Independent Review into the Future Security of the National Electricity Market

Preliminary Report

December 2016

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This Independent Review into the Future Security of the National Electricity Market Preliminary Report identifies the complex forces driving a rapid transition across the electricity sector. It seeks input on key questions to navigate the transition in line with consumer expectations for a secure and reliable service, at an affordable price, that delivers on our national emissions reduction commitments.

Executive Summary

The National Electricity Market (NEM) is the longest geographically connected power system in the world, supplying the states and territories of eastern and southern Australia – Queensland, New South Wales, the Australian Capital Territory, Victoria, South Australia and Tasmania. It generates around 200 terawatt hours of electricity annually, accounting for around 80 per cent of Australia's electricity consumption.

It was designed for a world that was less complex than today, in which traditional generation (coal, gas and hydro) provided all of our electricity needs. Since then, the parameters have changed.

New technologies are emerging more rapidly than previously envisaged. Variable renewable electricity generation[1], particularly wind and solar photovoltaic (PV), is increasing.

Concurrently, demand for electricity from the NEM has declined, driven by increasing energy productivity, improving energy efficiency, increasingly distributed self-generation, and a decline in industrial consumption.

Industrial, commercial and residential consumers are helping to drive the transformation. They are embracing new technologies to better manage their electricity bills and reduce our emissions. At the same time, they are rightly concerned that the security of the NEM is less assured than when it was designed. Retail prices for all three categories of consumers have also increased substantially in the last decade.

These changes are occurring as we transition to a lower emissions economy. As Australia's largest single source of emissions, the electricity sector itself understands that it has an important role in meeting our national emissions reduction target.

We now have a once-in-a-generation opportunity to reform the NEM, to make it more resilient to the challenges of change, and to enable the new and better services Australians want. Recent events in South Australia and the announced closure of Hazelwood Power Station in Victoria have underscored the urgency of this task.

The shift from coal-fired generators to wind and solar PV generators has implications for security and reliability. These variable renewable electricity generators do not inherently provide usable inertia to support power system security. They are also much less able to contribute to other ancillary services required to maintain a secure and reliable supply of power.

Fortunately, solutions are available to effectively integrate variable renewable electricity generators into the electricity grid, but we will have to change the way we operate. Such solutions include intelligent wind turbine controllers, batteries and synchronous condensers, all of which can contribute to system security. But the NEM does not currently encourage their adoption. Emerging markets for ancillary services, required to maintain system security, have not kept pace with the transition. New and updated frameworks, technical standards and rules may be required.

Open cycle gas-fired generators are well-placed to complement variable renewable electricity generators. However, Australia's east coast gas market has undergone profound change with the expansion of our liquefied natural gas export industry. Domestic gas prices have risen considerably as Australian gas markets have become linked to international markets and supply has been tight. The need for greater gas supplies for electricity generation is increasingly urgent.

1. In this report, variable renewable electricity generation is used to refer to generation that cannot be fully controlled and dispatched to meet customer loads.

Transmission infrastructure will remain a critical component of our electricity supply system. Careful consideration will need to be given to whether additional interconnectors are the most cost-effective way to strengthen the network.

More broadly, affordability must always be an important consideration when new measures are proposed. Improvements in consumer technologies and services, such as battery storage and digital meters, could help consumers to manage their costs whilst also contributing to the delivery of more efficient energy services, helping to address the integration of variable renewable electricity generation and support system security. New pricing models, digital metering and smart grid technologies can likewise be levers for the integration of distributed energy resources.

For all parties, be it households or large-scale investors, long-term, consistent policy signals will aid the required investment decisions and optimise the allocation of resources. In particular, an agreed national approach for addressing our emissions reduction commitments in the electricity sector would play an important role in supporting investor confidence.

As always, effective governance will be critical in managing the transition and implementing necessary changes.

A comprehensive program of work is already underway by a range of market bodies and reviews. However, there is an urgent need to expedite and integrate this work into a comprehensive work program able to keep pace with the rapid rate of change.

Our initial inquiries have made it clear that there is broad enthusiasm for a collaborative approach that can deliver better outcomes for all Australians.

This Preliminary Report does not contain findings or recommendations. Instead, it fulfils the role of an issues paper, setting out observations and questions to guide a process of open consultations on the design of a new blueprint for the electricity sector.

Seven key themes are identified, each supported by specific questions to be raised with the community.

1. Technology is transforming the electricity sector
2. Consumers are driving change
3. The transition to a low emissions economy is underway
4. Variable renewable electricity generators, such as wind and solar PV, can be effectively integrated into the system
5. Market design can support security and reliability
6. Prices have risen substantially in the last five years
7. Energy market governance is critical

Some of the key questions for the future of our energy system include:

- How do we ensure the NEM can take advantage of new technologies and business models?
- How do we ensure the NEM meets the needs of all consumers, including residential, large-scale industrial and vulnerable consumers?
- What role should the electricity sector play in meeting Australia's emissions reduction targets?
- What are the barriers to investment in the electricity sector?
- What immediate actions can we take to reduce risks to grid security and reliability?
- Is there a role for technologies at consumers' premises in improving energy security and reliability?
- What role is there for new planning and technical frameworks to complement current market operations?

- How can markets help support additional system security services?
- How can we improve the supply of gas for electricity generation to contribute to reliability and security?
- How can we ensure that competitive retail markets are effective and consumers are paying no more than necessary for electricity?
- What are the optimal governance structures to support system security, the integration of energy and emissions reduction policy, and affordable electricity?

The Panel welcomes submissions on either these questions or the more detailed questions contained throughout the Preliminary Report.

Submissions and the Review's consultations will aid the Panel to deliver a blueprint outlining national policy, legislative and rule changes required to maintain the security, reliability, and affordability of the NEM.

Consultation Process

This Preliminary Report outlines the Panel's observations about the current state of the NEM and offers questions on the major issues the Panel has identified. The questions are designed to elicit suggestions or answers that may help form the Panel's final recommendations.

The questions have been formed through an analysis of the events that led to this inquiry, advice from international and Australian experts, and the targeted consultation process that was undertaken during late 2016.

The questions and views presented in this Preliminary Report should not be interpreted as indicating the conclusions of the final report. This Preliminary Report serves as an issues paper for broad public consultation. As such, the questions and views will be subject to further consideration and discussion, in anticipation of the final blueprint being produced in 2017.

The Panel encourages submissions in response to this Preliminary Report by **21 February 2017**. Submissions can be made by email to NEMSecurityReview@environment.gov.au.

Stakeholders are encouraged to keep their submissions as succinct as possible, and include a one-page executive summary.

A link to this mailbox and other instructions for making a submission can be found on the Department of the Environment and Energy's website at www.environment.gov.au.

The Review's full terms of reference are at Appendix B.

PUBLICATION OF SUBMISSIONS

The Panel has a preference for all submissions to be made public, to generate open and transparent debate. It also considers it difficult to prosecute issues raised confidentially. Submissions will be published on the Department of the Environment and Energy's website unless specifically requested otherwise. Please indicate clearly in your submission if you do not wish it to be published, either in part or in full. Your name and organisation (if applicable) and state or territory will be included on the website to identify your submission. Other contact information will not be published.

The Australian Government reserves the right to refuse to publish submissions, or parts of submissions, which contain offensive language, potentially defamatory material or copyright infringing material. A request may be made under the *Freedom of Information Act 1982* (Commonwealth) for a submission marked 'confidential' to be made available. Such requests will be determined in accordance with provisions under that Act.

CONTACTS

For further information about the Review, the Panel or making a submission, contact the Secretariat for the Review at NEMSecurityReview@environment.gov.au.

Introduction

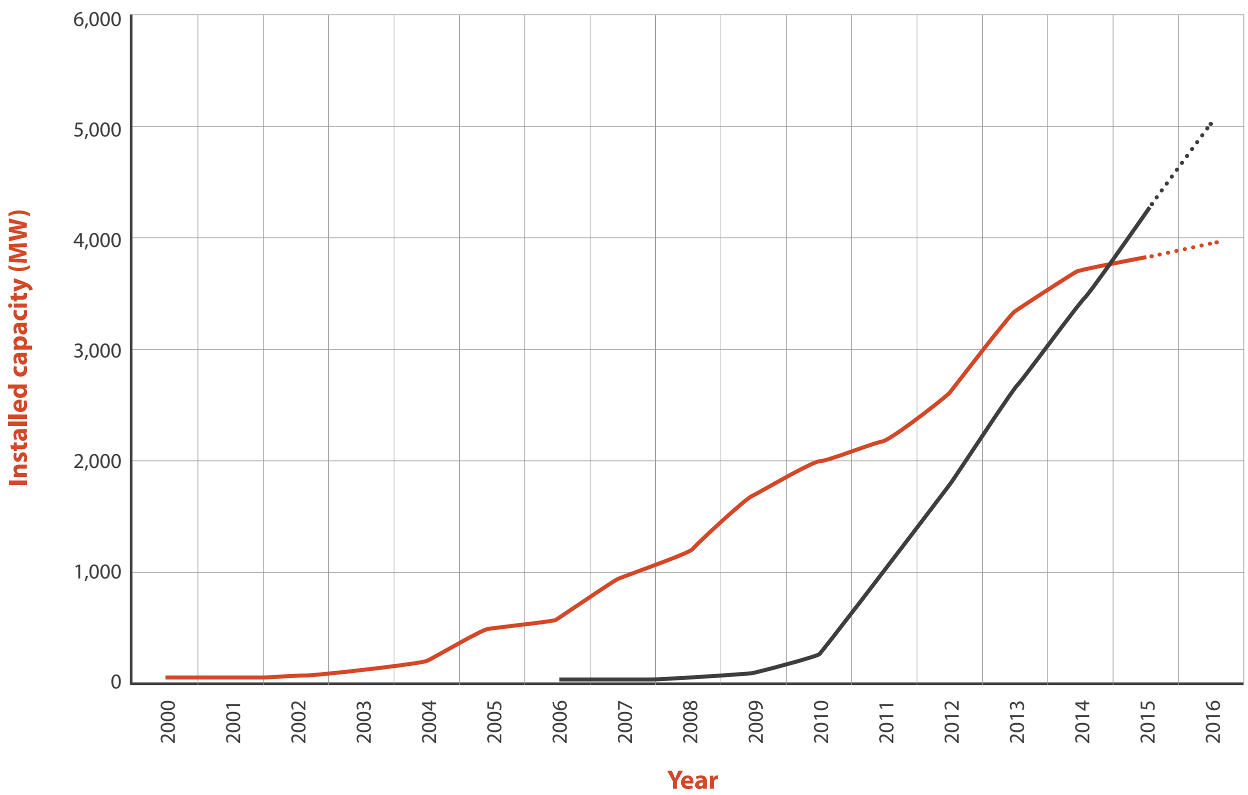
The physical electricity system is undergoing its greatest transition since Nikola Tesla and Thomas Edison clashed in the War of the Currents in the early 1890s. Tesla's alternating current (AC) generation and distribution system prevailed over Edison's direct current (DC) system, leading to more than a century of central generators supplying electricity grids.

Whether the source of primary energy was hydro, coal, oil or gas, the generators were all variations on the same type of generation technology. They use synchronous machines that generate AC electricity at the standard system frequency – 50 cycles per second (Hertz) in Australia.

Now, for the first time since the War of the Currents, our electricity supply is undergoing a profound transition. Substantial numbers of non-synchronous, variable renewable electricity (VRE) generation sources have entered the market, in particular wind and solar PV (see Figure 0.1[2]). Most solar PV is distributed on rooftops throughout the grid, the antithesis of the central generation model. Another significant change, still in its earliest stages, is the consumer-driven decision to install home battery storage systems.

Since the turn of the century the electricity sector has been transformed by responses to international commitments to reduce emissions, the emergence of new technology, and changing consumer preferences. This is testing existing market arrangements, Australia's ageing generation fleet and our energy infrastructure. VRE generators do not inherently have the characteristics to support and stabilise our electricity system that we have long taken for granted. The transition presents challenges but also opportunities.

Figure 0.1: Installed capacity of wind and rooftop solar PV generation



2. Data courtesy of AEMO, Market Trends and Outlooks in *Australia's Electricity Markets*, 2016. p.4.

Australians rightly have high expectations of our electricity supply system. We expect to be able to flick a switch, plug in and receive power. Our electricity supply is integral to our lives. It is the lifeblood of our economy.

The NEM has served us well for over two decades, adapting to many changes in the economy. However, the "system black" in South Australia at 4:18 PM on 28 September 2016 – in addition to other recent events – brought into sharp focus some of the critical issues now confronting the NEM. It was the first time a whole state has gone black since the formation of the NEM. It highlighted the importance of security and reliability of the NEM to all Australians.

There is now an urgent need for action to ensure that the energy system we take for granted can continue to adapt to the changes currently taking place and likely to accelerate.

A MARKET DESIGNED IN DIFFERENT TIMES

The design of the NEM has become increasingly complex over time as new sources of supply and new patterns of demand have come into play. The creation of the NEM – the longest geographical interconnected power system in the world – was a significant policy and engineering achievement but it was designed for a different world to the one it confronts today. For example, in the new world, VRE is progressively replacing the traditional generation fleet and introducing greater intermittency. More than 1.5 million solar PV systems generate electricity from the rooftops of Australian homes. The Australian Energy Market Operator (AEMO) and local distributors have to take account of their performance while having no control or visibility of their output.

At the same time, projecting future consumer demand for electricity is becoming increasingly difficult. With increasing energy productivity, improved electricity efficiency, distributed generation and changing consumption patterns, total electricity consumption from the grid could continue to decline while peak demand increases. But equally, as electricity is substituted for petrol in transport and for natural gas in heating, both electricity consumption and maximum demand could substantially increase.

Electricity is also becoming more expensive – household electricity bills increased 61 per cent between 2008-09 and 2012-13[3], mainly on the back of network investments. This is compared to a 10.4 per cent increase in the consumer price index over the same period[4]. In the next few years, wholesale electricity prices are expected to rise, driven by the closure of coal-fired generators and the increasing cost of gas – an essential fuel in the energy market transition. Additional gas supply is urgently needed but the domestic supply is constrained by international LNG demand, state and territory moratoria, low rates of exploration and pipeline capacity shortages. This is adding to price pressures.

In addition, Australia has committed to reducing greenhouse gas emissions by 26 to 28 per cent below 2005 levels by 2030. Energy policies must work together with policies to reduce emissions to avoid price shocks and unintended impacts on the resilience of the electricity system. Owner-investors are exiting emissions intensive power stations as these reach the end of their design lives. It has been clear from our consultations that no-one is contemplating investing in new ones, nor would financial institutions provide finance. New investment in solar and wind generation is encouraged by government policy outside the electricity market and it is playing an increasingly significant role in supplying our electricity needs. This transition presents some challenges for system integration.

Governance of our energy markets needs to keep up with the pace of change. All governments must work together to facilitate a smooth transition. The energy market transition is a challenge requiring whole-of-system thinking and a national commitment to energy and emissions reduction policy integration.

3. 46040DO008_201314 Energy Account, Australia, 2013-14, http://www.abs.gov.au/ausstats%5Cabs@.nsf/0/5E025753112D1A80CA2578800019C952?Opendocument accessed 13 December 2016.

4. 6401.0 Consumer Price Index, Australia, TABLES 1 and 2. CPI: All Groups, Index Numbers and Percentage Changes, http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6401.0Sep%202016?OpenDocument; accessed 13 December 2016.

With the electricity industry broken up into its component parts of generation, transmission, distribution and retail we cannot expect the existing industry participants to alone solve the electricity and energy problems facing Australia. Each participant has a primary responsibility to their shareholders to maximise their own position in the electricity industry. Responsibility for setting an energy direction in the national interest ultimately rests with governments.

With this responsibility in mind, the Council of Australian Governments (COAG) Energy Council has requested the Panel deliver a blueprint outlining national policy, legislative and rule changes required to maintain the security and reliability, and affordability of the NEM. We have a unique opportunity to undertake a whole-of-system review of the NEM; to consider how it can facilitate the transition underway and the changes that will come in future.

It is worth remembering that we are not alone. Energy markets across the world are grappling with many of the same issues. There is much we can learn from them and, as we develop solutions, there will be much we can share.

The Review has had the benefit of the expert input of the International Energy Agency (IEA) on the experience of other countries facing similar challenges. A summary of the IEA's advice is at Appendix A.

RECENT EVENTS HIGHLIGHT THE NEED FOR ACTION

Recent events highlight the opportunities and risks associated with the transition currently underway in Australia's electricity market:

- In July and August 2016, South Australia experienced high and volatile prices not experienced in the electricity market since 2009.
- On 28 September 2016, South Australia experienced the first state wide blackout since the NEM began.
- In the first half of 2016 after a record dry spring and extended Basslink cable fault, Hydro Tasmania had to install more than 200 MW of temporary diesel generation to help protect Tasmania's electricity supply in the event of further contingencies.
- On 3 November 2016, Australia's most emissions intensive power station, Hazelwood, announced its closure from 31 March 2017.

THE NEED FOR SYSTEM INTEGRATION

These events provide a preview of the future if decisive action is not taken to manage the transition effectively. Some regions of the NEM, like South Australia, are already exposed to challenges associated with the transition. If we do not act soon the rest of the NEM will also face security issues related to declining coal generation and limited gas supply. Nothing less than a national commitment to these system integration challenges is required.

The changes to how power is generated and how Australians receive and use it cannot be reversed. If anything, change is likely to accelerate in coming years. One only need look at the number of reviews underway or recently completed into the energy system to get a sense of the range of issues confronting governments, market participants and consumers (see Appendix C). This work requires support and processes for faster implementation so that it can keep up with the rapid rate of change. These issues cannot be resolved independently of each other. A whole of system review is also required to identify where there are gaps or blind spots in the work program, such as the possible underuse of existing technological solutions that can help integrate wind and solar electricity by providing ancillary services that ordinarily would be provided by synchronous generators.

The transition needs to be managed by ensuring that new sources of supply are to all practical extents integrated into the system. Achieving low emissions goals while maintaining appropriate system security will require a more coordinated and planned approach to the adoption and integration of system-wide technology.

ADDRESSING THE 'ENERGY TRILEMMA'

The heart of the Review's task is to find solutions to address the so-called energy trilemma – policies that simultaneously provide a high level of energy security and reliability, universal access to affordable energy services, and reduced emissions. This is easier said than done. There is a tension between these three objectives. For example, a higher level of energy security has cost implications. A careful balancing exercise is required. At the centre of the energy trilemma triangle, and the core of the Review, are consumers and the choices they make.

It is consumers who will pay the price on how the balance is struck between security, affordability and environmental objectives. This is why a focus on good energy and emissions reduction policy governance is critical – it is governments that play a crucial role in getting the balance right between the trilemma objectives, through design of the system and implementation of policy.

The COAG Energy Council has made it clear that the security and reliability of our electricity supply is paramount. Our review of the NEM commences with security and reliability as the fundamental driving considerations. The need to reduce emissions and to keep electricity affordable for consumers, particularly those who are vulnerable, is also front of mind.

This high level problem breaks down into a number of complex regulatory and technical issues. The key question is this – how can we best achieve the required outcomes through the right mix of markets, regulation and standards? This preliminary report outlines the issues and questions for broad public consultation about the future of the NEM and how to achieve the optimum levels of security and reliability.

While the terms 'security' and 'reliability' have defined meanings in the context of energy system operations, the Review is also taking a broad view of energy security to encompass the full range of market operations, technical responses and policy settings that impact on the energy system's ability to meet Australian consumers' expectations. The broader investment environment, market innovations and consumer participation in energy consumption and production must also be considered.

Security and Reliability

A *secure power system* is one that is able to continue operating within defined technical limits, even in the event of the disconnection of a major power system element such as an interconnector or large generator.

A *reliable power system* is one in which there is sufficient generation and transmission capacity to meet all grid demand. The National Electricity Rules include mechanisms to ensure reliable supply. These include a reliability standard that requires that no more than 0.002 per cent (11 minutes in a year) of customer demand within a region go unmet.

APPROACH OF THIS PRELIMINARY REPORT

In the time available to the Panel since our appointment we have held a series of meetings with stakeholders in the sector and market bodies. This has enabled us to make a number of preliminary observations. The structure of this report and its chapters correspond with those observations and the questions that arise from them.

We have endeavoured to write this report for readers who may not have a deep background in the NEM to help fully inform discussions and debate about these issues.

This Preliminary Report begins with a focus on innovation and the consumers in our energy system. In addition to the importance of affordability, the scale of the transition is in large part driven by rapidly evolving technological change and consumer appetite, in particular as residential consumers adopt better ways of managing their household energy needs, and contribute to emissions reduction. How the NEM adjusts to these forces will be critical to our future energy security.

Chapter 1:

Technology is Transforming the Electricity Sector

New technologies are transforming the electricity sector in unprecedented ways.

In the electricity sector, innovation involves the introduction of new products, processes and business models across the entire supply chain – from the generation of electricity, through to its end use.

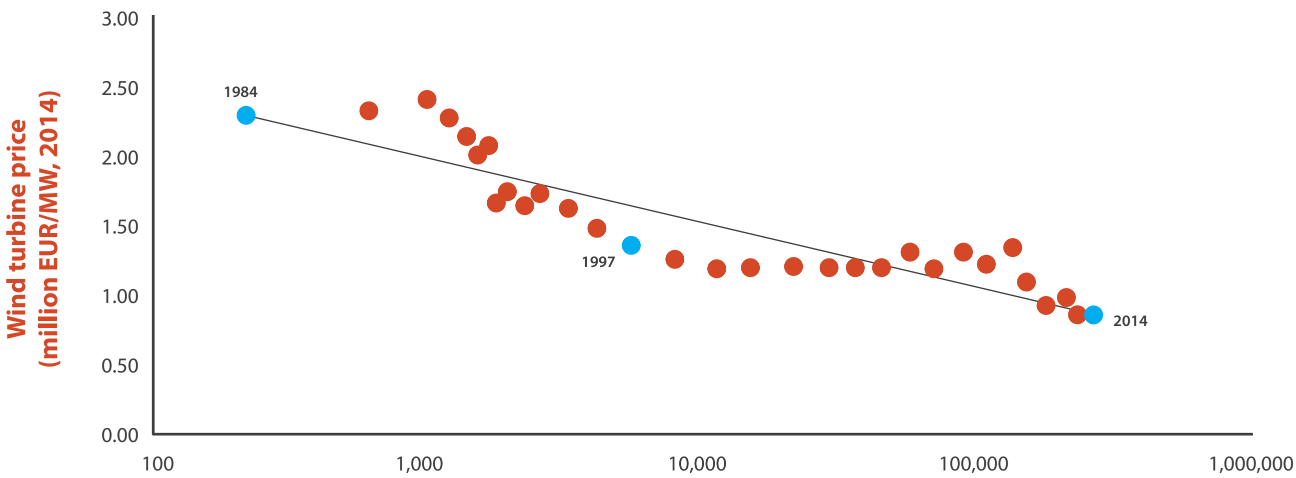
Recent advances include low emissions electricity generation technologies, distributed energy resources such as digital metering, rooftop solar PV, battery storage systems and electric vehicles, and software for peer-to-peer electricity trading. It has been predicted that innovations in data collection and analytics ('Big Data') will have a disruptive effect on the electricity sector, including by facilitating the integration of unprecedented levels of renewable generation[5]. Future innovations could come in many other forms.

There are inevitably challenges integrating new technologies and services into existing markets and regulatory arrangements, which if not properly managed could lead to adverse outcomes for consumers. Our electricity sector needs to be flexible enough to accommodate innovation in a range of forms, while maintaining security, reliability and affordability.

LOW EMISSIONS ELECTRICITY GENERATION

There is a transition towards low emissions forms of electricity generation such as wind and solar PV. This has been reflected in a fall in the costs of wind turbines (as shown in Figure 1.1[6]) and both rooftop and utility-scale solar PV.

Figure 1.1: Historical price of wind turbines



5. Citi GPS, *Disruptive Innovations IV: Ten More things to Stop and Think About*, 2016, pp.17-19.
6. Bloomberg New Energy Finance, *New Energy Outlook 2016*.

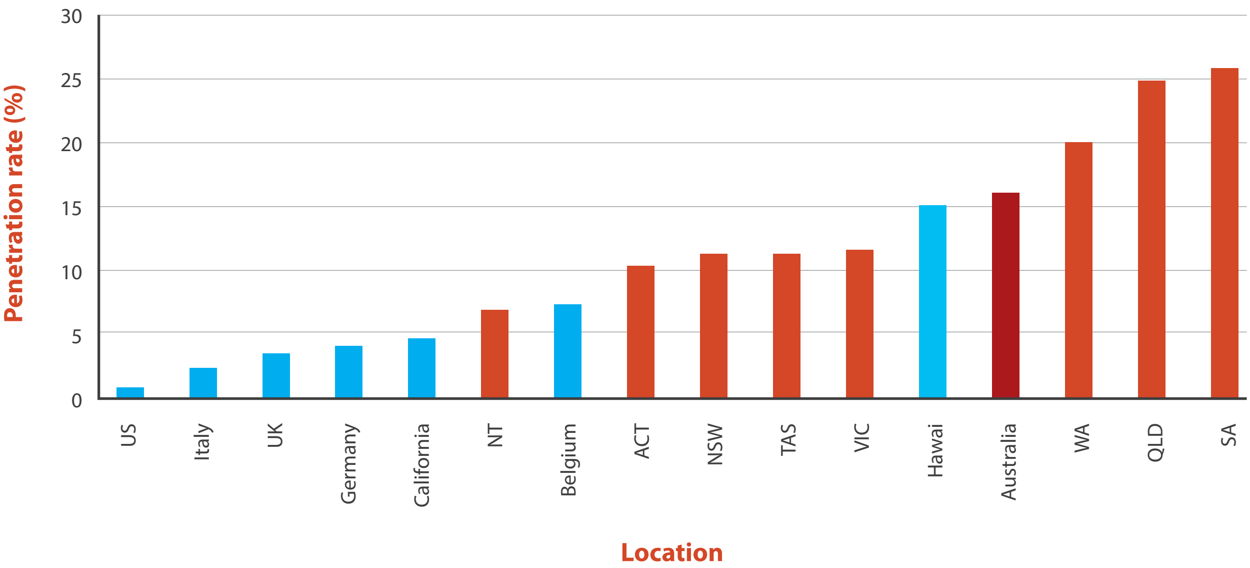
The variable nature of wind and solar PV generators creates technical challenges for grid security unless they are optimally integrated into the grid. Technological solutions for optimal integration exist and are discussed further in Chapter 4.

Wind and solar PV are the most common renewable generation technologies being installed today. There are a number of other zero-emission electricity generation technologies, such as concentrated solar thermal, geothermal, ocean, wave and tidal, and low emission electricity generation technologies such as biomass combustion and coal or gas-fired generation with carbon capture and storage. Some of these sources provide the system benefits associated with synchronous generation. These other electricity generation technologies might become commercially significant in future years. This Preliminary Report makes no judgement on their future role. For clarity, we use wind and solar PV generators throughout as examples of at-scale variable renewable electricity (VRE) generators.

DISTRIBUTED ENERGY RESOURCES

Distributed energy resources represent another wave of innovation. At the centre of this innovation are residential consumers, who now have more choice and control over how they engage with the electricity market (see Chapter 2). Already more than 1.5 million rooftop solar PV systems have been installed in Australia[7], with the result that most of Australia's states and territories (and the country as a whole) now have a higher penetration of rooftop solar PV per household than other countries, as shown in Figure 1.2[8]. These rooftop solar PV systems will increasingly be complemented by other technologies.

Figure 1.2: Rooftop PV penetration rates as a percentage of households



Battery storage systems and electric vehicles continue to gather momentum both internationally and within Australia, with industry and consumers keen to adopt these new technologies. Declining battery costs and increasingly numerous and attractive offerings from car manufacturers will likely accelerate uptake of these technologies. By 2020, costs of some battery technologies are expected to fall another 40 to 60 per cent[9]. AEMO's

7. http://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations#SGU--Solar-Deemed, accessed on 30 November 2016.
8. Data courtesy of the International Energy Agency, *Renewable Energy Medium-Term Market Report 2016*, p.144.
9. AECOM, *Energy Storage Study*, 2015, p.10.

forecasts suggest that by FY2035 there will be approximately 1.1 million battery storage systems installed alongside new rooftop solar PV systems in households across the NEM[10]. The uptake of electric vehicles has been relatively modest to date, constituting only 0.2 per cent of Australia's total vehicle sales in 2015[11]. However AEMO has projected an uptake of around 1.5 million electric vehicles in the NEM by 2030 – around 10 per cent of vehicles on the road[12].

Increasingly third party agents or aggregators will be able to offer a variety of energy management solutions to the market, such as web applications using digital meter data. New sensor and data technologies along, with advanced energy management systems, will enable distributed energy resources to be aggregated, for example, to form virtual power plants or micro-grids.

In response to this transition, CSIRO and the Energy Networks Association have together developed the Electricity Network Transformation Roadmap. It forecasts that by around 2050 up to 50 per cent of Australia's annual electricity consumption could be provided by millions of distributed energy resources (mostly rooftop solar PV systems)[13].

The efficient uptake and integration of solar PV, battery storage, electric vehicles and other new technologies and services could significantly reduce the incidence and level of peak demand, improve reliability and reduce expenditure on network augmentation. But if the integration of these technologies is not well managed, they could have a detrimental impact on security. This must be addressed, otherwise the costs of supporting an increasingly distributed system will fall on other consumers, including those least able to afford it. Cost reflective pricing, which involves charging prices that accurately reflect the efficient cost of providing network services to each consumer (see Chapter 6), could help avoid this potential problem. International experience also shows that new tariff structures can aid investment in and operation of distributed resources (see Appendix A).

An additional challenge will be to integrate this new two-way electricity system, scattered over millions of homes, into a network that was built to transport electricity one-way from large power stations. The future level of electricity demand from consumers is becoming more uncertain, and operating the power system is becoming more challenging (also discussed in Chapter 4). Visibility and orchestration of distributed energy resources will be key to achieving optimal integration.

RESPONDING TO CHANGE

There is little certainty as to precisely what the future electricity sector will look like. However, we do know that it will be heavily influenced by new technologies that, amongst other things, reduce emissions, and enable consumers to exercise ever-increasing choice and control over how they source, use and manage their electricity. Existing markets and regulatory frameworks will need to adapt to these changes.

It is important to provide the right price signals for efficient uptake of new technologies and services that will help deliver system benefits to all consumers – residential, commercial and industrial. Regulatory frameworks should promote innovation and competition, and help ensure a level playing field. Consumer choices should determine which technologies succeed and which fail. The use of subsidies could distort this process.

Work is already in progress to respond to current and future changes. The COAG Energy Council's Energy Market Transformation work program, which commenced in early 2016, aims to ensure regulatory frameworks are able to respond to the effects of emerging technologies, and ensure consumers can benefit from innovative services while mitigating any risks[14]. Other current reviews and work by governments include the Power of

10. AEMO, *Emerging Technologies Information Paper*, 2015, pp.4,29-32; assuming a 7kWh system size.
11. AEMO and Energeia, *AEMO Insights – Electric Vehicles*, 2016.
12. AEMO and Energeia, *AEMO Insights – Electric Vehicles*, 2016, p.43 (neutral scenario).
13. CSIRO and Energy Networks Association, *Electricity Network Transformation Roadmap: Interim Program Report,* 2015, p.57.
14. http://www.scer.gov.au/council-priorities/energy-market-transformation, accessed on 25 November 2016.

Choice reforms (including a competitive metering framework and cost reflective pricing to begin in 2017), the *National Energy Productivity Plan 2015-2030*, and the Australian Energy Market Commission (AEMC)'s monitoring and annual reporting on the effectiveness of the national economic regulatory framework in light of distributed energy resources. Further work will be required.

Other countries are undergoing similar change in their electricity sector, and responding. For example, in the United States, the Federal Energy Regulatory Commission recently proposed rule changes to enhance competition through more effective integration of battery storage systems into wholesale markets. The rule changes would require market operators to revise their electricity tariffs in order to better accommodate the participation of battery storage systems and allow distributed energy resource aggregators to participate in the market[15].

CONSULTATION QUESTIONS

The energy market is changing. New technologies create opportunities for a more integrated, predictable and responsive system, including to better manage peak congestion and provide reliability at lower cost. There are opportunities for new businesses and service models to meet this need. But if the integration of these technologies is not well managed, they could have a detrimental impact on security.

1.1 How do we anticipate the impacts, influences and limitations of new technologies on system operations, and address these ahead of time?

1.2 How can innovation in electricity generation, distribution and consumption improve services and reduce costs?

1.3 What other electricity innovations are you aware of that may impact the market in the future?

15. https://www.ferc.gov/media/news-releases/2016/2016-4/11-17-16-E-1.asp#.WD4fik2F6Uk, accessed on 25 November 2016.

Chapter 2:

Consumers are Driving Change

Consumers are at the centre of the energy trilemma and the core of this Review. While consumers rightly expect a secure and reliable energy system, they also want to find ways to better manage their energy costs, and help reduce our emissions[16].

As discussed in Chapter 1, rapid innovation is occurring. This is providing the opportunity for consumers to change from being passive participants in the electricity sector to active players. Already, consumers have demonstrated their desire to adopt new technologies and gain associated benefits, including financial incentives provided under various emissions reduction policies (some of which are described in Chapter 3).

For residential and commercial consumers, distributed energy resources are allowing them to become investors and electricity traders (with or without the NEM), and new technologies are providing them with new ways of managing their energy use and costs. For example:

- Solar PV located on consumers' premises has become a partial alternative to traditional grid-supplied electricity. Australians households have invested several billion dollars in such systems over the past decade.
- Rooftop solar PV combined with battery storage can save consumers money. Instead of selling excess electricity to the retailer during the day at low feed-in prices they can store the excess and avoid purchasing electricity in the evening and night at higher retail prices.
- Advances in batteries and other storage technologies are likely to make it cost-effective for increasing numbers of residential and commercial consumers to partially or even fully disconnect from the grid and operate independently, or be supplied by a micro-grid (for example, small-scale local generation and storage supporting an entire town or suburb using its own separate network).
- Digital meters, the 'Internet of Things' and energy management software can help consumers trade, track and control their electricity usage to manage their electricity costs.

Industrial consumers have different characteristics from residential and commercial consumers, in terms of the profile of their electricity demand, the way they participate in the electricity market, and how they are affected by the energy trilemma. While variable renewable electricity (VRE) and energy storage technologies are generally not yet cost-effective at an industrial scale, some industrial consumers are engaging with more industry-specific means of reducing their electricity costs, through energy management, fuel substitution, cogeneration and tri-generation.

ENERGY PRODUCTIVITY AND MORE FLEXIBLE DEMAND

Energy productivity measures are critical to a power system that optimises security and reliability, affordability and emissions reduction. In December 2015, the Australian Government and the COAG Energy Council published the National Energy Productivity Plan. It sets out the framework and initial steps to attain the target of a 40 per cent improvement in energy productivity by 2030.

By using new products and services to improve energy productivity, residential consumers can reduce their ongoing costs, and businesses can become more competitive and reduce exposure to future price rises. Energy productivity can also reduce the shared costs of managing energy security and emissions. Much has already been achieved, and further improvement opportunities exist across the electricity sector.

16. CSIRO and Energy Networks Association, *Electricity Network Transformation Roadmap: Interim Program Report*, 2015, p.88.

Flexible consumer demand can also help to achieve security and reliability benefits while minimising costs and reducing emissions. Security and reliability require balancing demand and supply, continuously, in all locations across the grid. But rather than just making available more supply (as is usually the focus), the cost of achieving security can be lowered by actively managing demand. For example, if consumers shift demand from peak to off-peak periods, there will be direct cost savings for those consumers and it will be possible to defer or avoid future network upgrades that would add costs to all consumers.

More granular and real-time data about demand and the impact of distributed energy resources will assist with more efficient operation of the system to manage reliability and security issues. This will require investment in digital metering, improved pricing signals, new communication services and technology enabled data management. Smart grid technologies provide opportunities to use distributed generation and storage to move electricity within the system to where it is needed. This avoids expensive infrastructure investment and provides services to manage system security issues.

Digital meters

Digital meters (also known as smart meters) are an enabling technology for a range of innovations in the electricity sector. They allow consumers to choose different types of tariffs and get better access to their electricity use data. They also allow retailers to offer new services like real-time electricity monitoring, and distribution network businesses to improve network management by improving monitoring and fault detection. Digital meters also allow third-party access, with the permission of the consumer, who can then participate in new services such as peer-to-peer trading. This may give rise to privacy concerns.

Victoria already has digital meters following a government mandated deployment undertaken by network businesses, but this approach led to significant costs and consumer backlash. The Victorian Auditor General found that not all of the benefits included in the Victorian Government's cost benefit analysis would be realised, and the mandated deployment would result in a net cost to consumers. In practice, the mandated rollout did not incentivise network businesses to achieve the lowest cost solutions or ensure that consumers were offered a full range of services offered by digital meters.

A competitive market framework for the national introduction of digital meters was proposed by the COAG Energy Council and is currently being implemented based on market rules finalised by the AEMC in 2015. The new rules are designed to drive investment in digital meter deployment based on the value they offer to consumers and the market. This will be based on metering companies, retailers and distribution network businesses developing a business case to deploy digital meters. A business case must be built on the benefits to consumers from being able to choose new tariffs or behind-the-meter management services for products like solar PV and battery storage, and the operational savings from remote services and improved network management.

GETTING INCENTIVES RIGHT

Consumer choices can help avoid the cost of future network upgrades and improve grid security, but this requires the right price signals and incentives.

Consumers are not homogenous. Large commercial and industrial users already face a more comprehensive set of price signals. More responsive demand management in this sector, given its scale, can be effective in balancing peaks in the system. Work has been underway for some years to create a more attractive market for large user demand response[17]. Smaller users could be engaged through retailers, network businesses or new entrants such as demand-side aggregators attracted by adequate incentives to innovate and provide new services.

17. https://scer.govspace.gov.au/workstreams/energy-market-reform/demand-side-participation/wholesale-market-demand-response-mechanism-in-the-national-electricity-market/, accessed on 5 December 2016.

The increasingly active role of consumers will be important in supporting the future security and affordability of the power system.

AFFORDABILITY AND IMPACTS ON VULNERABLE CONSUMERS

Without the right price signals and incentives, there will be inefficient investment by both consumers and networks, which may result in consumers disconnecting from the grid. This would result in the costs of building and maintaining the network being spread over a smaller number of users. Most of the impact would be on vulnerable consumers who do not have the resources to invest in technologies to reduce their demand or generate their own electricity, and on passive or loyal consumers who are not engaged in managing their electricity demand and costs.

It will be important to address the barriers to active engagement in the transition underway, as experienced by vulnerable groups. For example, consumers can be prevented from adopting new technologies – such as rooftop solar PV or battery storage – by a limited ability to pay large up-front costs or to obtain finance. Consumers who rent properties or live in apartments are limited in their ability to install such technology. Limited English language skills or poor financial literacy might make it harder for other consumers to engage in a market that offers increasingly complex choices. It is important that vulnerable consumers are not left behind or required to incur increased costs to subsidise households or businesses that are able to invest in new technologies. The COAG Energy Council is examining regulatory frameworks in the context of new technologies, new patterns of demand and consumer protection.

CONSULTATION QUESTIONS

Consumers are helping to drive electricity sector transition by embracing new technologies, choosing ways to better manage their energy costs and help reduce our emissions. The increasingly active role of consumers will be important in supporting the future security and affordability of the power system, but this requires the right prices and incentives. It will be important to address the needs of vulnerable groups.

2.1 How do we ensure that consumers retain choice and control through the transition?

2.2 How do we best meet the needs of vulnerable and hardship consumers?

2.3 How do we ensure the needs of large-scale industrial consumers are met?

2.4 How can price structures be made more equitable when consumers are making different demands on the grid according to their electricity use and their investments behind the meter?

2.5 How do we ensure data sharing benefits and privacy are appropriately balanced?

Chapter 3:

The Transition to a Low Emissions Economy is Underway

The transition to a lower emissions economy is underway and cannot be reversed. Ensuring that the transition is smooth will require major investments in assets with long life spans. Policy stability and predictability is necessary to ensure that investors have confidence to build the assets that will deliver the required security and reliability of the electricity supply.

Energy and emissions reduction policies must operate effectively together to address the trilemma and avoid regulatory and technical blind spots. A clear, national approach for reducing electricity sector emissions is important for investor confidence. This goes hand in hand with COAG initiatives to integrate energy and emissions reduction policies.

THE ROLE OF THE ELECTRICITY SECTOR IN MEETING OUR EMISSIONS REDUCTION TARGETS

Australia has had national emissions reduction targets since 1990 and a range of policies to reduce emissions. Recently, Australia committed to reducing its greenhouse gas emissions by 26 to 28 per cent below 2005 levels by 2030. Australia committed to these targets under the 'Paris Agreement', an international agreement reached in 2015 (COP21). In ratifying the Paris Agreement, Australia joined a collective commitment to ensure global emissions peak as soon as possible, achieve net zero emissions in the second half of the century, and keep warming to below two degrees Celsius. The Agreement involves 195 countries and covers over 97 per cent of global emissions. The world is taking action to lower emissions and the level of action is likely to increase over time.

The electricity sector has an important role in international efforts to reduce emissions. Electricity generation is the largest source of emissions in Australia – representing 35 per cent of emissions[18] – and an important source of opportunity for abatement (see Figure 3.1[19]).

Reductions in the cost of solar and wind technologies continue to exceed expectations. Over the past seven years, the cost of wind has dropped over 50 per cent, and solar PV costs have dropped over 80 per cent[20].

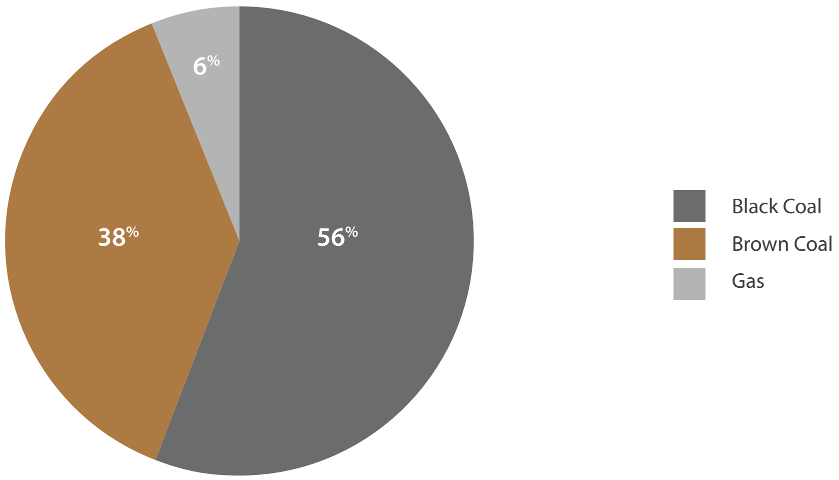
Beyond renewable energy, there are a number of other opportunities for emissions reduction from electricity. Fuel switching from coal-fired to gas-fired generators and improvements to energy efficiency across the economy will make a sizeable reduction in total emissions. A table showing the emissions intensities of different generation technologies is included in Appendix D.

Electricity also has the potential to help reduce emissions in other sectors of the economy. Switching from existing transport, heating and industrial fuels to grid-based electricity could see large reductions in emissions from these sectors.

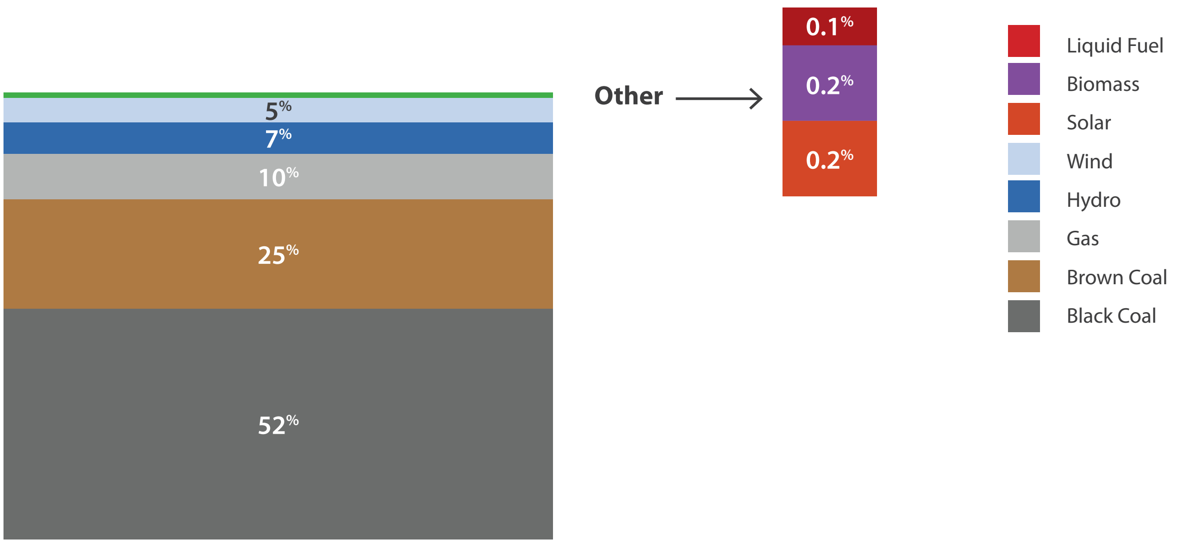
18. Department of the Environment, *Quarterly Update of Australia's National Greenhouse Gas Inventory*, December 2015. p.9.
19. Department of the Environment and Energy estimates based on AEMO Market Management Data, 2016
20. Bloomberg New Energy Finance, *The State of Play*: presentation to the Carbon Market Institute Summit, 3 May 2016.

Figure 3.1: NEM generation and emissions by fuel type for FY2016

NEM emissions



NEM generation



While the electricity sector must play an important role in reducing emissions, current policy settings do not provide a clear pathway to the level of reduction required to meet Australia's Paris commitments. The three principal policies to reduce emissions in the electricity sector are the Renewable Energy Target, the Emissions Reduction Fund and its Safeguard Mechanism, and the National Energy Productivity Plan.

The Renewable Energy Target is designed to achieve an increase in large-scale renewable energy generation to 2020 but not beyond. The policy also ends in 2030, meaning that projects commencing in 2020 will need to recover their capital costs over only a ten year period. While the Emissions Reduction Fund has encouraged land-sector abatement, projects seeking to improve the efficiency of electricity consumption are relatively few and small in scale. The Safeguard Mechanism is designed to prevent emissions reductions purchased under the Fund being offset by growth in emissions above business-as-usual levels elsewhere in the economy. At present, this policy is not calibrated to drive emissions reduction. The electricity sector's baseline under the Safeguard Mechanism is set at 198 million tonnes of CO_2-e (carbon dioxide equivalent) – well above the current level of emissions from the sector of 178 million tonnes of CO_2-e[21]. The National Energy Productivity Plan, developed by the COAG Energy Council, brings together a wide range of opportunities to achieve the National Energy Productivity Target, which aims to improve Australia's energy productivity by 40 per cent between now and 2030. This is expected to contribute to Australia's emissions reduction objective, though the extent to which this would be attributable to the electricity sector is uncertain.

The Australian Government's 2017 review of its climate policy settings is expected to clarify the electricity sector's role in helping meet the 2030 emissions reduction target, and the adjustments to policy that will achieve this. The 2017 climate policy review will build on this review into the security and reliability of the NEM.

The lack of clarity about emissions reduction policy beyond 2020 has been a major contributor to the current investment uncertainty in the electricity sector. Reducing emissions in the electricity sector and the need to replace the ageing coal and gas generation fleet will involve significant investment in long-lived assets. In order for businesses to invest in these assets with confidence, they need to be able to form long-term expectations from the investment signals they receive.

Australia has a mix of national policies to reduce emissions in the electricity sector.

The **Renewable Energy Target (RET)** provides a financial incentive for the deployment of renewable energy. It does this by creating a market for certificates that are created for each megawatt hour (MWh) of eligible renewable energy generated. Liable entities (such as electricity retailers) acquire these certificates to meet their annual renewable energy obligations imposed by legislation.

In 2011, to address the reduction in certificate prices driven by the rapid growth in rooftop solar, the RET was separated into two parts: the Large-scale Renewable Energy Target and the Small-scale Renewable Energy Scheme. By separating the certificate markets, large-scale and small-scale technologies no longer compete with each other[22].

The **Emissions Reduction Fund** is an economy-wide program in which the Government purchases abatement through a reverse auction. Abatement can be purchased from a wide variety of sectors, including energy efficiency. The Government has allocated $2.55 billion to purchase emissions reduction.

The Emissions Reduction Fund includes the **Safeguard Mechanism** which started in July 2016 and establishes a limit on emissions from facilities that emit more than 100,000 tonnes CO_2-e a year and report under the National Greenhouse and Energy Reporting Scheme. The Safeguard Mechanism covers all large non-renewable electricity generators. In general, emissions limits (baselines) for facilities are set at the highest level of emissions over the period FY2010 to FY2014. For the electricity sector, limits on individual facilities will not apply until the sector's emissions rise above a sectoral baseline of 198 million tonnes CO_2-e a year.

The **Australian Renewable Energy Agency** (ARENA) and the **Clean Energy Finance Corporation** (CEFC) provide support to clean energy technologies. ARENA provides financial assistance for research into, and the development and deployment of, renewable energy technologies. The CEFC makes commercial loans in energy efficiency and low emissions technologies.

21. http://www.cleanenergyregulator.gov.au/NGER/National%20greenhouse%20and%20energy%20reporting%20data/electricity-sector-emissions-and-generation-data/electricity-sector-emissions-and-generation-data-2014-15, accessed on 1 December 2016.

22. Climate Change Authority, *Renewable Energy Target Review-Final Report*, 2012, p.6.

THE IMPORTANCE OF PREDICTABILITY AND POLICY STABILITY

For businesses to take risks on the future and invest, they need to be confident that emissions reduction policies and the mechanisms to achieve them are consistent with Australia's international commitments and will not change drastically in the future. Because of the long-term nature of electricity sector investments, investment confidence depends strongly on long-term policy signals.

The lack of predictability in the electricity sector creates uncertainty around which generation and network assets investors should either invest in or divest from. If businesses do not invest when needed, this will impact on the security and reliability of electricity supply.

There is evidence that investment in the electricity sector has stalled and investors have become less responsive to investment signals. This is due to policy instability and uncertainty driven by numerous reviews into the RET and a lack of clarity about the policies to reduce emissions after 2020. Investment in renewable energy dropped by 52 per cent between 2013 and 2014[23] and has not yet recovered to the level required to satisfy the Renewable Energy Target. Large-scale generation certificates (LGCs) are now trading close to the effective price cap of $93, which is based on the non-tax deductable shortfall charge of $65 payable by retailers if they fail to surrender sufficient certificates. Spot prices were around $89 per megawatt hour on average over October 2016 and forward prices for 2017 and 2018 are at similar levels. This is around twice the price of LGCs between 2010 and 2015 (see Figure 3.2[24]) and is higher than the amount theoretically required to make renewable generation competitive.

High LGC prices will ultimately lead to higher electricity prices for consumers. Further, the hiatus in investment has now created a risk that the target may not be met on time. If the target is not met, some retailers will be unable to acquire sufficient LGCs and will pay the shortfall charge. In other words, part of the higher cost passed through to consumers would be for renewable energy that is not generated. This would undermine both emissions reduction and affordability objectives.

Figure 3.2: Spot prices for large-scale generation certificates

23. Bloomberg New Energy Finance data, 2016.

24. Mercari Energy data, 2016.

THE IMPORTANCE OF INTEGRATING ENERGY AND EMISSIONS REDUCTION POLICIES

For both system security and affordability reasons, it is important that governments ensure energy and emissions reduction policies are integrated. The energy system needs to be able to adapt to changes in technology and in supply and demand that are stimulated by emissions reduction policies. Emissions reduction policies that are aligned with the operation of the electricity system will better support efficient investment decisions by consumers and in generation and network assets.

At the request of the COAG Energy Council, the AEMC[25] and AEMO[26] assessed a range of potential emissions reduction policies and their impact on wholesale markets, consumer prices and energy security. This work is particularly relevant to the Review because it has been prepared by institutions with responsibility for the promotion of reliable and secure energy markets. They assessed:

1. An **emissions intensity scheme**. An emissions intensity baseline is established for the generation sector. Power stations generating electricity above the baseline are required to purchase credits, while less emissions intensive power stations receive credits, which they can sell.
2. An **extended Large-scale Renewable Energy Target** (LRET). The target for the LRET is extended to 86,000 GWh by 2030.
3. **Regulated closure of fossil-fuelled power stations**. A regulatory policy mechanism to close the number of fossil-fuelled power stations needed to reach the emissions reduction target.

The AEMC and AEMO found that of the three policies assessed, an emissions intensity scheme best integrated with the electricity market's pricing and risk management framework, had the lowest economic costs and the lowest impact on electricity prices. AEMC and AEMO also found that an emissions intensity scheme had the least impact on system security whereas the extended LRET had the most impact. This is because the extended LRET was expected to create the highest share of non synchronous generation with a resulting loss in system inertia, if not otherwise compensated for. They found that an emissions intensity scheme is lower cost than the extended LRET because it can access broader emissions reduction options. According to the modelling, gas fired generation would play an important role, increasing to around 30 per cent of the generation mix by 2030 and 23 per cent under a scenario with assumed higher gas prices.

The regulated closure policy had a slightly higher economic cost than the emissions intensity scheme. However, the regulated closure policy had the largest impact on electricity prices. This is because as coal plants are retired, supply of low cost power is reduced which puts upward pressure on wholesale prices. The AEMC also noted that a regulated closure policy that involved payments to generators to close down may create a barrier to exit. This is because generators might no longer respond to price signals in the market, but instead wait for payment signals from the government.

Nonetheless, a challenge for the sector will be reducing emissions in a manner that recognises the lumpy nature of capital investment. Large power stations cannot be installed in small increments. As such, if the removal of a large power station occurs within a timeframe that does not allow replacement capacity to be installed, system security will be compromised.

The Climate Change Authority recently assessed[27] potential emissions reduction policies in the electricity sector. These policies included market mechanisms such as the emissions intensity scheme, technology pull policies such as the RET and regulation-based policies such as mandatory closure of high emissions generators. The

25. Australian Energy Market Commission, *Final Report: Integration of Energy and Emissions Reduction Policy*, 2016.
26. Australian Energy Market Operator, *Advice on the Integration of Energy and Climate Policy: AEMO Stage Two Report*, 2016.
27. Climate Change Authority, *Policy Options for Australia's Electricity Supply Sector: Special Review Research Report*, 2016.

Climate Change Authority found that market mechanisms had the lowest average cost of abatement. Of the market mechanisms modelled, the emissions intensity scheme had the lowest impact on average residential electricity prices.

CONSULTATION QUESTIONS

The world is acting to reduce greenhouse gas emissions. Australia has a target to reduce emissions by 26 to 28 per cent below 2005 levels by 2030. The electricity sector has an important role to play in achieving Australia's emissions reduction targets. Not only is it Australia's largest source of emissions, but also a large source of opportunity for abatement and innovation. This will require stable and effective emissions reduction policies to support the necessary investment in long-lived generation and network assets while maintaining security and reliability.

3.1 What role should the electricity sector play in meeting Australia's greenhouse gas reduction targets?

3.2 What is the role for natural gas in reducing greenhouse gas emissions in the electricity sector?

3.3 What are the barriers to investment in the electricity sector?

3.4 What are the key elements of an emissions reduction policy to support investor confidence and a transition to a low emissions system?

3.5 What is the role for low emissions coal technologies, such as ultra-supercritical combustion?

Chapter 4:

Integration of Variable Renewable Electricity

Until recently, the fundamentals of electricity generation in Australia had not changed for over a century. Synchronous generation through coal, gas and hydro provided a reliable and secure supply of electricity.

Today, variable renewable electricity (VRE) generation, particularly from wind and solar PV, has become a significant contributor to the generation mix. Its efficiency continues to evolve and its cost continues to decline. But wind and solar PV generators need to be carefully integrated into our power system. This is because they lack spinning inertia and the inherent ability to contribute to instantaneous or medium-term security and frequency control. Also, VRE generators cannot provide a system restart capability. The increasing penetration of wind and solar PV generators creates a need to develop new effective processes for integrating them into the NEM, along with any other future sources of VRE or related technology.

Australia's Large-scale Renewable Energy Target requires an estimated 6,000 megawatts (MW) of new renewable power stations to be built by 2020, which is likely to consist of approximately 75 per cent wind and 25 per cent solar[28]. This represents a doubling of the total renewable capacity installed since 2001[29]. The Small-scale Renewable Energy Scheme will continue to incentivise rooftop solar PV for households and small and medium businesses. State and territory governments have also introduced policies and schemes to increase renewable energy generation. Moreover, Australia's international commitment to reduce emissions by 26 to 28 per cent below 2005 levels by 2030 will require greater levels of low emissions and renewable generation.

Coal-fired power stations continue to provide the majority of Australia's electricity generation (see Figure 3.1). But reduced total electricity demand, increased competition from renewable energy generation, volatility of wholesale prices, investor concerns over long-term viability and the high maintenance costs of older power stations have led to a number of coal-fired generators being withdrawn from the market. Nine coal-fired power stations have closed since FY2012, representing around 3,600 MW of installed capacity[30]. In addition, it has recently been announced that the 1,600 MW Hazelwood Power Station in Victoria will close by 31 March 2017[31].

One characteristic of wind and solar PV generators is their intermittency. As a result, their capacity to deliver electricity is lower than that of a coal-fired power station of an equivalent size – for wind by approximately half, and for utility-scale solar PV, by approximately a quarter[32]. When assessing the reliability of electricity supply, this difference in 'capacity factor' is taken into account.

28. Clean Energy Regulator, *Renewable Energy Target Administrative Report and Annual Statement*, 2015, p.68.

29. Ernst & Young, *Meeting the Renewable Energy Target: Innovative approaches to financing renewables in Australia*, 2016, p.4.

30. Australian Energy Regulator, *State of the Energy Market 2015*, p.38.

31. AEMO, Update to the *2016 Electricity Statement of Opportunities*, p.1.

32. Derived from http://www.nrel.gov/analysis/tech_cap_factor.html, accessed on 5 December 2016.

DECLINE OF TRADITIONAL GENERATION CREATES TECHNICAL CHALLENGES

As synchronous generators (such as coal, gas and hydro) are increasingly displaced by non-synchronous generators (such as wind and solar PV), the fundamental operational characteristics of the power system are being challenged. To maintain power system security, parameters such as system inertia, transient security, fault levels, instantaneous load and generation balance, instantaneous reactive power balance, frequency and system voltage need to be controlled within narrow ranges to avoid major disruptions to power supply.

Frequency control (including under extreme power system conditions) is a particularly high priority challenge.

Frequency is a measure of the instantaneous balance of power supply and demand. To avoid damage to or failure of the power system the frequency may only deviate within a narrow range below or above 50 Hertz, as prescribed in the frequency operating standards for the NEM.

AEMO uses a number of mechanisms, including careful matching of supply and demand, and frequency control ancillary services, to help maintain frequency within its prescribed range. In response to regular minor imbalances between power supply and demand, frequency is automatically and continually corrected using regulation frequency control ancillary services.

From time to time the power system may experience a large disruption known as a contingency event. This will cause a more significant imbalance between power supply and demand (and can produce rapid changes in frequency – measured as the rate of change of frequency).

Where a contingency event is deemed reasonably possible ('credible'), AEMO procures contingency frequency control ancillary services to correct the frequency. Under abnormal conditions, such as severe weather, AEMO can apply criteria to determine whether there is a credible contingency event. However, where there is a non-credible contingency event, the rules do not enable AEMO to procure frequency control ancillary services to correct the frequency, or take pre-emptive action to minimise the possible change in frequency.

Synchronous generators have inertia because of their large rotating mass. The important contribution from inertia is to mitigate the immediate impact of a disturbance of the power system – the spinning mass of the generator resists the change of frequency on the grid during the disturbance. As the transition to more non-synchronous and intermittent generation progresses and the physical inertia in the power system reduces, higher rates of change of frequency are challenging the effectiveness of existing frequency control mechanisms. For instance, at very high rates of change of frequency, AEMO needs to rely on emergency frequency control schemes, such as load shedding – however, these schemes might not operate quickly enough to prevent a widespread disruption to power supply[33].

Additionally, as synchronous generators are increasingly displaced by non-synchronous generators, the level of frequency control ancillary services provided inherently by these generators will need to be acquired from other sources (such as wind turbines fitted with synthetic inertia controllers, batteries with power conversion electronics, or spinning motors known as synchronous condensers). These sources have not participated in the frequency control ancillary services market to date, and it is uncertain whether this is due to a technical or regulatory barrier[34].

While frequency control ancillary services (including inertia) can normally be supplied across regional boundaries via high voltage alternating current interconnectors, it is also important that they are available within individual regions or sub-regions in the event of becoming separated from the NEM (islanded). This is particularly the case for regions that can more easily become islanded, such as South Australia, Tasmania and Queensland.

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33. AEMO, *Future Power System Security Program Progress Report*, 2016, p.21.
34. AEMO, *Future Power System Security Program Progress Report.*, 2016, p.25.

Another high priority challenge associated with the displacement of synchronous generators by non-synchronous generators is that of reduced system strength. System strength is a characteristic of a power system that is defined by how localised sections of the system react in the event of a fault (an abnormal flow of electrical current, such as a short circuit). Synchronous generators supply larger fault currents than non-synchronous generators and contribute more to system strength by helping protection systems to clear faults quickly[35]. Currently the rules do not contain any requirements or responsibilities around system strength, on either a local or a system-wide basis[36].

INTERCONNECTION: GETTING THE BALANCE RIGHT

Power system security and reliability can be improved by investing in new network assets to allow connected regions to access more firm installed capacity across the NEM. All five regions of the NEM are connected by high voltage transmission lines known as interconnectors. These interconnectors provide normal supplies to allow trading between regions and backup capacity when needed.

With growing VRE generation, it may be necessary to invest in new and upgraded interconnectors. The benefits of this for power system security and reliability need to be weighed up against the added cost to consumers. Recent analysis of potential solutions to the technical challenges posed by high renewable integration in South Australia found that some proposed interconnector options could be effective in addressing a range of technical issues, but they are either very expensive or have long lead times, or both[37].

The COAG Energy Council has convened a review of the Regulatory Investment Test for Transmission (RIT-T) that applies to investments in new electricity transmission assets in the NEM, such as interconnectors. The review will assess whether the test remains effective and where appropriate recommend improvements. A report is due to the COAG Energy Council in December 2016.

GAS HAS A CRITICAL ROLE TO PLAY

Open cycle gas-fired generators are well placed to provide support for VRE generators due to their synchronous nature and rapid ramp up and ramp down capability. However, Australia's east coast gas market has undergone profound change in recent years with the expansion of our liquefied natural gas (LNG) export industry. Domestic gas prices have risen considerably due to tight supply (see Chapter 6). Against this backdrop several gas-fired generators have been less available and at higher prices, some have been withdrawn in recent years after becoming uneconomical, and several more are scheduled to be withdrawn over the next seven years[38]. A reduction in gas-fired generation capacity has implications for the security and reliability of the power system, due to the loss of its contribution to ancillary services and its ability to be rapidly dispatched to meet increases in demand or shortfalls in supply. These services are especially important at times of peak demand and low or fluctuating renewable generation.

DISTRIBUTED ENERGY RESOURCES

The growing number of distributed energy resources could also impact on power system security. They are not centrally controlled or visible to AEMO and there is currently no formal national framework for collecting information on them (such as their location, date of installation, controller settings, brand, model and real-time energy statistics). This means that power system models and forecasts are less accurate than in the past,

35. AEMO, *Future Power System Security Program Progress Report*, 2016, p.45.
36. AEMO, *Future Power System Security Program Progress Report*., 2016, p.46.
37. Australian Energy Council, *South Australia: Pioneering Australia's Energy Transformation*, 2016, p.3.
38. Australian Energy Regulator, *State of the Energy Market 2015*, pp.38,102.

particularly when the output from distributed energy resources is high and fluctuating. This compromises AEMO's ability to balance instantaneous and medium term power supply and demand. This situation will become even more challenging as energy storage is implemented.

To ensure the security and reliability of the NEM, it is critical that innovative solutions are found to better facilitate the integration of distributed energy resources, and to provide effective management of the two-way electricity flows between distribution networks and the wholesale market. This involves the development of forecasting and control techniques that provide AEMO and network operators with timely information and the potential to better manage outcomes. It may also include establishing an incentives framework to encourage consumers to use, store, or export energy at appropriate times (see Chapter 6 for discussion of incentives frameworks such as cost reflective tariffs).

EMERGING CHALLENGES

The challenges of maintaining power system security and reliability as discussed above have begun to materialise, as evidenced by recent events in Tasmania and South Australia.

1. Tasmania is often reliant on the Basslink interconnector from Victoria to bolster its power supply. While the interconnector was originally intended for Tasmania to export hydro power to mainland Australia, since commencing commercial operation in 2006 it has also been used to import power at times of diminished hydro generation capacity (such as during periods of drought).

   In December 2015 Basslink's undersea cable developed a fault, and repair work was not completed until mid-June 2016. During the extended outage, water storages were low and Tasmania could not generate sufficient hydro power to meet its needs. It was necessary to restart a closed gas-fired power station and commission emergency diesel generators. Major industrial electricity users also entered into load reduction arrangements.

   In response to the outage, on 28 April 2016, the Australian Government launched a feasibility study to investigate whether a second interconnector could improve Tasmania's energy security. The timeline for completion of the study has been extended to January 2017. The Tasmanian Government has established a separate independent Tasmanian Energy Security Taskforce.

   The Basslink outage highlights the challenge for Tasmania and other states of managing reliability with only a lengthy 'thin' connection between separate electricity markets. This is different from many other electricity markets around the world that have extensive interconnection. There is a risk of over-reliance on other states through interconnection rather than ensuring a balanced local portfolio of generation types.

2. South Australia is particularly affected by the power system security challenges described above. It has a much higher penetration of wind and solar PV generators than other regions in the NEM and has seen a succession of closures of synchronous generators.

   As the generation mix changes in a similar way across the NEM, over time these risks may impact the security of all five NEM regions. This is particularly the case if a region becomes separated from the NEM and must rely on its own resources to manage power system security – as is the case for South Australia, being at the 'end of the grid'.

   There had been forewarnings of the possibility of a blackout in South Australia in the event of its separation from the NEM[39], and this circumstance eventuated in September 2016. This is discussed further in the case study below.

39. AEMO, *Electricity Statement of Opportunities 2016*, p.4.

The case of South Australia highlights the need to advance new technical solutions, through appropriate regulatory and market frameworks, to support power system security. While the September 2016 blackout was not directly triggered by an increased presence of renewable energy, the response of the power system demonstrated its reliance on services traditionally provided by synchronous generators, and a failure to fully integrate new non-synchronous technologies (e.g. there was an incomplete understanding of the fault ride-through response of wind farms).

THERE ARE TECHNICAL SOLUTIONS, WHICH MUST BE EXPEDITED

There are technical solutions to increase grid security and reliability. For example, these may include:

- Synchronous condensers. These are spinning synchronous motors whose shafts are not connected to a mechanical load. They consume very little real energy (machine losses), and in addition to providing inertia, they can generate or absorb reactive power to help to stabilise the system voltage and supply fault current contributions to the network. They can be purchased as new, or reconfigured from decommissioned synchronous generators. For example, at Huntington Beach in California two natural gas-fired generator units (which had been closed since 1995) were converted into synchronous condensers in 2013[40].
- Synthetic inertia. New controllers are available that will transiently convert the non-synchronous mechanical inertia of a wind turbine into 'synthetic inertia'. These are compulsory, for example, for all new wind turbines installed in Québec, Canada[41].
- Power conversion systems. These allow the stored energy in large batteries to be used for a variety of power system tasks including the synthesis of inertia, reactive power control and system restart. Battery connected power conversion facilities are currently being installed in England and Wales.
- Fast interruption of loads to correct demand and supply imbalances.

Solutions could be implemented through a mix of market mechanisms and regulatory requirements. Further analysis, such as cost-benefit analysis, is needed to identify optimal solutions and implementation frameworks. It may be, for instance, that there should be appropriate underlying technical design and standards, over which a market can then provide the least cost solutions.

GENERATOR CONNECTION STANDARDS

All generators that are connected to the power system are required to meet certain connection standards set by the relevant jurisdiction. The behaviour of synchronous generators is determined by electromechanical design and is well understood by the participants in the industry. In contrast, the behaviour of VRE generators that use electronic power converters is determined by their software settings and pose a greater challenge to power system operators.

While wind and solar PV generators have different inherent behaviour, the power conversion electronics in their control circuits can be configured to provide desired behaviours. These can include:

- Fault ride-through. For power system stability, it is important that generators continue operating during a fault. Wind generators (and other non-synchronous power electronic devices) need to use control systems to invoke a 'ride-through response' when a fault is detected. A lack of detailed specifications regarding fault ride-through for wind generators can pose a threat to system security, as was seen in the South Australian blackout.

40. http://www.powermag.com/aes-uses-synchronous-condensers-for-grid-balancing/?pagenum=1, accessed on 25 November 2016.

41. http://spectrum.ieee.org/energywise/energy/renewables/can-synthetic-inertia-stabilize-power-grids, accessed on 5 December 2016.

- Inertial response. In some international jurisdictions all wind turbines connecting to the grid are required to have synthetic inertia controllers (as described above), but this is not the case in Australia.
- Primary frequency regulation, voltage and reactive power control and regulation, active power and ramping rate control and short-circuit current control.

Not having adequate connection standards for VRE generators can pose a threat to grid security and reliability as the proportion of VRE increases across the NEM.

WORK UNDERWAY

AEMO's Future Power System Security Program has identified broad areas of technical challenges. These include high priority challenges of frequency control (including under extreme power system conditions), reduced system strength, the impact of distributed energy resources as described above, and some lower priority challenges, including the adequacy of system restart services and cybersecurity. To illustrate the challenges faced regarding cybersecurity, it is noteworthy that in FY2016 the energy sector had the highest number of cybersecurity incidents as reported to CERT Australia[42].

In parallel with the AEMO work, the AEMC is undertaking a review into the market and regulatory frameworks that affect system security in the NEM – the System Security Market Frameworks Review. It will identify the changes to market and regulatory frameworks that will be required to deliver solutions identified under the Future Power System Security Program in relation to the challenges of frequency control and reduced system strength. An interim report is due to the COAG Energy Council by the end of 2016[43].

42. Australian Cyber Security Centre, Threat Report 2016, pp.14-15.

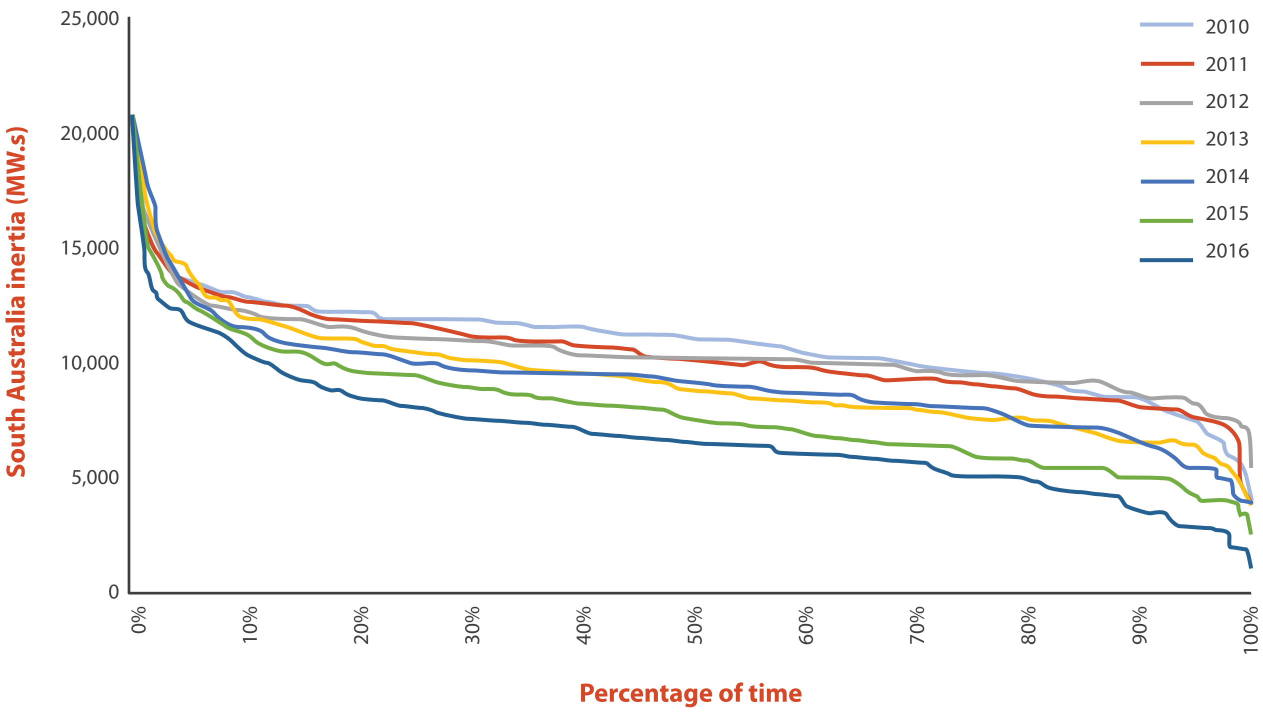
43. AEMC, System Security Market Frameworks Review Consultation Paper, 2016, pp.3-4.

Case Study:

South Australian Blackout

Over the last few years, VRE generation has increased rapidly in South Australia, which now has almost 1,600 MW of installed wind capacity and 700 MW of installed solar PV capacity in addition to almost 2,900 MW of gas-fired capacity. As a region, South Australia has a peak demand of around 3,300 MW. It has one the highest proportions of renewable generation in the world. South Australia is connected to the rest of the NEM by two interconnectors to Victoria. The Heywood AC interconnector has a capacity of 600 MW (being upgraded to 650 MW) and the Murraylink DC interconnector has a capacity of 220 MW. South Australian demand has not grown recently, and so there has been a reduction in the electricity provided by conventional synchronous generation as well as a withdrawal of synchronous generation capacity. One consequence of this is a reduction in system inertia, as shown in Figure 4.1[44].

Figure 4.1: Reducing system inertia in South Australia (as a percent of total operating time)



A SUMMARY OF THE BLACK SYSTEM EVENT

On Wednesday 28 September 2016 at 4:18 PM electricity supply to South Australia was lost across the entire state disrupting supply to about 850,000 electricity customers. The 'black system event' formally concluded at 6:25 PM the next day, although some customers still remained without power supply due to residual network faults[45]. The South Australian market remained suspended until 11 October, with AEMO implementing some special procedures to manage power system security. The primary sources for this summary are AEMO's Preliminary Report published on 5 October 2016 and Update Report published on 19 October 2016.

44. Data courtesy of AEMO, *Market Trends and Outlooks in Australia's Electricity Markets,* 2016, p.4.

45. AEMO, *Preliminary Report – Black System Event in South Australia on 28 September 2016*, p.20.

On the morning of 28 September AEMO assessed forecast severe weather, including destructive winds, as increasing the risk to power system failure. However, as there are no transmission lines in SA classified as 'vulnerable', AEMO did not consider this warranted a reclassification of the possibility of the loss of a transmission line as a 'credible contingency event'. AEMO has the ability to re-classify non-credible contingencies as credible when the power system is forecast to be in an 'abnormal state', with the most common reasons being severe weather, lightning in vulnerable areas and bushfires. This is a manual process, and requires AEMO to publish a justification report after the event. AEMO considered whether to reclassify these contingencies as credible, but based on forecasts at the time and the known vulnerabilities of the area, decided not to place additional constraints on the power system.

Before the black system event South Australia had a total of 1,826 MW of electricity demand, of which 883 MW was being supplied from wind farms, 330 MW from gas-fired generators and 613 MW was being imported from the Heywood and Murraylink interconnectors with Victoria[46]. The Heywood Interconnector was importing 525 MW of power, out of its operating limit of 600 MW.

The circumstances leading to the black system event were triggered by the severe weather conditions, including at least seven tornadoes[47]. The severe weather has been linked to five faults and six voltage dips on three transmission lines over a period of about 90 seconds[48]. While not yet known conclusively, it is likely that the faults were due to short circuits in the transmission lines, as a result of lightning strikes and structural damage to transmission towers from high winds.

At the time of the power system faults 13 wind farms were in operation. Eleven wind farms observed voltage dips and initially invoked their fault ride-through responses – but nine of those wind farms subsequently exceeded a pre-set limit for the number of ride-through responses in a two minute period (the other two wind farms had a higher pre-set limit, which was not exceeded). Upon exceeding the pre-set limit the nine wind farms disconnected or cut their output.

This reduction in wind farm generation resulted in a compensating increase in the power flow on the Heywood Interconnector to the point that it overloaded and was disconnected by its protection systems. At this point, grid frequency and voltage collapsed and there was a loss of power supply to the whole of South Australia.

The capability to restart the electricity grid after a blackout (System Restart Ancillary Service) is provided by contracted generators, which can restart without power from the grid and provide power to the transmission network and other generating units. However, the two contracted System Restart Ancillary Service participants in South Australia experienced unexplained failures (despite each having successfully demonstrated its restart capability to AEMO during routine performance tests earlier in 2016)[49]. Restoration of power supply began once the Heywood Interconnector was reconnected and used to assist the Torrens Island Power Station to restart its generating units.

Since the black system event, a number of actions have been taken to manage power system security in the near term, including:

- On 4 October 2016, the South Australian Government directed AEMO under the *Electricity (General) Regulations 2012* (SA) to operate the power system more conservatively in order to limit the rate of change of frequency to less than three Hertz per second in the event that the Heywood interconnector was to fail. This is in addition to the rule change request submitted in July 2016 for AEMO to be granted additional powers to manage rate of change of frequency.

46. AEMO, *Preliminary Report – Black System Event in South Australia on 28 September 2016*, p.8.

47. Bureau of Meteorology, *Severe thunderstorm and tornado outbreak South Australia 28 September 2016*, 2016, p.1.

48. AEMO, *Preliminary Report – Black System Event in South Australia on 28 September 2016*, p.7; Update Report – Black System Event in South Australia on 28 September 2016, p.14.

49. AEMO, *Update Report – Black System Event in South Australia on 28 September 2016*, p.28.

- Since then, five wind farms had reconfigured their control systems in relation to their fault ride-through settings. AEMO is also working with wind farms across the NEM to determine if this problem is more widespread.

Investigations by various agencies into this event are ongoing. A detailed report from AEMO might not be complete until April 2017. Meanwhile, the Australian Energy Regulator is investigating any breaches or possible breaches of the national energy laws, having the following primary areas of focus:

- Pre-event actions of the market operator (AEMO) and transmission network operator (ElectraNet);
- Technical issues that contributed to the event, including the fault ride-through settings of wind farms and the role of protection and control systems;
- Issues experienced with contracted System Restart Ancillary Service providers; and
- The extended period of market suspension and directions to participants regarding power system security.

CONSULTATION QUESTIONS

The closure of coal-fired generators and their replacement with wind and solar PV generators has technical implications for the security and reliability of the power system. This is because wind and solar PV generators lack spinning inertia and the ability to contribute to medium and long-term frequency control, reactive power control, system voltage control, and system restart. Gas-fired generators can help address technical challenges, but there has been a reduction in gas-fired generation capacity. Work is underway on implementing technical and market solutions to increase grid security and reliability.

4.1 What immediate actions could be taken to reduce the emerging risks around grid security and reliability with respect to frequency control, reduced system strength, or distributed energy resources?

4.2 Should the level of variable renewable electricity generation be curtailed in each region until new measures to ensure grid security are implemented?

4.3 Is there a need to introduce new planning and technical frameworks to complement current market operations?

4.3.1 Should there be new rules for generator connection and disconnections?

4.3.2 Should all generators be required to provide system security services or should such services continue to be procured separately by the power system operator?

4.4 What role can new technologies located on consumers' premises have in improving energy security and reliability outcomes?

4.4.1 How can the regulatory framework best enable and incentivise the efficient orchestration of distributed energy resources?

4.5 What other non-market focus areas, such as cybersecurity, are priorities for power system security?

4.6 How could high speed communications and sensor technology be deployed to better detect and mitigate grid problems?

4.7 Should the rules for AEMO to elevate a situation from non-credible to credible be revised?

Chapter 5:

Market Design to Support Security and Reliability

The design of the NEM has significant implications for achieving security and reliability objectives in the context of the transition taking place in the electricity sector.

The NEM relies on price signals and market information to incentivise investment. If the price signals do not bring forward appropriate investments, this has significant implications for reliability and security. In this context, a key question is whether the balance of incentives within the NEM is bringing forward generation capacity that supports security and reliability outcomes.

The Renewable Energy Target is incentivising investment in variable renewable electricity (VRE) generation. VRE generators are not currently configured to provide ancillary services that help the system to operate within its technical limits. This is occurring at a time when grid demand has declined and is forecast to be flat for the foreseeable future. Increased penetration of VRE generators is pushing thermal generators, which provide synchronous inertia, out of the market. This is creating security and reliability challenges.

Reform is required to ensure the NEM provides incentives for efficient investments to achieve reliable and secure supply. The nature and extent of the reforms required needs to be considered.

WHOLESALE MARKET DESIGN

The NEM is designed as an energy-only market in which generators are paid for selling electricity. They are not paid for keeping generation capacity available in case it is required to meet demand, as occurs in capacity markets. In FY2015, 194 TWh of electricity with a traded value of around $8.3 billion was delivered to consumers through the NEM, at an average price of $43/MWh.

In the NEM there is limited scope to direct the market towards particular investment outcomes. The NEM relies on price signals (subject to market price caps and floors), performance standards and market information to incentivise the development and retirement of generation infrastructure. When there is sufficient baseload supply, average prices tend to be low, signalling that no new investment in base load generation is needed. When base load supply tightens, average prices increase, signalling that investment in base load generation is needed. Peaking generators respond to similar patterns but look to higher price periods associated with peak demand.

Bidding in the NEM – how does it work?

AEMO operates the NEM. Generators bid (offer) a quantity of electricity available for purchase into a central pool administered by AEMO. Those bidding into the market are chosen for dispatch in price order up to the quantity required to balance demand. The price of the marginal generator – the highest price generator needed to meet demand – sets the dispatch price every five minutes. The dispatch prices are averaged over half hour trading intervals to determine the settlement price. All dispatched generators receive the settlement price for each 30 minute trading interval, irrespective of their bid price.

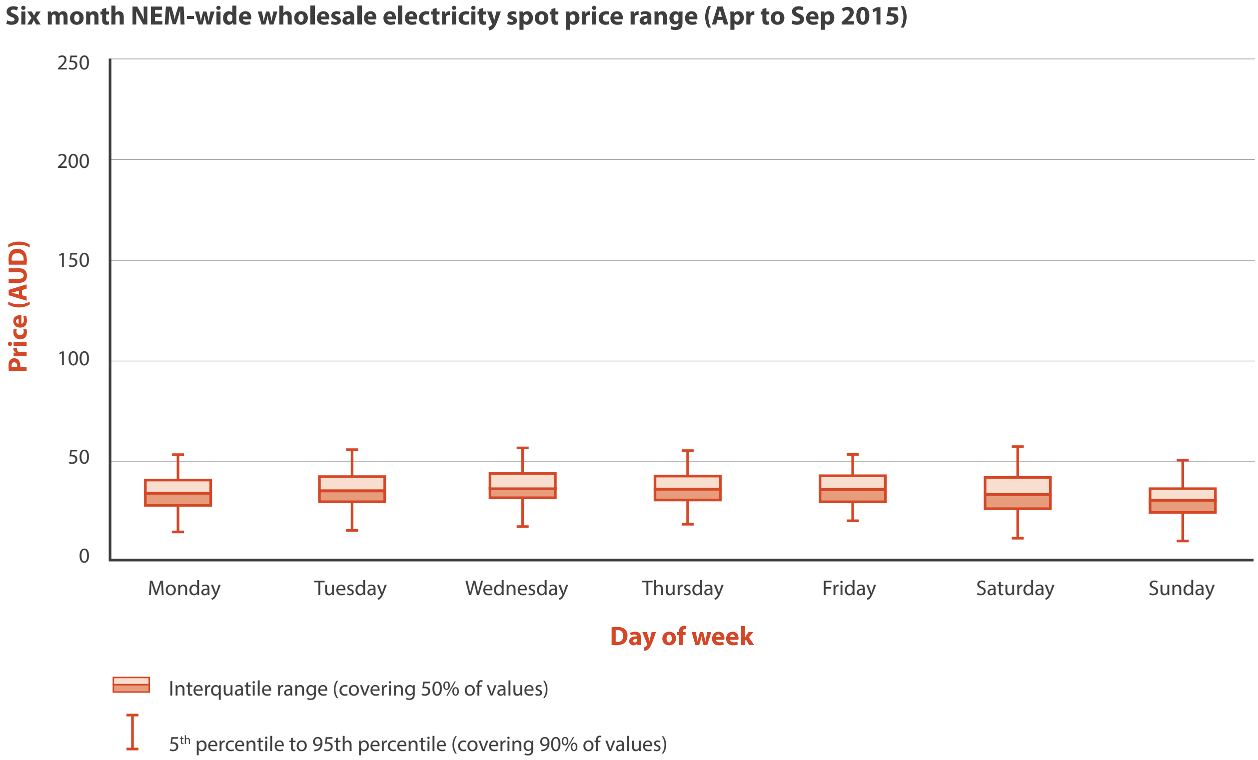
Price volatility is an important feature of the wholesale market. As prices are often set at the marginal cash cost of the lower cost generators, periods of high prices are essential for generators to recover their fixed and capital costs, including finance costs. Generators that are unable to recover their costs will operate at a loss and eventually exit the market. Analysis of wholesale market prices has shown a widening price range in recent years (Figure 5.1[50]).

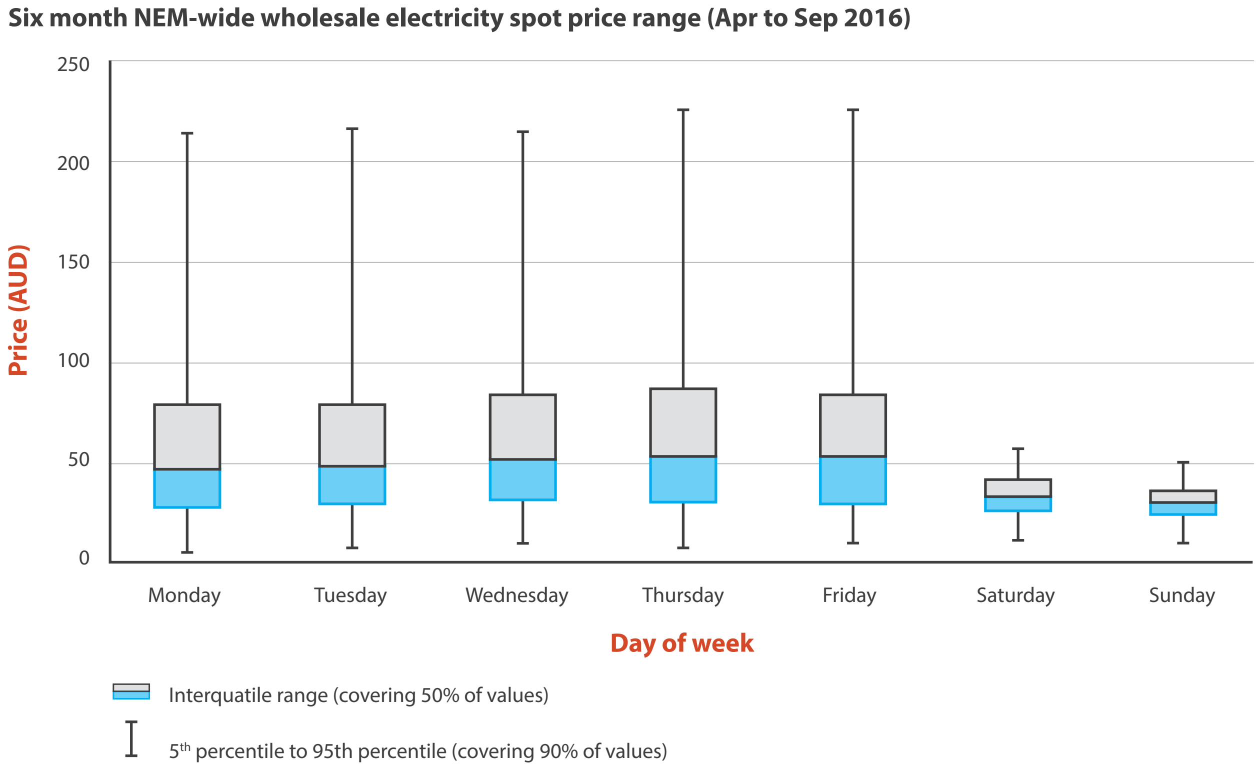
Thermal generation is being dispatched less as a result of declining demand and competition from other generators, particularly wind and solar PV, which have short-run marginal costs close to zero (wind and sunshine are free). As a result, wind and solar supress wholesale prices when they are producing. They rely on subsidies under the Renewable Energy Target through the sale of large-scale generation certificates to make up their fixed costs.

Wind and solar are disrupting the business models of thermal generators but are not currently configured to replace the ancillary services thermal generators provide. Technical integration solutions are available that enable this challenge to be overcome. Thermal generators are still needed to ensure reliability and security of supply, but they are becoming more reliant on revenue from high prices during a smaller number of hours.

50. AEMO, *Market Management System Data*, 2016.

Figure 5.1: Comparison of 2015 and 2016 NEM-wide winter wholesale electricity prices by day of the week





ENSURING RELIABILITY OF SUPPLY

Within the wholesale market, the primary risks to the reliable supply of electricity to consumers arise from:

- underinvestment in generation capacity and maintenance; and
- an inability of market participants to manage wholesale market price risks, such as high prices over a trading period or over a sustained period.

The National Electricity Rules include mechanisms to manage the effects of price volatility and the risks it presents for reliable supply. These include a reliability standard, price cap, cumulative price threshold and floor price. An administered price cap applies in the event that the cumulative price threshold is reached. These mechanisms are intended to achieve generation reliability requirements by incentivising investment in generation capacity without allowing prices to increase to such a level that financial risks cannot be managed by other market participants, particularly retailers. These mechanisms have contributed to delivering reliable electricity supply, albeit in a context of declining electricity demand. The reliability standard has only been breached twice, during a January 2009 heatwave that affected Victoria and South Australia[51].

NEM Reliability Measures and Settings

The **reliability standard** currently requires that no more than 0.002 per cent of customer demand within a region (11 minutes per year) be unserved as a result of a shortage of generation capacity once demand-side response and imports from other regions are taken into account.

The **market price cap** enables the market to achieve prices that support the efficient operation of the market and provide signals for efficient investment while providing a degree of protection from high prices for market participants. In FY2017, the price cap is set at $14,000/MWh.

The **market floor price** promotes electricity trade when demand is low while providing protection from the instability that would be caused by excessively negative prices. In FY2017, the floor price is set at -$1,000/MWh.

The **cumulative price threshold** places a limit on the exposure market participants have to high wholesale market prices in a rolling seven-day period. It also ensures the price cap remains effective while allowing the market to send efficient price signals to incentivise sufficient investment to meet the reliability standard. In FY2017, the cumulative price threshold is set at $210,100, which is an average price of $1,250/MWh during the seven-day period.

The **administered price cap** of $300/MWh limits exposure to what would otherwise be extremely high prices after the cumulative price threshold is reached, while maintaining incentives for electricity supply.[52]

As the market transitions, it will be important that AEMO has an appropriate set of mechanisms at its disposal so it can operate the market effectively. As renewable energy penetration increases, it may be necessary to reconsider the level at which the NEM's reliability mechanisms are set. The settings need to be at a level that reflects the value consumers place on reliability and support investment in generation when it is needed, but prevent excessive prices when there are constraints on supply. The AEMC Reliability Panel is currently undertaking a review of its reliability standard and settings guidelines to ensure future decisions are consistent with the National Electricity Objective (NEO) and adequately reflect the cost of providing reliability and the value consumers place on reliability.

51. AER, *State of the Energy Market 2015*, p.59.

52. Australian Energy Market Commission (AEMC), *Draft Guidelines: Review of Reliability Standard and Settings Guidelines*, October 2016, p. 1-2.

ELECTRICITY FINANCIAL MARKETS

Electricity financial markets support the wholesale market and help to maintain reliability of supply. Financial markets enable energy market participants to hedge the financial risks arising from price volatility in the wholesale market, including generators looking to secure a return on their assets and retailers or large consumers seeking price certainty. In turn, this protects consumers from the effects of price volatility. In FY2015, 534 TWh of electricity was traded on financial markets. The face value of Australian Securities Exchange electricity trades in FY2015 was $16 billion or 446 TWh of traded electricity. The remaining 88 TWh was traded in bilateral over the counter contracts[53].

Financial markets need sufficient liquidity to operate effectively. As thermal generation exits the market, liquidity in the contract market may become a problem. This is because market participants are less likely to enter long term contracts for electricity generation that is variable. This may put upward pressure on the overall cost of electricity or limit the availability of retail offers.

Some South Australian commercial and industrial consumers have reported to the Review that retailers are not prepared to offer them supply contracts. This is consistent with a lack of liquidity in contract markets, making it difficult for retailers to effectively manage their risks.

SECURITY OF SUPPLY AND THE VALUE OF ANCILLARY SERVICES

The price of electricity in the NEM does not distinguish between sources of electricity or the contribution those sources make to the security and reliability of the system as a whole. The wholesale price for a megawatt hour of electricity is the same regardless of whether its source is dispatchable or variable, synchronous or non-synchronous, close to the load or remote from it. This means generators' primary investment incentive is aligned with the reliability standard, but not with the security needs of the network. This is partially addressed through the creation of ancillary service markets.

The NEM has several ancillary service markets to support network security. These enable generators to earn income for providing some ancillary services that ensure the network operates in accordance with its technical specifications and can be restarted after a blackout. At present, the NEM has three categories of ancillary service markets that operate when there is an identified need, such as where a contingency event is deemed credible. The categories are:

- Frequency Control Ancillary Services;
- Network Support & Control Ancillary Services that control active and reactive power flow in the network; and
- System Restart Ancillary Services.

The revenue generators currently earn for providing ancillary services is small compared to revenue from electricity sales. In 2015, the total value of ancillary services purchased in the NEM was $112 million, being 1.4 per cent of the $8.3 billion traded on the NEM.

The need to integrate large volumes of VRE generation has stimulated discussion about whether the ancillary services are appropriately valued and whether additional types of ancillary services are required. For example, as part of its System Security Market Frameworks Review, the AEMC is considering changes to market and regulatory frameworks to support the provision of additional system security services, including mechanisms to purchase system security services, such as inertia, on a competitive basis. Some stakeholders also believe there is a need for very fast response (<6 seconds) Frequency Control Ancillary Services markets.

53. Australian Financial Management Association, *Australian Financial Markets Report 2015*, p.16.

When all regions of the NEM were dominated by synchronous generators that inherently provided frequency and voltage control as part of their normal operation, the value of ancillary services was low. As the penetration of VRE generators has increased and synchronous generators have exited the market, the intrinsic availability of ancillary services has decreased. Over time, this will cause the value of ancillary services to rise, thereby providing a stronger investment incentive for those generators or non-generator technology operators that can provide them. Already the total value of Frequency Control Ancillary Services has risen from $30 million in 2010 to $63.2 million in 2015[54]. Whether ancillary services markets will provide adequate incentives for investments that support the network is unknown, but if they do not other approaches will need to be considered.

CAPACITY MARKETS

Most electricity markets globally include some form of mechanism to direct investment towards maintaining security and reliability, such as prescribed reserve margins, capacity payments or a combination of these measures (Table 5.1).

Table 5.1: Comparison of Energy Market Designs

Options	Used	Characteristics
Energy only.	Texas, Alberta, **Australia (NEM)**, Nord Pool (North east Europe), Ontario.	Energy spot market, high price caps, reserves not enforced, secondary financial hedging. Alberta has announced that it will move away from an energy only market.
Energy only with administered capacity payments.	Argentina, Chile, Colombia, Peru, Spain, South Korea, Ireland.	Central determined capacity payments supplement energy revenues.
Energy with a requirement to cover reserve margin.	Southwest Power Pool, California, some Canadian markets.	Reserve satisfied through bilateral contracts, reserve monitored but no central market.
Energy with reserve requirements, central capacity market.	**Australia (Wholesale Electricity Market in WA)**, PJM Interconnection, New England Independent System Operator, New York Independent System Operator, Midcontinent Independent System Operator, Brazil, UK (new), Ireland (new), Italy.	Administered capacity market, centralised capacity market, auction. WEM capacity requirement is met by bilateral contracts, in practice the capacity market has not been run.

Source: AEMO

Under a capacity market, the market operator bids for capacity based on estimated future demand and capacity requirements. Participating generators receive payments for being available, regardless of how much they ultimately generate. Unlike energy-only markets, the investment signal comes from the operator, instead of the market. Some stakeholders have suggested that a shift towards a market with capacity payments for certain services is required. For example, AGL has submitted a rule change request to the AEMC to introduce an 'Inertia Ancillary Services' market to the NEM[55].

54. AEMO, *Guide to Ancillary Services in the National Electricity Market*, 2015, p.15, and AEMO, Public Billing Ancillary Services Payment Report 2015, courtesy AEMO Information and Support Hub.

55. AGL, letter to AEMC proposing a rule change, 24 June 2016, p. 1, at http://www.aemc.gov.au/getattachment/bacba344-8989-4107-ae2a-480427c9c9f9/Rule-change-request.aspx accessed 7 December 2016.

Designing and operating capacity markets can be challenging. It requires operators to predict future electricity demand. Projections can therefore result in under or overinvestment in generation capacity. Overinvestment can increase the prices paid by consumers. In addition, capacity markets can limit innovation in the event that all options to meet supply, including demand response, are not considered consistently.

CONSULTATION QUESTIONS

The design of the NEM has significant implications for maintaining security and reliability objectives in the context of the transition taking place in the electricity sector. It is critical that the design of the NEM provides appropriate incentives for efficient investments that achieve secure and reliable electricity supply.

5.1 Are the reliability settings in the NEM adequate?

5.2 Is liquidity in the forward contract market for electricity adequate for the needs of commercial and industrial consumers and, if not, what can be done?

5.3 Are commercial and industrial users experiencing difficulties in obtaining quotes for supply?

5.4 What impact will an increasing level of renewable generation have on the forward contract market and what new products might be required?

5.5 Rule changes are in process to make the bid interval and the settlement interval the same, both equal to 5 minutes. Are there reasons to set them to a longer or shorter duration?

5.6 What additional system security services such as inertia, as is currently being considered by the AEMC, should be procured through a market mechanism?

- 5.6.1 How can system security services be used as 'bankable' revenue over a sufficient period of time to allow project finance to be forthcoming?

- 5.6.2 How will generators and retailers mitigate price risk in such a market?

Chapter 6:

Prices Have Risen Substantially

Australians should pay no more than necessary for a secure, reliable and low emissions electricity supply. Electricity is an essential service and price rises affect all consumers – industrial, commercial and household. The least well off in our community, in particular, struggle to cope with electricity price rises. Affordability must be carefully considered in developing new measures to meet security and reliability.

Traditionally, Australians have enjoyed very low electricity prices by OECD standards. This is no longer the case. Over the five years to FY2013, Australian electricity prices rose by around 10 per cent annually driven primarily by network investments[56]. Figure 6.1[57] provides a comparison of average Australian household electricity prices with those in other OECD countries. Comparisons are provided on both a market exchange rate and purchasing power parity basis. Purchase power parities are the currency conversion rates that equalise the purchasing power of different countries by eliminating differences in price levels between countries. The OECD average is weighted by consumption to account for different market sizes. Figure 6.1 shows that Australia's electricity

Figure 6.1: OECD household electricity prices 2015

56. Australian Energy Regulator, *State of the Energy Market 2015*, p. 134; (note: this reflects inflation-adjusted prices)

57. International Energy Agency, *Energy Prices and Taxes* 2016.

prices are now above the OECD average but when purchasing power is accounted for, they are still below most other countries. Price rises have moderated in recent years but are now expected to begin rising again in the next three years in most states and territories because of increases in the wholesale price driven by generator closures, gas supply constraints and international parity gas prices. This will place further financial pressure on consumers and undermine the competitiveness of Australia's economy.

The electricity prices that consumers actually pay are made up of a number of components:

- wholesale electricity charges;
- network charges (transmission and distribution); and
- retail charges, including the cost of compliance with the RET.

WHOLESALE ELECTRICITY COSTS AND THEIR GROWING DEPENDENCE ON GAS PRICES

Over the next three years, increases in residential electricity prices are likely to be driven by an increase in the wholesale price after a long period in which prices were suppressed by a large excess of supply over demand. This change is caused by the retirement of two large coal-fired generators – Northern in South Australia in May 2016, and Hazelwood in Victoria in March 2017. Rising wholesale gas prices will also affect wholesale electricity prices. This is particularly the case where gas generation sets the wholesale price, as it often now does in South Australia. As traditional generators leave the market, liquidity in electricity financial markets may become a problem, also putting upward pressure on the overall cost of generation.

Gas has the potential to smooth the transition to a lower emissions electricity sector. Gas generation provides the synchronous operation that is key to maintaining technical operability with increased renewable generation until new technologies are available and cost-effective. Furthermore, gas is dispatchable when required.

The role of gas in the NEM's future generation mix is complicated by events in both domestic and international gas markets. Australia's east coast gas market was previously quarantined from international markets, but in recent years has transformed into a major liquefied natural gas (LNG) export industry with prices dependent upon international oil prices.

Domestic gas prices have risen considerably and become more volatile due to being dependent on the international price, in conjunction with a tight supply-demand balance and rising costs for the development of new reserves. System security and retail prices are both negatively impacted by the recent increases in gas prices and constraints in gas supply.

Additional gas supplies for electricity generation are needed urgently. Reviews by the Australian Competition and Consumer Commission and the AEMC have identified a range of issues affecting gas market competitiveness. The COAG Energy Council is currently implementing a package of reforms. However, even after they are implemented there will still be uncertainty as to whether sufficient gas will be available to meet future domestic demand. This is due to supplies being diverted to meet international LNG supply contracts, low levels of exploration and forecast production, restrictions on onshore exploration and development in some states and territories, and infrastructure constraints[58]. Tighter gas supply translates to higher gas prices.

Most consumers are not directly exposed to the wholesale electricity markets and these cost pressures. Nevertheless, increased wholesale prices due to the generator retirements and higher gas prices will inevitably flow through to higher retail prices for consumers.

58. Australian Competition and Consumer Commission (ACCC), *Inquiry into the East Coast Gas Market 2016*, p.2.

The cost of policies, such as the Renewable Energy Target and premium feed-in-tariffs, are included in all electricity bills. In FY2015 the cost of these policies represented around 6.2 per cent of the average household bill[59].

NETWORK CHARGES

On average, network charges accounted for 43 per cent of residential electricity prices in FY2015, although the exact share varies between different states and territories. Of this amount, transmission network charges accounted for 7 per cent and distribution network charges accounted for 36 per cent[60].

Increased network charges were the main driver of recent electricity price rises[61]. The Australian Energy Regulator (AER) estimated network operating revenues over the five-year regulatory cycle from 2008 to 2012 at $60 billion – a 30 per cent increase on the cycle before that. This increase was required to replace aging assets, meet stricter reliability and bushfire standards and augment the grid to cope with forecast increases in peak demand that in fact never eventuated. The 2013 Productivity Commission inquiry into electricity network regulation found that the price rises were also "partly driven by inefficiencies in the industry and flaws in the regulatory environment". It recommended:

- modified reliability requirements to promote efficiency
- improved demand management
- more efficient planning of large transmission investments
- changes to state regulatory arrangements and network business ownership.[62]

The AER Regulatory determinations made since 2012 have allowed for network investment levels that are on average 25 per cent lower than levels in previous periods[63].

Economic regulation of networks

Transmission and distribution networks are natural monopolies – they are capital intensive and their average costs decline as their output increases. Network business are subject to economic regulation by the AER, who determines the amount of revenue that network businesses can recover from consumers. It aims to provide efficient outcomes for consumers and adequate returns on investment for network businesses.

Widespread community concern about the scale of electricity price rises led the COAG Energy Council's predecessor, the Standing Council on Energy and Resources, to recommend changes to the economic regulatory framework to improve the strength and capacity of the AER to determine network revenue increases, so consumers do not pay more than necessary.

The COAG Energy Council is currently undertaking a review of the Limited Merits Review regime, the process by which the AER network revenue determinations can be reviewed by the Australian Competition Tribunal. Reviews of 25 network revenue determinations between June 2008 and June 2013 increased network revenues by around $3.3 billion[64]. Across the 12 AER decisions which have been the subject of review since 2013, the total additional revenue requested has been of the order of $7.3 billion[65]. The findings of this review will be presented to the COAG Energy Council in December 2016.

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59. AEMC, *Residential Electricity Price Trends*, 2015, p.212.
60. AER, *State of the Energy Market 2015*, p. 132.
61. AER, *State of the Energy Market 2015*, p.133.
62. Productivity Commission, *Electricity Network Regulatory Frameworks - Inquiry report*, 2013, p.2.
63. AER, *State of the Energy Market 2015*, p. 6.
64. AER, *State of the Energy Market 2013*, p. 12.
65. Internal calculations from the Department of the Environment and Energy, 2016.

Reliability standards

Networks are required to meet reliability standards determined by individual states and territories. For example, state governments in New South Wales and Queensland increased distribution network reliability standards in the mid-2000s following a series of blackouts. This change in standards resulted in a significant decrease in outages, but came at a cost to consumers, highlighting the difficulty in achieving balanced network investment that meets security and reliability, and affordability objectives.

In its 2013 Inquiry Report, the Productivity Commission found that reliability standards were set at higher levels than consumers actually value. It recommended that reliability standards should be set against an examination of the costs that consumers are willing to pay, rather than by prescriptive standards[66]. A review by the AEMC found that consumers value reliability highly but a significant proportion would be willing to accept slightly lower reliability outcomes in return for the cost savings that would result[67].

Australia's networks are built to be capable of delivering power to consumers during periods of peak demand, even though this level is reached on fewer than five days each year, generally when air conditioning load spikes. Network investments are made ahead of forecast increases in peak demand to ensure reliability standards are met. The demand forecasts on which network investments from FY2008 to FY2013 were made assumed peak demand would continue to rise, but it did not. Instead, demand reduced as consumers responded to higher prices and policy incentives by improving energy efficiency, reducing consumption and installing rooftop solar.

Peak demand and cost reflective pricing

Preventing increases in peak demand is critical if network driven price rises are to be avoided in future. Cost reflective pricing has been proposed as an efficient method of reducing peak demand. Cost reflective pricing involves charging prices that accurately reflect the cost of providing network services to different consumer groups. This will result in consumers paying for network services according to their peak usage and will provide a financial incentive for consumers to shift their demand, which should reduce the overall size of the peak (see Chapter 2). From 2017 onwards, there will be national requirements for distribution network businesses to ensure that prices are more cost reflective. However, distribution network businesses are also required to comply with any jurisdictional requirements, which may slow implementation. For example, some jurisdictions are introducing cost reflective pricing on an opt in basis only.

The AEMC has estimated that cost reflective pricing will result in up to 80 per cent of consumers having lower network charges in the medium term[68]. Analysis by Energeia estimates that there are net economic benefits of $1.8 billion by moving to an opt-out basis from 2021, with an average reduction in network bills of 9.6 per cent by 2026 compared to continuing with an opt-in approach[69]. However, even without cost reflective pricing consumers have responded to investment signals by increasing energy efficiency and by installing rooftop solar and, more recently, batteries. It is possible that this consumer-initiated action will reduce the size of the peak network demand irrespective of cost reflective pricing.

RETAIL

Since the 2005 Australian Energy Market Agreement, states and territories have been progressively introducing full retail contestability and removing price regulation. Competition is intended to yield efficiencies in the operation of energy businesses and enable the introduction of new technologies and services for consumers. However, it is difficult to get full transparency of the drivers of retail prices.

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66. Productivity Commission, *Electricity Network Regulatory Frameworks - Inquiry report*, 2013, p.2.

67. AEMC, *Review of distribution reliability outcomes and standards – NSW workstream*, 2012, pp.51-52.

68. AEMC, *New rules for cost reflective network prices*,27 November 2014, http://www.aemc.gov.au/News-Center/What-s-New/Announcements/New-rules-for-cost-reflective-network-prices, accessed 5 December 2016.

69. Energeia, *Network Pricing and Incentives Reform* prepared for the Energy Networks Association and CSIRO, 2016, p.7.

Retailer operating costs include:

- electricity costs.
- risk management costs – retailers use hedge contracts to protect their customers to exposure from volatile wholesale market prices.
- billing, customer service, connections, hardship policies, the costs of managing bad debts, the costs of managing financial contracts and the costs of meeting jurisdictional obligations.
- marketing and customer acquisition and retention costs.
- a return on investment.

There is very little public information available about retailer operating costs and margins across the industry or how much they contribute to retail prices. For example, the AER's 2015 State of the Energy Market Report aggregates wholesale and retail costs[70], while the AEMC's 2015 Residential Electricity Price Trends report uses a residual method and does not report retail costs separately[71].

The Victorian Government recently commissioned a Review of Electricity and Gas Retail Markets in Victoria in response to recent reports that Victorian retailers may have some of the highest electricity margins in the NEM, particularly for consumers on standing offers. The Review will examine the operation of Victorian retail markets and provide options to improve outcomes for consumers.

TRANSPARENCY

Transparency is important for the efficient operation of all markets. Policy makers need high level outcomes statistics in order to evaluate the impact of policy decisions. The technical operator may benefit from access to a complete flow of real time data in order to understand and manage the security status of the grid. The market operator needs access to generator data and fuel supply data in order to ensure the market is operating fairly.

To make efficient business decisions, investors and operators need to understand the market dynamics and regulatory settings. Of particular importance to businesses are the levels of supply and demand and the factors that determine those levels. These include the prices businesses are likely to receive in the market, the level of competition, the liquidity of the market, and the regulatory settings that constrain or promote supply or demand. Businesses that have a good understanding of how the market is operating can make informed investment decisions. This will support the security and reliability of electricity supply and minimise the impact on electricity prices.

For these reasons it is important to consider whether the NEM could benefit from greater transparency.

COMPETITION AND NEW TECHNOLOGY

The widespread rollout of enabling technologies, such as digital meters, is considered to be important if the potential benefits to consumers through retail competition are to be realised. Market and regulatory frameworks that allow consumers to take full advantage of their consumption data and provide incentives for efficient investment by consumers in demand side technologies will also be critical.

Policy makers will need to closely monitor the evolution of competition to ensure that it delivers the anticipated benefits to consumers. The AER has recently published new national distribution ring fencing guidelines that require distribution network businesses to separate the part of their business that provides regulated services from that part of their business or related entities that provide other services in order to avoid cross

70. AER, *State of the Energy Market 2015*, p.132.

71. AEMC, *2015 Residential Electricity Price Trends*, p.43.

subsidisation, the misuse of information or discriminatory behaviour. The AEMC has recently received two requests for rule changes to promote greater contestability of energy services and clarify the boundary between services that are regulated and services that should be provided through competitive markets.

CONSULTATION QUESTIONS

Australians have experienced rising electricity prices in recent years. Affordability must be an important consideration as the regulatory framework seeks to also meet the objectives of energy security and reduced emissions. Where new measures are proposed to meet security and reliability objectives, it is critical that the potential impact on affordability is minimised and any trade-off between the objectives is transparent and reflects the long term interests of consumers. This will require attention to the costs associated with each element of the NEM: distribution and transmission networks, wholesale electricity generation, and electricity retail.

The Panel is considering a number of issues regarding electricity prices and affordability:

6.1 What additional mechanisms, if any, could be implemented to improve the supply of natural gas for electricity generation?

6.2 What are the alternatives to building network infrastructure to service peak demand?

6.3 What are the benefits of cost reflective prices, and could the benefits be achieved by other means?

6.4 How can we ensure that competitive retail markets are working?

  6.4.1 What outcomes of competition should we monitor?

Chapter 7:

Energy Market Governance is Critical

Governance matters. Effective energy market governance is essential for managing the transition that is currently underway.

Strategic policy leadership is urgently required to resolve the tensions that currently exist between energy and emissions reduction policies. A failure to advance reform of the NEM, to improve the resilience of the system and better integrate renewables, will heighten the risk of repeated events like the blackout in South Australia, to the detriment of energy consumers and the economy as a whole.

Sound governance arrangements will ensure that institutions accountable for managing the electricity system – the COAG Energy Council (policy-maker), the AEMC (rule-maker), AEMO (operator) and the AER (regulator) make best use of their experience, skills and expertise to address the complex set of challenges highlighted in this Preliminary Report. Similarly, Energy Consumers Australia, which was created by COAG in early 2015 to provide a national advocacy on matters of strategic importance to energy consumers, plays a role in helping governments to understand issues affecting the long-term interests of Australian consumers.

It is therefore important to identify any gaps in the governance framework, including whether the current arrangements can achieve a national approach to emissions and energy policy integration. Are the allocation of accountabilities and decision rights sufficiently clear? Are further changes needed to ensure the governance framework remains fit-for-purpose as technologies and consumer expectations transform the very nature of the electricity system?

WHOLE-OF-SYSTEM PERSPECTIVES

Our energy market institutions have key insights into the challenges facing the energy system, linked to their respective roles and responsibilities. While they work closely together on cross-cutting issues and directly advise energy ministers and officials on areas with respect to their responsibilities, the division of responsibilities between the institutions means no single entity provides a 'whole-of-system' perspective and advice to ministers, officials or the general public.

Whether or not a whole-of-system perspective is best achieved through multiple or single bodies is not so much the issue. The question is how we best achieve that perspective with the arrangements we have.

The division of responsibilities between rule-maker, operator and regulator has a sound rationale. But it does mean our system of governance needs to find ways of achieving a comprehensive understanding of challenges facing the sector by maximising insights across these bodies. Similarly, public understanding of the roles of our energy market institutions may not be as high as it is for other regulatory institutions.

This can be contrasted with other areas of economic regulation where the profile and responsibility of governance institutions is well understood. For example, there is clear understanding that the Australian Competition and Consumer Commission is responsible for competition and consumer protection regulation and enforcement; the Australian Securities and Investments Commission is Australia's corporate, markets and financial services regulator; the Australian Prudential Regulation Authority is the prudential regulator.

Public understanding of the roles and responsibilities of some institutions is always going to be higher than others. Given the prominence of energy issues for all consumers, it is, however, worth considering whether more can be done to highlight the roles and responsibilities of our energy institutions. This is particularly important when achieving a 'whole-of-system' perspective depends on the contributions of multiple bodies.

Governance bodies in the National Electricity Market

The **COAG Energy Council** is a Ministerial forum for the Commonwealth, States and Territory Governments to oversee national energy policy and law.

Three market bodies report to the COAG Energy Council:

- The **Australian Energy Market Operator** (AEMO) is 1) the system market operator of the NEM and 2) the power systems operator of the NEM. It also operates the Wholesale Electricity Market (WEM) and power system in Western Australia, the Victorian wholesale gas market and transmission system, various other gas markets and hubs, and it is the national transmission planner.
- The **Australian Energy Market Commission** (AEMC) is responsible for rule making and market development in respect of electricity and natural gas transmission and distribution networks, and retail markets other than retail pricing.
- The **Australian Energy Regulator** (AER) enforces the electricity and gas rules and is responsible for the economic regulation of electricity and gas transmission and distribution networks and retail markets other than retail pricing.

Although not a governance body *per se*, **Energy Consumers Australia** was established by the COAG Energy Council to promote the long-term interests of Australian energy consumers, particularly in the context of AER regulatory determinations. It provides advocacy on national energy market matters of importance for energy consumers, in particular household and small business consumers.

The **Clean Energy Regulator** is responsible for administering national schemes to measure and manage greenhouse gas emissions, including the National Greenhouse and Energy Reporting Scheme, the Emissions Reduction Fund, and the Renewable Energy Target. It is a portfolio agency of the Australian Government Department of the Environment and Energy.

The whole-of-system perspective is particularly important given the increasing interrelationship of energy and emissions reduction policy. There is, for example, no requirement or mechanism to ensure that emissions reduction and energy market policies operate together. Nor does the governance of the NEM draw on the expertise of the bodies responsible for advising on and implementing emissions reduction policy. Some policies to promote the uptake of renewable energy have had consequences, such as reduced system security, for the electricity market.

COAG ENERGY COUNCIL

The COAG Energy Council (the Council) is the primary decision making body for national energy legislation. The Council is supported by a Senior Council of Officials (SCO) comprised of officials from Commonwealth, State and Territory Government energy departments, some of which include Environment portfolios. An extensive work programme overseen by the Council and the SCO, working closely with the AEMC, AEMO and the AER, covers broad policy issues such as how to integrate emissions reduction and energy policies, gas market reform, tariff reform and ways to improve the Regulatory Investment Test for Transmission, through to technical rule changes and system security requirements (see Appendix C). Resources ministers and officials are also represented on the Council and SCO respectively.

In December 2015 the Council committed to a number of governance reforms to help lift the strategic focus of its deliberations and the work program of SCO, following the 2015 *Review of Governance Arrangements for Australian Energy Markets* (the 'Vertigan Governance Review'). The reforms include a commitment to better prioritisation of work, including an enhanced role for SCO in shaping and monitoring progress on the Council's policy agenda. There were also commitments to improve energy market body processes.

ACHIEVING A NATIONAL APPROACH

The Australian Energy Market Agreement (AEMA) establishes our energy market governance arrangements, agreed to by the Commonwealth and all State and Territory Governments in 2004 and last updated in 2013. It provides for shared ministerial oversight of national energy policy and law through the Council, chaired by the Commonwealth Energy Minister, and the establishment of the AEMC, AEMO and the AER.

The AEMA also provides for states and territories to make limited variations in the application of the national laws where they are generally consistent with the national objectives. Variations may be necessary to address specific state conditions but they also make it difficult to achieve a national approach to energy policy. A lack of a consistent approach might also act as a barrier to the integration of new technologies.

Differing, and at times inconsistent, approaches to renewable energy, as between the State, Territory and Commonwealth Governments, can add to costs and amplify investment uncertainty. Incentives in the national Renewable Energy Target combined with feed-in tariffs introduced by states and territories and declining costs drove a boom in small-scale solar installations and subsequent collapse in the certificate price due to oversupply. This created uncertainty in the industry and forced policy changes to correct the imbalance. Experiences such as this remind us of the potential problems caused by differing national and jurisdictional policies.

NATIONAL ELECTRICITY AND GAS OBJECTIVES

The National Electricity and Gas Laws establish a National Electricity Objective (NEO) and a National Gas Objective (NGO), respectively. These objectives guide the AEMC, AEMO and the AER in executing their respective responsibilities.

The **NEO** is:

> *to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to – price, quality, safety, reliability, and security of supply of electricity; and the reliability, safety and security of the national electricity system.*

The **NGO** has similar wording, in relation to gas.

Some stakeholders have suggested that the NEO be amended to include an environmental or emissions reduction objective. The Panel is interested in views on how that would be achieved, including with respect to the specific (statutory) responsibilities of energy market bodies. Keeping in mind the policy role of the Council, the Panel is also interested in the question of whether the AEMA should be similarly or alternatively amended to guide governments on the integration of energy and emissions reduction policy at a national level.

CONSULTATION QUESTIONS

Effective energy market governance is essential for managing the transition that is currently underway in Australia's energy market. The Review is considering whether the current institutional architecture can do this and support effective national coordination of energy policy.

7.1 Is there a need for greater whole-of-system advice and planning in Australia's energy markets?

7.1.1 If so, what are the most appropriate governance arrangement to support whole-of-system advice and planning?

7.1.2 Do the roles of ministers and energy market institutions need further clarification?

7.2 What lessons can be drawn from governance and regulation of other markets that would help inform the review?

7.3 How should the governance of the NEM be structured to ensure transparency, accountability and effective management across the electricity supply chain?

7.4 Are there sufficient outcome statistics for regulators and policy makers to assess the performance of the system?

7.5 What governance measures are required to support the integration of energy and emissions reduction policies?

7.5.1 Should the AEMA be amended?

7.5.2 Should the NEO be amended?

7.6 How can decision-making be appropriately expedited to keep up with the pace of change?

Appendix A:

International Energy Agency Country Comparisons

Electricity security issues arising from an increase in variable renewable electricity (VRE) generation can be addressed using best practices and lessons learnt from other markets in the world. This section draws out some of those lessons and is primarily based on material prepared for the Review by the International Energy Agency (IEA).

Several countries in Europe and North America are modernising their market design and regulatory framework to allow high shares of VRE generation while ensuring security of electricity supply.

New interconnectors and grid reinforcements to increase resilience are often useful for better integration of markets and renewables. Deploying large shares of VRE generation requires modernisation of technical network codes.

The September 2016 blackout in South Australia was mainly due to a storm. Electricity grids in other countries have faced similar problems, with a few examples being:

- France, which in December 1999 saw 3.4 million consumers without electricity after a cyclone.
- Eastern states of the United States, in October 2012 had 8 million consumers without electricity after Hurricane Sandy flooded the coastal regions of eastern United States.

Electricity grids are affected by extreme weather events and this is a bigger concern with the increase in the number of weather-dependent electricity generation sources such as wind and solar. Integration of large shares of VRE generation in Denmark, Ireland, Spain and Germany is being achieved without any detrimental impact on electricity security. The annual share of VRE generation in many systems around the world is forecast to increase considerably over the coming years. This could create a significant challenge for grid security but can be managed by implementing appropriate policy and regulatory frameworks:

According to the IEA key market design improvements in these countries include:

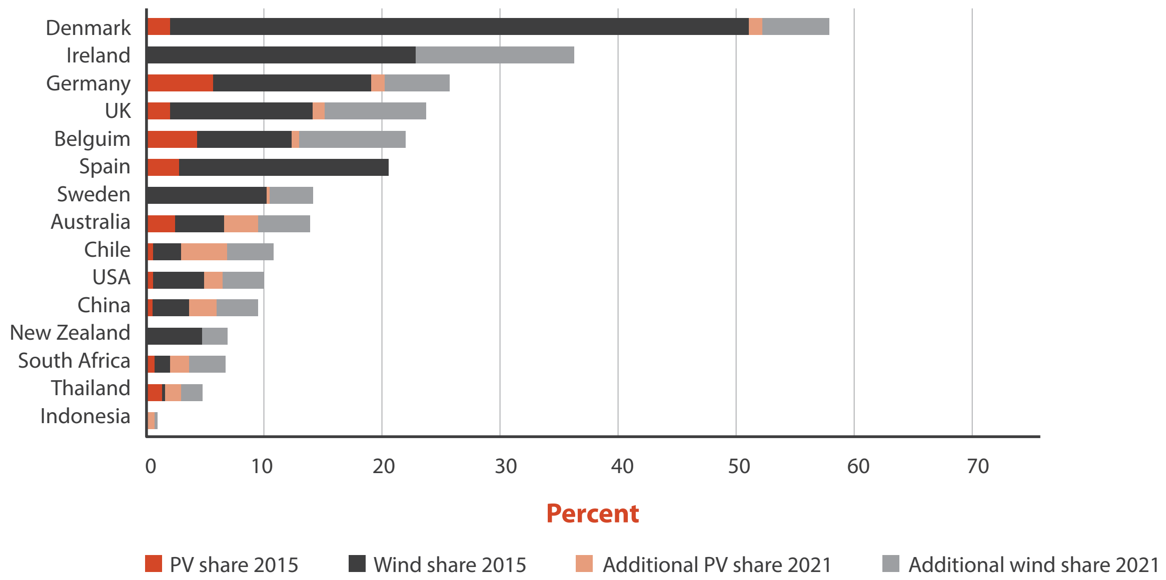
- increasing the temporal and geographical resolution of prices;
- improving the balancing and ancillary services markets; and
- scarcity price formation and better-designed capacity mechanisms.

Many of these markets are also working to develop appropriate distributed market platforms to better integrate fast-growing distributed energy resources such as rooftop solar, battery storage and other behind the meter resources and by improving coordination and communication between distribution and transmission networks.

Countries with large shares of VRE generation are:

- Denmark and Ireland. They on track to reach almost 60 per cent and 40 per cent share of VRE generation, respectively, by 2021.
- Germany, UK, Belgium and Spain. They are anticipating over 20 per cent share of VRE generation by 2021.

Figure 1: Annual share of VRE generation in selected power systems in 2015 and forecasts for 2021



Several countries as well as the Nordic market, the EU, Texas and New Zealand have demonstrated that it is possible to manage the challenge of integrating a rising share of VRE generation into their electricity networks.

The right set of policies to support the development and implementation of grid connection codes is essential for successful integration of VRE generators and for maintaining the security of the electricity system.

According to the IEA, with declining electricity demand and various incentives for renewable energy, most countries are seeing an increase in wind and solar installed capacity, which depresses wholesale electricity prices. This reduces the annual load factor of conventional electricity generators that are still needed to maintain system security and complement variable renewables.

The great challenge is designing markets that are fit for purpose for high shares of renewables. Achieving cost-effective and secure integration of VRE generators by transforming electricity systems requires better integration of VRE generators through the development of flexible technologies that provide dispatchable generation, improved grid infrastructure, storage and demand side management. Successful system transition involves:

- improving short-term system and market operations to ensure efficient dispatching and ensure security of electricity supply;
- ensuring resource adequacy in the longer term, including system-friendly VRE deployment to maximise the benefits of VRE and investment in additional flexible resources;
- better coordinating policies and actions across several jurisdictions on a regional basis; and
- tapping the potential of distributed resources to boost retail competition and supply security: micro generation, demand response, storage, behind the meter.

IMPROVED SYSTEM AND MARKET OPERATIONS

Denmark, Germany, Spain and Ireland have experience in operating power systems with high shares of VRE, which create operational challenges in power systems such as short-term flexibility, network congestion and system security. These challenges can be addressed through market and operational measures for example increasing the resolution of market design by increasing the number of technical constraints that are taken into account when the market is cleared.

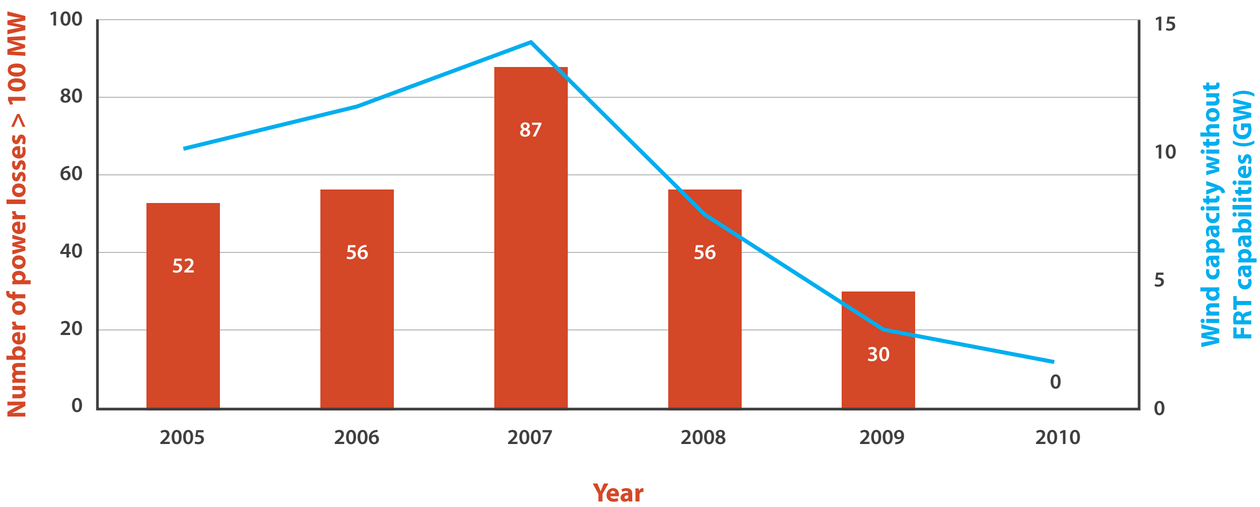
In small power systems low levels of synchronous inertia can lead to increased rates of change of frequency, which can be a challenge during contingency situations.

- Ireland manages this by limiting the combined share of wind power and HVDC interconnectors to 50 per cent of power demand for system security purpose. Work is underway to raise this limit to 75 per cent. UK has developed the system operability framework and from the findings established a new market for enhanced frequency response to mitigate the operational impact of lower levels of synchronous inertia.
- In the US, Independent System Operators (ISOs) and Regional Transmission Operators (RTOs) operate their systems with a high resolution, including five minute internal dispatching and a-nodal pricing, to help improve system operations.
- In Europe, the design of markets is much more decentralised, with day ahead and intraday markets playing a key role for market participants (particularly renewable generators) to compensate forecast errors close to real time.

Technical standards for generators connecting to the electricity network need to specify appropriate technical behaviour. As VRE use electronic power converters to connect to the grid, their behaviour is determined by the software settings of the power converter devices. VRE can thus provide higher flexibility in terms of how they behave on the system, but this requires well-designed technical standards.

With wind energy, the requirement to disconnect in the case of a fault following a short voltage dip was found to be a threat to system security in Europe about 10 years ago. This problem was due to the way it was configured to operate. By requiring fault ride through (FRT) capabilities from VRE power plants, this issue of single voltage dips has been since resolved, as shown by the Spanish example where occurrences of VRE generators disconnecting after a voltage dip have been reduced to zero (Figure 2).

Figure 2: Evolution of wind power capacity without FRT and number of power losses >100 MW by voltage sags in Spain



Note: FRT = fault ride through.

Source: Red Eléctrica de España.

ENSURING RESOURCE ADEQUACY: NETWORK INVESTMENTS AND CAPACITY MECHANISMS

Transmission grids and new interconnectors can be a cost-efficient alternative to investing in other resources when seeking to balance a system with high shares of wind and solar power.

- In Texas, ERCOT undertook a study to determine the most cost-effective transmission investments for delivering electricity from the renewable energy zones to the load centres. A plan to invest USD 4.93 billion in a number of 345 kV transmission lines was put in place allowing about 64 GWh of wind generation annually. This will help in removing capacity constraints and improving security.
- The European Union is promoting the development of international interconnectors in order to achieve an internal energy market and improve price convergence between countries.
- In Germany, the development of wind in the north, combined with the shutdown of generation facilities in the south has led to internal congestion. The German government has decided to build new underground (due to local opposition to overhead lines) HVDC transmission lines to increase capacity from north to south.

Conventional generation has been squeezed-out in several markets by declining demand and competition from wind and solar power. However this capacity is still needed to ensure adequacy. The need to continue decarbonisation is expected to continue having a depressing effect of wholesale prices and to exacerbate the issue of maintaining flexible conventional capacity in operation.

- Energy-only markets operate in a number of cases outside Australia, including New Zealand and ERCOT in Texas. The case of ERCOT is particularly relevant to Australia. In 2012 to 2014, the Public Utility Commission of Texas carried out a review of whether or not to introduce a capacity market. A majority of commissioners decided to keep an energy-only market and to improve scarcity price formation by introducing an Administrative Operating Reserve Demand Curve, which is a form of regulatory intervention on the price formation in case of capacity shortage.
- Nordic countries and the Netherlands have recently expressed their wish to rely on an energy-only market in the long run, by removing price caps on their energy markets and progressively abandoning the strategic reserves mechanisms that had been introduced in Sweden and Finland in the years 2004 to 2005.
- Germany is promoting a Power Market 2.0 that promotes free price formation on wholesale markets and competition for flexibility, and at the same time has introduced recently four different types of reserves (grid reserve, capacity reserve, grid security reserve and lignite reserve), to provide safety net and reduce emissions.
- New Zealand's government has implemented a suite of reforms to strengthen competition and security of supply in the electricity market following the Ministerial Review of 2010. The government has abolished the strategic reserve plant in favour of a penalty payment for all retailers in the form of a consumer compensation charge for an electricity shortage. In addition, the transmission system operator assessed potential future shortages and stimulated the conclusion of bilateral contracts among market participants to continue operations at the back-up plant (Huntly coal power plant).

Capacity mechanisms exist in all other markets in one form or another including PJM, NYISO, ISONE and MISO. In Europe, capacity mechanisms have been introduced recently in particular France, the UK and Italy, with the objective to secure new investments in a context of retirement of ageing capacity, and in France, to contribute to the development of demand response.

COORDINATION OF MULTIPLE JURISDICTIONS

Increased market integration requires increased coordination. Without a sound reliability framework and clearly defined roles and responsibilities, electricity security events can easily derail progress. Compared to the situation in the NEM, coordination between jurisdictions in Europe and North America is more complex.

- The North American Electricity Reliability Corporation (NERC) is responsible for defining and disseminating reliability standards across North America (including Canada and a small portion of Mexico). Within the US, the Federal Energy Regulatory Commission (FERC) is the national regulator. Its role, however, is limited to areas that relate to inter-state trade; FERC primarily has oversight over wholesale markets and transmission. States have control over their energy mix and decisions on unbundling, and markets remain fragmented. In some regions, ISOs and RTOs organise markets and manage system operations, often across multiple states. For instance: PJM serves a mixture of both vertically integrated and restructured utilities in 13 states plus the District of Columbia; MISO serves primarily vertically integrated utilities across 15 states. Utilities have some discretion on whether to participate in ISOs/RTOs, leading to further fragmentation at the state level.
- The situation in Europe is no less complex. The European Commission's efforts centre on the development of a common market, including an Internal Energy Market (IEM). There is no direct equivalent in the EU to FERC or NERC, though organisations such as the Agency for the Cooperation of Energy Regulators (ACER) and the European Network of Transmission System Operators for Electricity (ENTSO-E) do act as coordinating bodies and have some limited authority. While much work on the IEM has been done, Europe's fragmented nature – including differing national regulations, the authority each State retains over its own energy mix, and the large number of national transmission system operators – has slowed progress. Current efforts focus in large part on developing a European-wide balancing market. The EU, through ACER and ENTSO-E, is developing a set of network codes, including one on balancing, which should ensure a greater convergence of market designs.

Increasing penetration of distributed generation will require greater coordination at a local level, and better management of the interfaces between transmission and distribution grids and resources located behind the meter.

TAPPING THE POTENTIAL OF NEW DISTRIBUTED RESOURCES: MICRO GENERATION, DEMAND RESPONSE, STORAGE, BEHIND THE METER

The greater uptake of distributed VRE shifts the historic balance of supply and demand in the electricity network. This requires innovative approaches to the planning and operation of low-voltage and medium-voltage grids.

On the technical side, more dynamic and bi-directional flows of electricity (from lower to higher voltage levels and vice versa) require reinforced monitoring and control capabilities as well as upgrades to infrastructure. This also has consequences for the technical standards (grid codes) regulating small-scale solar PV systems. As a general trend, systems with high penetration of rooftop solar PV tend to impose technical requirements on these systems after a certain penetration level has been reached. On the financial side, there is a need to reform retail electricity pricing. Where citizens install their own solar PV systems behind the electricity meter, the design of retail tariffs becomes a critical lever to guide investment in and operation of distributed resources. In the past, consumers did not have a strong incentive to substitute grid-based electricity by generating their own power. The rise of distributed solar PV, combined with cost reductions in smart-home and battery technology, has begun to change this. However, the design of electricity tariffs is often based on the assumption that consumers have no alternative to the grid for obtaining their electricity. In a situation where consumers use their own solar PV generation such pricing arrangements may be rendered dysfunctional.

On the institutional side, the coordination of system operations between the transmission level and the distribution level becomes more relevant.

Demand response and small scale storage are important new sources of flexibility that are allowed to participate in electricity markets and can also enhance system security. CAISO, in California, allows participation of distributed resources and has introduced special tariffs for "Non-Generator Resources". FERC has recently approved rules allowing distributed resources to participate in other wholesale markets.

CONCLUSION

Electricity security issues raised by the transition of the electricity sector based on distributed resources and VRE can be addressed by implementing best practices in terms of network codes and by mobilising sufficient levels of power system flexibility.

Many countries are continuously improving their system operations and short-term market designs to make them fit for purpose for high shares of renewables. They are modernising their market frameworks to make power systems more flexible and ensure resource adequacy over time. In addition, sufficient levels of investments in system resources, including grid infrastructure, flexible generation, demand response and storage are required. A new balance between regulation and competitive markets might be needed to 'keep the lights on' at least cost.

Appendix B:

Terms of Reference

COAG
Energy Council

7 October 2016

BLUEPRINT FOR ENERGY SECURITY IN THE NATIONAL ELECTRICITY MARKET

INDEPENDENT REVIEW

The Australian electricity market is undergoing a significant transition, including due to rapid technological change, the increasing penetration of renewable energy, a more decentralised generation system, withdrawal of traditional baseload generation and changing consumer demand.

Energy security is the paramount responsibility of governments. Recent events have once again highlighted the importance of ensuring the security and reliability of the National Electricity Market (NEM).

The COAG Energy Council has initiated a number of processes and work programs to properly understand the causes of these specific events as well as to examine and advise on the broader issues facing the system due to the increasing penetration of intermittent generation. These include:

- Reviews into the South Australian 'system black' event by AEMO, AER and the AEMC
- Detailed analysis and reports by AEMO and the AEMC into future power system security and market frameworks
- Analysis by AEMO and the AEMC into the impact of carbon mitigation policies at both the Federal and State level on energy markets
- A review of governance arrangements (Vertigan review)
- National Gas market reforms which relate to NEM security, reliability and affordability; and
- A review of the appropriateness of existing regulatory arrangements for interconnector investment

In light of this body of work, the Australian Government's commitment at Paris and the integration of climate and energy policy at the federal level, it is timely for a wider process to take stock of the current state of the security, reliability and governance of the NEM and provide advice to governments on a coordinated, national reform blueprint.

Review purpose and scope

The purpose of the review is to develop a national reform blueprint to maintain energy security and reliability in the NEM, for consideration by the Council of Australian Governments through its Energy Council.

The review will draw together and build on the analysis and findings of the recent and ongoing work streams, as identified above. It will also consider any other matters and processes that may be relevant to system security and reliability.

The blueprint will outline national policy, legislative and rule changes required to maintain the security, reliability and affordability of the NEM in light of the transition taking place.

Consistent with the National Electricity Objective, the review will examine the costs and benefits, including to consumers and industry, of the options to address any current or future vulnerabilities identified in the NEM.

The report will be by chaired by Dr Alan Finkel AO, Commonwealth Chief Scientist, and supported by two deputies to be determined by Council.

It is envisaged a preliminary report will be prepared for the COAG Leaders' Meeting in December with a final report early in the new year.

Appendix C:

Current and Recent Reviews and Reforms

Work underway by government and market bodies	Scope	Targeted areas to date	Status
COAG Energy Council energy market transformation work program	Examine the regulatory frameworks needed to support the market transition being driven by new technologies, new patterns of demand and customer engagement, and new business models.	Micro-grids and standalone systems Energy battery storage Consumer protections Contestability and competition	Mixed. Most are slated for consultation for 2nd half of 2016
COAG Energy Council gas market reform package and the Vertigan review	Improve gas supply, market operation, gas transportation and market transparency. A key component of the reform package is the Vertigan review, which is examining whether a new test is needed for determining if a gas transportation pipeline should be subject to economic regulation.	Domestic gas	Mixed. Vertigan report on ACCC's recommendation on pipelines due to COAG Energy Council Dec 2016
COAG Energy Council Regulatory Investment Test for Transmission (RIT-T)	Assess whether the RIT-T remains appropriate in the changing energy market, with a particular focus on its application to interconnectors given their capacity to contribute to system resilience and security in the future.	New Transmission and interconnection investments above $6 million	Final report due to COAG Energy Council Dec 2016
COAG Energy Council Review of the Limited Merits Review regime	Assess the effectiveness of the LMR regime, including the role of the Australian Competition Tribunal.	Networks	Final report due to COAG Energy Council Dec 2016
COAG Energy Council National Energy Productivity Plan	Improve Australia's energy productivity by 40 per cent between 2015 and 2030, driving improvements in how households and businesses use energy in their homes, offices, and industrial facilities. This included a $2 million grant to Energy Consumers Australia to lead research on consumer decision making and how to make energy choices easier, and a $6 million grant to develop an Energy Use Data Model to support better forecasting and policy.	Consumers: covers all energy use and incorporates energy market reforms and energy efficiency measures that support better energy use in buildings, equipment and vehicles.	Ongoing. A report card is due to COAG Energy Council Dec 2016
COAG Energy Council's Review of Governance Arrangements (Vertigan Review)	Examine the broad energy market institutional structure (AEMO, AEMC, and AER) created by COAG as well as the legislative framework that establishes and assigns functions to institutions.	Governance	Completed in October 2015.

Work underway by government and market bodies	Scope	Targeted areas to date	Status
AEMC's Power of Choice Reforms	Enable consumers to make more informed choices about how they use energy services and provide incentives for network businesses to adopt alternatives to building poles and wires.	Cost reflective network tariffs, metering, demand management incentive scheme and innovation allowance for non-network options, Better information provision requirements on retailers and networks, ring-fencing, powers to AEMO for demand-side monitoring, shared market protocol between service providers and metering etc.	Progress is mixed. Cost reflective pricing and metering to begin in 2017
AEMC's System Security Market Frameworks Review	Consider the regulatory and market frameworks that may be necessary to support the increasing volume of renewable energy and enable the maintenance of power system security. The AEMC is working closely with AEMO on this review, which will also progress three recent rule change requests.	Generation: new markets for ancillary services and introduces new standards	Commenced in July 2016
AEMC's annual reporting on Electricity Network Economic Regulatory Framework Review	Conduct annual monitoring and reporting on the effectiveness of the economic regulatory framework for electricity networks in responding to increased uptake of decentralised energy supply.	Networks	Commenced in Aug 2016
AEMC's biennial reporting on drivers of change that impact transmission frameworks	Report on a series of drivers that could impact on future transmission and generation investment.	Transmission and generation	Commenced July 2016
AEMO's Future power systems security program	Address operational challenges arising from the changing generation mix in the electricity market, in particular to ensure efficient and adequate operational and market processes remain.	Generation	N/A
AER's proposed rule change request on replacement expenditure planning arrangements	Proposes extending the RIT-T process to also include all replacement network transmission infrastructure rather than just new network transmission infrastructure subject to the existing cost threshold.	Transmission	AEMC is investigating
Department of the Environment and Energy 2017 review of climate policies	Consider how to best calibrate emissions reduction policies beyond 2020, in close consultation with businesses and the community.	Climate	Due to commence in 2017

Work underway by government and market bodies	Scope	Targeted areas to date	Status
Department of the Environment and Energy and CSIRO Low Emissions Technology Roadmap	Identify opportunities and barriers to research, development and take-up of new and emerging technologies across Australia.	Generation, investment and technologies	Due early 2017
Australian Government's Feasibility Study	Undertake a feasibility study of whether a second electricity interconnector would help to address long-term energy security issues and facilitate investment in renewable energy.	Transmission and interconnection, renewable energy	Due early 2017
Tasmanian Government independent Energy Security Taskforce	Undertake an independent energy security risk assessment for Tasmania.		Final report due mid 2017
Productivity Commission's Inquiry into Electricity Network Regulation	Inform the Australian Government on the use of benchmarking of network businesses, provide advice on how benchmarking could deliver efficient outcomes, consistent with the National Electricity Objective (NEO) and examine if the regulatory regime is delivering efficient levels of interconnection to support the market.	Networks	Completed in 2013
Independent Review of the Renewable Energy Target	Australian Government commissioned review by an Expert Panel of the Renewable Energy Target.	Generation and investment	Completed in late 2014
Climate Change Authority's 2014 Review of the Renewable Energy Target	Review the renewable energy target in light of encouraging additional generation of electricity from renewable sources, reducing emissions of greenhouse gases in the electricity sector and ensuring that renewable energy sources are ecologically sustainable.	Generation and investment	Completed August 2014
Climate Change Authority, 2016, Policy Options for Australia's Electricity Supply Sector: Special Review Research Report	Special Review research report on policy options for Australia's electricity supply sector, drawing on analysis including commissioned economy-wide and electricity sector modelling to compare the performance of a range of possible electricity sector emissions reduction policies.	Climate	Released August 2016
Work underway by Industry	**Scope**	**Targeted areas to date**	**Status**
Energy Networks Association Transformation Roadmap (partnership with CSIRO)	Identify the preferred transition which the electricity network industry must make in the next decade, to support the evolving needs customer, innovate and develop new services, and foster resilience and efficiency.	Networks and consumers	Final report due early 2017

OPEN OR PENDING RULE CHANGES

Government or market body initiated	
COAG Energy Council	Contestability of energy services
AER	Replacement expenditure planning arrangements
AEMO	Generating system model guidelines
Industry initiated	
Australian Energy Council	Contestability of energy services
AGL	Inertia ancillary service market
Western Power	Alternatives to grid-supplied network services
Sun Metals Corporation	Five minute settlement
South Australian Government system security rule changes	
South Australian Minister for Mineral Resources and Energy	Managing power system fault levels
South Australian Minister for Mineral Resources and Energy	Managing the rate of change of power system frequency
South Australian Minister for Mineral Resources and Energy	Emergency frequency control schemes for generation
South Australian Minister for Mineral Resources and Energy	Emergency frequency control schemes for excess generation

Appendix D:

Estimated Operating Emissions for New Power Stations[72]

Generation type	Estimated operating emissions as generated[73] (kg CO_2-e/ MWh)
Subcritical brown coal	1,140
Supercritical brown coal	960
Subcritical black coal	940
Supercritical black coal	860
Ultra-supercritical brown coal	845
Ultra-supercritical black coal	700
Open cycle gas turbine (OCGT)	620
Combined cycle gas turbine (CCGT)	370
Wind	0
Hydro	0
Solar PV	0
NEM electricity grid emissions intensity	**820** [74]

72. Commonwealth, *A Cleaner Future for Power Station - Interdepartmental Task Group Discussion Paper*, p.6.

73. For simplicity, where a generation technology has a range of emissions intensities associated with it, the average has been used.

74. Department of the Environment and Energy, *National Greenhouse Accounts Factors - Australian National Greenhouse Accounts 2016*, p.18.