.

_____ (2015b). *NEM – Market Event Report – High FCAS Prices in South Australia*. published December 2015. Australian Energy Market Operator. https://www.aemo.com.au/-/media/Files/PDF/NEM--Market-Event-Report--High-FCAS-Price-in-SA--October-and-November-2015.pdf.

_____ (2016a). *Energy Adequacy Assessment Projection – November 2016*. Australian Energy Market Operator. https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Energy-Adequacy-Assessment-Projection.

_____ (2016b). *Electricity Statement of Opportunities 2016*. Australian Energy Market Operator. https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Statement-of-Opportunities.

_____ (2016c). *National Electricity Forecasting Report, published June 2016*. Australian Energy Market Operator. http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/-/media/080A47DA86C04BE0AF93812A548F722E.ashx.

_____ (2016d). *Fact Sheet: System Strength*. Australian Energy Market Operator. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/AEMO-Fact-Sheet-System-Strength-Final-20.pdf.

_____ (2016e). *Future Power System Security program, August 2016 progress report*. Australian Energy Market Operator. https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/FPSSP-Reports-and-Analysis.

_____ (2016f). *Update Report - Black System Event in South Australia on 28 September 2016, published 19 October 2016*. Australian Energy Market Operator. https://www.aemo.com.au/-/media/Files/Media_Centre/2016/AEMO_19-October-2016_SA-UPDATE-REPORT.pdf.

_____ (2016g). *Media Statement – Basslink Interconnector (Update)*. 14 January. Australian Energy Market Operator. https://www.aemo.com.au/Media-Centre/AEMO-statement-Basslink-Interconnector-update.

_____ (2016h). *Media Statement - South Australia*. 1 December. Australian Energy Market Operator. https://www.aemo.com.au/Media-Centre/Media-statement---South-Australia.

_____ (2017a). *STTM Price and Withdrawals*. Data accessed 7 April 2017. Australian Energy Market Operator. https://www.aemo.com.au/Gas/Short-Term-Trading-Market-STTM/Data.

_____ (2017b). *Victorian Wholesale Price and Withdrawals*. Data accessed 7 April 2017. Australian Energy Market Operator. https://www.aemo.com.au/Gas/Declared-Wholesale-Gas-Market-DWGM/Data/VIC-Wholesale-Price-and-Withdrawals.

_____ (2017c). *Gas Statement of Opportunities*. Australian Energy Market Operator. https://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities.

_____ (2017d). *Submission to the Independent Review into the Future Security of the National Electricity Market*. Australian Energy Market Operator. http://www.environment.gov.au/energy/national-electricity-market-review/submissions.

AEMO (2017e). *Fault at Torrens Island Switchyard and Loss of Multiple Generating Units on 3 March 2017*. Australian Energy Market Operator. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Report-SA-on-3-March-2017.pdf.

_____ (2017f). *Future Power System Security program, January 2017 progress report*. Australian Energy Market Operator. https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/FPSSP-Reports-and-Analysis.

_____ (2017g). *Fast Frequency Response Specification*. Australian Energy Market Operator. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/FFR-Coversheet-2017-03-10a.pdf.

_____ (2017h). *Pricing Event Reports*. Australian Energy Market Operator. https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Market-notices-and-events/Pricing-event-reports.

_____ (2017i). *Generation information, accessed 8 May 2017*. Australian Energy Market Operator. http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information.

_____ (2017j). *Black System South Australia 28 September 2016, Final Report, March 2017*. Australian Energy Market Operator. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Integrated-Final-Report-SA-Black-System-28-September-2016.pdf.

_____ (2017k). *System event report: South Australia, 8 February 2017*. published 15 February 2017. Australian Energy Market Operator. https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Market-notices-and-events/Power-System-Operating-Incident-Reports.

_____ (2017l). *System event report: New South Wales, 10 February 2017*. published 22 February 2017. Australian Energy Market Operator. https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Market-notices-and-events/Power-System-Operating-Incident-Reports.

_____ (2017m). *Power system not in a secure operating state in South Australia on 13 November 2016*. Australian Energy Market Operator. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2016/Power-System-Operations-Incident-Report_SA13Nov16.pdf.

AER (2015). *State of the energy market 2015*. Australian Energy Regulator. https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2015.

_____ (2017a). *Wholesale Statistics – Wind output as a percentage of regional output*. Data current as at 31 March 2017. Australian Energy Regulator. https://www.aer.gov.au/wholesale-markets/wholesale-statistics/wind-output-as-a-percentage-of-regional-output.

_____ (2017b). *Wholesale Statistics – Registered capacity in regions by fuel source*. Data current as at 31 March 2017. Australian Energy Regulator. https://www.aer.gov.au/wholesale-markets/wholesale-statistics/registered-capacity-in-regions-by-fuel-source.

_____ (2017c). *Wholesale Statistics – Annual volume weighted average spot prices*. Data current as at 31 March 2017. Australian Energy Regulator. https://www.aer.gov.au/wholesale-markets/wholesale-statistics/annual-volume-weighted-average-spot-prices.

_____ (2017d). *Wholesale Statistics – Quarterly volume weighted average spot prices*. Data current as at 31 March 2017. Australian Energy Regulator. https://www.aer.gov.au/wholesale-markets/wholesale-statistics/quarterly-volume-weighted-average-spot-prices.

AER (2017e). *Wholesale Statistics – Victorian gas market average daily weighted prices by quarter*. Data current as at 31 March 2017. Australian Energy Regulator. https://www.aer.gov.au/wholesale-markets/wholesale-statistics/victorian-gas-market-average-daily-weighted-prices-by-quarter.

_____ (2017f). *Wholesale Statistics – STTM Quarterly Prices*. Data current as at 31 March 2017. Australian Energy Regulator. https://www.aer.gov.au/wholesale-markets/wholesale-statistics/sttm-quarterly-prices.

_____ (2017g). *Wholesale Statistics – Comparative base futures, by region*. Data current as at 31 March 2017. Australian Energy Regulator. https://www.aer.gov.au/wholesale-markets/wholesale-statistics.

_____ (2017h). *Wholesale Statistics – South Australia daily base contract prices and traded volumes – Q1*. Data current as at 31 March 2017. Australian Energy Regulator. https://www.aer.gov.au/wholesale-markets/wholesale-statistics/south-australia-daily-base-contract-prices-and-traded-volumes-q1.

AGL (2016). "AGL calls for collaboration to enable orderly energy transition". *AGL Media Release*. https://www.agl.com.au/about-agl/media-centre/article-list/2016/october/agl-calls-for-collaboration-to-enable-orderly-energy-transition.

Basslink (2016). "Media statement: Basslink fault cause investigation completed". *Basslink online*. http://www.basslink.com.au/wp-content/uploads/2016/12/161205-Media-statement.pdf.

Belot, H. and Gribbin, C. (2017). "Nick Xenophon defends deal to pass Government's company tax cuts". *Australian Broadcasting Corporation*. http://www.abc.net.au/news/2017-04-01/xenophon-defends-deal-with-government-to-pass-company-tax-cuts/8407740.

Clean Energy Council (2016). *Clean Energy Australia Report 2015*. Clean Energy Council. https://www.cleanenergycouncil.org.au/policy-advocacy/reports/clean-energy-australia-report.html.

Climate Council (2017). *Pollution and price: the cost of investing in gas*. Climate Council of Australia Limited. https://www.climatecouncil.org.au/price-of-gas.

COAG Energy Council (2016a). *Terms of reference - 2017 Energy sector strategic priorities*. COAG Energy Council direction to the Australian Energy Market Commission. http://www.aemc.gov.au/getattachment/96d4d459-1f11-45a0-bd07-e3fc17040768/Terms-of-reference-2017-Energy-sector-strategic-pr.aspx.

_____ (2016b). *Meeting Communique Wednesday, 14 December 2016*. COAG Energy Council. http://www.coagenergycouncil.gov.au/publications/8th-coag-energy-council-meeting-communique.

Department of Industry, Innovation and Science (2016). *Australian energy update 2016*. Department of Industry, Innovation and Science, Canberra. https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Pages/Australian-energy-statistics.aspx#.

Department of the Environment and Energy (2016). *Australia's emissions projections 2016*. Department of the Environment and Energy (Commonwealth). http://www.environment.gov.au/climate-change/publications/emissions-projections-2016.

_____ (2017). *Submissions to the Independent Review into the Future Security of the National Electricity Market*. Department of the Environment and Energy. http://www.environment.gov.au/energy/national-electricity-market-review/submissions.

ERCOT (2016). *Load Resource Participation in the ERCOT Markets*. Electric Reliability Council of Texas. http://www.ercot.com/services/programs/load/laar.

Finkel, A. (2016). *Independent Review into the Future Security of the National Electricity Market, preliminary report*. Department of the Environment and Energy (Commonwealth). http://www.environment.gov.au/energy/national-electricity-market-review.

Holderhead, S. and Langenberg, A. (2017). “SA blackouts: What’s wrong with South Australia’s energy market and infrastructure?” *The Advertiser*. http://www.adelaidenow.com.au/news/south-australia/sa-blackouts-demystifying-whats-wrong-with-south-australias-energy-market-and-infrastructure/news-story/347e33eae322675f1e3c20a076fb1999.

Loussikian, K. (2017). “Energy bills soar in shift from coal power stations”. *The Australian*. http://www.theaustralian.com.au/business/mining-energy/energy-bills-soar-in-shift-from-coal-power-stations/news-story/f04ff69323c798fc05097e98defa858e.

Ludlow, M. (2017). “BHP Billiton says broken electricity market calls for back-up thermal generators”. *Australian Financial Review*. http://www.afr.com/business/bhp-billiton-says-electricity-market-broken-calls-for-backup-thermal-generators-20170301-guor4l.

Macdonald-Smith, A. (2014). “Calls for overhaul of power market”. *Sydney Morning Herald*. http://www.smh.com.au/business/calls-for-overhaul-of-power-market-20141007-10r84g.html.

_____ (2016). “‘Back to the 70s’ put-down for AGL’s suggested power market reforms”. *Australian Financial Review*. http://www.afr.com/business/energy/electricity/back-to-the-70s-putdown-for-agls-suggested-power-market-reforms-20160727-gqfejq.

_____ (2017a). “Origin Energy to provide gas to Pelican Point plant in SA”. *Australian Financial Review*. http://www.afr.com/business/energy/electricity/origin-energy-to-provide-gas-to-pelican-point-plant-in-sa-20170328-gv8nau.

_____ (2017b). “AGL Energy shreds blueprint for South Australia”. *Australian Financial Review*. http://www.afr.com/business/energy/electricity/agl-energy-shreds-blueprint-for-south-australia-20170331-gvams5#ixzz4dQglh2TS.

Massola, J. (2017). “‘Snowy Hydro 2.0’: Malcolm Turnbull announces plans for $2 billion expansion”. *Sydney Morning Herald*. http://www.smh.com.au/federal-politics/political-news/snowy-hydro-20-malcolm-turnbull-announces-plans-for-2-billion-expansion-20170315-guyozj.html.

McConnell, D. and Sandiford, M. (2016). *Winds of change: An analysis of recent changes in the South Australian electricity market*. Melbourne Energy Institute. http://energy.unimelb.edu.au/__data/assets/pdf_file/0017/2054132/SA_PRICES_FINAL.pdf.

Nelson, T. (2016). “Why we need a new NEM: AGL”. *Ecogeneration*. https://www.ecogeneration.com.au/why-we-need-a-new-nem-agl/.

Nelson et al. (2015). Nelson, T., Reid, C. and McNeill, J. “Energy-only markets and renewable energy targets: Complementary policy or policy collision?” *Economic Analysis and Policy* 46, pp. 25–42.

Office of the Chief Economist (2015). *Electricity Generation Major Projects 2015*. Department of Industry, Innovation and Science (Commonwealth). https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/megp/2015-Electricity-Generation-Major-Projects.pdf.

Potter, B. (2016). “AEMO bolsters SA energy market security”. *Australian Financial Review*. http://www.afr.com/news/aemo-bolsters-sa-energy-market-security-20161214-gtb92i#ixzz4Vb7bZBrB.

Priftakis, P. (2017). “Will coal play a role in the NEM?” *Australian Energy Council online*. https://www.energycouncil.com.au/analysis/will-coal-play-a-role-in-the-new-nem/.

Productivity Commission (2013). *Electricity Network Regulatory Frameworks – Inquiry report*. Productivity Commission. http://www.pc.gov.au/inquiries/completed/electricity/report.

Puddy, R. and Treloar, C. (2016). “Policy wobbles putting the wind up investors”. *The Australian*. http://www.theaustralian.com.au/national-affairs/climate/policy-wobbles-putting-the-wind-up-investors/news-story/a3bb35f530545d446e27be3bb0b3d482.

Robins, B. (2016). “Fears power prices to rise as coal-fired power stations close”. *Sydney Morning Herald*. http://www.smh.com.au/business/energy/fears-power-prices-to-rise-as-coalfired-power-stations-close-20161103-gshdks.html.

SA Power Networks (2017). *Guaranteed service level payments for 28 December storm, media release 11 January 2017*. SA Power Networks. http://www.sapowernetworks.com.au/centric/corporate/media_releases.jsp.

South Australian Government (2017). *Our Energy Plan*. http://ourenergyplan.sa.gov.au/.

Steed, J. and Laybutt, C. (2011). *Merchant Utilities: Who gets the Missing Money?* J.P. Morgan Securities.

Stevens, M. (2016). "National Electricity Market pioneer blames 'policy laziness' for SA system crisis". *Australian Financial Review*. http://www.afr.com/business/energy/national-electricity-market-pioneer-blames-policy-laziness-for-sa-system-crisis-20161207-gt62y5.

_____ (2017). "ACCC chairman Rod Sims 'excited' by Malcolm Turnbull's gas watchdog invitation". *Australian Financial Review*. http://www.afr.com/business/energy/rod-sims-excited-by-pms-gas-watchdog-invitation-20170420-gvoqeq.

Tingle, L. (2017). "Malcolm Turnbull needs to show he can fix broken energy market". *Australian Financial Review*. http://www.afr.com/opinion/columnists/laura-tingle/malcolm-turnbull-needs-to-show-he-can-fix-broken-energy-market-20170316-guzmwh.

Turnbull, M. (2017). *Delivering Affordable Gas for all Australians*. Prime Minister of Australia, media release. https://www.pm.gov.au/media/2017-04-27/delivering-affordable-gas-all-australians.

Turnbull, M. and Hodgman, W. (2017). "New Tasmanian Pumped Hydro". *Joint Media Release*. https://malcolmturnbull.com.au/media/new-tasmanian-pumped-hydro.

Vertigan et al. (2015). Vertigan, M., Yarrow, G. and Morton, E. *Review of Governance Arrangements for Australian Energy Markets – Final Report*. COAG Energy Council. http://www.coagenergycouncil.gov.au/publications/review-governance-arrangements-australian-energy-markets-final-report.

Waldhuter, L. (2016). "SA weather: Worsening conditions cause more blackouts as BOM warns of more storms". *Australian Broadcasting Corporation*. http://www.abc.net.au/news/2016-09-29/worsening-conditions-cause-more-blackouts-across-sa/7887020.

Weatherill, J. (2017). *South Australia's Energy Plan*. Speech to media, 14 March 2017. http://www.news.com.au/technology/innovation/south-australia-to-reveal-bold-new-plan-to-fix-its-power-problems/news-story/7fbb261b0b36761b30049880b8167882.

Wood, T. (2017a). "Malcolm Turnbull lets the sovereign risk genie out of the gas bottle". *Australian Financial Review*. http://www.afr.com/opinion/columnists/malcolm-turnbull-lets-the-sovereign-risk-genie-out-of-the-gas-bottle-20170427-gvtwfa.

_____ (2017b). "A four-step circuit-breaker for the energy row". *Australian Financial Review*. http://www.afr.com/opinion/columnists/a-fourstep-circuitbreaker-for-the-energy-row-20170214-guchil.

Wood et al. (2014). Wood, T., Carter, L., Harrison, C. and Button, J. *Fair pricing for power*. Report No. 2014-8. Grattan Institute. https://grattan.edu.au/report/fair-pricing-for-power/.

Wood et al. (2015). Wood, T., Blowers, D. and Moran, G. *Post Paris: Australia's climate policy options*. Working Paper No. 2015-13. Grattan Institute. https://grattan.edu.au/report/post-paris-australias-climate-policy-options/.

Wood et al. (2016a). Wood, T., Blowers, D., Moran, G. and McCamish, T. *Climate phoenix: a sustainable Australian climate policy*. Report No. 2016-6. Grattan Institute. https://grattan.edu.au/report/climate-phoenix-a-sustainable-australian-climate-policy/.

Wood et al. (2016b). Wood, T., Blowers, D. and Moran, G. *Keeping the lights on: lessons from South Australia's power shock*. Report No. 2016-12. Grattan Institute. https://grattan.edu.au/report/keeping-the-lights-on-lessons-from-south-australias-power-shock/.

Wood et al. (2017) _____ . *Price shock: Is the retail electricity market failing consumers?* Report No. 2017-04. Grattan Institute. https://grattan.edu.au/report/price-shock/.