



Independent Review into the Future Security of the National Electricity Market

Blueprint for the Future

June 2017

Dr Alan Finkel AO, Chief Scientist, Chair of the Expert Panel

Ms Karen Moses FAICD | Ms Chloe Munro | Mr Terry Effeney | Professor Mary O'Kane AC

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PREFACE

Dear Prime Minister, Premiers and Chief Ministers.

Imagine a world without electricity. Nearly two centuries of enterprise, health and entertainment would be wiped out. A smoothly functioning electricity system enables our economic growth and national security. But in recent times the system has struggled to cope with shifting policy imperatives and rapidly evolving technologies.

The cries for reform are loud, coming from our largest industrial consumers, businesses of all sizes, householders, electricity market participants and industry regulators. Their shared chorus is an appeal for an electricity system that can cope with today's technologies and practices, and adapt resiliently to take advantage of tomorrow's.

To achieve this resilience, we need a plan. COAG Energy Council asked the Review Panel to recommend enhancements to the National Electricity Market to optimise security and reliability, and to do so at lowest cost.

We quickly discovered that beyond the cost of gas, uncertainty around emissions reduction policies was pushing up prices and undermining reliability. Our plan removes that uncertainty. Its key feature is an orderly transition to bring new generation into the market to improve reliability. Participation is based on low emissions, not technology type. There are no prohibitions, just incentives.

It puts downward pressure on prices by bringing that new electricity generation into the market at lowest cost without prematurely displacing existing low-cost generators. It further ensures reliability by financially rewarding consumers for participating in demand response and distributed energy and storage.

To deliver the desired security, reliability, price outcomes and reduced emissions, the blueprint recommends strengthened governance, system planning and an orderly transition. Without these three supporting pillars, the system will stumble again in future.

If this blueprint is adopted, our electricity system will provide the performance and resilience that large and small consumers demand.

This Review is being submitted in the midst of a public debate about international commitments under the Paris Agreement. In that context, it should be noted that the current massive transformation in the operation of the electricity market is not driven solely by decisions of individual governments, no matter how large. It is driven by international trade competitiveness, innovation, business appetite for lower costs, competition to drive new technology, and consumers' desire to take greater control of their energy costs and do their bit for the environment.

In preparation of this report, the Panel consulted widely. Internationally, we visited regulators and operators across Europe and the United States, and we commissioned a review of international best practices from the International Energy Agency.

We observed that every country or jurisdiction has a unique electricity system. The one thing most have in common is a strategic plan to preserve energy security and affordability while transitioning to a lower emissions future.

In Australia, we held public and private consultations in every region of the National Electricity Market. We received 390 written submissions. Our consultations included large industrial users such as copper mines, small businesses such as meatworks, consumer and business representatives, market participants, regulators, government departments and your Energy Ministers.

The overwhelming message was the call for Australia to adopt a single, nationally agreed plan to manage the transition to a lower emissions economy. Stakeholders argued that business as usual is not an option. Policy reversals and piecemeal government interventions undermine investor confidence.

If, as I hope, this blueprint is adopted by you, then our National Electricity Market should return to being the high-performance servant of our community that it once was.

We will know that we have been successful if, in three years from now, our electricity system is no longer a topic of discussion in the general community, but is instead taken for granted.

Producing this report was a massive effort. As Chair of the Panel I take this opportunity to thank my fellow Panel Members: Chloe Munro, Karen Moses, Mary O’Kane and Terry Effeney, and the talented members of the taskforce. The Panel had regular and constructive engagement with the COAG Energy Council. Many staff from federal and state departments assisted, many members of the public and industry offered their advice, and the energy market bodies always made themselves available for consultation. Not once did I ask somebody for assistance without it being willingly and generously offered. To each and every person and organisation who shared their advice and time, I humbly thank you.

Prime Minister, Premiers and Chief Ministers, I highly commend to you this blueprint for the future security of the National Electricity Market.

Thank you

A handwritten signature in black ink, appearing to read 'Alan Finkel', with a long, sweeping underline.

Alan Finkel

Australia's Chief Scientist
Chair of the Panel

EXECUTIVE SUMMARY

Australia's electricity system is in transition. There is no going back from the massive industrial, technological and economic changes facing our electricity system. No country is immune to the change. What distinguishes countries' approaches to the transition is how well-prepared they are in ensuring a secure, reliable and affordable electricity system.

We are at a critical turning point. Managed well, Australia will benefit from a secure and reliable energy future. Managed poorly, our energy future will be less secure, more unreliable and potentially very costly. Governments have made commitments to a lower emissions future but the pathway is blocked by uncertainty about how to get there. If we don't take immediate action, or even if we continue as we have been, Australia risks being left behind.

This report recommends a way forward. This *Blueprint for the Future Security of the National Electricity Market* focusses on four key outcomes for the National Electricity Market (NEM): **increased security, future reliability, rewarding consumers**, and **lower emissions**. These outcomes will be underpinned by the three pillars of an **orderly transition, better system planning** and **stronger governance**.

Australia needs to **increase system security** and **ensure future reliability** in the NEM. Security and reliability have been compromised by poorly integrated variable renewable electricity generators, including wind and solar. This has coincided with the unplanned withdrawal of older coal and gas-fired generators. Security should be strengthened through **Security Obligations** for new generators, including regionally determined minimum system inertia levels. Similarly, reliability should be reinforced through a **Generator Reliability Obligation** implemented by the Australian Energy Market Commission (AEMC) and the Australian Energy Market Operator (AEMO) following improved regional reliability assessments. These obligations will require new generators to ensure that they can supply electricity when needed for the duration and capacity determined for each NEM region.

The reliability of Australia's future electricity system will be underpinned by an **orderly transition** that integrates energy and emissions reduction policy. All governments need to agree to an **emissions reduction trajectory** to give the electricity sector clarity about how we will meet our international commitments. This requires a **credible and durable mechanism** for driving clean energy investments to support a reliable electricity supply. Governments need to agree on and implement a mechanism as soon as possible. Ongoing uncertainty is undermining investor confidence, which in turn undermines the reliable supply of electricity and increases costs to consumers.

This report recommends a **Clean Energy Target** as the mechanism for the electricity sector. As part of the orderly transition, generators should also be required to provide **three years' notice of their intention to close**. This will provide time for replacement capacity to be built and for affected communities to plan for change. AEMO should also publish a **register of expected closures** to assist long-term investor planning.

Better **system planning** should see AEMO having a stronger role in planning the future transmission network, including through the development of a **NEM-wide integrated grid plan** to inform future investment decisions. Significant investment decisions on interconnection between states should be made from a NEM-wide perspective, and in the context of a more distributed and complex energy system. AEMO should develop a list of **potential priority projects** to enable efficient development of renewable energy zones across the NEM.

The transition presents significant opportunities to foster innovation. The deployment of new technologies and improved integration of variable renewable electricity generators needs to be supported by **better data, early testing of technology, cyber threat awareness** and **workforce preparedness**. As we increase our reliance on variable renewable electricity generators, AEMO must have access to the best available **weather impact and forecasting** capabilities. Improved confidence, understanding and management of the NEM will be reinforced by greater data transparency, including a **data dashboard** for power system information.

Governments and the community will have better visibility of emerging risks through **stronger governance**. The COAG Energy Council should agree on a **strategic energy plan** for the NEM, building on the recommendations of this blueprint, reflecting government priorities. A new **Energy Security Board** should drive implementation of this blueprint and coordinate whole-of-system monitoring of security, reliability and planning across the functions of our market bodies. **Faster rule change processes**, a **better funded regulator** with **enhanced market monitoring** capabilities and **an operator with a broader planning role** will help drive better overall system outcomes.





Gas plays an essential role in providing secure and reliable electricity for Australians. To help address problems caused by rising prices and reduced availability, AEMO should be given **expanded visibility on gas contracts** so that it can plan responses to shortages. Governments should also work with communities to encourage **safe exploration and production**, based on best available evidence, performance data and appropriate financial rights for landholders.

Consumers are at the heart of the transition. More attention should be paid to how we can best **reward consumers** for **demand management** and the power they generate through **distributed energy resources** like rooftop solar photovoltaic. When combined with **improved energy efficiency**, this will help reduce consumers' electricity bills. The future grid will be more distributed, but its security and affordability will be strengthened through smarter grids, meter data information and clear data ownership rules to promote new ways of trading, including a **demand response mechanism**.




The Panel is confident that adoption of the blueprint will ensure the optimal functioning of Australia's electricity system into the future.

Vision for the National Electricity Market

Key outcomes

	INCREASED SECURITY <ul style="list-style-type: none"> • Obligations on new generators to provide essential security services • More conservative operation in each region through maintaining system inertia and tighter frequency control • A stronger risk management framework to protect against natural disasters and cyber security attacks
	FUTURE RELIABILITY <ul style="list-style-type: none"> • Obligations on new generators will ensure adequate dispatchable capacity in all regions • New generators incentivised to enter the market • Existing low-cost generators don't close prematurely
	REWARDING CONSUMERS <ul style="list-style-type: none"> • Large and small consumers rewarded for reducing their demand when needed • System upgrades and new generation will be achieved at lowest cost • Better access to information to support consumer choice
	LOWER EMISSIONS <ul style="list-style-type: none"> • A continuous emissions reduction trajectory delivering certainty • Emissions reduced by 28% below 2005 levels by 2030, heading towards zero emissions in the second half of the century

Key pillars

		
ORDERLY TRANSITION To provide certainty through an agreed emissions reduction trajectory <ul style="list-style-type: none"> • Clean Energy Target adopted to drive investment and reduce emissions • All generators will be required to provide three years' notice of closure 	SYSTEM PLANNING To help make the transition to an innovative, low emissions electricity system: <ul style="list-style-type: none"> • A system-wide grid plan informs network investment decisions • Regional security and reliability assessments 	STRONGER GOVERNANCE To drive faster rule changes, overcome challenges and deliver better outcomes: <ul style="list-style-type: none"> • A new Energy Security Board to deliver the blueprint and provide system-wide oversight • Strengthened energy market bodies

THE BLUEPRINT WILL DELIVER

Four Key Outcomes



INCREASED SECURITY

A secure electricity system is one that continues to operate across the entire region despite disruptions. A more secure power system will be resilient to the integration of new technologies and resistant to the threat of natural disasters and cyber security attacks.



FUTURE RELIABILITY

Reliability of supply is one of the foundations of our electricity system. As ageing generators retire we must ensure that new generators enter the market to meet demand.



REWARD CONSUMERS

Consumers are at the heart of our electricity system. The actions of consumers will be harnessed to improve the reliability and security of the electricity system and keep costs down. Consumers will be better informed and rewarded for managing their electricity demand. System upgrades and new generation will be achieved at lowest cost.



LOWER EMISSIONS

The electricity sector will do its share to meet Australia's commitment to reduce emissions. A long-term emissions reduction trajectory will encourage investment in system capabilities.

ENABLED BY

Three Key Pillars



ORDERLY TRANSITION

The orderly transition package will integrate emissions reduction and energy policy. The package includes a long-term emissions reduction trajectory and a *Clean Energy Target* to drive clean energy investments and support a reliable electricity supply. Generators will be required to provide three years' notice of closure.



SYSTEM PLANNING

Enhanced system planning will ensure that security is preserved, and costs managed, in each region as the generation mix evolves. Network planning will ensure that new renewable energy resource regions can be economically accessed.



STRONGER GOVERNANCE

Stronger governance makes the system more adaptable and able to integrate emerging technologies. A new *Energy Security Board* will drive implementation of this blueprint.



THE BLUEPRINT WILL DELIVER

Security

Generator security obligations

Under strict new standards, all new generators connecting to the National Electricity Market must meet technical requirements to contribute to fast frequency response and system strength. Security will be improved through regular and comprehensive reviews of the generator connection standards for these technical requirements.

System security obligation

A minimum level of inertia in each region, supported by regular assessments, will be maintained so that the system operates more conservatively. This will make the system better able to withstand disruptions like generator outages or interconnector failures.

Strengthened risk management

A stronger risk management framework will provide greater protection against natural disasters and cyber security attacks.



AND

Reliability

Generator reliability obligation

Obligations on new generators will ensure adequate dispatchable capacity is present in all regions to ensure consumer demand for electricity is met. They can meet their obligation using a variety of technologies or partnership solutions. The obligation will provide regional investment signals.

Incentives for new generation

The *Clean Energy Target* mechanism will provide incentives to encourage new generators into the market, thereby ensuring reliability as Australia meets its international commitments to lower emissions.

Existing generators don't close prematurely

The focus of the *Clean Energy Target* is on incentivising new low emissions generation while supporting our emissions reduction trajectory. There is no penalty for high emissions generation. System security and reliability will benefit from existing thermal generators that can continue to operate.

Investor confidence

The market operator will publish a non-binding register of intended generator closures to signal investment opportunities and provide community awareness.



THE BLUEPRINT WILL

Reward consumers

Rewards for managing demand

Individual consumers, from householders through to large industry, will be financially rewarded if they agree to manage their demand and share their resources such as solar panels and battery storage.

Avoiding new network costs

Prices for all consumers, not just those who own solar panels or batteries, will be lower than they would otherwise be. Demand management, better planning and data sharing will reduce the need for expensive upgrades to the transmission and distribution networks.

Lowest cost generation

Prices for all consumers will benefit from more generators entering the market to complement the continuing contribution from existing low-cost generators.

Price inquiry and better information

The Australian Competition and Consumer Commission (ACCC) price inquiry is examining the electricity retail market. This provides an opportunity to improve the transparency and clarity of electricity retail prices and help customers be aware when the terms of their offer change or discounts expire.



AND

Lower emissions

International commitments

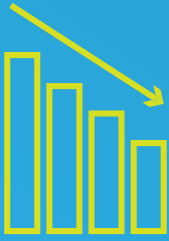
Australia has committed to reduce its emissions by 28 per cent below our 2005 levels by 2030, and ongoing reductions towards zero emissions in the second half of the century.

Electricity sector

The electricity sector is the largest single source of emissions in Australia and will need to play its part in reducing emissions. Modelling for the Review estimates that by 2030, 42 per cent of electricity demand will be met by renewable generation.

Emissions reduction trajectory

Certainty in emissions reduction policy will make it easier to plan and provide confidence to investors in new generation and network infrastructure.



THE BLUEPRINT IS ENABLED BY

An orderly transition

Throughout the transition, security and reliability will be preserved by a Generator Reliability Obligation, security obligations, conservative operation of the system, and a long-term and steady emissions reduction trajectory.

National agreement

The Review recommends that the Australian, State and Territory governments agree to a national emissions reduction trajectory.

Clean Energy Target

A *Clean Energy Target* will encourage new low emissions generation into the market in a technology neutral fashion. Under this mechanism, new low emissions generators such as wind, gas, or the combination of coal with carbon capture and storage, will receive incentives to enter the market.

Australia's existing Renewable Energy Target (RET) will continue to its scheduled 2020 end for new participants but should not be extended.

In addition to incentivising reliable generation into the market, a goal of the *Clean Energy Target* is to lower long-term emissions. For example, a mix of wind, solar and coal generation would be equally acceptable as a mix of wind, solar and gas generation as long as the emissions reduction trajectory is achieved.

Three years' notice of closure

All existing large electricity generators will be required to provide a binding three years' notice of closure. This will signal investment opportunities for new generation and give time for communities to adjust.



SUPPORTED BY

System planning

Regional assessments

Regular assessments will be undertaken to inform security and reliability obligations for each region. This will allow for early intervention by the market operator.

System-wide grid plan

The introduction of an integrated grid plan will inform investment decisions and ensure security is preserved in each region as the generation mix evolves. This will ensure that we can generate and deliver electricity more efficiently.

Priority projects

Significant investment decisions on the interconnection between states or between regions within states will be made from a system-wide perspective and in the context of a more complex energy system. The system operator will develop a list of potential priority projects to enable efficient development of renewable energy zones.



AND

Stronger governance

A new Energy Security Board

A new *Energy Security Board* will drive the implementation of the blueprint on behalf of the Council of Australian Governments (COAG) Energy Council. It will have an Independent Chair and Deputy Chair appointed by the COAG Energy Council.

Annual health check

The *Energy Security Board* will deliver an annual *Health of the National Electricity Market* report to COAG Energy Council that will track the performance of the system, the risks it faces, and the opportunities for improvement.

Strengthening existing market bodies

The existing market bodies – the Australian Energy Market Commission (AEMC), the Australian Energy Regulator (AER) and the Australian Energy Market Operator (AEMO) – will be resourced, strengthened and made more effective through coordination provided by the *Energy Security Board*.

Developing a national strategic energy plan

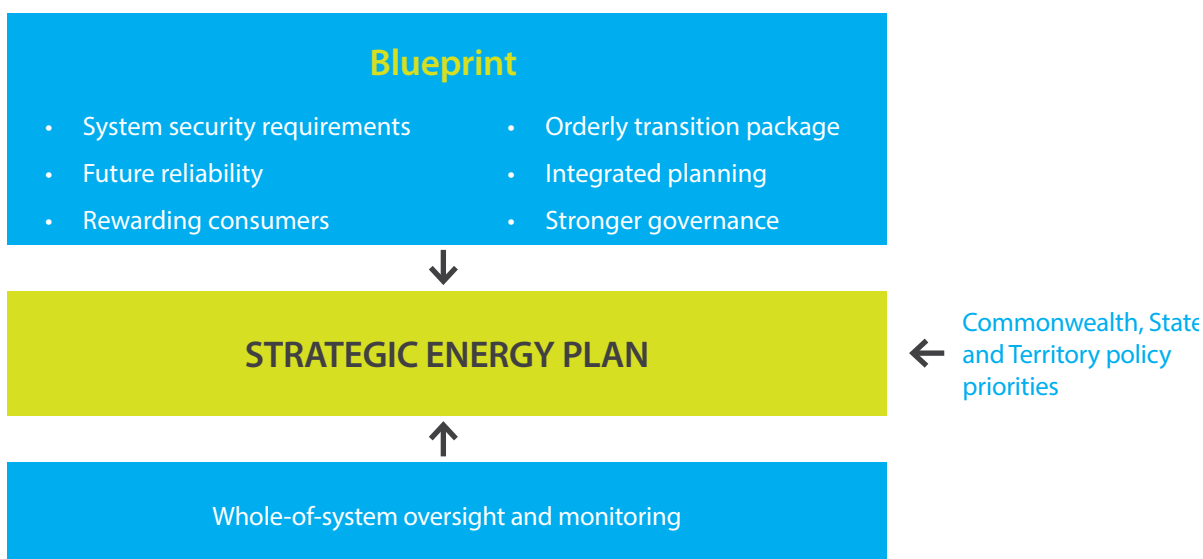
Clear strategic direction and shared accountability for outcomes will ensure that our electricity systems, now and into the future, will:

- Provide a secure, reliable and affordable electricity supply
- Support investor confidence
- Contribute to reducing emissions
- Be innovative and responsive to change.

This broad-based transition presents a range of opportunities and challenges for the National Electricity Market and for the institutional and regulatory framework in which it operates. At present, there is no strategic plan for addressing these challenges and capturing these opportunities.

One of the greatest challenges facing the nation is the development of an integrated emissions reduction and energy policy to support the orderly transition. This is a crucial first step.

This blueprint will inform the COAG Energy Council's development of a strategic energy plan.



How did we develop the blueprint?

In preparation of this report the Review Panel – Alan Finkel (Chair), Terry Effeney, Chloe Munro, Karen Moses and Mary O’Kane – consulted widely. Internationally, the Panel visited regulators and operators across Europe and the United States, and commissioned a review of international best practices from the International Energy Agency. The support from these international energy market bodies substantially informed the Review’s insights. Their generosity was underpinned by two decades of cooperation with their Australian counterparts, during which time they have come to see Australia as an innovative and forward thinking country.

Many of the challenges to energy security and affordability have been caused by a changing technology landscape in the National Electricity Market (NEM).

[Australian Academy of Technology and Engineering](#)

The Panel observed that every country or jurisdiction has a unique electricity system. The one thing most have in common is a strategic plan to preserve energy security and affordability while transitioning to a lower emissions future.

The Review undertook unprecedented public consultation through meetings and roundtables across Australia. More than 450 people attended meetings in Adelaide, Brisbane, Melbourne, Hobart and Sydney, including market participants, technology experts, consumer and business representatives and the public. The Panel attended more than 120 meetings with stakeholders.

Principles-based reforms are required to enhance the structure and operation of the NEM. These reforms should accommodate policy objectives while providing security and affordability of supply for industrial and residential users.

[BHP Billiton](#)

Following publication of the Preliminary Report, the Review called for submissions. More than 390 submissions were received from businesses, academics, governments and individuals. The vast majority of these were public and were published by the Review.

The National Electricity Market

Wholesale value of electricity traded
\$11.7 billion

40,000 kilometres of transmission lines

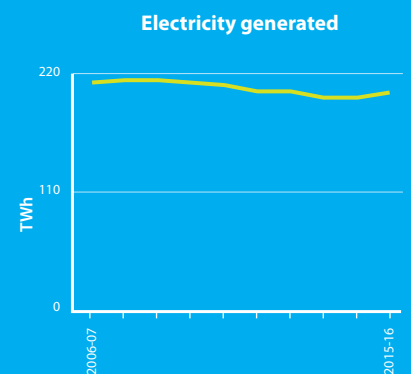
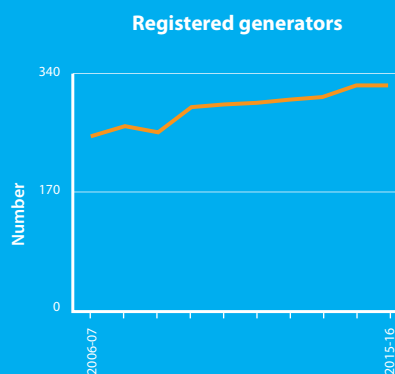
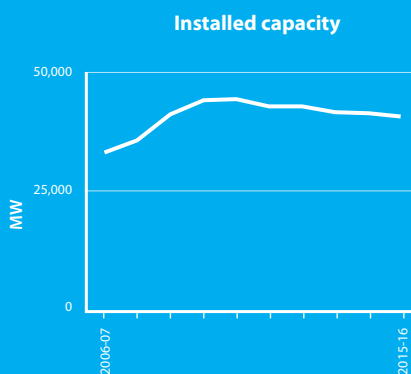
National maximum summer operational demand
32,859 MW

National maximum winter operational demand
31,977 MW

Number of metered customers
9.6 million

Installed capacity
47,148 MW

NEM emissions
162 Mt CO₂-e



RECOMMENDATIONS

The blueprint at a glance.

Number	Recommendation
Preparing for next summer	
1.1	By end-September 2017, the Australian Energy Market Operator should publish an independent third party review of its: <ul style="list-style-type: none"> • Short-term demand forecast methodology. • FY2018 summer forecast. • Preparedness for the FY2018 summer.
Increased security	
2.1	A package of Energy Security Obligations should be adopted. By mid-2018 the Australian Energy Market Commission should: <ul style="list-style-type: none"> • Require transmission network service providers to provide and maintain a sufficient level of inertia for each region or sub-region, including a portion that could be substituted by fast frequency response services. • Require new generators to have fast frequency response capability. • Review and update the connection standards in their entirety. <ul style="list-style-type: none"> • The updated connection standards should address system strength, reactive power and voltage control capabilities, the performance of generators during and subsequent to contingency events, and active power control capabilities. • To be approved for connection, new generators must fully disclose any software or physical parameters that could affect security or reliability. • Thereafter, a comprehensive review of the connection standards should be undertaken every three years.
2.2	A future move towards a market-based mechanism for procuring fast frequency response (as proposed as a subsequent measure in the System Security Market Frameworks Review) should only occur if there is a demonstrated benefit.
2.3	By mid-2018, the Australian Energy Market Operator and Australian Energy Market Commission should: <ul style="list-style-type: none"> • Investigate and decide on a requirement for all synchronous generators to change their governor settings to provide a more continuous control of frequency with a deadband similar to comparable international jurisdictions. • Consider the costs and benefits of tightening the frequency operating standard.
2.4	By mid-2018, the Australian Energy Market Operator should take steps to ensure the black system restart plan for each National Electricity Market region clearly identifies the roles of the parties involved at each stage of the restoration process, and includes regular testing of black start equipment and processes.

Number	Recommendation
2.5	<p>By mid-2018, the COAG Energy Council should direct the Australian Energy Market Commission to review the regulatory framework for power system security in respect of distributed energy resources participation.</p> <p>By mid-2019, the Australian Energy Market Commission should report to the COAG Energy Council on proposed draft rule changes to better incentivise and orchestrate distributed energy resource participation to provide services such as frequency and voltage control.</p>
2.6	<p>The COAG Energy Council, in addition to its project on energy storage systems, should develop a data collection framework (or other mechanism) to provide static and real-time data for all forms of distributed energy resources at a suitable level of aggregation. The project should be completed by mid-2018.</p>
2.7	<p>The Australian Government should lead a process to regularly assess the National Electricity Market's resilience to human and environmental threats. This should occur by mid-2019 and every three years thereafter.</p>
2.8	<p>By end-2018, the Australian Energy Market Commission should review and update the regulatory framework to facilitate proof-of-concept testing of innovative approaches and technologies.</p>
2.9	<p>Proof-of-concept testing of innovative grid-scale solutions will be required for as long as technology is continuing to rapidly evolve. A funding source for trials by the Australian Energy Market Operator and the Australian Renewable Energy Agency should be assured for the long-term.</p>
2.10	<p>An annual report into the cyber security preparedness of the National Electricity Market should be developed by the Energy Security Board, in consultation with the Australian Cyber Security Centre and the Secretary of the Commonwealth Department of the Environment and Energy.</p> <p>The annual report should include:</p> <ul style="list-style-type: none"> • An assessment of the cyber maturity of all energy market participants to understand where there are vulnerabilities. • A stocktake of current regulatory procedures to ensure they are sufficient to deal with any potential cyber incidents in the National Electricity Market. • An assessment of the Australian Energy Market Operator's cyber security capabilities and third party testing. • An update from all energy market participants on how they undertake routine testing and assessment of cyber security awareness and detection, including requirements for employee training before accessing key systems. <p>The initial report should be completed by end-2018.</p>
2.11	<p>In recognition of the increased severity of extreme weather, by end-2018 the COAG Energy Council should develop a strategy to improve the integrity of energy infrastructure and the accuracy of supply and demand forecasting.</p>
2.12	<p>By mid-2019, the COAG Energy Council should facilitate the development of a national assessment of the future workforce requirements for the electricity sector to ensure a properly skilled workforce is available.</p>

Number	Recommendation
A reliable and low emissions future – the need for an orderly transition	
3.1	By 2020, the Australian Government should develop a whole-of-economy emissions reduction strategy for 2050.
3.2	<p>There is an urgent need for a clear and early decision to implement an orderly transition that includes an agreed emissions reduction trajectory, a credible and enduring emissions reduction mechanism and an obligation for generators to provide adequate notice of closure.</p> <ul style="list-style-type: none"> • The Panel recommends that the Australian and State and Territory governments agree to an emissions reduction trajectory for the National Electricity Market. • Both a Clean Energy Target and an Emissions Intensity Scheme are credible emissions reduction mechanisms because they minimise costs for consumers, are flexible and adaptable, and satisfy security and reliability criteria. Both mechanisms are shown to deliver better price outcomes than business as usual. <p>With the additional context that a Clean Energy Target can be implemented within an already well understood and functioning framework, and has better price outcomes, the Panel recommends a Clean Energy Target be adopted.</p> <ul style="list-style-type: none"> • To support the orderly transition, the Panel recommends a requirement for all large generators to provide at least three years' notice prior to closure. The Australian Energy Market Operator should also maintain and publish a register of long-term expected closure dates for large generators. <p>These recommendations are made in the context of the need for a Generator Reliability Obligation and the Energy Security Obligations. (Recommendations 3.3 and 2.1).</p>
3.3	<p>To complement the orderly transition policy package, by mid-2018 the Australian Energy Market Commission and the Australian Energy Market Operator should develop and implement a Generator Reliability Obligation.</p> <p>The Generator Reliability Obligation should include undertaking a forward looking regional reliability assessment, taking into account emerging system needs, to inform requirements on new generators to ensure adequate dispatchable capacity is present in each region.</p>
3.4	<p>By mid-2018, the Australian Energy Market Operator and the Australian Energy Market Commission should assess:</p> <ul style="list-style-type: none"> • The need for a Strategic Reserve to act as a safety net in exceptional circumstances as an enhancement or replacement to the existing Reliability and Emergency Reserve Trader mechanism. • The effectiveness of the new licensing arrangements being developed for generators in South Australia and whether they should be applied in other National Electricity Market regions. • The suitability of a 'day-ahead' market to assist in maintaining system reliability.

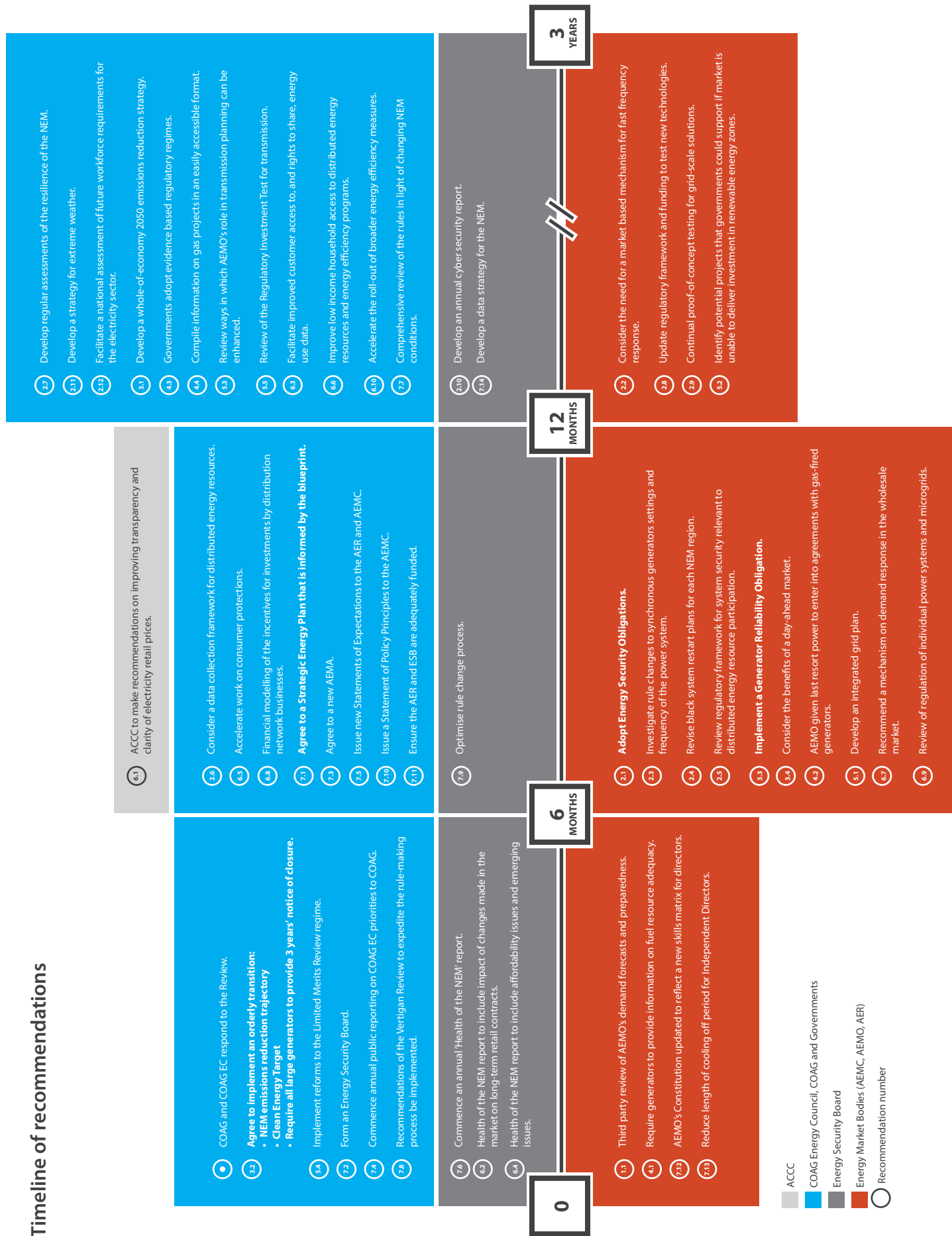
Number	Recommendation
More efficient gas markets	
4.1	By end-2017, the Australian Energy Market Operator should require generators to provide information on their fuel resource adequacy and fuel supply contracts, to enable it to better assess fuel availability.
4.2	By mid-2018, the Australian Energy Market Operator should be given a last resort power to procure or enter into commercial arrangements to have gas-fired generators available to maintain reliability of electricity supply in emergency situations.
4.3	<p>Governments should adopt evidence based regulatory regimes to manage the risk of individual gas projects on a case-by-case basis.</p> <p>This should include an outline on how governments will adopt means to ensure that landholders receive fair compensation.</p>
4.4	By mid-2019, the COAG Energy Council should bring together relevant regulatory and scientific data on gas in an informative and easily accessible format.
Improved system planning	
5.1	By mid-2018, the Australian Energy Market Operator, supported by transmission network service providers and relevant stakeholders, should develop an integrated grid plan to facilitate the efficient development and connection of renewable energy zones across the National Electricity Market.
5.2	<p>By mid-2019, the Australian Energy Market Operator, in consultation with transmission network service providers and consistent with the integrated grid plan, should develop a list of potential priority projects in each region that governments could support if the market is unable to deliver the investment required to enable the development of renewable energy zones.</p> <p>The Australian Energy Market Commission should develop a rigorous framework to evaluate the priority projects, including guidance for governments on the combination of circumstances that would warrant a government intervention to facilitate specific transmission investments.</p>
5.3	The COAG Energy Council, in consultation with the Energy Security Board, should review ways in which the Australian Energy Market Operator's role in national transmission planning can be enhanced.
5.4	By end-2017, the COAG Energy Council should finalise and implement the proposed reforms to the Limited Merits Review regime.
5.5	<p>By mid-2020, the COAG Energy Council should commission a further review of the Regulatory Investment Test for Transmission to ensure the suite of reforms implemented following the 2017 COAG Energy Council review have been effective in addressing stakeholder concerns.</p> <p>A review of the Regulatory Investment Test for Distribution should be conducted at the same time.</p>

Number	Recommendation
Rewarding consumers	
6.1	<p>As part of its inquiry into the electricity retail market, the Australian Competition and Consumer Commission should make recommendations on improving the transparency and clarity of electricity retail prices to make it easier for customers to:</p> <ul style="list-style-type: none"> • Understand and compare prices. • Be aware when the terms of their offer change or their discounts expire. • Make more informed decisions about investing in rooftop solar photovoltaic, batteries or energy efficiency measures. <p>The Australian Competition and Consumer Commission should also consider whether the Australian Energy Regulator requires further powers to collect and publish and share retail price data.</p>
6.2	<p>The Energy Security Board's annual <i>Health of the NEM</i> report to the COAG Energy Council should include the impact of changes in the market on the price and availability of long-term retail contracts for commercial and industrial customers.</p>
6.3	<p>By mid-2020, the COAG Energy Council should facilitate measures to remove complexities and improve consumers' access to, and rights to share, their energy data.</p>
6.4	<p>The Energy Security Board's annual <i>Health of the NEM</i> report to the COAG Energy Council should report on affordability issues and proactively identify emerging issues.</p>
6.5	<p>By mid-2018, the COAG Energy Council should accelerate its work on applying consumer protections under the National Energy Retail Law and National Energy Retail Rules to new energy services, and also consider safety issues as part of that work.</p>
6.6	<p>The COAG Energy Council should engage with relevant portfolio areas including housing, and with state, territory and local governments, to identify:</p> <ul style="list-style-type: none"> • Opportunities to accelerate the roll out of programs that improve access by low income households to distributed energy resources and improvements in energy efficiency. • Options for subsidised funding mechanisms for the supply of energy efficient appliances, rooftop solar photovoltaic and battery storage systems for low income consumers.
6.7	<p>The COAG Energy Council should direct the Australian Energy Market Commission to undertake a review to recommend a mechanism that facilitates demand response in the wholesale energy market. This review should be completed by mid-2018 and include a draft rule change proposal for consideration by the COAG Energy Council.</p>
6.8	<p>By mid-2018, the COAG Energy Council or the Australian Energy Market Commission should commission financial modelling of the incentives for investments by distribution network businesses, to test if there is a preference for capital investments in network assets over operational expenditure on demand-side measures.</p> <p>If this work demonstrates that there is a bias towards capital expenditure, the COAG Energy Council should direct the Australian Energy Market Commission to assess alternative models for network incentives and revenue-setting, including a total expenditure approach. This should be completed by end-2019.</p>

Number	Recommendation
6.9	<p>By mid-2018, the COAG Energy Council should direct the Australian Energy Market Commission to undertake a review of the regulation of individual power systems and microgrids so that these systems can be used where it is efficient to do so while retaining appropriate consumer protections.</p> <p>The Australian Energy Market Commission should draft a proposed rule change to support this recommendation.</p>
6.10	Governments should accelerate the roll out of broader energy efficiency measures to complement the reforms recommended in this Review.
Stronger governance	
7.1	By mid-2018, the COAG Energy Council should develop and maintain a strategic energy plan informed by the Panel's blueprint to guide the operation and evolution of the National Electricity Market.
7.2	<p>The COAG Energy Council should immediately agree to establish an Energy Security Board to have responsibility for the implementation of the blueprint and for providing whole-of-system oversight for energy security and reliability.</p> <ul style="list-style-type: none"> • The Energy Security Board should be provided with the necessary funding to operate. • The Energy Security Board should be comprised of an independent Chair, supported by an independent Deputy Chair, with the Chief Executive of the Australian Energy Market Operator and the Chairs of the Australian Energy Regulator and the Australian Energy Market Commission as members. • Administrative support for the Energy Security Board should be provided by the Australian Energy Market Operator.
7.3	<p>By mid-2018, COAG leaders should agree to a new Australian Energy Market Agreement that re-commits all parties to:</p> <ul style="list-style-type: none"> • Taking a nationally consistent approach to energy policy that recognises Australia's commitment in Paris to reduce emissions and governments' commitment to align efforts to meet this target with energy market frameworks. • Notifying the COAG Energy Council if they propose to take a unilateral action that falls within the scope of the Australian Energy Market Agreement prior to taking the action. <ul style="list-style-type: none"> • Within 28 days of notification, the Energy Security Board will provide advice to the COAG Energy Council on the impacts of the proposed action taking into account the objectives of the Australian Energy Market Agreement.
7.4	By end-2017, the COAG Energy Council should commence annual public reporting to COAG leaders on its priorities for the next 12 months and progress against the strategic energy plan.
7.5	By mid-2018, the COAG Energy Council, in consultation with the Energy Security Board, should issue new Statements of Expectations to the Australian Energy Regulator and the Australian Energy Market Commission, and a Statement of Role to the Australian Energy Market Operator containing a comprehensive set of outcomes-based performance indicators.

Number	Recommendation
7.6	<p>By end-2017, the Energy Security Board should provide an inaugural, annual <i>Health of the NEM</i> Report to the COAG Energy Council describing:</p> <ul style="list-style-type: none"> • The performance of the system. • Performance against whole-of-system key performance indicators. • Opportunities for market development including actual and emerging risks. • Progress against a Statement of Expectations.
7.7	<p>The COAG Energy Council should request that the Australian Energy Market Commission, or alternatively the Energy Security Board or other suitable body, complete by end-2020 a comprehensive review of the National Electricity Rules with a view to streamlining them in light of changing technologies and conditions.</p>
7.8	<p>Recommendations of the Vertigan Review to expedite the rule-making process should be implemented by end-2017.</p>
7.9	<p>The Energy Security Board should prioritise work with energy market bodies, the COAG Energy Council, and other relevant stakeholders to further optimise the end-to-end rule change process.</p>
7.10	<p>By mid-2018, the COAG Energy Council should issue a Statement of Policy Principles to the Australian Energy Market Commission to provide further clarification and policy guidance on applying the National Electricity Objective in the rule-making process.</p>
7.11	<p>The COAG Energy Council should ensure that the Australian Energy Regulator and the Energy Security Board are adequately funded to undertake their responsibilities, including implementing the blueprint.</p>
7.12	<p>By end-2017, the Australian Energy Market Operator should update its Constitution by developing a new skills matrix for directors that will ensure appropriate representation of professional power systems engineering or equivalent expertise.</p>
7.13	<p>The three-year cooling off period for independent directors of the Australian Energy Market Operator should be reduced to six months.</p>
7.14	<p>By end-2018, the Energy Security Board, in collaboration with the Australian Energy Regulator, should develop a data strategy for the National Electricity Market.</p> <ul style="list-style-type: none"> • The initial design of the data strategy must be developed in consultation with industry bodies and consumer bodies, and be consistent with open government data principles. • The Energy Security Board must report to the COAG Energy Council on the completion of the first stage. This should include costs for design and implementation for initial set up, plus indicative costs for ongoing maintenance of the key deliverables under the data strategy. • The first phase of the data strategy must be completed by end-2017, with the functionality of the components of the strategy reviewed annually to ensure that they continue to be fit-for-purpose.

Timeline of recommendations



INTRODUCTION

Australia has a once-in-a-generation opportunity to reshape our electricity system for the future. A wave of technological change is sweeping across us. The key driver – innovation – cannot be reversed. Taking advantage of these technological changes requires a culture of proactively developing new approaches, and ways of thinking to facilitate the next wave of development rather than hold it back.

The Council of Australian Governments (COAG) Energy Council (the Energy Council) must take stock of the current state of security, reliability and governance of our electricity systems to develop a strategic energy plan for coordinated national reform. Clear strategic direction and shared accountability for outcomes will ensure that our electricity sector, now and into the future, will:

- Provide a secure, reliable and affordable electricity supply.
- Support investor confidence.
- Contribute to reducing emissions.
- Be innovative and responsive to change.

Though this Review is specific to the National Electricity Market (NEM) – Queensland, New South Wales, the Australian Capital Territory, Victoria, South Australia and Tasmania – where applicable, the Western Australian and Northern Territory governments should consider adopting the Panel's recommendations for their individual electricity systems.

Increased opportunities for the NEM

The NEM is being transformed from a 20th century grid dominated by large-scale, fossil fuel-fired synchronous generators into a 21st century grid. New and emerging generation, storage and demand management technologies are being connected into a system that was not designed for them. Older generators are reaching the end of their life, becoming less reliable and closing. These changes are placing pressure on the NEM, as demonstrated by the 28 September 2016 state-wide blackout in South Australia and the load shedding during the February 2017 heatwave in South Australia and New South Wales.

A range of policy and market factors are influencing the operation and development of the NEM. There is significant uncertainty about the future direction of energy and emissions reduction policies and how these will be integrated. There is also a high degree of uncertainty about when Australia's ageing fleet of coal-fired generators will be retired, what will replace them and where they will be located.

Energy efficiency improvements are already changing the pattern of electricity consumption. Future demand will also be impacted by the possible shifts from petrol and diesel-powered vehicles to electric vehicles and from natural gas space heating to electric space heating.

This broad-based transition presents a range of opportunities and challenges for the NEM and for the institutional and regulatory framework in which it operates. At present, there is no overarching strategic plan for addressing these challenges and capturing these opportunities. This creates significant difficulties for future investment decisions. Without urgent attention to the need for better planning and policy, the benefits to Australia delivered by the creation of the NEM will deteriorate.

The nature of the future grid

It is not possible to predict exactly what the NEM will look like in the future. Based on current technology trends and investments, some of the key features are likely to include:

- Declining coal-fired generation over the next three decades. Australia's coal fleet is old and coming towards the end of its design life. Investors have signalled that they are unlikely to invest in new coal-fired generation.
- Reduced emissions as ageing coal-fired generation retires and is replaced by lower emissions forms of generation.
- Declining demand due to distributed generation (such as rooftop solar photovoltaic) and increased energy efficiency, countered by increasing demand for electricity in transport and space heating.
- Increased investment in large, medium and small-scale variable renewable electricity (VRE) generation capacity and microgrids.¹
- Increased investment in dispatchable generation and storage at grid-scale in response to high levels of VRE penetration. The backup and storage technologies deployed will include gas-fired generation, batteries and pumped hydro.
- An ongoing role for networks, including between resource-rich areas (solar, wind, pumped hydro) and load centres, and between NEM regions.
- Big data and the internet-of-things will drive innovation and create new business opportunities that transform residential, commercial and industrial energy use.

Governments need to take decisive action to ensure that the transition to the future grid, whatever it looks like, is smooth and that the electricity system continues to serve the interests of all consumers.

Transforming Australia's electricity generation is not a matter of choosing just one technology over another. It is using a combination of existing and emerging technologies in a structural policy environment consistent with emissions reductions and meeting the demand for electricity while providing a stable environment for investors. A secure energy future will be reliant on these policy approaches being successfully deployed.²

Engineers Australia

The policy challenge

The Australian Government has committed, through the Paris Agreement,³ to reduce Australia's greenhouse gas emissions by 26 to 28 per cent on 2005 levels by 2030. There is a widespread expectation, from the electricity sector and the public at-large, that Australia will meet its target. Electricity generation is a major source of emissions, accounting for around 35 per cent of Australia's national emissions in 2016.⁴ Any effort to significantly reduce Australia's emissions will require a reduction in emissions from the electricity sector. Investors require clarity regarding the future of Australia's emissions reduction policy in order to bring forward the investments that will deliver a secure, reliable, affordable and low emissions electricity supply.

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1. Microgrids are smaller grids that can disconnect from the large traditional grid to operate autonomously while the main grid is down, for example, the proposed Moreland microgrid in Victoria.
 2. Engineers Australia submission to the Review, p.7.
 3. The Paris Agreement is an international agreement by parties to the United Nations Framework Convention on Climate Change (UNFCCC) to undertake ambitious efforts to combat climate change and adapt to its effects. Australia has committed to reduce national emissions by 26 to 28 per cent on 2005 levels by 2030 under the Agreement.
 4. Department of the Environment and Energy, *Quarterly Update of Australia's National Greenhouse Gas Inventory: June 2016*, 2016, p.9.

There is strong stakeholder support for reform to achieve these outcomes. Discussions with stakeholders and submissions to the Panel reveal a desire to see the NEM deliver for all Australians. The submissions from large and small companies, representative organisations and individuals to this Review evidence the widespread interest in this subject. They are united by a common sense that we can and must do better in energy policy. Groups representing generators, networks, consumers, business and industry, unions, social services and environmental groups, issued a joint statement calling for:⁵

Reform of Australia's energy systems and markets to ensure reliability and affordability as we decarbonise the energy system.

The status quo of policy uncertainty, lack of coordination and unreformed markets is increasing costs, undermining investment and worsening reliability risks.

Delivering a secure and reliable electricity supply is the highest priority. Low emissions and affordable supply must be delivered through a power system that is secure and reliable. While delivering 100 per cent reliability would be prohibitively expensive, it is also clear that there is no public appetite for a reduction in delivered levels of reliability. The level of reliability in the system needs to closely align with the willingness of consumers to pay for it.

The guiding objective for the work of the Review, and in turn the NEM, is to ensure a secure and reliable electricity supply that meets our emissions reduction targets at the lowest cost.

A blueprint for reform

The Energy Council must agree to a strategic energy plan to guide the operation and evolution of the NEM to navigate the transition to a low emissions future. It is clear from the Panel's international consultations that Australia is behind other countries in developing a clear, national strategy to ensure that our electricity and gas sectors operate and transition effectively and efficiently.

Central to Australia's strategic energy plan must be a credible, stable emissions reduction policy for the electricity sector. Stakeholders have identified the absence of such a policy as the critical challenge facing the electricity sector.

This Review provides a blueprint for reform, as a balanced and mutually reinforcing set of actions that are designed to restore certainty and facilitate a smooth transition to a lower emissions future. By committing to the blueprint, governments will facilitate a NEM that is innovative, responsive, affordable and that will provide investor confidence. There is every reason to expect that the NEM will, once again, be a world-class electricity system and a source of competitive advantage for the Australian economy. The elements of the blueprint are shown in Figure i.1.

5. AI Group, <https://www.aigroup.com.au/policy-and-research/mediacentre/releases/Joint-Statement-Energy-Reform-13Dec/>, accessed 25 May 2017.

Figure i.1: Elements of the blueprint

Preparing for next summer

Severe heatwave conditions in south-east Australia in February 2017 and the need for involuntary load shedding of consumers highlighted the challenges associated with maintaining electricity supply during extreme weather conditions. Australian Energy Market Operator (AEMO) forecasts a potential supply shortfall in Victoria and South Australia following the closure of the Hazelwood Power Station. This has raised concerns about the NEM's ability to maintain a reliable electricity supply during the FY2018 summer. Prudent actions are required to manage this risk.

AEMO and governments are implementing a range of measures to address this issue, including seeking assurance that generators have sufficient fuel and are available to run. AEMO will also be working with the Australian Renewable Energy Agency (ARENA) to pilot a new demand response market. In addition to the measures underway, AEMO should commission and publish an independent third party review of its short-term demand forecasts and preparedness for the FY2018 summer.

The need for increased security

Increased penetration of VRE generators and the withdrawal of synchronous generators is reducing the supply of essential security services, such as physical inertia, which historically have been supplied by synchronous generators. As VRE penetration grows it will be important to ensure that there remains a ready supply of security services, and that VRE generators are able to respond appropriately and predictably to power system disturbances. It will also be important to ensure that there is sufficient availability of system restart capabilities in each NEM region to cope with the possibility of a system-wide blackout. Increasing quantities of distributed energy resources (DER), such as rooftop solar photovoltaic, also presents challenges. At present, AEMO lacks sufficient visibility of DER, which makes it difficult to manage the power system effectively.

Technical solutions exist to address many of these issues and ensure power system security is maintained. AEMO and the Australian Energy Market Commission (AEMC) have already started developing and implementing measures to deliver essential security services. These should be complemented with additional security obligations imposed on new generators to strengthen technical performance, including through revised connection standards. Regulatory changes are required to enable DER to be coordinated to provide security services.

The environment in which the NEM operates is also changing. The power system will need to be robust in order to cope with new and emerging threats, such as cyber attacks and an increased frequency of extreme weather events. Action is required to increase the NEM's resilience in the face of these threats.

A reliable and low emissions future – the need for an orderly transition

Uncertainty related to emissions reduction policy and how the electricity sector will be expected to contribute to future emissions reduction efforts has created a challenging investment environment in the NEM. Ageing generators are retiring from the NEM, but are not being replaced by comparable dispatchable capacity. Policy stability is required to give the electricity sector confidence to invest in the NEM.

Reliability in the NEM will be strengthened by establishing a framework for an orderly transition to a low emissions future. This must include a long-term emissions reduction target for the electricity sector, a credible and enduring mechanism for the sector to achieve the emissions reduction trajectory and better management of generator closures.

New standards will also be required to give greater confidence that reliability will be maintained as technological developments continue to affect the system. New VRE generators will need to contribute to regional reliability by ensuring dispatchable capacity is brought forward to the market.

Securing adequate and affordable gas supply

Battery and pumped hydro storage will be able to support a reliable and secure NEM, as and when they are deployed at scale. For the short to medium-term the NEM is likely to require higher levels of flexible, gas-fired generation to support VRE. However, the economics of gas-fired generators are being challenged by rising gas prices and tightening gas supply. For gas-fired generators to continue to have a role in affordable electricity supply, they will need to be highly efficient. Gas-fired generation typically sets the spot price for the wholesale electricity market when VRE generation is low or demand is high, and this flows through to consumers as higher electricity prices.

In addition to measures being undertaken by the Energy Council, governments have announced a number of initiatives to address supply tightness in the east coast gas market. These include an Australian Competition and Consumer Commission inquiry into gas prices, transport and supply and the Australian Domestic Gas Security Mechanism, which will give the Australian Government the power to impose export controls when there is a shortfall of gas supply in the domestic market. AEMO should have better oversight of gas supply contracts for gas-fired generators to ensure they have sufficient supply available.

Facilitating the development of additional gas resources will require a concerted effort to acknowledge and respond to community concerns about the environmental and social impacts associated with unconventional gas extraction. Increased transparency will be essential in this regard.

Better system planning

Transmission and distribution networks are essential for the operation of the NEM. As coal-fired generation exits, transmission networks will require reconfiguring to connect large-scale VRE generation in areas that are not served by the existing transmission network.⁶ New VRE generators will likely be smaller in scale but more numerous than coal-fired generators, so a more coordinated approach to transmission planning is required.

6. AEMO, *National Transmission Network Development Plan*, 2016, p.3.

Transmission network planning needs to be undertaken from a whole-of-system perspective to enable the efficient development of the grid into new areas. A long-term, integrated grid plan is required to establish an optimal transmission network design to enable the connection of new renewable energy resources. Coordination of generation and transmission investment so that networks connect the areas with the best renewable energy resources, at an efficient scale, will be a critical challenge.

Transmission businesses need to be incentivised to build the network infrastructure required for the future of the NEM, but not to build unnecessarily. Similarly, it will be important to find the right balance between investment in inter-regional transmission and intra-regional transmission, and between investment in network and non-network solutions. This will require transmission network service providers to work closely with generation businesses in making investment decisions.

Rewarding consumers

The uptake of new technologies is putting residential, commercial and industrial consumers at the centre of the electricity market. DER systems installed at commercial and residential premises, energy efficiency improvements, and demand response actions by consumers can all be harnessed to improve the security and reliability of the NEM. All consumers should be rewarded for taking those actions, which will benefit them individually and also help reduce overall system costs.

Achieving this outcome requires action. The retail electricity market must operate effectively and serve consumers' interests. Improved access to data is needed to assist consumers, service providers, system operators and policy makers. Increased use of demand response, and changes to the role of networks and how they are incentivised are required to unlock these benefits. Governments need to take steps to ensure that all consumers, including low income consumers, are able to share in the benefits of new technologies and improved energy efficiency.

Stronger governance

A strong and resilient system of energy governance will be central to ensuring a secure and reliable low emissions future. Energy market institutions, the Australian Energy Regulator (AER), AEMO and the AEMC, will need to respond in a coordinated way to the rapid changes occurring in the NEM. Good governance requires trusted, capable, empowered and accountable institutions. This will require a clear strategic direction from the Energy Council for energy policy and shared accountability for whole-of-system outcomes.

A new Energy Security Board (ESB) should drive implementation of the recommendations of this Review. It should provide a vehicle for coordinated action and accountability for whole-of-system performance. Market arrangements will also need to respond effectively to the rapid changes in the NEM. This will require changing the rule-making processes to allow a faster response to emerging issues, and consideration of whether the National Electricity Rules can be simplified.

Beyond the blueprint

Energy technologies continue to develop and evolve. A range of technologies have the potential to further transform Australia's electricity system and deliver benefits to the Australian community. Australia is well-placed to facilitate the development and deployment of these technologies through Australian Government initiatives such as ARENA and the Clean Energy Finance Corporation (CEFC).

Consultation and engagement

Consultation for the Review within Australia was managed in a two-stage process. The Panel afforded the consultation process the utmost importance, given the significant opportunity that this Review provided. The Panel values the insights provided by submissions and through consultation sessions.

Stage one: targeted

The first stage was held during late October and early November 2016 and was a tight and targeted consultation process, owing to the 9 December 2016 deadline for delivering the Preliminary Report. The aim of this process was to collect as much knowledge as possible on the state of the NEM. These targeted consultations were held with key stakeholders, and involved both individual and roundtable meetings with the Chair, and other Panel members.

More than 50 individuals from 30 organisations were involved in these meetings, from peak bodies (across the energy industry spectrum), electricity industry businesses, consumer representatives, unions and environmental groups.

The views from these consultations were fundamental to forming the Preliminary Report, publicly presented as an Issues Paper.

Stage two: comprehensive consultation

The second stage of consultations was held during late January and through February 2017.

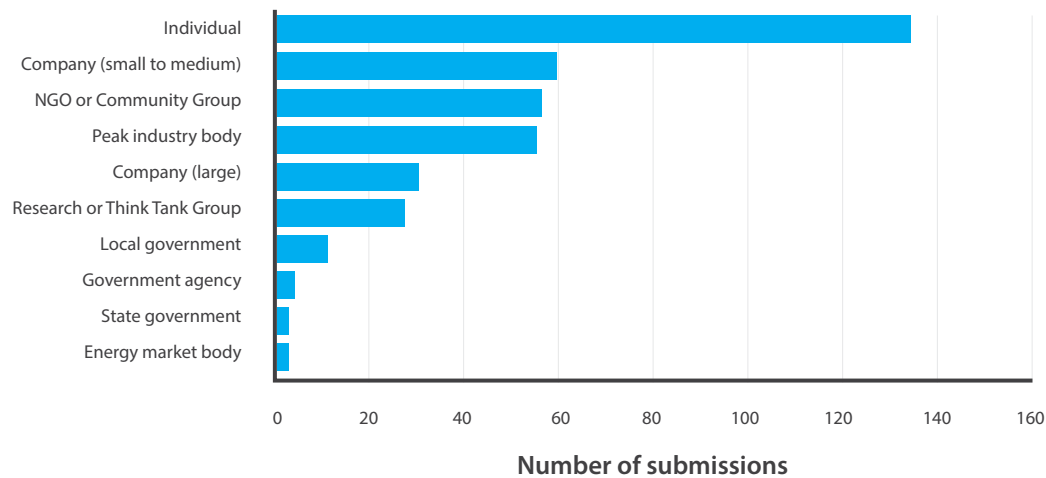
Meetings were held between stakeholders and the Chair and Panel members with the aim of involving as many individuals, companies and groups as possible. Public invitations for these meetings were advertised online and in the print media, and sessions were held in Adelaide, Brisbane, Melbourne, Hobart and Sydney. Approximately 450 people from across the energy industry, including market participants, technology experts, consumer and business representatives, and the public attended, providing the Panel with a wide breadth of views.

Submissions to the Review

In conjunction with the second stage of consultations, the Review called for public submissions. More than 390 submissions were received and informed the Panel's considerations and development of recommendations. Key themes that emerged in the submissions included that:

- A clear, national transition strategy is needed to aid the energy sector's transformation and provide clear investment signals.
- An ongoing and flexible gas supply is critical to the transformation and to maintain system reliability.
- Leadership by the Energy Council is crucial to set the strategic direction for the energy sector; and stronger governance arrangements are required.
- A variety of technologies can be adopted to provide system security services to support VRE and DER.

A breakdown of submissions received is provided in Figure i.2.

Figure i.2: Stakeholder submissions by organisation type

International engagement

International engagement has been a valuable element of the Review process. The Panel has sought to learn from international experience on a range of issues, but particularly on how countries and regions have integrated VRE generation into their power systems.

A small delegation from the Panel met with policy makers, market operators and regulators for power systems across Europe and the United States – specifically, in Ireland, the United Kingdom, Denmark, Germany, New York State, the Pennsylvania-New Jersey-Maryland Interconnect, Texas and California. The delegation also met with the International Energy Agency, the European Commission, the European Consumer Organisation, the Department of Energy and the Federal Energy Regulatory Commission in the United States, and a small number of energy technology companies.

The International Energy Agency also provided valuable input to the Preliminary Report.

The information gathered through international engagement has directly informed the blueprint. The Panel appreciates the generosity shown by our international colleagues.

Going forward, continued international engagement will allow Australia to pursue and promote its energy interests and expertise globally, track fast-moving technological changes and share knowledge and experience of first adopters and new policy approaches. This allows us to gain better insights to ensure the most cost-effective, reliable and flexible energy supply for Australia. There are significant two-way investment, business and research opportunities that can flow from international engagement. Proactive engagement by government to build on the established relationships and forge new ones will ensure Australia maintains its competitive advantage, and pursues and protects its national interests.

Key concepts

This report deals with technical issues associated with electricity systems. Some of the key concepts that are essential for understanding this report and its recommendations are provided below.

Electrical power: Electrical power is the rate at which electrical energy is generated or used to meet the electricity demand, and is measured in watts.

- One kilowatt (kW) is equal to a thousand watts.
- One megawatt (MW) is equal to a million watts.
- One gigawatt (GW) is equal to a billion watts.

Capacity: The capacity of a generator or load represents its peak output power, usually in MW. Manufacturers of electrical equipment generally use nameplate capacity or rated capacity to represent the continuous output of a generator or a motor under certain operating conditions such as temperature, humidity and location of the equipment above sea level.

Electrical energy: Electrical energy is measured in watt-hours (Wh) or multiples such as kWh, MWh, GWh and TWh (terawatt-hours). 1 MWh is equivalent to the energy output from a 1 MW generator operating for one hour at its peak capacity.

Capacity factor: The capacity factor of a generator is the ratio of actual electrical energy generated in a year to the theoretical maximum possible energy generation if the generator were to operate 24 hours per day 365 days per year. For example, a single-axis tracking solar photovoltaic generator might have a capacity factor of 25 per cent. To generate the same annual energy as a theoretical 100 MW baseload generator operating at 100 per cent capacity factor a 400 MW solar photovoltaic generator would be needed. Of course, no real-world generators operate at 100 per cent capacity factor.

Load: An electrical load is any device (such as industrial motors, lights or home appliances) or a large collection of devices powered by electricity. This is usually expressed in watts.

Demand: Electrical demand may either refer to the rate at which electrical energy is instantaneously consumed by a load (in MW), or the amount of electrical energy consumed by a load over a given period (in MWh).

Operational demand: Operational demand in a NEM region is the electrical load that is supplied by generators with 30 MW or more capacity and through interconnectors from other NEM regions. It excludes the demand met by intermittent generating units of capacity less than 30 MW and rooftop solar PV.

Levelised Cost of Electricity (LCOE): The LCOE is the discounted lifetime cost of ownership and use of a generation asset, converted into the cost per MWh. It takes into account capital expenditure, fuel costs, operating hours per year, operation and maintenance costs but not costs incurred elsewhere in the system.

Synchronous generators: Synchronous generators produce alternating current electricity. They have a heavy spinning rotor that provides synchronous inertia that slows down the rate of change of frequency. Hydro generators, thermal generators such as coal, gas and biomass, and solar thermal generators are synchronous. Synchronous generators help in voltage control by producing and absorbing reactive power and also provide high fault current to improve system strength.

Chapter 1

PREPARING FOR NEXT SUMMER

Overview

AEMO forecasts a potential supply shortfall in Victoria and South Australia for the FY2018 summer. AEMO and governments are implementing a number of measures to reduce the potential for energy supply problems.

The Panel is supportive of these measures and is confident that they will improve power system security and reliability. To boost confidence the Panel recommends a third party review of AEMO's short-term demand forecast techniques used for the FY2018 summer.

Nevertheless, extreme weather events and major equipment failures are always possible. Being prepared in the event of disruption to electricity supply is crucial so electricity supply can be restored as soon as practicable.

1.1 Improving the resilience of the NEM

During consultations, significant concerns were raised with the Panel that more work is needed to secure the NEM and ensure a reliable electricity supply for the FY2018 summer.

While this Review is recommending a package of measures to strengthen the NEM from a medium and longer-term perspective, the Panel considers it prudent to also highlight the actions underway to maintain reliability for the FY2018 summer. Supplying electricity to consumers while maintaining the power system within its specified operating limits during the summer period is crucial.

Heatwaves and the number of extreme fire weather days in Australia are increasing and the fire season is becoming longer.⁷ There is also a strong correlation between hot weather events and increased demand for electricity, primarily driven by an increase in air conditioning loads.

The extreme weather events of the FY2017 summer put immense pressure on the security and reliability of the NEM. The FY2017 summer saw five tropical cyclones, one major fire outbreak, four separate heatwaves, 21 days of major storm activity, and major floods.⁸

The high intensity storms that hit South Australia in September 2016, bringing extremely high winds, tornadoes and lightning, caused significant damage to key electricity infrastructure and resulted in a state-wide blackout. The Preliminary Report outlined the factors leading to the blackout in more detail.

There were three intense heatwaves in south-east Australia in January and February 2017, with the highest temperatures recorded over 9 to 12 February 2017. Electricity demand tends to increase in the third and fourth days⁹ of consecutive hot days, as air conditioners use more electricity to manage the accumulated heat in buildings. Consistent high temperatures over three consecutive days in February 2017 placed significant demand on the NEM, which led to the South Australian and New South Wales power systems being temporarily pushed into insecure operating states (see Box 1.1).^{10,11}

7. Bureau of Meteorology and CSIRO, *State of the Climate 2016*, 2016, p.2.

8. Bureau of Meteorology, *National Climate and Water Briefing 30 March 2017*, 2017, p.63.

9. Australian Energy Council, *Heatwaves and Electricity Supply; Background information for media December 2016*, 2016, p.2.

10. AEMO, *System Event Report South Australia: 8 February 2017*, 2017, p.4.

11. AEMO, *System Event Report New South Wales: 10 February 2017*, 2017, p.4.

Box 1.1 – Case study – February 2017 heatwave events in South Australia and New South Wales

In early February 2017, the east coast of Australia experienced severe heatwave conditions. These conditions led to an insecure operating state for the South Australian and New South Wales power systems on 8 and 10 February respectively. AEMO intervened to restore security by directing load shedding in both states.

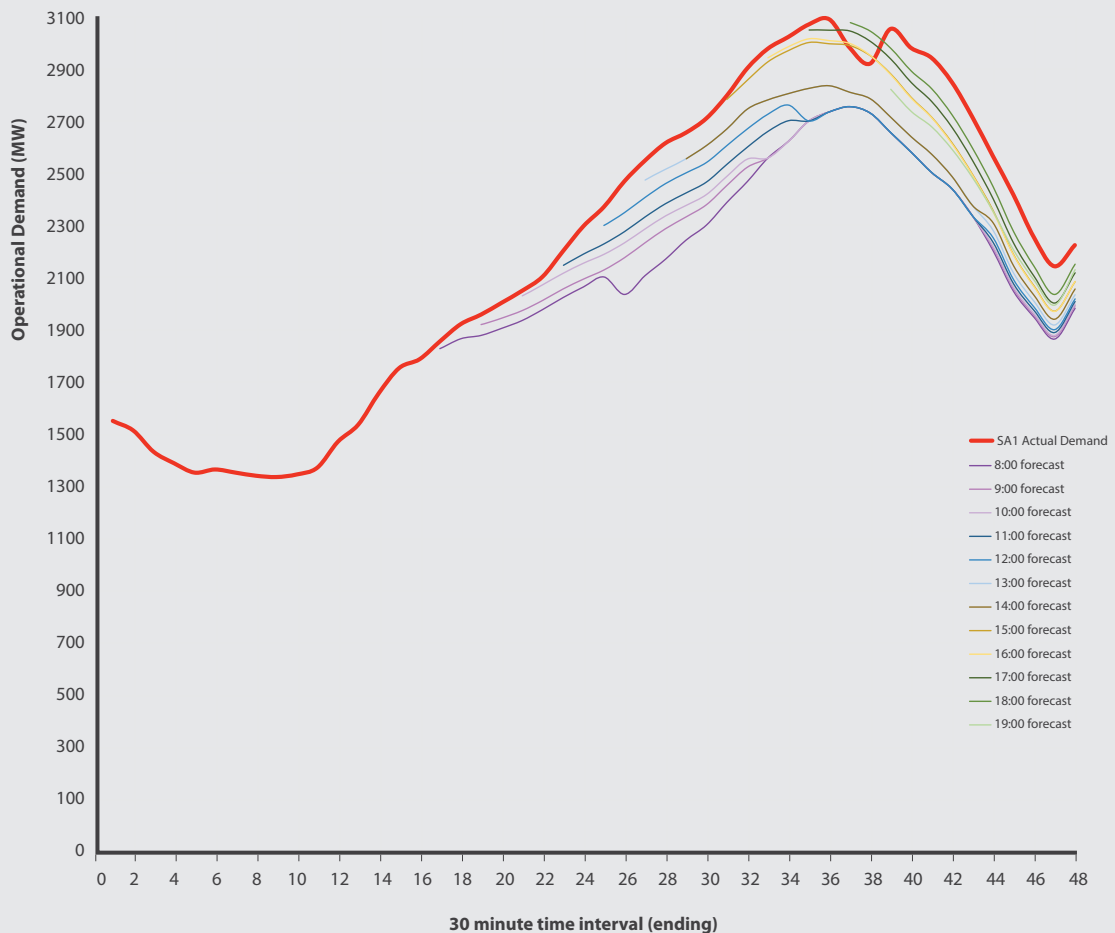
South Australia

On 8 February, temperatures in Adelaide peaked at 41.6°C at 4:00 PM. A combination of issues led to South Australia's power system not being in a secure operating state at 6:00 PM:

- Peak operational demand was higher than forecast (see Figure 1.1).
- Wind generation declined more rapidly than forecast.
- Rooftop solar photovoltaic generation was declining, as expected, due to low solar resource in the late afternoon.
- Some gas-fired generators were forced to reduce capacity due to high temperatures and communications faults.
- The Heywood interconnector was effectively operating at its full capacity as it imported power from Victoria.

Prior to the event the Murraylink interconnector was restricted to manage grid voltage constraints, but due to the deteriorating supply and demand balance it was pushed above its operating limits to import additional power from Victoria, thereby creating a security issue.

Figure 1.1: South Australia's operational demand, forecast and actual, 8 February 2017¹²



Increased supply was needed to restore power system security, but no additional generation could be brought online within the 30 minute requirement. At 6:03 PM AEMO directed ElectraNet to interrupt 100 MW of customer supply to restore system security and avoid the risk of wider scale disruption. The load shedding software used did not operate correctly and resulted in 300 MW being shed and the loss of supply for an additional 60,000 customers (resulting in a total of 90,000 customers being disconnected).^{13,14} By 6:40 PM, AEMO determined that the system had returned to a secure operating state and directed the restoration of load.

Errors in temperature forecasts were found to be a factor in AEMO underestimating the operational demand.^{15,16}

12. AEMO, *System Event Report South Australia: 8 February 2017*, 2017, p.15.
13. SA Power Networks, *Statement re load shedding event (8 February 2017)*, 2017, p.1.
14. Government of South Australia, *Our Energy Plan*, 2017, p.16.
15. AEMO, *System Event Report South Australia: 8 February 2017*, 2017, p.14.
16. AER, <https://www.aer.gov.au/communication/aer-reports-on-8%E2%80%93939-february-high-wholesale-electricity-prices-in-south-australia-and-new-south-wales>, accessed 30 May 2017.

New South Wales

On 10 February, parts of New South Wales reached 42°C with peak demand reaching 14,181 MW at 4:30 PM. This peak was likely lower than it could have been, due to a New South Wales Government media campaign to encourage reduced electricity consumption.

A combination of issues led to New South Wales' power system not being in a secure operating state:

- Wind generation was below forecast, and solar photovoltaic generation was declining in the late afternoon.
- Some thermal generators were operating at reduced capacity due to high temperatures.
- One gas-fired generator had a forced outage due to a technical fault, and another gas-fired generator was unable to start due to low gas pressure in the fuel supply lines.

As a result, the three interconnectors supplying New South Wales breached their operating limits from approximately 4:30 PM. This reliability issue became a security issue due to the overloading of the interconnectors.¹⁷

With all available generation already online, all interconnectors running above full capacity and demand still exceeding supply, as a last resort AEMO directed TransGrid to shed some load at the Tomago Aluminium smelter for a period of approximately an hour (in addition to some load shedding that had already occurred at the smelter, not instructed by AEMO).¹⁸ This action helped to restore the power system to a secure operating state.

1.2 FY2018 summer forecast

Through its medium-term Projected Assessment of System Adequacy process, AEMO has identified a possible supply shortfall in South Australia and Victoria for the FY2018 summer.

If south-east Australia experiences similar conditions to the FY2017 summer and if the market does not respond, there is a risk that there could be insufficient generation and network capacity available to meet demand on very hot days in South Australia and Victoria. Victoria can typically support South Australia through the Murraylink and Heywood interconnectors. However, without supply from the Hazelwood Power Station, if two or more states face high-temperature days at the same time, the ability to get more energy from the interconnected state is reduced. Such coincident high-temperature days in South Australia and Victoria occur and can exacerbate the supply shortfall.

AEMO's demand forecasts are based on temperature forecasts provided by two external service providers, neither of which is the Bureau of Meteorology.¹⁹ AEMO's report into the events in South Australia on 8 February 2017 found that errors in the temperature forecast led to errors in the demand forecast.²⁰ AEMO has commenced

17. AEMO, *System Event Report New South Wales: 10 February 2017*, 2017, pp.6-8.

18. AEMO, *System Event Report New South Wales: 10 February 2017*, 2017, pp.8-20.

19. AER, *Electricity Spot Prices above \$500/MWh: South Australia 9 February 2017*, 2017, p.9.

20. AEMO, *System Event Report South Australia: 8 February 2017*, 2017, p.14.

a number of initiatives to improve demand forecasting, including working more closely with the Bureau of Meteorology.

Nevertheless, the Panel considers that more needs to be done to predict and manage any potential reliability issues. To provide assurance that decisions are made on the most robust information, an independent peer review of the underlying assumptions that AEMO uses in its short-term demand forecast techniques and reliability projections would boost confidence in the adequacy of these measures. This should occur prior to the start of the FY2018 summer.

Recommendation 1.1

By end-September 2017, the Australian Energy Market Operator should publish an independent third party review of its:

- Short-term demand forecast methodology.
- FY2018 summer forecast.
- Preparedness for the FY2018 summer.

1.3 A collaborative approach for a reliable electricity supply

Since this Review commenced, energy market bodies and governments have undertaken a significant amount of work to improve the resilience of the NEM for the FY2018 summer.

As the power system operator, AEMO is responsible for maintaining power system security and reliability. If an event occurs which causes significant disturbances to the power system, AEMO must take all reasonable actions to return the power system to a secure operating state as soon as it is practical to do so, and, in any event, within 30 minutes.²¹

AEMO's Power System Emergency Management Plan (PSEMP) enables a coordinated response across states to power system incidents. These arrangements are governed by the National Electricity Rules, the NEM Emergency Powers Memorandum of Understanding, and the NEM Emergency Protocol. The PSEMP is designed to complement each state's own power system emergency response arrangements and communications plans. AEMO is reviewing the PSEMP to ensure that it is current before the FY2018 summer.

AEMO five point program to a secure FY2018 summer

Taking a more conservative approach to operating the NEM could improve power system security. This means operating the power system with increased generator, transmission and interconnector margins. This can be achieved by leaving sufficient headroom and running the power system components well within their technical envelope.

AEMO will continue to monitor conditions leading up to the start of the FY2018 summer and undertake the necessary measures to ensure the NEM remains stable. AEMO is currently progressing five measures underpinned by the implementation of the final recommendations from its review of the South Australian blackout,²² and the ongoing work of its Future Power System Security Program.

21. NER, r.4.2.6 (b).

22. AEMO, <https://www.aemo.com.au/Media-Centre/AEMO-publishes-final-report-into-the-South-Australian-state-wide-power-outage>, accessed 4 June 2017.

The five measures for the FY2018 summer include:

- **Supply availability:** AEMO is focussing on increasing electricity supply from existing resources. There will be no scheduled summer maintenance of generators and all mothballed fleet will be required to be made available from October 2017.
- **Fuel availability:** AEMO is contacting generators to ensure they will have enough fuel available to generate electricity at peak times, even after several successive hot days.
- **Network availability:** AEMO is working with network businesses to ensure that required transmission network capacity is available and scheduled maintenance during summer is minimised.
- **Peak demand response:** Under the Reliability and Emergency Reserve Trader provisions, AEMO is seeking expressions of interest for the provision of 'long notice reserve' in Victoria and South Australia for the FY2018 summer.²³ Reserve contracts could be used to access embedded generation, such as diesel and gas-fired generators connected to transmission and distribution systems (mostly located at industrial premises for their own use). It could also incentivise large consumers to reduce peak demand by load shifting. In addition to the use of the Reliability and Emergency Reserve Trader mechanism, AEMO is working with ARENA to pilot a new demand response initiative (see below).
- **Resilience and recovery:** To maximise power system resilience and recovery, AEMO will be conducting emergency event planning and exercises.²⁴

Under its System Security Market Framework Review, the AEMC is progressing a number of rule changes to maintain the security of the NEM. To help prevent system-wide blackouts, the AEMC has introduced a new rule to enable AEMO to declare 'protected events'. This is discussed further in Chapter 2.

Proof of concept – procuring demand response to manage reliability issues

ARENA and AEMO will be jointly piloting a new demand response initiative, set to begin in December 2017. This will help to manage electricity supply during extreme peaks. The three year program will be trialled in South Australia and Victoria to reduce demand during extreme weather and unplanned outages. Initially, the program will aim to secure 100 MW of demand response capacity by December 2017, with the potential to be scaled up in subsequent years. ARENA is committing up to \$22.5 million over three years to fund the pilot.

Participants will receive incentive payments to be on standby in emergencies or peak demand days. They could be called upon by AEMO to switch off or reduce their electricity use temporarily, and would receive a further compensation payment for doing so. The program is expected to be open to demand response aggregators, large industrial and commercial users.²⁵

South Australia region

Since the South Australian blackout on 28 September 2016, AEMO and the South Australian Government have implemented a number of measures to reduce the risk of the South Australia region becoming separated from the rest of the NEM, and to address other technical issues highlighted by investigations into the event.

23. AEMO, <http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Emergency-Management/RERT-panel-expressions-of-interest>, accessed 25 May 2017.

24. Courtesy of AEMO: Managing a power system in transition: five point program to a secure summer fact sheet.

25. ARENA media release, <https://arena.gov.au/news/arena-and-aemo-join-forces-to-pilot-demand-response-to-manage-extreme-peaks-this-summer/>, accessed 26 May 2017.

AEMO's short-term initiatives include:

- New constraints on the Heywood interconnector during credible contingencies.
- A minimum requirement of two sufficiently large synchronous generators to be online at all times.
- Improvements to emergency frequency control schemes.
- New processes for reclassifying credible contingencies in response to changing network conditions.
- Enhanced voltage ride-through settings on South Australian wind farms.
- Addressing generator capabilities to withstand rapid changes in frequency.

As part of its Energy Supply Plan, the South Australian Government has also announced a number of measures to improve the resilience of the South Australian power system.²⁶ While these measures are progressed, the South Australian Government will work with the State's transmission and distribution companies to provide up to 200 MW of temporary generation to be used in situations where extreme peaks in demand cannot be met in other ways. The South Australian Government has also introduced the *Emergency Management (Electricity Supply Emergencies) Amendment Bill 2017*, which gives the South Australian Energy Minister powers of direction in an electricity supply emergency for use as a last resort.

New South Wales region²⁷

The New South Wales Government established the Energy Security Taskforce chaired by Mary O'Kane AC, NSW Chief Scientist & Engineer in response to events relating to the February 2017 heatwave (as discussed in Box 1.1).²⁸ The Taskforce's initial report was publicly released on 22 May 2017 and the New South Wales Government is acting on the recommendations.²⁹ The New South Wales Taskforce highlighted the need to monitor fuel availability (especially coal and gas) and suggested key priorities for the New South Wales Government in the lead up to the FY2018 summer are to:

- Through the Premier and the Minister, take a leadership role in COAG and the Energy Council to have a national policy approach to climate change and the technology and market implications of these policies, to safeguard energy security and reliability.
- Take measures to manage peak demand proactively, and through engaging community and industry support, with the Government to lead by example through development of a 'code warm'³⁰ protocol.
- If preventative measures fail and load shedding is required, make sure the processes are optimised and effectively communicated.
- Improve the links between emergency management and the energy system, and make sure provisions, procedures and communications are refined and well-practised.

26. Government of South Australia, *Our Energy Plan*, 2017.

27. The Australian Capital Territory (ACT) falls within the NSW region.

28. NSW Energy Security Taskforce, <http://www.chiefscientist.nsw.gov.au/reports/nsw-energy-security-taskforce>, accessed 26 May 2017.

29. NSW Energy Security Taskforce, <http://www.chiefscientist.nsw.gov.au/reports/nsw-energy-security-taskforce/initial-report>, accessed 26 May 2017.

30. A code warm protocol is a set of procedures that government agencies could follow to reduce energy in the workplace if needed, for example changing air conditioning settings and turning off non-essential office equipment.

Victoria region

In preparation for summer, the Victorian Government is working with the energy industry to progress a number of measures including:

- Commencing an expression of interest process to build two 20 MW battery storage facilities to improve grid stability.
- Working with Emergency Management Victoria to strengthen coordination regarding emergencies involving energy supply disruptions. This includes the preparation and implementation of an annual Energy Sector Resilience Plan.
- Ensuring compliance by operators of vital critical infrastructure under Part 7A of the *Emergency Management Act 2013 (Vic)*.
- Leading the Energy Sector Resilience Network – a forum for information sharing between government and industry, and between different industry sectors, concerning critical energy infrastructure resilience.
- Supporting, with AEMO, the joint exercise to test the NEM arrangements for managing an event that affects the security of gas or electricity across NEM regions.

Tasmania region

In response to energy security challenges experienced in Tasmania in FY2016, the Tasmanian Government established the Tasmanian Energy Security Taskforce to undertake an independent energy security risk assessment for Tasmania.³¹

The interim Tasmanian Taskforce report was released in December 2016 and assesses that ‘there are no immediate threats to energy security in Tasmania’. The report also notes that the severity and occurrence of energy security incidents in Tasmania calls for ‘more conservative’ energy security settings, particularly given the unique characteristics of the whole Tasmanian energy system and the associated impact of rainfall variability on the state’s hydroelectric storages.

The Tasmanian Taskforce initial report identifies five priority actions (supported by 32 recommendations) to support Tasmania’s energy security over the short-term:

1. Define energy security and responsibilities.
2. Strengthen independent energy security monitoring and assessment.
3. Establish a more rigorous and more widely understood framework for the management of water storages.
4. Retain the Tamar Valley Power Station as a backup power station for the present and provide clarity to the Tasmanian gas market.
5. Support new on-island generation and customer innovation.

The Tasmanian Taskforce intends to focus its final report on the medium to long-term, including assessing options that could address some of the issues and challenges identified in their initial report. The final report will be delivered to the Tasmanian Government in June 2017.

31. Tasmanian Government, http://www.stategrowth.tas.gov.au/tasmanian_energy_security_taskforce, accessed 2 June 2017.

Queensland region

The Queensland Government prepares for the summer storm season each year. This includes ensuring that the best available predictive information is available and reviewing emergency processes and contingency procedures.

Queensland's government-owned electricity corporations' summer preparations include:

- Undertaking asset overhauls and maintenance outside of the storm season to ensure reliability during the summer period.
- Electricity generators reviewing and testing their emergency procedures, managing staff levels and increasing supply stocks including coal stockpiles.
- Electricity networks carrying out a number of preparative measures including: vegetation management, inspection and maintenance of assets, reviewing and testing emergency management plans, undertaking staff training and managing staffing levels, increasing supply stocks and undertaking stakeholder disaster management engagement.

1.4 Conclusion

AEMO, market participants and governments are working together to ensure that consumers continue to receive a reliable supply of electricity for the FY2018 summer. However, it is not possible to prevent or mitigate all impacts from extreme weather events or major equipment failure. The impacts of such events may be reduced through summer preparedness measures, ongoing monitoring, and innovative solutions. A more resilient NEM is crucial to restoring electricity supply as soon as practicable in the event of a disruption.

Going forward, the recommendations outlined in this blueprint provide a framework for governments to assure all Australians a secure, reliable and affordable power supply.

Chapter 2

INCREASED SECURITY

Overview

Security is a measure of the power system's ability to continue operating, even in the event of a disturbance such as the unexpected loss of generation or load. With increasing penetration of variable renewable electricity generators, the rules and market frameworks must be revised to ensure essential security services can be sourced from a range of technologies. It is also necessary to ensure that new generators have appropriate capabilities.

The Panel recommends the implementation of a set of Energy Security Obligations to ensure generators have appropriate technical capabilities, including in relation to changes in frequency and system strength. The Panel also makes recommendations around other challenges for system security, including black start capabilities and integrating distributed energy resources.

The environment in which the NEM operates is also changing. As the future grid evolves it will continue to be vulnerable to multiple risks from both natural and human hazards. The Panel makes recommendations around how governments, the energy market bodies and the electricity industry should ensure appropriate risk management strategies are in place to improve the resilience of the NEM.

2.1 New challenges need new approaches

Australia is dependent on a secure, reliable and affordable electricity supply for economic growth and maintaining our modern lifestyle. From telecommunications and finance to transportation and emergency services, every aspect of our daily lives relies on electricity supply. Electricity is also critical for maintaining Australia's national security, including our defence capabilities.

There are growing concerns about power system security.³² The NEM was designed in the 1990s when large centralised generation (coal, gas and hydro) supplied almost all electricity. The operational parameters for power system security were developed around the characteristics of these generators. However, in the last decade the NEM has seen a significant increase in variable renewable electricity (VRE) generation from wind and solar photovoltaic, and a decline in traditional coal and gas-fired generation.

Increased penetration of VRE generators requires new means to be introduced to address the reduced availability of essential security services that historically have been provided by fossil fuel and other synchronous generators. In addition, the connection standards for new generators must ensure that their capabilities and settings are appropriate. This includes technical requirements such as frequency control, voltage control, and response to power system disturbances. Other challenges for power system security through the energy transition include black start capabilities and integrating distributed energy resources.

There are technical solutions to address many of these issues and ensure that power system security meets community expectations. International experience suggests that delivering a secure power system with a high VRE penetration is technically and economically feasible,³³ while a number of studies have found that there are no technical barriers to a high VRE penetration in the Australian context.³⁴ It is important that there are efficient

32. AEMO submission to the Review, p.4.; Australian Energy Council submission to the Review, p.1.; Energy Users Association of Australia submission to the Review, pp.1-4.

33. GE submission to the Review, p.3.

34. Clean Energy Finance Corporation submission to the Review, p.2.

and equitable approaches for providing security services, and capturing their benefits. Work is already underway by AEMO and the AEMC in this regard. Solutions must be implemented on a region-by-region basis, so that costs and needs are balanced.

A secure power system is a necessary condition for a reliable supply of electricity to consumers. Chapter 3 will address broader reliability concerns.

As the future power system evolves, it will continue to be vulnerable to multiple risks from both natural and human hazards. These include emerging national security risks such as cyber attacks, the possibility of more frequent and intense extreme weather events, and shortfalls in certain workforce skills.

While energy businesses are generally well advanced in responding to weather events, emerging risks may not be as predictable or as amenable to traditional risk management strategies. It is crucial for governments, energy market bodies and the electricity industry to enhance their engineering, technical and ICT capabilities. In addition, ensuring appropriate risk management strategies are in place will improve the resilience of the NEM.

Box 2.1 – Definitions

Security

Security is a measure of the ability of the power system to tolerate disturbances and maintain electricity supply to consumers. Security is achieved by operating the system in a satisfactory and stable operating state and within the required bounds of a number of technical parameters such as frequency, voltage, fault current levels, and the operation of equipment within its design limits.

For example, the unexpected disconnection of a large generator or load can cause frequency deviations outside the normal range, leading to a rapid rate of change of frequency and resulting power system instability. This can then lead to cascading failures and ultimately even a “black system” where a significant part of the power system experiences a failure of the electricity supply.

Reliability

Reliability is a measure of the ability of generation and transmission capacity to meet consumer demand. Having adequate supply to match demand at all times raises new challenges and opportunities in a future with high proportions of VRE generators, and where generation and storage is distributed rather than centrally dispatched. Reliability is quantified as the proportion of total electricity demand that is not delivered.

A secure power system is a necessary, but not sufficient, condition for reliability.

Frequency

Stable 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 cycles per second (hertz), as prescribed in the frequency operating standards for the NEM.

When there is a mismatch between supply and demand the frequency will change. The rate of change of frequency (also known as RoCoF) is the measure of the speed at which the frequency deviates from 50 hertz.

Physical inertia

Physical inertia from synchronous machines plays an important role in slowing the rate of change of frequency when there is a mismatch between supply and demand, allowing time for frequency control mechanisms to respond.

Voltage

Areas within the network operate at different voltages, ranging from high voltage transmission lines to low voltage distribution networks.

Voltage control is important for the proper operation of electrical equipment and to reduce transmission losses. Alternating current (AC) power systems control voltage by managing the production and absorption of reactive power.

Essential security services

Essential security services are synchronous inertia, system strength and voltage control. Synchronous generators provide all these essential security services. As thermal synchronous generators retire new sources of essential security services will be required. In the future, batteries with specially designed power converters will be able to provide voltage control. Synchronous condensers can provide all essential security services.

System strength

System strength 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). System strength is usually measured by the available fault current at a given location.

2.2 State of security in the NEM

Power system security is represented by a number of technical parameters, as described in Box 2.1. The rules and market frameworks are still largely premised on these parameters being managed through services from large, central, synchronous generators. In contrast, the energy transition is taking the NEM on a path to increasingly smaller, distributed and non-synchronous generators. It follows that, without appropriate changes to the rules and market frameworks, there will be diminished capability to maintain power system security.

It is difficult to show quantitatively that the state of power system security is decreasing. However, some warning signs are emerging.

The Reliability Panel's annual market performance review characterises the security performance of the NEM by assessing deviations from technical standards for security parameters and the number of instances of certain events. In the 2016 annual market performance review (covering the FY2016 reporting period), it was found that:³⁵

- The amount of time the NEM spent outside the normal operating frequency band in FY2016 was greater than in FY2015 and FY2014.
- For the past three years, the number of times the normal operating frequency band has been exceeded on the mainland and in Tasmania has increased.³⁶

35. AEMC Reliability Panel, *Annual Market Performance Review 2016: Final Report*, 2017, p.48.

36. The mainland NEM has different frequency operating standards from Tasmania. The frequency operating standards for the mainland and Tasmania are available at [http://aemc.gov.au/getattachment/436495bb-89b9-4da6-b258-e24437df9b8a/Frequency-Operating-Standards-\(Mainland\).aspx](http://aemc.gov.au/getattachment/436495bb-89b9-4da6-b258-e24437df9b8a/Frequency-Operating-Standards-(Mainland).aspx) and [http://aemc.gov.au/getattachment/310247d0-85a5-408d-b3ae-c4a7cca328bc/Frequency-Operating-Standards-\(Tasmania\).aspx](http://aemc.gov.au/getattachment/310247d0-85a5-408d-b3ae-c4a7cca328bc/Frequency-Operating-Standards-(Tasmania).aspx), accessed 6 June 2017

In addition, some security parameters differ from historical levels, whilst others are projected to differ in the future. For example:

- The level of physical inertia in South Australia was lower in 2015 and 2016 compared to any previous year since 2010.³⁷
- AEMO has projected that by FY2036 system strength is likely to deteriorate further in much of South Australia, western Victoria and Tasmania, while local areas of poor system strength will start to emerge in New South Wales and Queensland.³⁸

Another indicator of power system security that the annual market performance review monitors is the number and nature of 'reviewable operating incidents'. The annual market performance review notes that the number of these incidents can fluctuate significantly each year and there is no evidence of any year-on-year trend.³⁹ The reviewable operating incidents that occurred in FY2016 included three major incidents – load shedding in Tasmania in August 2015, a trip of the Heywood interconnector in November 2015, and an outage on Basslink from December 2015 to June 2016.

Over the spring and summer of FY2017, further incidents have included the blackout in South Australia in September 2016 (as was discussed in the Preliminary Report) and the need for load shedding to restore the power system to a secure operating state during the heatwaves in South Australia and New South Wales in February 2017 (as was discussed in Chapter 1). Among other things, these events illustrate how power system security can be affected by more frequent and intense extreme weather events.

New approaches are needed to mitigate increasing risks to power system security. Those risks, and recommended actions, are described in the remainder of this chapter.

2.3 Integrating new technologies

It is important that any new technology – generation, storage, or otherwise – is properly integrated into the power system. In the short to medium-term, the main challenges are around integrating increasing levels of VRE generation. In the medium to longer-term, other generation technologies may play a role in supporting power system security (as discussed in Chapter 8).

An increased penetration of VRE generators relative to traditional fossil fuel generators requires new measures to ensure an adequate supply of essential security services. The following services are inherently supplied by fossil fuel and other synchronous generators, but are now in decline as fossil fuel generators have started to retire:

- **Physical inertia:** Historically in the NEM, physical inertia has been provided by synchronous generators.
- **System strength:** Substantial fault currents that support system strength are presently only provided by synchronous generators.⁴⁰
- **Voltage control:** Synchronous generators are useful for voltage control due to their ability to produce and absorb reactive power.

Because these services were historically plentiful, as essentially a by-product of power supply from synchronous generators, they were not explicitly valued in the NEM. With their growing scarcity, the hidden value of these services has emerged. New mechanisms will be needed to source these services, or appropriate alternatives, from synchronous machines and a range of other technologies.

37. AEMO, *Market Trends and Outlooks in Australia's Electricity Markets*, 2016, p.14. ; AEMO, *Future Power System Security Program: Progress Report*, 2016, p.21.

38. AEMO, *National Transmission Network Development Plan*, 2016, pp.66-67.

39. AEMC Reliability Panel, *Annual Market Performance Review 2016: Final Report*, 2017, p.62.

40. AEMO, *Future Power System Security Program: Progress Report*, 2017, p.20.

There is also a need to update the standards for generators to connect to the NEM. Unlike synchronous generators, for which technical performance characteristics are well understood, there is less experience with VRE generators.

A well-known characteristic of VRE generators is their variability. Their power output can change quickly due to changes in weather conditions (clouds, storm fronts, or wind speeds). The security implications of this have been identified by AEMO as a challenge for the future power system. The main issues are around managing flows of electricity within and between NEM regions, and the increased demand for frequency control services.⁴¹

Geographic and technological diversity in the NEM can allow security services to be supplied across regional boundaries, and can smooth out the impacts of variability. To the extent that existing transmission networks and interconnectors are congested or constrained, this may necessitate new or expanded transmission infrastructure. The NEM grid is long and linear, with much less network meshing than many international power systems. Some submissions to the Review suggested that greater meshing of the NEM grid, including from Queensland to South Australia, may have benefits.⁴² The considerations around developing transmission infrastructure are discussed in Chapter 5.

It is also important that security services are available within individual NEM regions in the event they become separated from the NEM (islanded). This is particularly the case for regions at the ends of the NEM that can more easily become islanded. Other solutions will need to be deployed in conjunction with increased diversity of supply.

Solution design

There are many existing or emerging technical solutions to address the issues described. Some available technologies are synchronous condensers and power converters with batteries, super capacitors or direct current interconnectors. These technologies are described in Chapter 8. Careful consideration must be given to designing mechanisms that enable the optimal technical solutions to be deployed at least net cost.

In line with the principle of technology neutrality, the approach should preferably be flexible to how the service is provided – whether by a generator or another type of energy resource or technology, including on the demand-side. This means specifying the technical parameters of the service required, but not how it is provided.

There are choices to be made between using market or non-market approaches. Under the right conditions, a well-designed market-based mechanism can be the most cost-efficient means of delivering a service.⁴³ For the delivery of technically-specific or location-dependent services, the absence of sufficient competition and other practicalities may necessitate a non-market approach, such as selective procurement or a regulatory requirement. At present, only frequency control services are procured through a market mechanism.⁴⁴

While new mechanisms to maintain power system security are being developed, AEMO will need to take a more conservative approach to operating the NEM. This may mean constraining certain power system components to run well within their operating limits.

41. AEMO, *Future Power System Security Program: Progress Report*, 2016, p.52.

42. Australian Academy of Technology and Engineering submission to the Review, p.4.; Engineers Australia submission to the Review, p.20.

43. AEMC, *System Security Market Framework Review: Interim Report*, 2016, p.xii.

44. The current frameworks for procuring security services are described in AEMO's Guide to Ancillary Services in the National Electricity Market, available at <https://www.aemo.com.au/-/media/Files/PDF/Guide-to-Ancillary-Services-in-the-National-Electricity-Market.ashx>, accessed 6 June 2017.

Energy Security Obligations

To address the issues described, it is important to develop and implement new mechanisms to promote:

- frequency control capabilities
- system strength capabilities
- other technical performance capabilities.

Some work is already underway by AEMO and the AEMC, including through the Future Power System Security Program and System Security Market Frameworks Review, as described in Box 2.2. The approaches being developed through that work, combined with some additional initiatives proposed by the Panel, can be characterised as a set of Energy Security Obligations for the NEM.

Box 2.2 – Security reviews underway

Future Power System Security Program

AEMO is undertaking the Future Power System Security Program, which aims to ensure power system security is maintained in the NEM in the face of a changing generation mix and demand profiles.

AEMO commenced this work in July 2016, and published a progress report in January 2017 outlining key focus areas for the next six months in relation to challenges of frequency control, reduced system strength and power system visibility.

System Security Market Frameworks Review

In parallel with the Future Power System Security Program, in July 2016 the AEMC commenced a review into the market and regulatory frameworks that affect system security in the NEM – the System Security Market Frameworks Review.

Its scope is to 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 challenges of frequency control and reduced system strength. In March 2017 the AEMC published a Directions Paper setting out its proposed approaches in relation to those challenges and seeking consultation.

Frequency control capabilities

The NEM is designed to operate at a frequency of 50 hertz. For the power system to remain secure the frequency must be maintained within a narrow band around this level. The frequency operating standard defines the range of allowable frequency under different conditions.

Rate of change of frequency

As the physical inertia in the power system reduces, higher rates of change of frequency will increasingly challenge the effectiveness of existing frequency control mechanisms. This issue will be more pronounced in those NEM regions with lower availability of physical inertia. Under the Future Power System Security Program, AEMO has been projecting the future exposure of the NEM to high rates of change of frequency, and the likely impacts, particularly in South Australia.⁴⁵

45. AEMO, *Future Power System Security Program: Progress Report*, 2017, pp.6-9.

Technologies that provide a fast frequency response (FFR, described in Box 2.3), including ‘synthetic inertia’ from wind turbines, can partially compensate for a decrease in physical inertia. However, international experience shows that at present, in large power systems such as the NEM, FFR cannot provide a complete substitute for physical inertia.⁴⁶ That is, a minimum level of physical inertia from synchronous technologies is required.

In the future, the capability may emerge for inverter technologies to set and constantly maintain frequency.⁴⁷ For the interim, the required level of physical inertia will need to be supplied by synchronous generators (including zero emissions generators such as hydro, biomass and solar thermal generators), synchronous condensers and synchronous motors.

The Melbourne Energy Institute has conducted a detailed analysis of the required minimum level of physical inertia under a range of scenarios modelled for the Review.⁴⁸ The analysis is based on an assessment of frequency response adequacy, and concludes that security challenges associated with a high penetration of VRE generation can be overcome by optimising inertia and frequency control services and by having appropriate operational constraints.

Box 2.3 – Fast frequency response capabilities

Fast frequency response (FFR) is a rapid injection of power or reduction of demand that helps arrest the rate of change of frequency. Different FFR technologies have different characteristics and economics, and respond at different speeds and durations. AEMO’s work under the Future Power System Security Program has included a review of international experience and analysis of the technical capabilities and potential value of FFR services.⁴⁹

Power system events	Minimum	Maximum
50 Hertz AC cycle	20 milliseconds	N/A
Protective relay operation	20 milliseconds	80 milliseconds
Inertial response	20 milliseconds	3 seconds
Under frequency load shedding	100 milliseconds	400 milliseconds
Existing frequency control services	6 seconds	5 minutes
5 minute dispatch	5 minutes	N/A
Service restoration from outages	1 hours	8 hours
Fast frequency response (under development)	500 milliseconds	3 seconds

While there is often a focus on FFR technologies on the supply-side, it is important to recognise the valuable potential of demand-side resources, which, according to AEMO, are likely to be technically effective, and cost-efficient in providing FFR.⁵⁰ ARENA’s submission to the Review notes that “the ability for the demand side to provide frequency control ancillary services, including sub-second fast

46. DGA Consulting prepared for AEMO, *International review of frequency control adaptation*, 2016, p.3.

47. DGA Consulting prepared for AEMO, *International review of frequency control adaptation*, 2016, p.3.

48. University of Melbourne, Melbourne Energy Institute, *Power system security assessment of the future National Electricity Market*, 2017.

49. AEMO, *Future Power System Security Program: Progress Report*, 2017, pp.6-7.

50. AEMO, *Fast Frequency Response Specifications: Release of the GE Energy Consulting Report*, 2017, p.2.

*frequency response, has been demonstrated across multiple global markets including through the Special Protection Service in Tasmania”.*⁵¹

Interruptible consumer loads can provide very fast frequency response services. Commercial and industrial consumers can be equipped with a device that includes a frequency sensor, a relay, and a high-speed recorder. The relay is wired into the load’s control system or a circuit breaker and once power system frequency falls below a defined threshold (typically the result of a sudden, unexpected loss of generation or transmission), the relay triggers, and the load is interrupted. This form of interruptible load can respond very quickly. Alberta and New Zealand are examples of markets that have large amounts of interruptible load providing fast frequency response services through independent aggregators, in timeframes of within 0.2 seconds (in Alberta) or within one second (in New Zealand).⁵²

Through the System Security Market Frameworks Review, the AEMC has proposed a staged approach to mitigating high rates of change of frequency. The staged approach reflects the AEMC’s assessment that, ultimately, market-based mechanisms for procuring inertia and FFR are preferable, but there are first some practicalities to be overcome.⁵³ Separate measures are proposed for inertia and FFR in recognition of the distinct characteristics of these services.⁵⁴ However, the measures are designed to reflect that, beyond a minimum level of physical inertia, it will be most cost efficient to manage power system security through some combination of additional inertia and FFR services.⁵⁵

The AEMC’s proposed measures in respect of inertia are to:

- Initially – require transmission network service providers (TNSPs) to maintain a specified level of inertia (as determined by AEMO). Subject to AEMO’s agreement, the TNSPs could enter into contracts to procure FFR services from third parties in substitute for some of the inertia.
- Subsequently – implement an incentive framework for TNSPs to provide additional inertia above the required operating level, to the extent that the additional inertia would provide net benefits to the power system by alleviating network constraints and improving power transfer capability.

The Panel supports the need for AEMO to quantify an appropriate level of inertia for each region or sub-region (as well as the portion that could be substituted with FFR services). The level of inertia required should decrease over time as technologies evolve and their costs reduce.

Many submissions to the System Security Market Frameworks Review consultation process questioned giving TNSPs the responsibility to provide inertia,⁵⁶ with some suggesting that AEMO would be better placed to perform this function.⁵⁷ AEMO itself supports the approach of TNSPs having the responsibility to provide inertia.⁵⁸ A particular benefit of this approach is that it will allow TNSPs’ investments to be co-optimised to also manage system strength.⁵⁹

51. ARENA submission to Review, p.9.

52. EnerNOC submission to the Review, p.19.

53. AEMC, *System Security Market Frameworks Review: Directions Paper*, pp.23-24, 37-38.

54. AEMC, *System Security Market Frameworks Review: Directions Paper*, p.11.

55. AEMC, *System Security Market Frameworks Review: Directions Paper*, p.vi.

56. Australian Energy Council, Reach Solar Energy, South Australian Council for Social Service, RES Australia, Origin Energy Limited, ENGIE, and ATCO Australia submissions to AEMC, *Australian Energy Market Commission System Security Market Frameworks Review Directions Paper*, 2016.

57. ENGIE and Origin Energy Limited submissions to AEMC, *Australian Energy Market Commission System Security Market Frameworks Review Directions Paper*, 2016.

58. AEMO submission to AEMC, *Australian Energy Market Commission System Security Market Frameworks Review Directions Paper*, 2016, p.3.

59. AEMC, *System Security Market Frameworks Review: Directions Paper*, 2017, p.22.

The AEMC's proposed measures in respect of FFR are to:

- Initially – require new non-synchronous generators (wind and large-scale solar) to have capability to provide FFR services.
- Subsequently – establish a market for provision of FFR services.

The Panel strongly supports a requirement for new generators be able to provide FFR services. Some submissions to the Review proposed a similar requirement.⁶⁰ It is a step towards promoting competition in the provision of FFR services from generators. The AEMC could also consider developing additional short-term measures to promote FFR capabilities from other sources, such as distributed energy resources and demand response.⁶¹

The Panel conditionally supports the AEMC's subsequent measure to establish a market for provision of FFR services, but considers that some further refinement is needed to ensure a well-designed solution. In particular, there will need to be clear evidence that a market-based approach will be effective in procuring sufficient quantities of FFR to avoid compromising security. The market design would need to incorporate the desired technical parameters of an FFR service, including the response speed, sustain times and control systems.⁶²

Emergency frequency control

Despite the AEMC's proposed measures to mitigate changes in frequency, there is still a risk that under very high rates of change of frequency, emergency frequency control schemes would not operate quickly enough to prevent a widespread disruption to power supply. In this context, the AEMC has recently made rule changes to enhance the operation of emergency frequency control schemes. The rule changes also allow for schemes to replace under frequency load shedding relays at substations with schemes for faster tripping of selected loads. This would help to prevent embedded generator tripping and would benefit distribution networks with a high proportion of rooftop solar photovoltaic.

The rule changes newly define a 'protected event' – a power system disruption that has a low likelihood of occurring, but a high consequence. Previously AEMO did not consider that the rules allowed pre-emptive action to minimise the possible change in frequency due to such an event; instead, controlled load shedding would be used. Now, when a protected event is identified, AEMO may take pre-emptive action, such as purchasing frequency control services or applying constraints in the dispatch process.

Under frequency load shedding (UFLS) is designed to disconnect blocks of load when the frequency drops below a given threshold. However, UFLS schemes are primarily based on experience about the behaviour of the power system rather than system-level testing. Individual relay settings are tested and revised until a successful UFLS scheme is obtained. This process is unsophisticated and generally leads to shedding more load than is strictly required. A review of the UFLS design and emerging alternatives is necessary to improve security as the NEM moves to lower levels of inertia. This will ensure that the UFLS evolves to be more predictable and supportive of distributed energy resource orchestration.

Primary frequency control

Concerns have also been raised about primary frequency control capabilities in the NEM, as it is now seeing more regular frequency variations.⁶³

While the mainland frequency remained within the normal operating frequency band in FY2016, frequency control is poorer than it was in the early years of the NEM. A contributing factor to this has been the decision,

60. GE submission to the Review p.5; TasNetworks submission to the Review, p.17.

61. AEMO submission to AEMC, *Australian Energy Market Commission System Security Market Frameworks Review Directions Paper*, 2017, p.22.

62. AEMO, *Fast Frequency Response Specifications: Release of the GE Energy Consulting Report*, 2017, pp.2-3.

63. Pacific Hydro submission to the Review. p.3.

over time, by many synchronous generators to disable their governors⁶⁴ so that they do not respond to frequency variations under normal conditions. This helps prevent wear and tear from repeated activation and deactivation of governors.⁶⁵ The frequency range within which generator governors do not respond is known as 'deadband'.

Many international power systems that operate at 50 hertz have a tighter frequency operating standard than the NEM,⁶⁶ such as ± 0.1 hertz or ± 0.05 hertz, and require generators to adopt an even tighter deadband.⁶⁷ Having more generators in the NEM contribute towards frequency control by requiring a tighter deadband would help to reduce frequency variations.

A tighter deadband was proposed in submissions to the Review from GE and Pacific Hydro.⁶⁸ GE suggests this would support a quicker response to frequency changes and improve the capacity to maintain network security.⁶⁹

Tightening the frequency operating standard could improve the security and resilience of the system, increasing the time the frequency is close to 50 hertz and away from the load shedding range. A change to the frequency operating standard would need to be supported by a cost-benefit analysis. Requiring generators to adopt a tighter deadband could reduce the cost of such a change. Consequential adjustments to the existing frequency control services markets would also need to be assessed.

System strength capabilities

New technological approaches, such as innovative protection and control systems, will be required to address issues around low fault currents in a higher non-synchronous system. If this is not addressed, current network protection systems will become less effective. AEMO has a range of work underway through the Future Power System Security Program in relation to system strength.⁷⁰

The AEMC's proposed approach to addressing system strength is to clarify in the National Electricity Rules that network service providers have responsibility for maintaining an agreed minimum short circuit ratio to connected generators.⁷¹ Network service providers would use a 'causer-pays' approach to address situations where the connection of a new generator causes the local short circuit ratio to drop below its minimum. However, where the cause is the retirement of an existing generator, the costs instead would be socialised.⁷² The Panel agrees with this proposed approach.

Additionally, in conjunction with the AEMC's proposed approach, newly connecting generators should be required to ensure that they can meet all their performance standards at the minimum short circuit ratio expected at their location in the future.

64. A governor is a device that regulates the supply of fuel, steam, or water a power station turbine, ensuring uniform motion or limiting speed.

65. EY prepared for IMO, *2014 ancillary service standards and requirements study Report to the Independent Market Operator*, 2014, p.25.

66. The allowable frequency range for the NEM under normal operating conditions is ± 0.15 hertz.

67. EY prepared for IMO, *2014 ancillary service standards and requirements study Report to the Independent Market Operator*, 2014, pp.130-135.

68. Attachment to Pacific Hydro submission to the Review, p.11.

69. GE submission to Review, p.11.

70. AEMO, *Future Power System Security Program: Progress Report*, 2016, pp.45-47.

71. The short circuit ratio is the ratio of the grid's short circuit megavolt-amperes before a new generator is connected, to the MW capacity of the connecting generator. The short circuit ratio is used to quantify the strength of the power system. The lower the short circuit ratio, the weaker the strength.

72. AEMC, *System Security Market Frameworks Review: Directions Paper*, 2017, pp.80-83.

Other technical performance capabilities

All generators that connect to the NEM are required to meet acceptable levels of performance in respect of a number of technical requirements, including frequency control, voltage and reactive power control, active power control, and response to power system disturbances.⁷³

The framework in the National Electricity Rules provides that generators can negotiate a connection standard between a minimum level (below which they cannot connect), and an automatic level (that they cannot be asked to exceed). Some states and territories apply additional requirements, up to the automatic level, through conditions in generator licences or development approval processes. For instance, in South Australia additional connection standards have been applied through licence conditions.

It has been more than ten years since a comprehensive review of the connection standards was last undertaken. It is important that the connection standards are now updated so that they are harmonised across the NEM, and are fit-for-purpose in a modern and rapidly transforming power system. In its submission to the Review, GE recommends developing *“a rules regime that is agile and incentivises generation performance that supports grid stability”*.⁷⁴ Going forward, in light of the ongoing technological change facing the NEM, the AEMC should undertake a comprehensive review of the connections standards every three years.

Updated standards should apply to all new generators, in accordance with the principle of technology neutrality, but are particularly relevant for VRE generators. Technology has improved significantly over the past ten years thus higher standards that significantly improve those generators’ contribution to system security need not be a barrier to entry.

VRE generators connect to the grid through power electronics, or inverters, which must be designed and configured to provide the desired technical performance. Understanding their capabilities and settings is important to maintaining power system security. This was a prominent factor in the blackout in South Australia in September 2016, as discussed in Box 2.4. The connection standards and protection settings need to be optimised to protect both the generator and the power system.

Box 2.4 – Wind generator fault ride-through response settings

One of the factors that led to the blackout in South Australia in September 2016 was that some wind generators had a control setting that disconnected or reduced their output in response to multiple power system disturbances. In particular, upon detecting a series of voltage dips, nine wind farms simultaneously disconnected or cut their output after exceeding a pre-set limit for the number of ride through responses in a two minute period.

AEMO was not aware of their pre-set protection limits.⁷⁵

The event highlighted that access to correct technical information about grid-connected equipment is critical for system security. Performance standards must describe, unambiguously, the expected performance of each generating system or unit. While wind generator settings were changed shortly after the event to remove the risk of recurrence under similar conditions, to address the broader issue, AEMO is carrying out work to support changes to performance standards for new generators to address deficiencies identified as a result of the event.⁷⁶

73. NER, r.5.2.

74. GE submission to Review, p.4.

75. AEMO, *Black System South Australia 28 September 2016: Final Report*, 2017, p.24.

76. AEMO, *Black System South Australia 28 September 2016: Final Report*, 2017, p.132.

In consultation with AEMO, the Essential Services Commissions of South Australia (ESCOSA) is undertaking a process to change licence conditions relating to the connection of generators in South Australia. This process has considered the technical requirements of the modern power system, including reactive power supply, voltage control capabilities, the performance of generators during and subsequent to contingency events, and active power control capabilities.

The requirements identified through the ESCOSA process should be extended to have NEM-wide applicability. AEMO intends to make a submission to the AEMC by July 2017, which will build on the ESCOSA process, by requesting corresponding changes to the connection standards.⁷⁷

A key conclusion from the final report of AEMO's review of the South Australian blackout was that *"access to correct technical information about grid-connected equipment is critical for system security"*.⁷⁸ The Panel agrees with this conclusion. Accordingly, there should be a NEM-wide requirement that to be approved for connection new generators must fully disclose any software or physical parameters that could affect security or reliability.

In updating the connection standards it would also be useful to have regard to international connection standards, such as those recently developed by the European Network of Transmission System Operators for Electricity.⁷⁹

Whilst it will be difficult to apply updated standards to existing generators, other incentives could be considered to encourage those generators to augment their technical capabilities. In particular, a large number of older generators do not have to comply with any connection standards. AEMO currently has limited knowledge about the capabilities and settings of those generators, which constrains their ability to manage power system security.⁸⁰

Recommendation 2.1

A package of **Energy Security Obligations** should be adopted. By mid-2018 the Australian Energy Market Commission should:

- Require transmission network service providers to provide and maintain a sufficient level of inertia for each region or sub-region, including a portion that could be substituted by fast frequency response services.
- Require new generators to have fast frequency response capability.
- Review and update the connection standards in their entirety.
 - The updated connection standards should address system strength, reactive power and voltage control capabilities, the performance of generators during and subsequent to contingency events, and active power control capabilities.
 - To be approved for connection, new generators must fully disclose any software or physical parameters that could affect security or reliability.
 - Thereafter, a comprehensive review of the connection standards should be undertaken every three years.

77. AEMO, *Recommended Technical Standards for Generator Licensing in South Australia: Advice to ESCOSA*, 2017, p.2.

78. AEMO, *Black System South Australia 28 September 2016: Final Report*, 2017, p.7.

79. TasNetworks submission to Review, p.16.

80. AEMO submission to the Review, p.8.

Recommendation 2.2

A future move towards a market-based mechanism for procuring fast frequency response (as proposed as a subsequent measure in the System Security Market Frameworks Review) should only occur if there is a demonstrated benefit.

Recommendation 2.3

By mid-2018, the Australian Energy Market Operator and Australian Energy Market Commission should:

- Investigate and decide on a requirement for all synchronous generators to change their governor settings to provide a more continuous control of frequency with a deadband similar to comparable international jurisdictions.
- Consider the costs and benefits of tightening the frequency operating standard.

Black start services

Extreme events can disrupt the power system and result in a significant part of the electricity grid suffering a total shutdown. This is known as a 'black system' event. To restore power to the system immediately after a black system event, AEMO procures 'black start' services (formally known as System Restart Ancillary Services) from contracted generators that are capable of restarting without the need for an external electricity supply. These generators provide power to the grid, enabling other generators to restart and the process of progressively restoring electricity supply to consumer loads to proceed.

Only some generators, often hydro or open cycle gas turbines, can provide black start services. Black start services cannot be provided by VRE generators such as wind or solar photovoltaic.⁸¹ However, black start services can be provided by other existing and emerging technologies, such as pumped hydro storage systems,⁸² voltage source converter interconnector technology (HVDC-VSC),⁸³ and battery storage systems. In north-eastern Germany a 5 MW battery system has been installed to provide black start services,⁸⁴ while in southern California the use of a battery system to restart a gas turbine from an idle state has been successfully demonstrated.⁸⁵

It is important to maintain sufficient black start services as the generation mix changes. It is also important that new entrant generators have sufficient capabilities to contribute to system restoration following a major supply disruption such as a black system event.⁸⁶

The black system event in South Australia in September 2016 was the first time AEMO has ever had to call on its contracted black start services.⁸⁷ However, the two contracted sources failed to deliver black start services on that occasion, due to technical difficulties.

The System Restart Standard guides AEMO in contracting black start services, and defines the processes and timeframes for restoring supply. It was recently reviewed and updated by the AEMC. The new System Restart

81. AEMO, *Recommended Technical Standards for Generator Licensing in South Australia: Advice to ESCOSA*, 2017, p.54.

82. Stocks, M, Blakers, A, and Lu B, <http://energy.anu.edu.au/files/Senate%20submission%20-%20ANU%20pumped%20hydro%20energy%20storage%20030217.pdf>, accessed 3 June 2017.

83. Australian Academy of Technology and Engineering submission to the Review, p.9.

84. Batstorm, <http://www.batstorm-project.eu/one-battery-do-it-all-demonstration-black-start-capability-germany>, accessed 31 May 2017.

85. Energy Storage News, <https://www.energy-storage.news/news/california-batterys-black-start-capability-hailed-as-major-accomplishment-i>, accessed 31 May 2017.

86. AEMO, *Recommended Technical Standards for Generator Licensing in South Australia: Advice to ESCOSA*, 2017, p.54

87. AEMC, *Annual Market Performance Review 2016*, 2017, p.55.

Standard provides a more stringent target for the procurement of black start services by AEMO. It will apply from July 2018, when the current contracts end.

A well-designed restoration process requires a detailed plan, clear identification of various roles of the parties involved at each of the restoration stages and a regular test schedule.

Recommendation 2.4

By mid-2018, the Australian Energy Market Operator should take steps to ensure the black system restart plan for each National Electricity Market region clearly identifies the roles of the parties involved at each stage of the restoration process, and includes regular testing of black start equipment and processes.

The security implications and opportunities of distributed energy resources

The electricity system was not originally designed to accommodate millions of distributed energy resources (DER) such as rooftop solar photovoltaic and battery storage systems. CSIRO and Energy Networks Australia estimate that 30 to 45 per cent of annual electricity consumption could be supplied from consumer-owned generators by 2050.⁸⁸

Growing numbers of DER greatly increases the complexity of operating the power system, requiring management of large amounts of data, advanced operating and communication systems and development of software for stable and efficient operation; and can undermine the effectiveness of existing mechanisms for maintaining security. Some issues include:

- Clusters of DER can cause localised voltage spikes and flicker.
- Distribution networks with high levels of DER can reverse power flows within short time intervals, which can adversely impact transmission networks – for instance, by reducing the effectiveness of the under frequency load shedding scheme.⁸⁹
- Increasingly extreme ramp events resulting from the surge and decline in solar photovoltaic generation when the sun rises and sets.
- A lack of information about the settings of control systems that determine how battery storage systems are charged and discharged. For example, a large number of battery storage systems may discharge electricity to the grid all at the same time due to a programmed response to price signals or coordinated action by a third party aggregator. This can undermine AEMO's supply and demand forecasts.
- A risk that homogenous settings for rooftop solar photovoltaic inverters could result in a loss of generation during a frequency disturbance – though for the NEM this risk has been assessed as generally of low probability due to a large proportion of inverters having settings that will keep them connected for frequency disturbances within the required frequency operating ranges.⁹⁰

AEMO's ability to address these issues is affected by outdated connection standards and control mechanisms. In particular, AEMO has identified the visibility of DER as a high-priority challenge to future power system security,⁹¹ as discussed in further detail below.

88. Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Final Report*, 2017, p.i.

89. AEMO, *Future Power System Security Program: Progress Report*, 2016, p.30.

90. AEMO, *Response of Existing PV Inverters to Frequency Disturbances*, 2016, pp.1-4.

91. AEMO, *Future Power System Security Program: Progress Report*, 2016, p.17.

With appropriate communications infrastructure, standards and aggregation mechanisms in place, DER can provide significant opportunities to improve power system security. Rooftop solar photovoltaic and battery storage systems could complement large-scale technologies for providing services such as frequency control, reactive power and voltage control.

It will become increasingly necessary, and valuable, for power system security to be achieved through DER ‘orchestration’ – that is, using communication signals to coordinate and optimise their dispatch in a dynamic manner. However, without early consideration and planning this could limit the opportunities for optimising the use of DER. Accordingly, the AEMC should review the regulatory framework for power system security in respect of DER, and develop rule changes to better incentivise and orchestrate DER to provide essential security services such as frequency and voltage control.

Ultimately, with an increase in the number of consumers with smart appliances and home energy management systems, and with resources likely to be owned and controlled by a number of parties, an already complex system will become more complex. Eventually the current approach of having AEMO as a single centralised system operator will need revisiting as the NEM may become too complex to be managed by a single entity working on its own. This complexity may require aggregators to have distributed regional operational control to ensure that all the markets in aggregate are operated within the technical envelope of the network.

Recommendation 2.5

By mid-2018, the COAG Energy Council should direct the Australian Energy Market Commission to review the regulatory framework for power system security in respect of distributed energy resources participation.

By mid-2019, the Australian Energy Market Commission should report to the COAG Energy Council on proposed draft rule changes to better incentivise and orchestrate distributed energy resource participation to provide services such as frequency and voltage control.

Visibility of DER

A lack of visibility of DER directly impacts on AEMO’s ability to forecast power system load, and to understand and account for the response of load, in aggregate, to power system disturbances. At a minimum, AEMO requires data on the location, capacity, technical characteristics, real-time output and consumption by controllable loads for new DER installations. AEMO does not have access to complete data of this nature for past or present DER installations.⁹²

While there is a clear need for greater visibility of DER, it will be necessary to decide what point of data collection provides a sufficient level of visibility whilst minimising the costs of implementing and managing the data collection process. For example, instead of collecting data from each individual DER system, aggregated data could be collected from the distribution transformer or the zone substation. This decision needs to be considered carefully, including with reference to:

- The latest telemetry technologies and data analytics and modelling approaches,⁹³ and the need to obtain a statistically valid data set.⁹⁴
- Opportunities to use existing mechanisms and frameworks for data collection.

92. AEMO, *Visibility of Distributed Energy Resources: Future Power System Security Program*, 2017, p.3.

93. Engineers Australia submission to the Review, p.22.

94. TasNetworks submission to Review, p.18.

Another important issue to be addressed is the regulatory framework for hosting and sharing the data. This includes who is responsible for data collection and maintenance (for example, by AEMO directly, or by other entities and fed through to AEMO), and who has access to the data (with consideration to consumer privacy concerns and the commercial and public value of the data).

Additionally, the need for DER visibility for power station management purposes will overlap with the need for DER visibility for other purposes – in particular, for safety reasons, to enable the orchestration of DER, and for better optimisation of network planning. The approach to data collection and access will need to be co-optimised for these purposes. For example, as data has a key role in enabling the orchestration of DER, better defining the possible modes of orchestration will help shape what type of data are required.

Some stakeholders advocate that a market approach to the wider challenge of DER orchestration will implicitly solve the visibility problem. In theory, this would provide an incentive for DER owners to provide their data in order to participate in the market – without the need for a costly new data collection framework.⁹⁵

Internationally, power systems at the forefront of DER installations have recognised the importance of DER visibility for power system management,⁹⁶ and some market operators are already taking action. The Electric Reliability Council of Texas has identified the visibility of static DER data as a foundation of reliable and efficient management of the future distributed grid and has proposed a process of working collaboratively with Distribution Network Service Providers and TNSPs to map the locations of large clusters of small DERs (or individual large DERs) into their power system model.⁹⁷

The generally preferred approach to DER visibility in the United States is one that essentially equates to the system operator having visibility of aggregated DER data (a ‘single virtual resource’) at the zone substation point, as part of an overarching model of distribution network operators having responsibility for DER orchestration.⁹⁸

The COAG Energy Council has a project underway that specifically focusses on energy storage systems, investigating the possibility of establishing a registration process to collect static data on these systems. Static data from such a registry would solve part of the challenge of DER visibility. AEMO has proposed that this project be extended to a broader registry that would cater for a wider range of technologies.⁹⁹

Separately, AEMO is proceeding with an engagement process to identify the viability of different options for a future data collection framework amongst key industry stakeholders.¹⁰⁰

The work underway by AEMO is timely, and more should be done to support it – that is, to accelerate the identification and deployment of a least-cost approach for obtaining static and real-time DER data, with openness to whether this could be achieved through a market mechanism rather than a data collection framework.

Recommendation 2.6

The COAG Energy Council, in addition to its project on energy storage systems, should develop a data collection framework (or other mechanism) to provide static and real-time data for all forms of distributed energy resources at a suitable level of aggregation. The project should be completed by mid-2018.

95. New York ISO, *A Review of Distributed Energy Resources*, 2014, p.122.

96. California ISO, *Final Report for Assessment of Visibility and Control Options for Distributed Energy Resources*, 2012.

97. ERCOT, http://www.ercot.com/content/wcm/lists/121384/DERs_Reliability_Impacts_FINAL_032217.pdf, accessed 13 April 2017.

98. Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Future market Platforms and Network Optimisation Synthesis Report*, 2017, pp.70–71.

99. AEMO submission to the Energy Market Transformation Project Team: COAG Energy Council Working Group, *Energy Storage Registry*, 2016, pp.3–4.

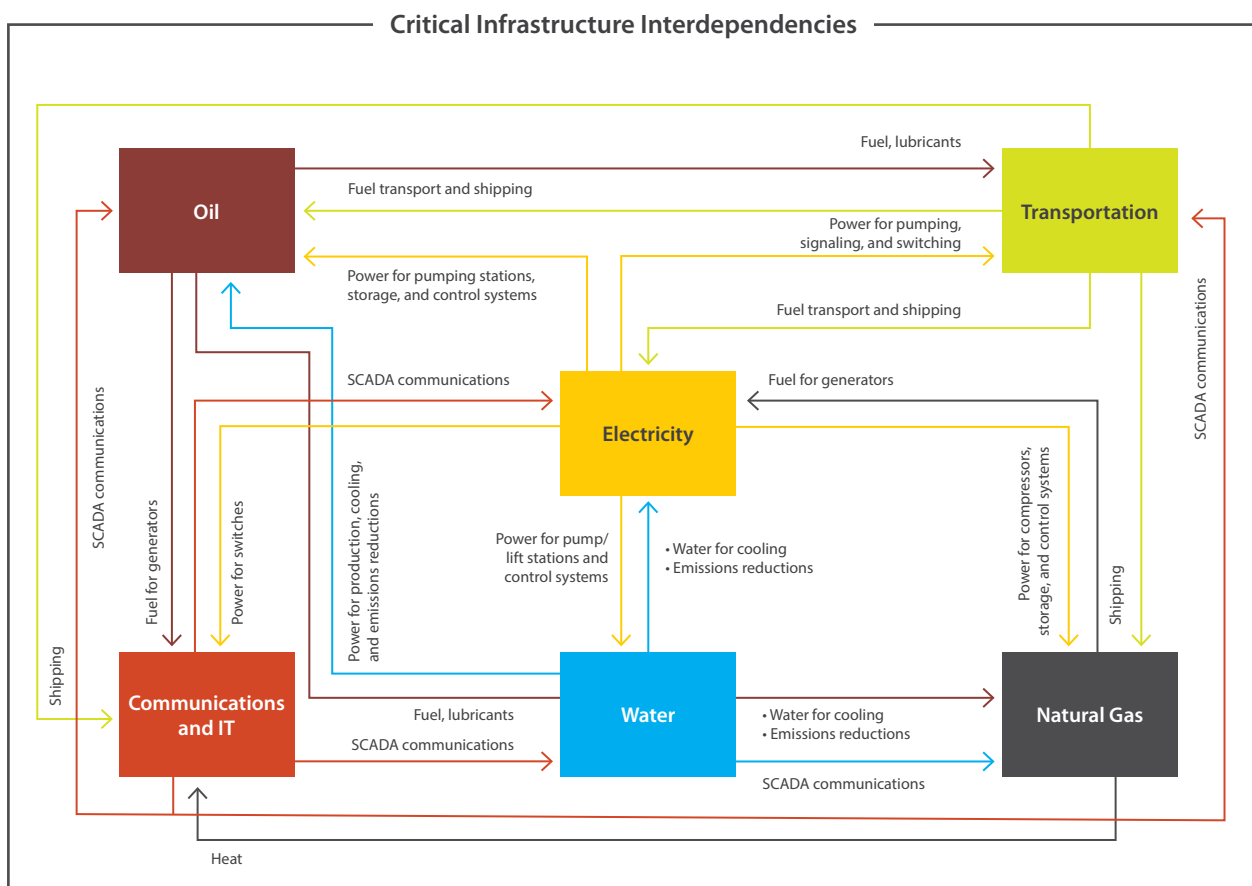
100. AEMO, *Future Power System Security Progress Report*, 2017, p.16.

2.4 Evolving risks for a multifaceted NEM

The NEM is categorised as critical infrastructure, that is, “those physical facilities, supply chains, information technologies and communication networks, which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact the social or economic wellbeing of the nation or affect Australia’s ability to conduct national defence and ensure national security”.¹⁰¹

The NEM’s ability to supply electricity depends on other critical infrastructure sectors, such as ICT, banking and finance, and water; and other sectors depend on the NEM to provide them with electricity (see Figure 2.1). As such, a disruption in the supply of electricity would impact the security and resilience of other critical infrastructure sectors.

Figure 2.1: Electricity system interdependencies¹⁰²



The future NEM will likely operate with a multitude of new digital control devices, sensors, and smart meters. These technologies will bring many benefits for the operation and control of the power system.

The Trusted Information Sharing Network was established by the Australian Government to build a stronger understanding of critical infrastructure cross-sector dependencies and a shared understanding of operational continuity. Continued cooperation through the Trusted Information Sharing Network to share information across sectors and to identify evolving risks for the NEM is integral.

The Australian Government currently takes a non-regulatory approach to critical infrastructure resilience, as businesses are best placed to assess and mitigate risks to their operations. The Australian Government monitors

101. 2015 Critical Infrastructure Resilience Strategy - Australian, State and Territory governments definition of critical infrastructure.

102. Adapted from U.S Department of Energy, *Quadrennial Energy Review: Second Instalment*, 2017, p.9.

energy security in the electricity sector through the National Energy Security Assessment. However, a new National Energy Security Assessment has not been released since 2011. Given the limited data and experience with respect to emerging human and environmental threats, there is a future role for the Australian Government to assess the resilience of the NEM to build an understanding of potential emerging threats.

Recommendation 2.7

The Australian Government should lead a process to regularly assess the National Electricity Market's resilience to human and environmental threats. This should occur by mid-2019 and every three years thereafter.

Enabling innovation

The emergence of new technologies and increased consumer participation in energy choices can drive innovation in the NEM. Innovative technologies can help reduce the costs of providing secure and reliable electricity supply and contribute to reducing emissions.

Irrespective of the type of electricity innovation that may occur in the future, there must be a framework for rapid proof-of-concept testing to demonstrate new technologies and accelerate their integration into a competitive market. To some extent, proof-of-concept testing is already being supported through grants provided by ARENA, which aims to accelerate Australia's shift to secure, affordable and reliable renewable energy. Support for ARENA should continue and proof-of-concept projects should be a focus.

The rules, market frameworks and processes should be aligned to support emerging technologies and the ability to test them. At present, new concepts that are inconsistent with the National Electricity Rules must be proven to the point where a rule change can be made prior to being used in the NEM. Formal proof of concept provisions in the Rules would help.

There may be an opportunity to learn from mechanisms used in the United Kingdom to achieve similar objectives. The Office of Gas and Electricity Markets administers an annual Electricity Network Innovation Competition, which provides funding to develop and demonstrate new technologies, operating arrangements and commercial arrangements for the power system.¹⁰³ It also administers an Innovation Rollout Mechanism, providing limited funding for the roll-out of proven innovations which would not be cost-effective under a business as usual approach.¹⁰⁴

Recommendation 2.8

By end-2018, the Australian Energy Market Commission should review and update the regulatory framework to facilitate proof-of-concept testing of innovative approaches and technologies.

Recommendation 2.9

Proof-of-concept testing of innovative grid-scale solutions will be required for as long as technology is continuing to rapidly evolve. A funding source for trials by the Australian Energy Market Operator and the Australian Renewable Energy Agency should be assured for the long-term.

103. Ofgem, <https://www.ofgem.gov.uk/network-regulation-riio-model/network-innovation/electricity-network-innovation-competition>, accessed 26 May 2017.

104. Ofgem, https://www.ofgem.gov.uk/sites/default/files/docs/so-irm_guidance_document_docx_final.pdf, accessed 26 May 2017.

Stronger cyber security measures

Strong cyber security measures for the NEM will be essential for maintaining Australia's growth and prosperity in an increasingly global economy. Most digital technologies are dependent on the internet. While this will continue to create new opportunities for innovation, there will be an increased need to work together to build resilience to cyber security threats. Gaining a better understanding of cyber security risks and preventing the electricity sector from becoming a target for cyber crime is important.

Since 2009, there have been five known significant instances of cyber vulnerabilities being exploited in power systems globally. The cyber attack in Ukraine in December 2015 was the first publicly acknowledged incident to result in a power outage. The attack on three regional electricity distribution companies impacted 225,000 customers.¹⁰⁵ Restoration efforts were delayed as the attack disabled control systems, disrupted communications and prevented automated system recovery.

In October 2014, CERT Australia – the national Computer Emergency Response Team and main point of contact for Australian businesses in relation to cyber security – issued a warning that some malicious cyber activity was specifically targeting organisations in the energy sector.¹⁰⁶

The growing integration of ICT and connectivity with open networks with the NEM systems increases the cyber vulnerabilities of electricity market participants (see Figure 2.2).¹⁰⁷ For example:

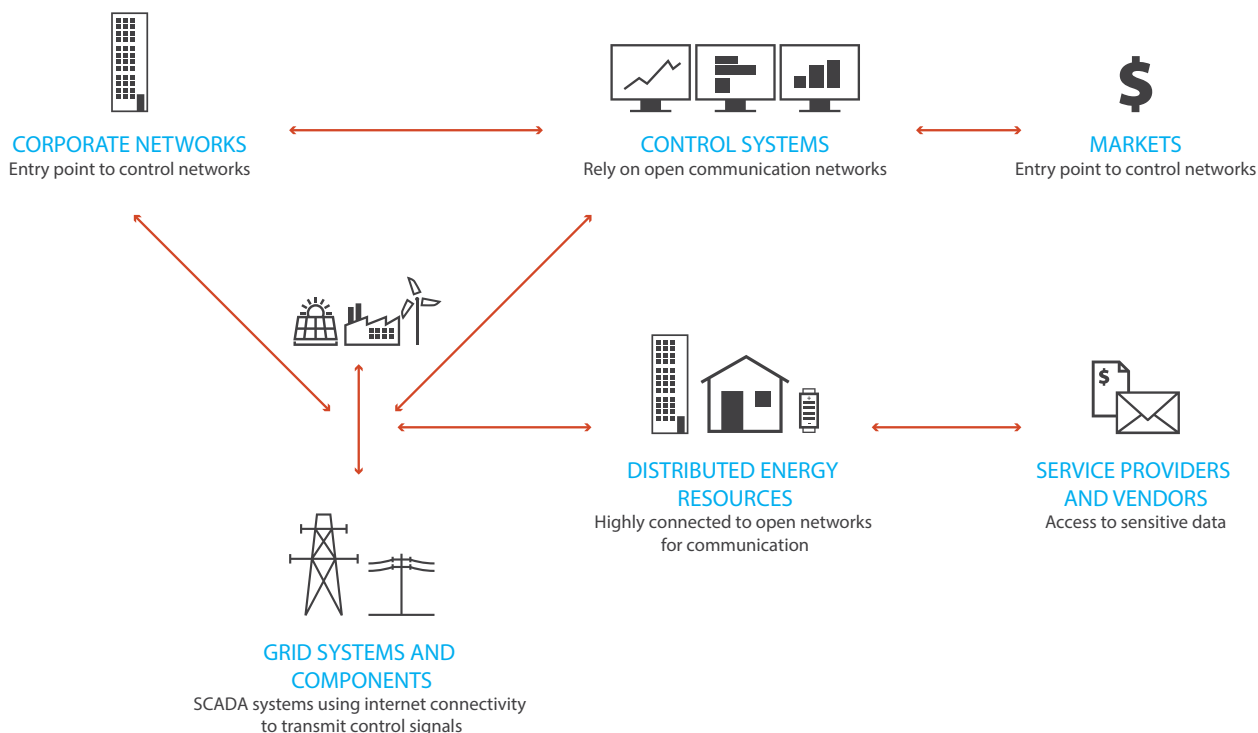
- AEMO's systems rely on real-time data on the status of critical power system components, outputs from generators, power flows on transmission networks and voltages across the NEM network. AEMO's systems depend on highly reliable and secure communication networks. AEMO also uses internet connectivity for lower security purposes, which increases its vulnerability.
- Supervisory control and data acquisition (SCADA) systems previously used dedicated networks to transmit control signals to generators. However, some modern SCADA systems are using the internet for that purpose, which makes them vulnerable to cyber attacks.
- Increasing numbers of DER can be controlled by network signals. DER are typically connected to open networks for communication and are unlikely to have cyber security standards, which makes them vulnerable.
- Smart grids, smart meters and smart appliances use software-based components and are connected to open networks for communication and control.
- Energy service providers, vendors and electricity users are less likely to have stringent cyber security protocols on their corporate systems. They can be easy targets because they provide an entry point to other control networks and access to sensitive information.

105. US Department of Homeland Security, <https://ics-cert.us-cert.gov/alerts/IR-ALERT-H-16-056-01>, accessed 26 May 2017.

106. Australian Cyber Security Centre, *ACSC Threat Report 2015*, 2015, p.13.

107. Adapted from Energy Networks Australia, http://www.energynetworks.com.au/sites/default/files/16022017_cyber_security_and_energy_networks_a4.pdf, accessed 26 May 2017.

Figure 2.2: Basic representation of the key dimensions in cyber security relevant to the electricity system¹⁰⁸



While there is a great benefit in using modern control systems in the electricity sector, this should be balanced by enhancing our capability to mitigate threats from any malicious cyber activity.

AEMO has protocols in place for accessing its market systems. These ensure that the integrity and security of the information contained in these systems, and the systems themselves, are maintained at all times, and to minimise the chance of unauthorised access.¹⁰⁹

The Electricity Network Transformation Roadmap notes that “*cyber security strategies will be essential to mitigate risks of damage and unauthorised use, or, exploitation of information and data, to ensure confidentiality, integrity, and availability*”.¹¹⁰

To ensure AEMO’s cyber security protocols are sufficient to mitigate against malicious cyber activity, these should be tested and assessed regularly by a third party.

An initiative of the Australian Government’s Cyber Security Strategy, the Joint Cyber Security Centres will bring together industry, government and law enforcement to boost cyber security resilience. AEMO, Origin Energy and Powerlink are participating in the Joint Cyber Security Centre in Brisbane.¹¹¹ The establishment of these Centres in Sydney, Melbourne, Adelaide and Perth will provide a further opportunity for the electricity sector to collaborate on shared cyber security challenges.

108. Adapted from Energy Networks Australia, http://www.energynetworks.com.au/sites/default/files/16022017_cyber_security_and_energy_networks_a4.pdf, accessed 26 May 2017.

109. AEMO, <https://www.aemo.com.au/media/Files/Other/registration/0310-0003%20pdf.pdf>, accessed 26 May 2017.

110. Energy Network Australia and CSIRO, *Electricity Network Transformation Roadmap: Final Report*, 2017, p.69.

111. Joint Cyber Security Centre, <https://www.ag.gov.au/RightsAndProtections/CyberSecurity/Documents/JCSC-partner-organisations.pdf>, accessed 26 May 2017.

While there has been progress on the Cyber Security Strategy, the Panel considers that the Australian Government should accelerate the following actions:

- The development and publication of voluntary good practice guidelines and industry specific standards, particularly for systems of national interest.
- Enhanced collection, speed and automation of threat intelligence sharing amongst local industry, Australian government and international energy peers.
- Greater clarity on roles, responsibilities and protocols in responding to a nationally significant cyber attack, and increased scale and tempo of exercises to test and improve response capability at an industry and national level.¹¹²

There is currently no specific organisation or place that accurately captures the cyber maturity of all participants in the NEM. This is a critical gap in understanding where the cyber vulnerabilities and real risks are to the NEM. CERT Australia and the Australian Cyber Security Centre (ACSC) rely on voluntary self-reporting of cyber security incidents. As such, they do not have a complete view of incidents in the electricity sector. The ACSC states that *"increased reporting of cyber security incidents by the private sector would subsequently increase the ACSC's knowledge of cyber adversaries who target Australian industry and critical infrastructure"*.¹¹³

While the NEM has not suffered a successful cyber attack, there is a growing concern about the cyber security of Australia's critical infrastructure. Going forward, there is a need for greater identification and monitoring of potential malicious threats to the NEM that would significantly impact government, business and the community.

Recommendation 2.10

An annual report into the cyber security preparedness of the National Electricity Market should be developed by the Energy Security Board, in consultation with the Australian Cyber Security Centre and the Secretary of the Commonwealth Department of the Environment and Energy.

The annual report should include:

- An assessment of the cyber maturity of all energy market participants to understand where there are vulnerabilities.
- A stocktake of current regulatory procedures to ensure they are sufficient to deal with any potential cyber incidents in the National Electricity Market.
- An assessment of the Australian Energy Market Operator's cyber security capabilities and third party testing.
- An update from all energy market participants on how they undertake routine testing and assessment of cyber security awareness and detection, including requirements for employee training before accessing key systems.

The initial report should be completed by end-2018.

112. AEMO submission to the Review.

113. Australian Cyber Security Centre, *ACSC Threat Report 2016*, 2016, p.13.

Foreign investment and involvement

Foreign investment applications for acquisition of critical energy infrastructure are assessed by the Foreign Investment Review Board on a case-by-case basis. The assessment considers a range of factors, such as national security, competition, other Australian Government policies, the impact on the economy and community, and the character of the investor. The Foreign Investment Review Board provides advice to the Australian Government and, in reviewing applications, the Treasurer can consider whether to prohibit or impose conditions on foreign investment to ensure the investment is not contrary to the national interest.

On 18 March 2016, the Australian Government announced strengthened foreign investment rules on the sale of critical infrastructure assets owned by state and territory governments to foreign private investors. Prior to this change, a Foreign Investment Review Board assessment was only required when state-owned assets were sold to a foreign state-owned enterprise. The changes now mean that all critical infrastructure transactions above relevant thresholds must be assessed by the Foreign Investment Review Board.

In January 2017, the Australian Government established the Critical Infrastructure Centre. It brings together expertise from across the Australian Government to better manage national security risks to critical infrastructure, including from foreign involvement, and provides advice to support government decision making on investment transactions.¹¹⁴

The Critical Infrastructure Centre proposes to develop a confidential critical infrastructure asset register to track information on who owns and operates critical assets in high risk sectors. It has identified electricity assets to be of high risk.¹¹⁵

The establishment of the Critical Infrastructure Centre to maintain a register for ownership and operation of high risk electricity assets and to provide advice to support government decision making is supported by this review.

Adapting to environmental changes

The NEM is designed to respond to daily changes in temperature that affect demand and supply. However, the NEM is vulnerable to direct impacts from hazards such as heatwaves, bushfires, floods, tropical cyclones, drought, geomagnetic storms and earthquakes. Each poses different challenges with the potential to damage electricity infrastructure and create bottlenecks, leading to security concerns and potential blackouts (see Box 2.5).

The NEM is particularly exposed to climate change impacts. An increase in the frequency and intensity of extreme weather events can increase stress on the power system in several ways:

- Transmission and distribution networks are vulnerable to extreme weather events.
- High ambient temperatures reduce generator efficiency, and can lead to breakdowns and an increase in maintenance costs.
- Many elements in the power system have maximum operating temperatures above which they disconnect to avoid damage. These controls will be triggered more frequently and new investment may be required to make the equipment more resilient to high temperature events.

114. The Hon George Brandis QC media release, <https://www.attorneygeneral.gov.au/Mediareleases/Pages/2017/FirstQuarter/Keeping-australias-critical-infrastructure-secure.aspx>, accessed 30 May 2017.

115. Attorney-General's Department, <https://www.ag.gov.au/Consultations/Pages/Strengthening-the-national-security-of-australias-critical-infrastructure.aspx>, accessed 30 May 2017.

Box 2.5 – How natural hazards can impact the NEM

Heatwaves are an ongoing challenge as they can affect large parts of the network simultaneously. Heatwaves pose the most significant threat to the power system at a bulk supply level. The increase in air conditioning in response to high temperatures generally results in peak demand, which causes stress to electricity infrastructure. Higher temperatures also limit infrastructure capabilities and reduce generator capacity and efficiency. Transmission lines can expand with hot weather, causing the cable to sag below height limitations and potentially becoming an ignition source for bushfires. Even when a heatwave has been forecast, any errors for electricity demand can lead to risks to the security of the NEM.

Bushfires may damage transmission lines and can trigger lines to be de-rated or shut down to prevent damage. Smoke can also induce transmission line faults, resulting in a loss of supply. Transmission lines may also be shut down for the safety of emergency personnel. A bushfire can severely damage electricity infrastructure and result in communities being without power until repairs can be made. AEMO specifically monitors lightning and bushfires, assesses the threat to the NEM and will send out market notices if required.

Cyclones can damage power stations, substations and transmission lines, resulting in a loss of generation or ability to transmit power. Cyclones and severe storms often result in restoration costs for network businesses. Network businesses have a comprehensive range of measures to prepare the network and employees for each storm and cyclone season.

Floods can lead to damage to electricity infrastructure, resulting in significant repairs or rebuilds. The FY2012 flooding in Queensland resulted in significant damage which meant that power supply could not be reconnected for periods ranging from weeks to months. Additionally for areas not directly affected by floods, power supply may still need to be disconnected due to other parts of the network being affected.

Tornadoes are not uncommon in Australia. They typically occur in late spring and summer, but can happen all year round in southern parts of Australia. Tornadoes consist of rotating columns of air that move across the ground, damaging infrastructure in their path.¹¹⁶ South Australia experienced at least seven tornados on 28 September 2016. Several of these tornadoes damaged electricity infrastructure, which contributed to the state-wide blackout.¹¹⁷

Drought can reduce the generating capacity of both hydro and thermal generation. During the FY2007 drought, generation was curtailed due to water shortages. Since then, information on the impact of water availability on generation capacity has improved and generators have invested in more efficient use of water. Nevertheless, protracted drought events will have an impact.

Geomagnetic storms caused by solar winds primarily affect the transformers in high voltage transmission systems. Geomagnetic induced currents can also damage or destroy electrical infrastructure and equipment, which may lead to power system collapse. In the event that the Bureau of Meteorology Space Weather Service forecasts a severe geomagnetic disturbance, AEMO will issue a market notice and invoke power system guidelines.

116. Bureau of Meteorology, <http://media.bom.gov.au/social/blog/1019/cool-season-tornadoes/>, accessed 30 May 2017.

117. Bureau of Meteorology, *Severe thunderstorm and tornado outbreak- South Australian 28 September 2016*, 2016, p.1.

Earthquakes can damage electricity generators and networks. There is no advanced notice before an earthquake occurs. Around 80 earthquakes of magnitude 3.0 or more occur in Australia each year.¹¹⁸ On 19 June 2012, the NEM was affected when a magnitude 5.4 earthquake struck Gippsland in Victoria and resulted in the disconnection of five major generating units.¹¹⁹

Natural hazards cannot be averted. The electricity sector is experienced in managing and recovering from such events. However, with increasing and more intense extreme weather events predicted to occur, forecasting and managing for these events to ensure balance of supply and demand will become more difficult.

Balancing supply and demand relies on robust forecast models. Weather is an important factor in demand modelling and increasingly important for supply. Modelling the supply of electricity from wind and solar generators relies on accurate weather forecasts to provide both short and long-term estimates of generator availability.

AEMO established the Australian Wind Energy Forecasting System in response to the growth in intermittent generation in the NEM and its increasing impact on NEM forecasting processes. The system produces forecasts from many inputs, including real-time SCADA measurements from wind farms. SCADA data from wind farms includes SCADA feed of wind speed, wind direction and temperature.

Technical measures to enhance the NEM's resilience to extreme weather include:

- Making transmission more secure by laying cables underground, using high strength towers, and active programmes for pruning and managing vegetation near overhead transmission lines.
- Strengthening coastal and flood-prone infrastructure against flooding and sea level rises.
- Designing wind turbines and large solar photovoltaic generators for resilience against high wind speeds and flooding.
- Drought-proofing thermal generators by introducing improved cooling systems, recirculating cooling water systems and using air-cooled systems.

A system with more distributed energy should be more resilient to extreme weather events as not all regions are likely to be affected to the same extent. DER, if correctly configured, can continue to supply electricity during power supply interruptions.

Demand management is critical in managing potential disruptions of electricity due to extreme weather conditions. Microgrids, stand-alone power systems and DER can strengthen the NEM's resilience as well as function as a grid resource for faster system response and recovery. Inter-regional connections can help regions draw power from unaffected areas and make the power system more resilient to extreme weather and other natural hazards.

Recommendation 2.11

In recognition of the increased severity of extreme weather, by end-2018 the COAG Energy Council should develop a strategy to improve the integrity of energy infrastructure and the accuracy of supply and demand forecasting.

118. Geoscience Australia, <http://www.ga.gov.au/scientific-topics/hazards/earthquake/basics>, accessed 4 June 2017.

119. AEMO, *Multiple contingency event following an earthquake in Victoria on 19 June 2012*, 2013, p.13.

Ensuring a skilled and flexible workforce

Given the importance of a secure and reliable power supply to the national economy, it is imperative to make provision for the skilled workforce needed to facilitate the NEM's transition and its future operation.

A significant proportion of occupations in the traditional network and electricity supply industry will be affected by emerging technologies and services.¹²⁰ As in other economic and technology shifts, traditional jobs will be lost and new jobs will be created. Some jobs may require upskilling, re-training or relocation, or may no longer exist.¹²¹

Given the regional location of many coal-fired generators, the transition of these employees must be well planned. A notice of closure requirement for generators, as discussed in Chapter 3, would facilitate a well-planned transition. New jobs could be created by building large-scale VRE generators in those regions.¹²²

The skillsets required by a future energy workforce will be influenced by digitalisation and the increased use of ICT at various points in the grid. Attracting and retaining this workforce will pose significant challenges for the energy industry. Recruitment of digitally-enabled specialists with knowledge of the electricity sector is already being reported as difficult, and this has potential to increase over time as the demand for these occupations grow.

The speed with which emerging technologies are entering the market will result in a skills gap should the existing and future workforce not have adequate training and development.¹²³ The speed and complexity will increase the number of workers who will need to be upskilled or reskilled in the short to medium term.

New and existing job roles include:

- power systems engineers
- data specialists in analytics and visualisation
- cyber security specialists
- software and application programmers with an energy specialisation.

Science, technology, engineering and mathematics (STEM) qualifications are critical for the electricity sector. Specialist ICT skills will also be required to manage a power system with higher connectivity, complex hardware and multiple platform software integration. Vocational and university courses will need to be flexible enough to keep up with emerging technologies. Education institutions will need to work with industry to redesign curricula to address future skills needs. For example, there is no specific ICT degree that specialises in energy.¹²⁴

Work undertaken for Energy Networks Australia outlines a number of recommendations for development of the workforce.¹²⁵ These include:

- A coordinated approach to higher level skills and investment, and prioritisation of educating and training the existing workforce.
- Education and training package process review to ensure there are ongoing mechanisms to support rapid change and new technologies.
- Skills awareness for both consumers and the workforce.

120. Energyskills Queensland, *Changing Industry, A changing workforce – Electricity network transformation roadmap workforce skilling impacts*, 2016, p.12.

121. Climate Council, *Renewable Energy Jobs: Future Growth in Australia*, 2016, p.2.

122. Climate Council, *Renewable Energy Jobs: Future Growth in Australia*, 2016, p.ii.

123. Energy Network Australia and CSIRO, *Electricity Network Transformation Roadmap: Final Report*, 2017, p.93.

124. Energy Network Australia and CSIRO, *Electricity Network Transformation Roadmap: Final Report*, 2017, p.93.

125. Energyskills Queensland, *Changing Industry, A changing workforce – Electricity network transformation roadmap workforce skilling impacts*, 2016, p.11.

The Electricity Network Transformation Roadmap notes that *“a skills ready workforce is imperative to ensure the successful rollout of new technologies, products and services for the future power system. Successful outcomes will see Australia becoming a leading player within this industry that will have numerous economic benefits”*.¹²⁶

Recommendation 2.12

By mid-2019, the COAG Energy Council should facilitate the development of a national assessment of the future workforce requirements for the electricity sector to ensure a properly skilled workforce is available.

126. Energy Network Australia and CSIRO, *Electricity Network Transformation Roadmap: Final Report*, 2017, p.94.

Chapter 3

A RELIABLE AND LOW EMISSIONS FUTURE – THE NEED FOR AN ORDERLY TRANSITION

Overview

The uncertain and changing direction of emissions reduction policy for the electricity sector has compromised the investment environment in the NEM. The lack of a transparent, credible and enduring emissions reduction mechanism for the electricity sector is now the key threat to system reliability. Without investment in new generation capacity, the reliability of the NEM will be compromised. It is critically important that there is widespread political and community acceptance of the need for a stable policy framework.

The Panel recommends a policy package to achieve an orderly transition to a low emissions future. Achieving an orderly transition will require a long-term emissions reduction trajectory for the electricity sector, notice of closure requirements for large generators and an emissions reduction mechanism to drive new investment in the sector in line with Australia's international commitments.

New standards are also required to give greater confidence that reliability will be maintained as technological developments continue to affect the system. The Panel recommends establishing a Generator Reliability Obligation for new generators such as wind and solar. New generators will be required to bring forward dispatchable capacity to the market in regions where reliability is identified to be at risk in coming years. The Panel also recommends that market bodies should consider the necessity and desirability of a Strategic Reserve and a 'day-ahead' dispatch bidding market, for the purposes of increasing the available measures to maintain a reliable system.

3.1 Policy uncertainty threatens to stall the NEM

The NEM has a strong history of delivery. Between 2001 and 2015, the reliability target of 99.998 per cent was met at all times bar one occasion in Victoria and one in South Australia.¹²⁷ Yet recently the NEM has started to show signs of stress.

Under the existing framework, reliability of supply is maintained through wholesale and contract market signals. It is presumed that markets will provide adequate incentives to bring forward the right mix of generation capacity, in the right place, at the right time, to maintain a reliable system. However, new investment is not guaranteed.

A number of factors are now disrupting the conditions under which the NEM framework was originally designed. In particular, uncertainty around how the electricity sector is expected to contribute to emissions reduction objectives has hampered investment in existing or new thermal capacity. This lack of investment is a threat to reliability and price stability in the NEM.

During the Review, the overwhelming view from stakeholders, especially from within the electricity sector,¹²⁸ was the need for a credible and enduring emissions reduction mechanism. The electricity sector acknowledges the role it will play in Australia's national emissions reduction efforts. For a sector characterised by very high-cost and long-lived assets, policy transparency, credibility and durability are key.

127. AEMC, *Annual Market Performance Review 2015: Final Report*, 2016, p.15; AEMC, *Annual Market Performance Review: Final Report*, 2012, pp.10-11.

128. AGL, AI Group, Australian Energy Council, Business Council of Australia, Energy Australia, and Origin submissions to the Review.

*There is a need to move the policy debate away from political ideology particularly as it relates to the diametrically opposed views on climate change, with renewed focus on the need for investment certainty in an industry where there are long lead times for the development of assets that last up to 40 years. Without timely investment the key objectives of reliability and security and consequently the delivery of cost effective energy cannot be realised.*¹²⁹

Origin

*Climate policy development in Australia has suffered from significant instability over the last decade which has severely challenged investor confidence in energy infrastructure; the introduction and, then removal, of a Carbon Price Scheme and changes to the renewable energy target are two key examples. Policy frameworks need to be perceived as credible by investors if they are to achieve efficient and effective outcomes. Even an astutely designed policy with relatively strong incentives for change will struggle to catalyse the required investment unless it is perceived by investors to be politically secure and robust at the outset. This is particularly acute in the case of investments with long time horizons such as those typically required in the NEM.*¹³⁰

Energy Australia

*Investment will be best supported by emissions reduction policy that provides macro level certainty as to the timeframe and operating life of incumbent plant and reduced levels of uncertainty as to the market environment within which current investments will operate in post 2030. Greater certainty in these areas will support a more efficient transition, guiding decisions on new investments, management of existing capital stock, policy development, community transition and energy market development.*¹³¹

AGL

3.2 A challenging and changing market environment

The need for dispatchable capacity

The past few years has seen the retirement of significant coal-fired capacity from the NEM, while there has been no corresponding reinvestment in new dispatchable capacity (see Figure 3.1). New variable renewable electricity (VRE) generation is being incentivised and brought forward by the Renewable Energy Target (see Table 3.1), but other investment has been lacking.

This is a problem because, at present, a certain amount of dispatchable capacity is required to maintain system reliability. Capacity is dispatchable if it can respond to electricity demand on call. Dispatchable capacity can be provided by a range of sources, including dispatchable generation (for example, coal, gas, hydro, solar thermal, and biomass), interconnectors, storage and demand response mechanisms. VRE generators, like wind and solar photovoltaic, have variable generation and so require complementary dispatchable capacity to maintain system reliability.

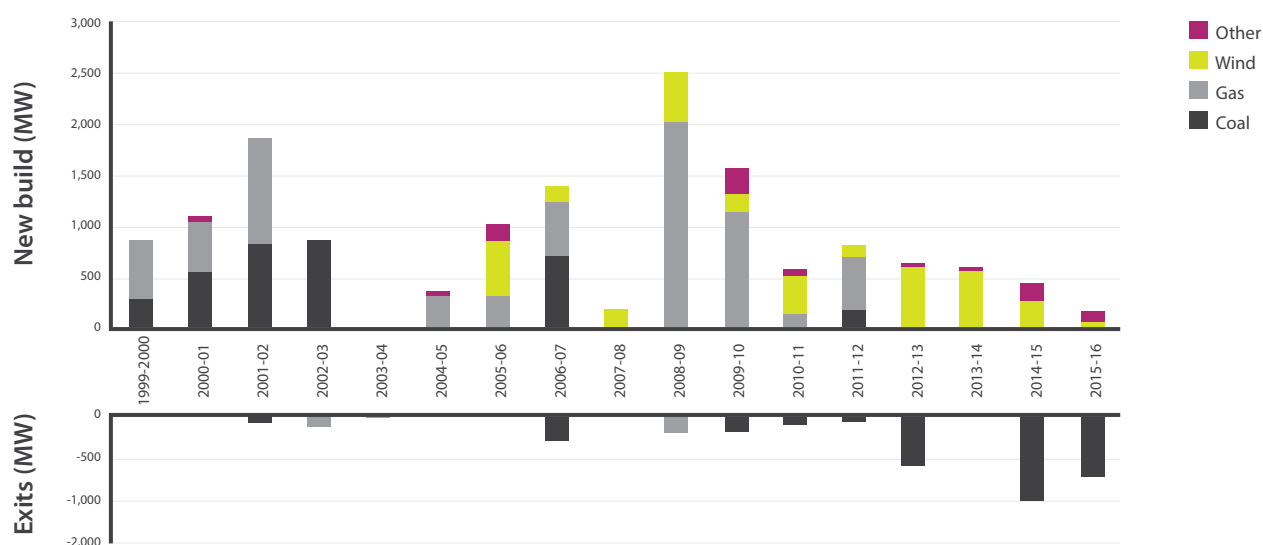
If new dispatchable capacity is not brought forward soon, the reliability of the NEM will be compromised. Without a market response, AEMO forecasts a breach in the reliability standard by FY2018 in South Australia and in Victoria.¹³²

129. Origin submission to the Review, p.10.

130. Energy Australia submission to the Review, p.8.

131. AGL submission to the Review, p.6.

132. AEMO, *Update: Electricity Statement of Opportunities*, November 2016, p.5. (Neutral Scenario)

Figure 3.1: Investment in new generation and plant retirements in the NEM¹³³Table 3.1: Recent Generation Investment in the NEM¹³⁴

Owner	Power station	Technology	Summer capacity (MW)	Date commissioned
Queensland				
EDL OCI	Oaky Creek 2	Waste Coal Mine Gas	15	2016
New South Wales				
AGL PV Solar Development	Broken Hill	Solar	53	2015
Moree Solar Farm	Moree	Solar	56	2016
Elementus Energy Pty Ltd.	Williamsdale	Solar	10	2017
Victoria				
Pacific Hydro Portland Wind Farm	Portland Stage 4	Wind	47	2015
Coonooer Bridge Wind Farm	Coonooer Bridge	Wind	20	2016
South Australia				
Hornsedale Wind Farm	Hornsedale (stage 1)	Wind	102	2016
Waterloo Windfarm	Waterloo Expansion	Wind	20	2017

133. Adapted from AER, *State of the Energy Market 2017*, 2017, p.38. 'Other' includes solar photovoltaic, liquid fuel, landfill gas, coal seam methane, waste coal mine gas and biomass.

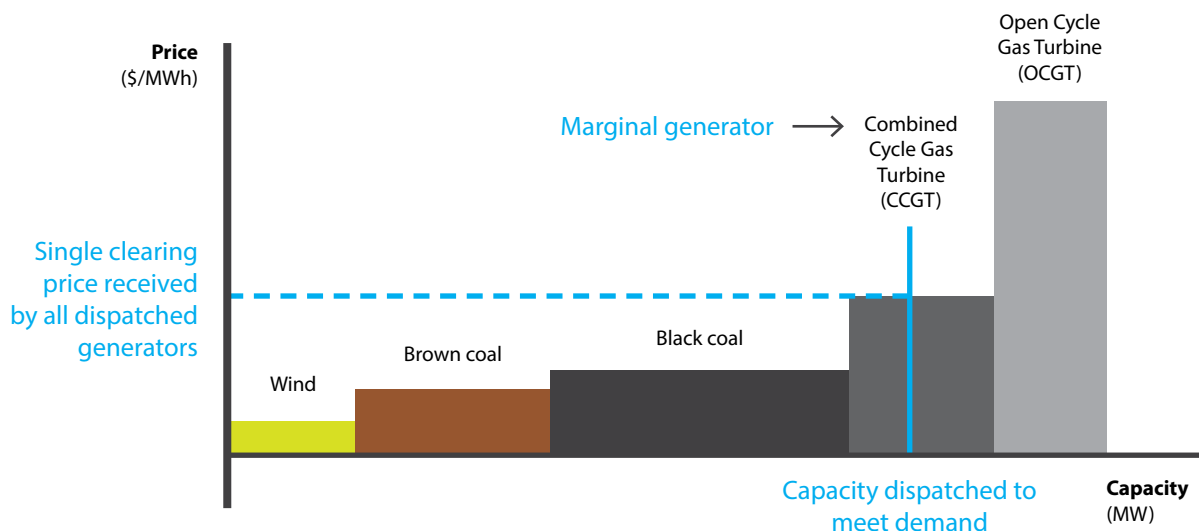
134. Adapted from AER, *State of the Energy Market 2017*, 2017, p.39.

A changing wholesale market

Dispatch and settlement in the wholesale market

In the wholesale electricity market, generators bid the quantity of electricity they are willing to supply and the price they want to receive in five minute dispatch intervals. Generators are dispatched in price order from lowest to highest up to the level required to match demand in five minute blocks. The most expensive generator (the 'marginal generator') sets a single clearing price that is paid to all generators dispatched (see Figure 3.2 for a stylised example). For the purpose of settlement, generators are paid the dispatch price averaged across 30 minutes (i.e. six 5 minute intervals).

Figure 3.2: Stylised illustration of price setting in the wholesale market ¹³⁵



The difference between the dispatch (five minutes) and settlement (30 minutes) intervals is a result of the technology available when the NEM was designed in the 1990s.¹³⁶ Limitations in metering and data processing, and technical considerations for generators, meant that different dispatch and settlement periods were appropriate at that time.

The difference in dispatch and settlement periods opens the possibility for strategic bidding behaviour, potentially increasing the cost of supplying electricity in the long-term.¹³⁷ Technological progress since the 1990s means that there is now potential for market participants to respond on a five minute basis, for example with battery storage or demand response mechanisms.

The Australian Energy Market Commission (AEMC) is currently considering a rule change request to align the dispatch and settlement periods to five minutes. The AEMC notes that a market in which the dispatch and settlement periods align would drive more efficient wholesale market outcomes, but that there are potentially negative consequences that need to be assessed. In particular, the effect of the proposed change on the supply of financial contracts available to the market is of concern.¹³⁸ A draft recommendation on the rule change is expected 4 July 2017.¹³⁹ A number of submissions to the Review supported an alignment between the dispatch and settlement periods.¹⁴⁰

135. Adapted from Climate Change Authority, *Policy Options for Australia's Electricity Supply Sector: Special Review Research Report*, 2016, p.26.

136. AEMC, *Directions Paper: Five Minute Settlement*, 2017, pp.ii-iv.

137. AEMC, *Directions Paper: Five Minute Settlement*, 2017, pp.ii-iv.

138. AEMC, *Directions Paper: Five Minute Settlement*, 2017, pp.ii-iv.

139. AEMC, <http://aemc.gov.au/Rule-Changes/Five-Minute-Settlement#>, accessed 3 June 2017.

140. For example, EnerNOC, MOJO Power and ANU Energy Change Institute submissions to the Review.

Variable renewable electricity

The increasing penetration of VRE generators in the NEM also has the potential to change how returns are distributed in the wholesale market. VRE generators, like wind and solar photovoltaic, are fundamentally different from traditional thermal generation assets in that they have no fuel cost and are non-dispatchable. Because these generators' short-run operating costs are essentially zero, they will generally bid into the wholesale market at zero, to ensure they are called to generate while other generators set the clearing price that is paid to all generators. At high penetration, VRE generators can become the price setter and set a zero or negative clearing price in the wholesale market.

At other times, the output from VRE generators can drop relatively suddenly (when there is thick cloud cover that affects solar photovoltaic or the wind stops blowing, affecting wind generators). This can require other generation to rapidly ramp up or down to balance system load – a capability for which many existing dispatchable generators are ill-suited. Rapid fluctuations in output also increases volatility in the wholesale spot market, potentially increasing the cost of managing price risk for electricity users.

The fact that VRE generators operate with no fuel cost could, with the right policy framework and with further technological development, be used to reduce overall wholesale prices. However, at present, VRE generators are increasing price volatility in the wholesale market and are creating challenging investment conditions for other generators.

A market for different times

The NEM's 'energy-only' market framework means generators are only paid for the electricity they produce. Generators that cannot make adequate returns to cover their operating costs will eventually exit the market. Higher wholesale prices indicate a scarcity of generation capacity and are intended to incentivise new generators to enter the market.

In theory, the existing market framework is expected to deliver gradual increases and then decreases in average wholesale prices over the long-run, as generators retire and new generation is incentivised to enter the market. This is based on assumptions of increasing demand for electricity in the long-run and new entrant capacity being driven by wholesale electricity market conditions.¹⁴¹

Recently in the NEM, there has been relatively flat or decreasing demand, and additional VRE capacity has been incentivised to enter the market through the Renewable Energy Target scheme. This has resulted in a sustained period of relatively low wholesale prices, which gives little incentive for additional generation to enter the market. Uncertainty around emissions reduction policy has further inhibited new investment in dispatchable capacity.

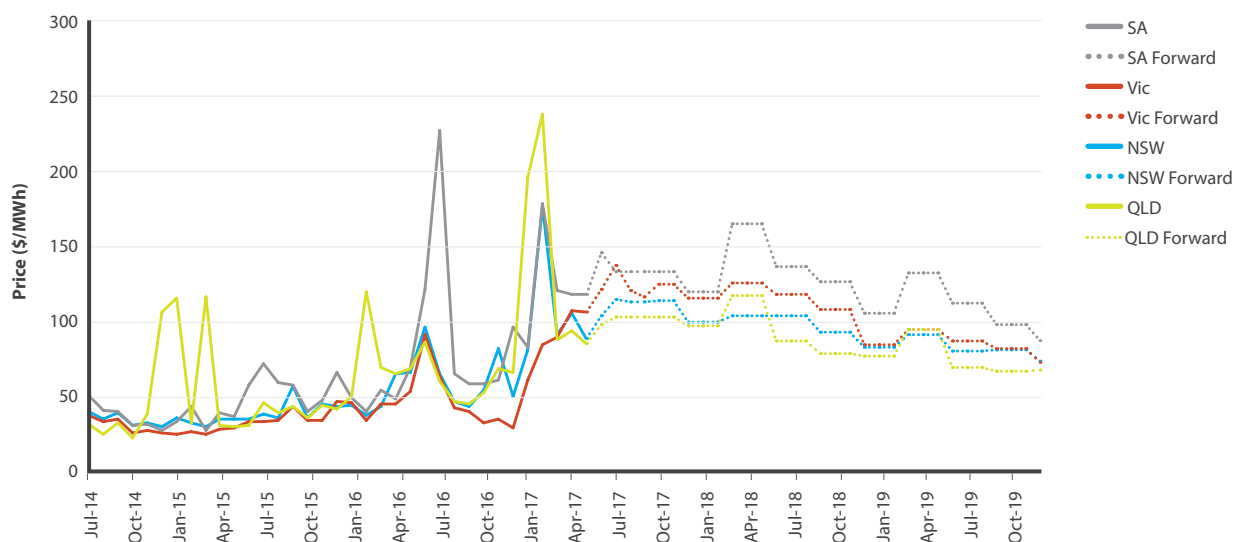
Under these conditions, the energy-only market is expected to quickly shift from a state of capacity oversupply to undersupply, when generators exit the market with relatively little notice.¹⁴² This leaves the system operating in a state of undersupply, which rapidly increases prices and has adverse implications for reliability.

141. Paper presented to the Review, Nelson, T, Orton F, and Chappel, T, *Electricity Market Design in a Decarbonised Energy System*, 2017, p.8.

142. Paper presented to the Review, Nelson, T, Orton F, and Chappel, T, *Electricity Market Design in a Decarbonised Energy System*, 2017, p.8.

Recent events in the NEM suggest this effect is taking place. The sudden retirement of a number of coal and gas-fired generators from the NEM (Northern in 2016, Hazelwood in 2017) and the mothballing of others (Swanbank E in 2014, part of Pelican Point in 2015) has tightened the supply and demand balance in some NEM regions and put upward pressure on prices in the forward contract market (Figure 3.3). If the market does not respond to incentives as expected, high wholesale prices and reliability issues may emerge.

Figure 3.3: Monthly average wholesale prices and base load futures prices¹⁴³



Changing fuel prices also impact on price stability. The rapid increase in gas prices above historic averages (discussed further in Chapter 4) means that even once additional generator capacity is brought forward, wholesale electricity prices may persist at higher levels than in the past.

Other developments have the potential to disrupt how returns are currently distributed in the wholesale market. Greater utilisation of demand response and large-scale application of peaking storage capacity from technologies, such as batteries and pumped hydro, have the potential to ‘shave’ the peak off wholesale price spikes. While these technologies can contribute to reliability in positive ways, they will likely further change the economic returns from the wholesale market for other generators. Over time, new technologies will likely continue to impact the operation of the wholesale market in ways that are difficult to anticipate.

Disruptions in the electricity financial market

The electricity financial market plays an important role in ensuring the reliable and efficient operation of the NEM. They provide a way for market participants, both electricity generators and purchasers, to reduce their exposure to volatility in the wholesale market and provide long-term investment signals. Some contract types, such as cap contracts, provide generators with an additional payment to remain in the market, even when they are not generating.

143. Figure compiled based on AEMO average price data, see: <https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data-dashboard#average-price-table>, accessed 6 June 2017.

Futures data sourced from base-monthly and base-quarterly ASX data. ‘Previous settlement prices’ for 3 June 2017 were used. See: <http://www.asx.com.au/products/energy-derivatives/australian-electricity.htm>, accessed 6 June 2017.

Electricity markets need sufficient liquidity to operate effectively. Submissions from large energy users and their associations noted that liquidity is an acute problem in South Australia, but less so in other states. In FY2016, South Australia accounted for only 1 per cent of NEM ASX energy derivatives traded.¹⁴⁴ This lack of liquidity appears to be a result of two separate factors:

- A decrease in the proportion of dispatchable capacity due to the retirement of dispatchable generation and an increasing penetration of VRE.
- An increasing degree of vertical integration between generators and retailers into 'gentailers'.

An increasing penetration of VRE has an effect on liquidity because VRE generators have not traditionally entered into exchange traded contracts that contribute to liquidity. This is a result of VRE generators' inability to determine the time or price conditions under which they generate electricity. If a VRE generator were to independently enter into a firm swap contract with an industrial consumer, they could be called on to provide electricity at a time they are unable to generate and could be required to purchase electricity on the spot market to fulfil their contractual commitment. To date, VRE generators have instead generally entered 'power purchase agreement' type contracts with parties who are able to offset the variable output of supply with other generation sources.

In future, as the proportion of VRE in the market continues to increase, it will be necessary for VRE generators to find a cost-effective way of entering firm contracts. This, for example, could involve VRE generators pairing with dispatchable capacity to act as a 'synthetic financial generator'. The Panel understands that some organisations are already investigating this possibility.¹⁴⁵

While the high penetration of VRE in South Australia has reduced contract liquidity, the very high degree of vertical integration between generators and retailers in South Australia may also be having an impact. Vertical integration provides a 'natural hedge', where the electricity producer (the generator) and buyer (the retailer) are owned by the same company (a 'gentailer'). This neutralises the risk that a generator might be underpaid or a retailer might have to over pay. However, the Australian Energy Regulator (AER)¹⁴⁶ notes that because of this 'natural hedge' vertically integrated gentailers contribute less to the supply and trading of financial instruments, which can be an issue for other market participants.

In the period from 2009 to 2017, the major retailers have increased their share of NEM generation capacity from 15 per cent to 48 per cent.¹⁴⁷ In South Australia in particular, recent events such as the closure of the Playford and Northern power plants have resulted in an increase in market concentration of the major vertically integrated gentailers (Energy Australia, Origin and AGL), which now account for 64 per cent of generation capacity (see Figure 3.4). By other measures, South Australia also has the least amount of competition and highest reliance on its largest generator of all NEM regions.^{148*}

144. Australian Financial Markets Association, *2016 Australian Financial Markets Report*, 2016, p.13.

145. AGL submission to the Review, p.5.

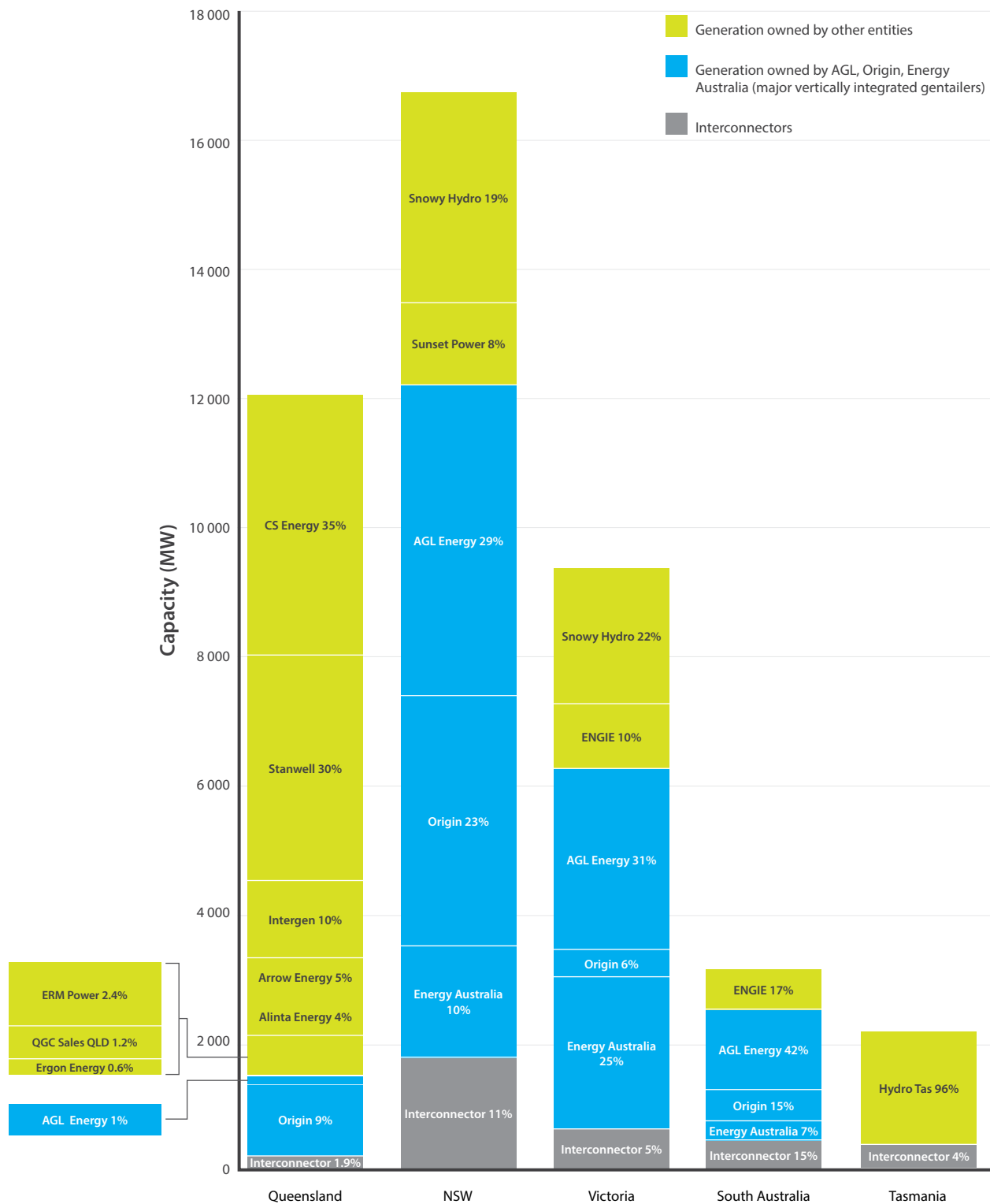
146. AER, *State of the Energy Market 2015*, 2016 p.43.

147. AER, *State of the Energy Market 2017*, 2017 p.47.

148. AER, *State of the Energy Market 2017*, 2017, pp.43-51.

Competition measured by the Herfindahl-Hirschman index and reliance on the largest generator measured by the residual supply index.

*Tasmania not included because the price of financial contracts are regulated.

Figure 3.4: Generation ownership by NEM region 2017¹⁴⁹149. Adapted from AER, *State of the Energy Market 2017*, 2017, p.44.

Submissions to the Review, particularly those from major energy users and their associations, noted that a lack of liquidity, combined with high volatility in the South Australia wholesale market is resulting in forward contracts attracting a significant risk premium. Industrial users are reportedly being offered forward contracts in South Australia between \$120 to \$190 per MWh.¹⁵⁰ In some cases, industrial users are taking exposure to the spot market instead of entering into costly hedging contracts.

The Panel notes that the Australian Competition and Consumer Commission is currently holding an inquiry into the retail electricity prices in the NEM, which includes an examination of the impact of vertical integration. The AER also has new powers and responsibilities as of December 2016 to monitor and analyse whether there is effective competition in the wholesale market. These processes are best placed to assess the impact that vertical integration is having on the contract market, and its flow-on effects.

3.3 A policy package for an orderly transition

The Panel is of the view that existing wholesale and contract market investment signals alone are no longer a suitably dependable mechanism to ensure the reliability of the NEM. Given the importance of a reliable electricity supply to the national economy and to national security, the NEM framework must provide a high degree of confidence that the system will perform as required.

There are multiple objectives for the electricity sector, including achieving security, reliability, affordability and emissions reduction outcomes. Policies aimed at individual objectives have the potential to have flow-on effects to other aspects of the system. All policies that impact the sector must therefore be designed with consideration of the holistic impact on the NEM. In particular, it has become evident in recent years that emissions reduction policy needs to be better integrated with energy policy.

To the Panel, policy integration requires a broad view of the overall objectives of the system. In the future, integration will be achieved by ensuring the right mix of planning, regulatory and market mechanisms are in place that work together to deliver positive outcomes.

Other jurisdictions around the world are responding to similar challenges created by the energy transition. In many cases, governments have sought to move to new market arrangements.¹⁵¹ An alternative to the energy-only market framework used in the NEM is the parallel operation of capacity markets and mechanisms to ensure the availability of dispatchable capacity (see Box 3.1).

Box 3.1 – Case study – international experience on capacity markets and mechanisms

Many electricity markets globally include some form of capacity mechanism to direct investment towards maintaining reliability. Capacity mechanisms come in various forms but generally fall into two categories – targeted mechanisms and market-wide mechanisms.¹⁵²

Amongst the market-wide capacity mechanisms is the ‘central buyer approach’, commonly known as a competitive capacity market. In a competitive capacity market, the market operator runs an auction to procure sufficient capacity to meet future electricity demand. Participating generators receive payments for being available, regardless of how much they ultimately generate. They pay

150. SA Chamber of Mines and Energy (SACOME) submission to the Review.

151. For example, the United Kingdom and Alberta.

152. European Commission, http://ec.europa.eu/competition/sectors/energy/capacity_mechanisms_working_group_10_en.pdf, accessed 2 June 2017.

penalties if they are not available when called upon. Unlike energy-only markets, the investment signal comes from the market operator, instead of the market.

Internationally, a common perspective is that competitive capacity markets are politically necessary, in contrast to the alternative of waiting for scarcity prices that are high enough to signal new investment.

Two prominent competitive capacity markets are the 'Reliability Pricing Model' in the Pennsylvania-New Jersey-Maryland Interconnect (PJM) that was introduced in 2007, and Great Britain's capacity market that was introduced in 2013. Both operate in a similar way (Great Britain's capacity market design having been based on PJM's Reliability Pricing Model):

- The amount of capacity auctioned is administratively determined based on forecast demand plus a reserve margin. The demand is expressed as a range that is a function of price; this helps promote cost-efficient outcomes because it procures a greater amount of capacity if the price is low, or a bare minimum amount of capacity if the price is high.
- The auction is held several years ahead of the delivery year – three years ahead in PJM and four years ahead in Great Britain. There is a balance between longer timeframes to provide longer reliability and maximise competitiveness (by enabling the participation of new resources), and shorter timeframes to facilitate more accurate demand forecasts.
- To address the risk of procuring more capacity than optimal due to inaccurate forecasts ('demand forecasting risk'), the initial auction takes a conservative approach and is followed by supplementary auctions. The supplementary auctions also address any failure to deliver due to resource unavailability.
- Penalty regimes provide incentives for resources to be available when required.¹⁵³

In addition to PJM and Great Britain, competitive capacity markets are also in place in the New York and New England power markets in the United States, and have been recently introduced in France and Italy.¹⁵⁴ Western Australia,¹⁵⁵ Ontario¹⁵⁶ and Alberta¹⁵⁷ are also looking to introduce competitive capacity markets. In the case of Western Australia and Ontario, the competitive capacity market will replace their existing targeted capacity mechanisms.

A key function of capacity markets is to manage generator retirements, including on a locational basis. The forward auctions provide forward notice of unit commitment (or lack of commitment, which can then be accounted for as a risk to future reliability). Upon the introduction of PJM's Reliability Pricing Model around 3 GW of capacity reversed its intention or decision to retire.¹⁵⁸

153. National Grid, <https://www.emrdeliverybody.com/CM/delivery.aspx>, accessed 3 June 2017.

154. International Energy Agency, *Re-powering Markets: Market design and regulation during the transition to low-carbon power systems*, 2016, p.124.

155. Public Utilities Office Government of Western Australia, *Electricity Market Review: Reserve Capacity Auction Final Design and Implementation*, 2017.

156. IESO, *The Future of Ontario's Electricity Market: A Benefits Case Assessment of the Market Renewal Project*, 2017.

157. Alberta Electric System Operator, *Alberta's Wholesale Electricity Market Transition Recommendations*, 2016.

158. US Federal Energy Regulatory Commission, <https://www.ferc.gov/CalendarFiles/20080507071850-Ott,%20PJM%20Interconnection.pdf>, accessed 3 June 2017.

More broadly, capacity markets are promoted as a way to engineer the mix of resources in a power system to balance a low emissions objective with the need to maintain sufficient synchronous capacity to provide security services and dispatchability, while ensuring adequacy of supply. However, there is ongoing debate over their efficiency and effectiveness, both in terms of their impacts on electricity prices and on decarbonisation objectives.¹⁵⁹

Depending on the circumstances, targeted capacity mechanisms may be a more efficient and effective means of ensuring reliability. For instance, a strategic reserve – a type of targeted mechanism that compensates surplus capacity for being available at times of scarcity – is suited to addressing short-term reliability needs.¹⁶⁰ Jurisdictions such as Germany and Belgium operate targeted capacity mechanisms.¹⁶¹ Even in Texas, which is widely considered to have a ‘pure’ energy-only market, there are administrative interventions to ensure adequate capacity.

The European Commission is introducing a framework that its Member States must follow in relation to introducing a competitive capacity market or other capacity mechanism. Notably, when countries plan to introduce capacity mechanisms, the European Commission will require them to first implement the necessary market reforms to remove regulatory distortions. Only if after those reforms there are residual barriers to investment, underpinned by a robust generation adequacy assessment, will a country be approved to introduce a capacity mechanism, in line with prescribed design requirements.¹⁶²

Some submissions to the Review proposed consideration of a competitive capacity market or other capacity mechanisms,¹⁶³ while others cautioned against the introduction of a capacity market in the NEM.¹⁶⁴

A capacity market is a significant market reform, which would require a long-term and costly departure from the existing market framework. Such a reform should only be considered in circumstances of irresolvable failure of the energy-only market to bring forward sufficient new capacity to ensure reliability. Given the more immediate nature of the reliability concerns facing the NEM, as well as the adequacy of other policy reforms available, the Panel does not believe a move to a competitive capacity market to be appropriate at this time.

Instead, to ensure a smooth energy system transition, reforms should focus on providing long-term investment confidence and direction to the electricity sector, and affording greater control to AEMO to ensure that a reliable and secure system is maintained.

The Panel recommends a policy package to facilitate an orderly transition for the electricity system. This package is envisaged to form the backbone of the strategic energy plan, recommended in Chapter 7. The orderly transition package should include:

- A long-term emissions reduction trajectory for the electricity sector.
- An obligation for all large generators to provide at least three years’ notice of closure.
- A credible and enduring emissions reduction mechanism.

159. For example, see http://www.ippr.org/files/publications/pdf/incapacitated_March2016.pdf?noredirect=1, accessed 6 June 2017.

160. International Energy Agency, *Re-powering Markets: Market design and regulation during the transition to low-carbon power systems*, 2016, p.127.

161. International Energy Agency, *Re-powering Markets: Market design and regulation during the transition to low-carbon power systems*, 2016, p.124.

162. European Commission, http://europa.eu/rapid/press-release_IP-16-4021_en.htm, accessed 3 June 2017.

163. Alinta Energy, Australian Chamber of Commerce and Industry, Australian Academy of Technology and Engineering, EnerNOC, Major Energy Users, and Santos submissions to the Review.

164. AEMC, AEMO, AGL, Grattan Institute, and Snowy Hydro submissions to the Review.

If implemented in combination, these policies will work to provide forward planning information, guide investment from the sector and give confidence that reliability will be maintained as the NEM continues to evolve.

An emissions reduction trajectory for the electricity sector

Certainty for the electricity sector

Action should be taken with the aim of creating a market environment in which the electricity sector has the confidence to invest. The impact of a high degree of market uncertainty is ultimately borne by consumers in the form of a more costly, less reliable system. Governments must provide the sector with a transparent, credible and enduring strategy that sets out priorities and expectations for the sector. This strategy should provide the framework under which the sector is confident to make long-term investment decisions. To be seen as credible and to deliver planning benefits to the sector, the strategy must include a long-term emissions reduction trajectory for the sector and an emissions reduction mechanism with widespread community and political support to achieve the trajectory.

Considerations for the electricity sector emissions trajectory

A long-term emissions reduction trajectory for the electricity sector will guide investment decisions. The Panel acknowledges that the specific emissions reduction trajectory that should be set for the electricity sector is a question for governments. At a minimum, the electricity sector should have a trajectory consistent with a direct application of the national target of 26 to 28 per cent reduction on 2005 levels by 2030, as per Australia's international obligations under the Paris Agreement. In monitoring progress against the trajectory, there should be some tolerance allowed for variation, for example plus or minus two per cent, to reflect the lumpiness of generator entry and exits.

It may be appropriate for governments to ask the electricity sector to do more than a direct application of the national target. The electricity sector may have more economically viable opportunities to reduce emissions than other sectors.¹⁶⁵ Moreover, emissions reduction efforts through electrification in transportation and industrial processes will be enhanced by lowering the emissions intensity of the electricity sector.

All governments have a role to play in supporting the transformation in the electricity sector. It is essential that efforts are coordinated, stable and long-term, as part of a system-wide response. A stable policy environment across all NEM regions is what is required to give the electricity sector confidence to invest in the NEM and to plan for the future.

Targets in the electricity sector that are more ambitious than the 28 per cent reduction on 2005 levels by 2030 trajectory may have consequences for security, cost and reliability, which AEMO would need to assess in the context of new security and reliability obligations recommended as part of this Review. Consistent with recommendations in Chapter 7, the proposed Energy Security Board should also be consulted by governments considering new or adjusted emissions reduction ambitions, to ensure market bodies have an opportunity to comment on system-wide impacts.

As part of the Australian Government's 2017 Review of Climate Change Policies, consideration should be given to a post-2030 emissions reduction goal. The Panel encourages the Australian Government to develop a national 2050 emissions reduction strategy by 2020, consistent with commitments under the Paris Agreement. This will set expectations and help to guide investment decisions in the electricity sector by providing an anchor point for Australia's long-term emissions trajectory.

165. Climate Change Authority, *Policy Options for Australia's Electricity Supply Sector: Special Review Research Report Summary*, 2016, p.4.

Recommendation 3.1

By 2020, the Australian Government should develop a whole-of-economy emissions reduction strategy for 2050.

Notice of closure requirement

A key challenge facing the NEM in the future will be managing the retirement of the existing coal-fired generators as they reach their end of life. In FY2016, 76 per cent of electricity produced in the NEM came from coal-fired generators.¹⁶⁶ By 2035, approximately 68 per cent of the current coal generating plants will have reached 50 years of age.¹⁶⁷

The existing conventional coal-fired generators are unlikely to be replaced with like-for-like generation assets. Increasingly, large centralised generators are likely to be replaced by a number of smaller generation assets due to the rapidly declining costs of technologies like wind and large-scale solar generation and the lower capital costs of new gas-fired generators.

The existing framework is not well suited to coordinating the transition ahead. This is because the NEM's energy-only market framework encourages new investment through scarcity price signals created by a gap between the exit and entry of new capacity. At the same time, generators retire with much shorter notice to the market than the time it takes for new capacity to be planned, financed and constructed. This will be problematic in the future where the retirement of large coal-fired generators could have implications for system security and reliability. The security and reliability services that these generators provide can and will be met by other means, but the transition will need to be more closely monitored and managed. Existing large generators will need to do more to assist the market to adjust to the impacts of their retirement.

*The lack of sufficient planning information appears to be the source of unnecessary abrupt price changes and a potential impediment to more timely and efficient investment behaviour.*¹⁶⁸

Energy Australia

Key to this will be obliging large generators to provide both the market operator and the wider community with more notice of their intention to close. For example, the Northern and Playford B generators gave only eleven months' notice¹⁶⁹ of closure, while Hazelwood gave only five months.¹⁷⁰ Such short notice is not atypical, but is well below the time required for replacement generation assets to come online. From a reliability and security perspective, a period of overlap between the entry of new capacity and exit of old is desirable. For this to be possible, the operator and the market must have better visibility over when existing large generators will exit the market.

The requirement for notice of closure should apply to generators whose retirement could pose an issue for reliability. All types of large-scale generation should be covered, including coal, gas, hydro, wind and solar.

166. AER, *State of the Energy Market 2017*, 2017, p.26.

167. Review taskforce analysis of Clean Energy Council and Energy Networks Australia, *2016 Electricity Gas Australia*, 2016.

168. Energy Australia submission to the Review, p.10.

169. Sydney Morning Herald, <http://www.smh.com.au/business/alinta-energy-to-shut-port-augusta-power-plants-amid-losses-on-supply-glut-20150611-ghlap3.html>, accessed 6 June 2017.

170. ENGIE media release, <http://www.gdfsuezau.com/media/UploadedDocuments/News/Hazelwood%20Clousure/Hazelwood%20closure%20-%20Media%20release.pdf>, accessed 3 June 2017.

In determining the length of notice required, there is a trade-off between additional certainty for new investors and flexibility for existing generators. A longer period may provide better planning information for those looking to enter the market, but may place an unrealistic expectation of foresight on existing generators. At a minimum, the notice period must give enough time for new generation capacity to enter the market. The Panel recommends a notice period of at least three years.

In addition to the requirement for a binding notice of closure, the Panel also recommends that AEMO create a non-binding register with long-term expected closure dates for large generators. While some information about expected closure dates is currently made public, AEMO should do more to gather and publicise informed and up-to-date estimates of closure. This should involve more active discussion with generator owners and operators.

Energy Australia proposed a notice of closure requirement in their submission to the Review and highlighted that, while such a policy would have implementation challenges, *“most operators and investors of large facilities have the balance sheet to plan five years into the future”*.¹⁷¹ The Business Council of Australia also argued for consideration of a notice period for the withdrawal of registered market participants in their submission to the Review.¹⁷² Advice provided to the Review by AGL concluded that, in their view, an orderly transition to a higher-penetration renewables system can be facilitated if generators provide sufficient notice of impending closures to allow new complementary capacity to be built.¹⁷³

The notice of closure requirement must be sufficiently binding for the planning and resulting reliability benefits to be realised. Flexibility in how the requirement is enforced could be appropriate in cases where there is no net impact on available capacity, for instance if an exiting generator brings forward replacement capacity in the same NEM region. However, there should be a firm expectation that generator owners and operators put in place the necessary insurance, maintenance schedule or otherwise to ensure compliance with the notice period requirement is possible.

A credible and enduring emissions reduction mechanism

In addition to a notice of closure requirement, a mechanism is required to guide investment in the electricity sector that is compatible with Australia's international emissions reduction commitments. The existing policies aimed at reducing emissions in the electricity sector are not consistent with Australia's 2030 emissions reduction goals. The Large-scale Renewable Energy Target, the Small-scale Renewable Energy Scheme and the Safeguard Mechanism are forecast to deliver an approximate 5 per cent reduction in electricity sector emissions on 2005 levels by 2030.¹⁷⁴ Consultation with electricity sector stakeholders and the wider community undertaken as part of this Review highlighted the broad expectation that Australia will meet its international emissions reduction commitments. The lack of a clear means by which the electricity sector is expected to contribute to this task is hampering investment in the NEM.

The Panel emphasises the urgency of the need for a credible and enduring emissions reduction policy for the electricity sector to provide investor confidence. To avoid further disruptions to the sector, the existing Large-scale Renewable Energy Target scheme should remain unchanged to the end of its design life, but not be extended in its current form.

A long-term emissions reduction mechanism should be implemented with the dual purpose of creating policy stability and bolstering investment signals to ensure new capacity is brought online. A number of policy options were considered for this purpose, with the preferable options outlined below.

171. Energy Australia submission to the Review, p.20.

172. Business Council of Australia submission to the Review, p.20.

173. Paper presented to the Review, Nelson, T, Orton F, and Chappel, T, *Electricity Market Design in a Decarbonised Energy System*, 2017, p.17.

174. Department of the Environment and Energy, *Australia's Emissions Projections 2016*, 2016, p.6.

The options selected were assessed against the following criteria:

- cost impacts for consumers
- degree of flexibility and ability to adapt to an uncertain future
- implications for security and reliability
- ability to reduce emissions in line with national commitments.

Policies considered

Clean Energy Target (CET)

A CET would provide an incentive for all new generators that produce electricity below a specified emissions intensity threshold. All fuel types, including coal with carbon capture and storage (CCS) or gas, would be eligible for the scheme provided they meet or are below the emissions intensity threshold. Eligible generators would receive certificates for the electricity they produce in proportion to how far their emissions intensity is below the threshold. New eligible generators would receive certificates for all electricity generated, while existing eligible generators could receive certificates for any electricity that they produce above their historic output. Consideration would also need to be given to the treatment of extensions to long-lived renewable assets like hydro.

Electricity retailers would be obliged to purchase these certificates to demonstrate that a pre-determined share of their electricity came from low emissions generators. Provisions to prevent renewable generators from benefiting from both the Large-scale Renewable Energy Target and the CET would need to be considered.

A CET calibrated to an emissions reduction target of 28 per cent on 2005 levels by 2030 with a linear trajectory to zero emissions by 2070 was modelled for this Review.¹⁷⁵

Emissions Intensity Scheme (EIS)

An EIS would see an emissions intensity baseline set for the whole electricity generation sector. Generators with an emissions intensity below the baseline would receive credits, while generators with an emissions intensity above the baseline would be required to purchase and surrender credits. Credits would be awarded or surrendered in proportion to how far a generator's emissions intensity is below or above the baseline, respectively. All generators, existing and new, would be required to participate in the scheme. Provisions to prevent renewable generators from benefiting from both the Large-scale Renewable Energy Target and the EIS would need to be considered.

An EIS calibrated to an emissions reduction target of 28 per cent on 2005 levels by 2030 with a linear trajectory to zero emissions by 2070 was modelled for this Review.

Lifetime limits on coal-fired generators

A lifetime limit would require coal-fired generators to close once they reach a certain age. The lifetime limit would be approximately consistent with the expected investment life of the generation asset. A lifetime limit of 50 years was modelled as a scenario for this Review.

Policy combinations

Combinations of a CET or an EIS with a lifetime limit on coal-fired generators were also considered.

There were no emissions intensity based prohibitions placed on new coal-fired generators under the scenarios modelled. This reflects the Panel's view that such a policy would not be effective in addressing cost, flexibility and security considerations.

175. Jacobs, *Report to the Independent Review into the Future Security of the National Electricity Market*, 2017.

Electricity price impacts

Prices are higher under a business as usual scenario

The modelling undertaken for this Review found that the CET and EIS policy scenarios both resulted in lower residential and industrial electricity prices than leaving policy settings unchanged under a business as usual (BAU) scenario (see Figures 3.5 and 3.6). Lower long-term prices are the result of the stability and reduction in risk for the electricity sector that commitment to a credible mechanism would bring. The CET, EIS and business as usual scenarios have similar overall resource costs (see Figure 3.7). Resource costs includes capital investment, fuel costs, fixed and variable operating costs and retirement costs.

Figure 3.5: Residential price, NEM average 2017 to 2050¹⁷⁶

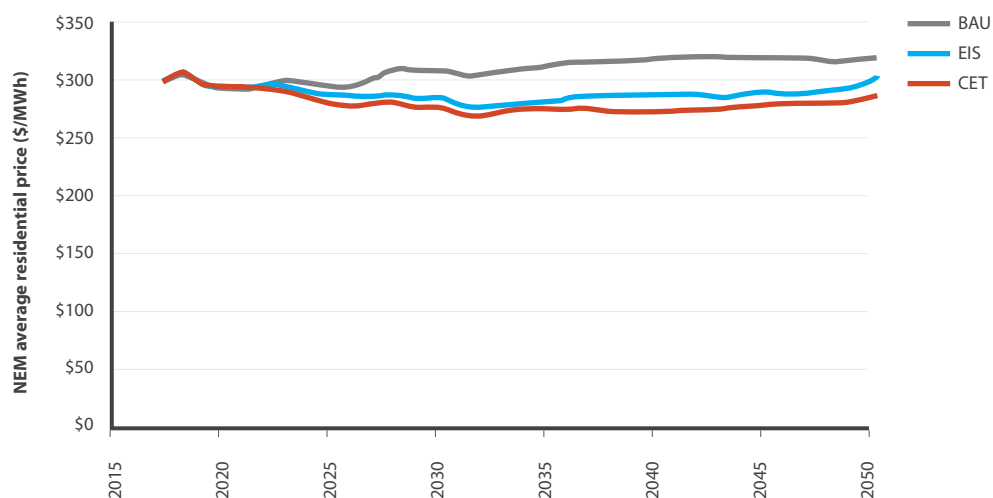
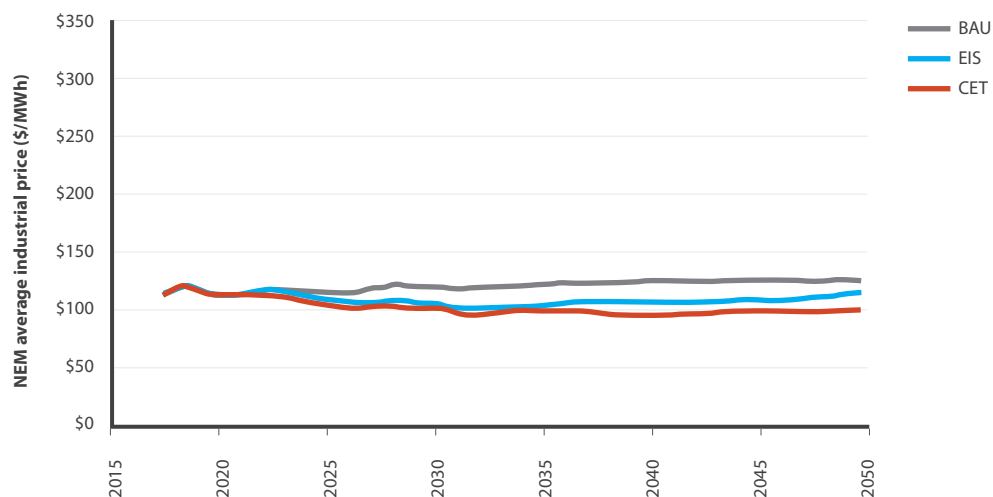
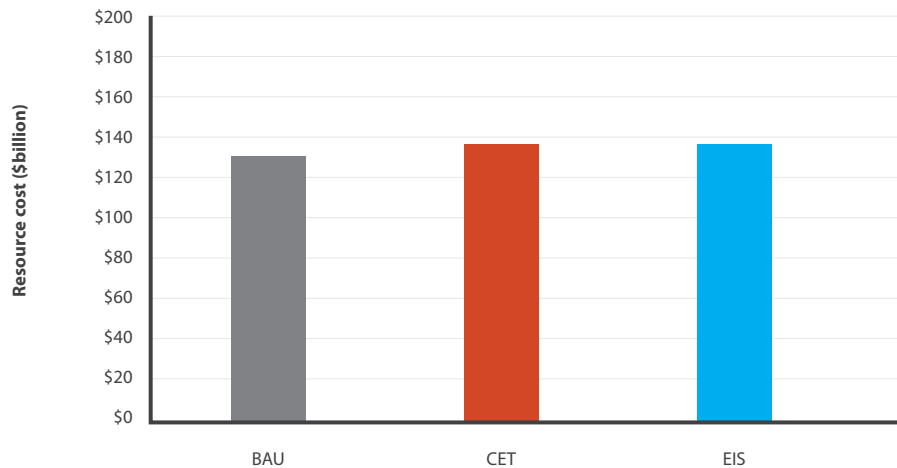


Figure 3.6: Industrial price, NEM average 2017 to 2050¹⁷⁷



176. Adapted from Jacobs, *Report to the Independent Review into the Future Security of the National Electricity Market*, 2017.

177. Adapted from Jacobs, *Report to the Independent Review into the Future Security of the National Electricity Market*, 2017.

Figure 3.7: Net present value NEM resource cost 2017 to 2050¹⁷⁸

The business as usual scenario aimed to capture the full expected effects of an unchanged policy environment in which existing electricity sector emissions reduction policies remain with no changes or additions through to 2050. This scenario represents a continual state of uncertainty for the sector because there will be an ongoing expectation that a more credible emissions reduction policy will be introduced. Submissions to the Review¹⁷⁹ and consultation with stakeholders suggests that, currently, the uncertainty around emissions reduction policy is having an impact on investment decisions and financing costs for generators.

*The cost of sustained policy inaction is now higher than the cost of efficient and durable policy action.*¹⁸⁰
 Australian Energy Council

The implications of ongoing emissions reduction policy uncertainty were accounted for in the business as usual scenario. Consistent with other studies,¹⁸¹ a risk premium was placed on investment, reflecting the cost of uncertainty for various generation types (see Table 3.2). This applied to both investment in new capacity and refurbishment of existing capacity. Differences in project finance debt and equity costs between fuel types reflect the differences in size and complexity and therefore project risk for different generator types.

Table 3.2: Project finance cost assumptions¹⁸²

Generator	Coal	Gas	Renewables
Debt to equity ratio	40:60	75:25	75:25
Cost of debt	5.3%	4.4%	4.4%
Cost of equity	13%	11%	11%
Weighted average cost of capital (policy scenarios)	9.9%	6.1%	6.1%
Risk Premium	5%	2%	1%
Weighted average cost of capital (BAU)	14.9%	8.1%	7.1%

178. Adapted from Jacobs, *Report to the Independent Review into the Future Security of the National Electricity Market*, 2017.

179. Australian Energy Council p.14, Clean Energy Finance Corporation p.5, Energy Australia p.19 and The Climate Institute p.3 submissions to the Review.

180. Australian Energy Council submission to the Review, cover letter p.1.

181. The Centre for International Economics, *Review of economic modelling exercises & assessment of the impact of uncertainty*, 2017; Nelson, T, Nelson, J, Ariyaratnam, J, Camroux, S, *An analysis of Australia's large scale renewable energy target: Restoring market confidence*, 2013.

182. Jacobs, *Report to the Independent Review into the Future Security of the National Electricity Market*, 2017.

Secondly, under a business as usual scenario, coal-fired generators were only able to make relatively short-term refurbishments on a five year horizon. Major refurbishments by coal-fired generators were deferred indefinitely because of uncertainty of long-term returns, resulting in eventual declining efficiency and a maximum possible lifetime of 60 years. Informed by electricity sector stakeholders,¹⁸³ the Panel considers these assumptions to be realistically reflective of what an extension of the current investment environment would mean for coal-fired generator owners and operators.

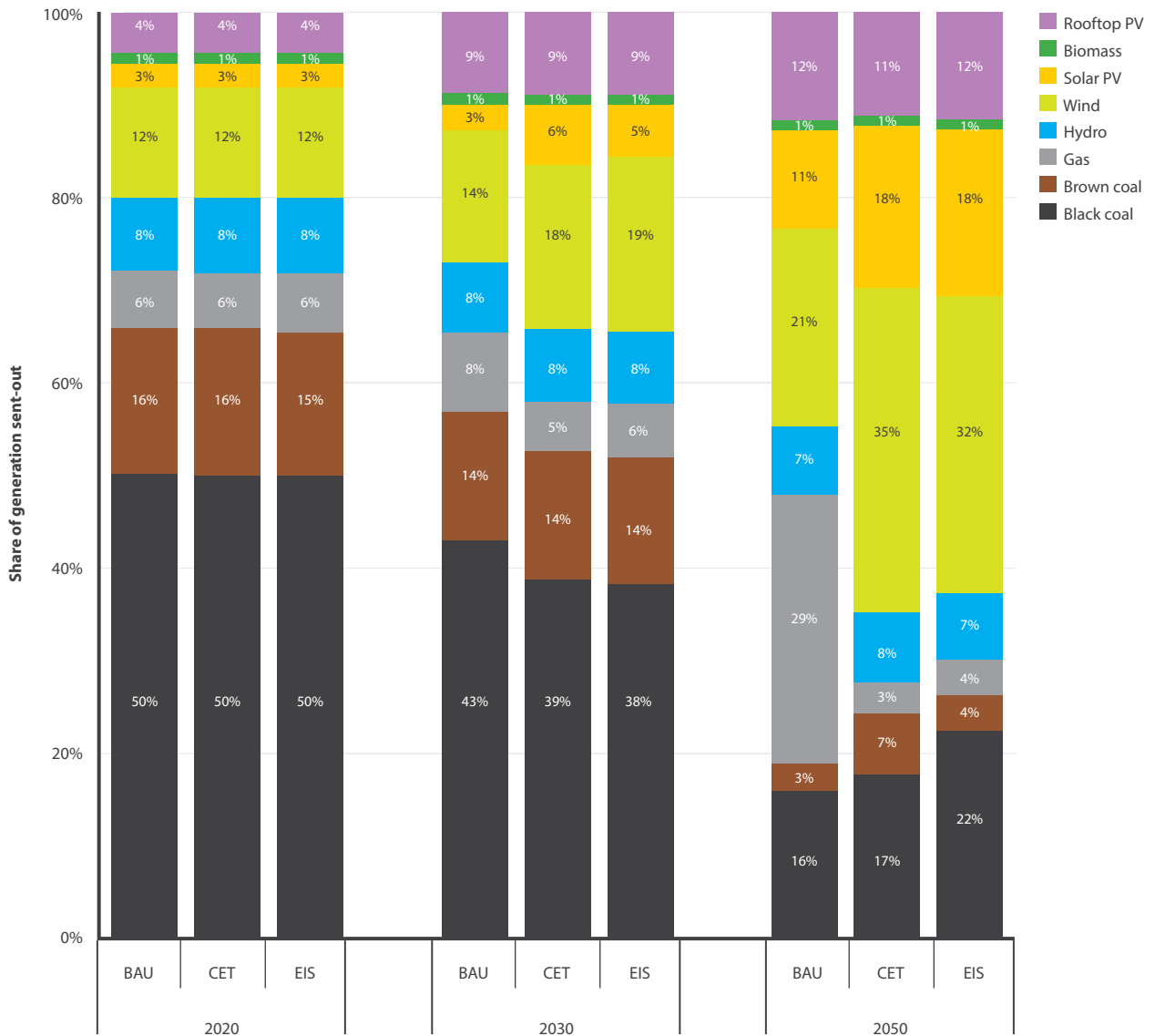
The CET and EIS scenarios represent a stable investment environment and so avoid the cost of policy uncertainty that the electricity sector faces at present. This environment enables existing coal-fired generators to make longer-term refurbishment decisions to extend their life and remain in the market for more years than in the business as usual scenario.

CET and EIS scenarios

The CET scenario resulted in lower consumer electricity prices than the EIS scenario. In the long-term, the CET scenario saw more electricity produced by brown coal than the EIS scenario because there is no penalty for high emissions generators. However, marginally more renewable capacity was built in the CET policy scenario that led to slightly higher overall resource costs over the modelling period. Under both the CET and EIS scenarios, the renewable generation mix in 2030 was 42 per cent of the generation sent out (see Figures 3.7 and 3.8).

183. For example see: <https://www.energycouncil.com.au/news/opinion-piece-another-destructive-decade-in-energy-policy-is-not-an-option/>, accessed 6 June 2017.

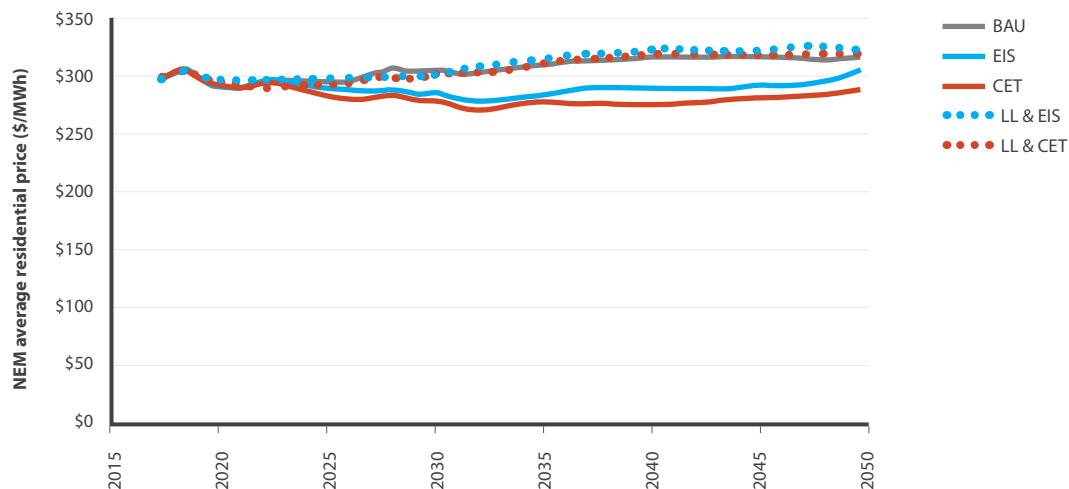
Figure 3.8: NEM generation mix, 2020, 2030, 2050¹⁸⁴



Quantitative modelling found that a 50 year lifetime limit on coal-fired generators alone would not achieve a 28 per cent reduction in emissions by 2030 on 2005 levels. Scenarios that combined a lifetime limit on coal-fired generators and another emissions reduction mechanism, such as a CET or an EIS, were found to result in higher electricity prices for consumers than a mechanism alone (see Figure 3.9).

184. Adapted from Jacobs, *Report to the Independent Review into the Future Security of the National Electricity Market*, 2017.

Figure 3.9: Residential price with limited lifetime scenarios, NEM average 2017 to 2050¹⁸⁵



While a lifetime limit policy would provide additional planning benefits for the sector, which are not quantified by the modelling, the Panel ultimately did not consider the lifetime limit policy combinations to be preferable because of the impact on electricity prices (see Figure 3.9).

As is the case with all complex modelling exercises, the modelling undertaken for this Review represents a simplification of reality. For example, the results presented above are based on an assumption, among many others, that the wholesale spot price determines consumer prices, whereas in reality the contract market also plays a role. The purpose of this modelling exercise was not to attempt to predict future electricity prices, but to compare the relative performance of the policies modelled.

The Panel were provided with an advance copy of the Climate Change Authority and AEMC report *Towards the Next Generation: Delivering Affordable, Secure and Lower Emissions Power*. The Climate Change Authority and AEMC had previously undertaken modelling of the impact of alternative emissions reduction mechanisms on the electricity sector which was drawn upon for their report. In the AEMC modelling, an Emissions Intensity Target (equivalent to an EIS) but a CET was not examined.¹⁸⁶ The Climate Change Authority examined seven different policy scenarios including an Emission Intensity Scheme and a Low Emissions Target (LET),¹⁸⁷ however, its LET scenario was significantly different to the CET examined in the modelling for this Review in terms of scheme design parameters, emissions targets, feasible generation types and assumptions. Neither the AEMC nor Climate Change Authority modelling results are directly comparable to the modelling undertaken for this Review.

Flexibility and adaptability

Given the high degree of uncertainty around future generation costs, the ability of an emissions reduction mechanism to adjust to new conditions and capture the benefits of new technologies is essential. Rather than have a limited duration, the mechanism itself should continue indefinitely in line with the commitment to reduce emissions well into the second half of the century. There could, however, be a limit on the number of years over which each generator can receive incentives. The CET scenario modelled assumed participants would be eligible for certificates for 15 years. The primary requirement is that the emissions reduction mechanism should be able to vary the degree of incentive for new investment over time. Certificate-based mechanisms do this by using scarcity pricing, which reduces the risk of over-incentivising new capacity. Both a CET and EIS mechanism could be certificate based, so both meet this criterion.

185. Adapted from Jacobs, *Report to the Independent Review into the Future Security of the National Electricity Market*, 2017.

186. AEMC, *Integration of energy and emissions reduction policy*, 2016.

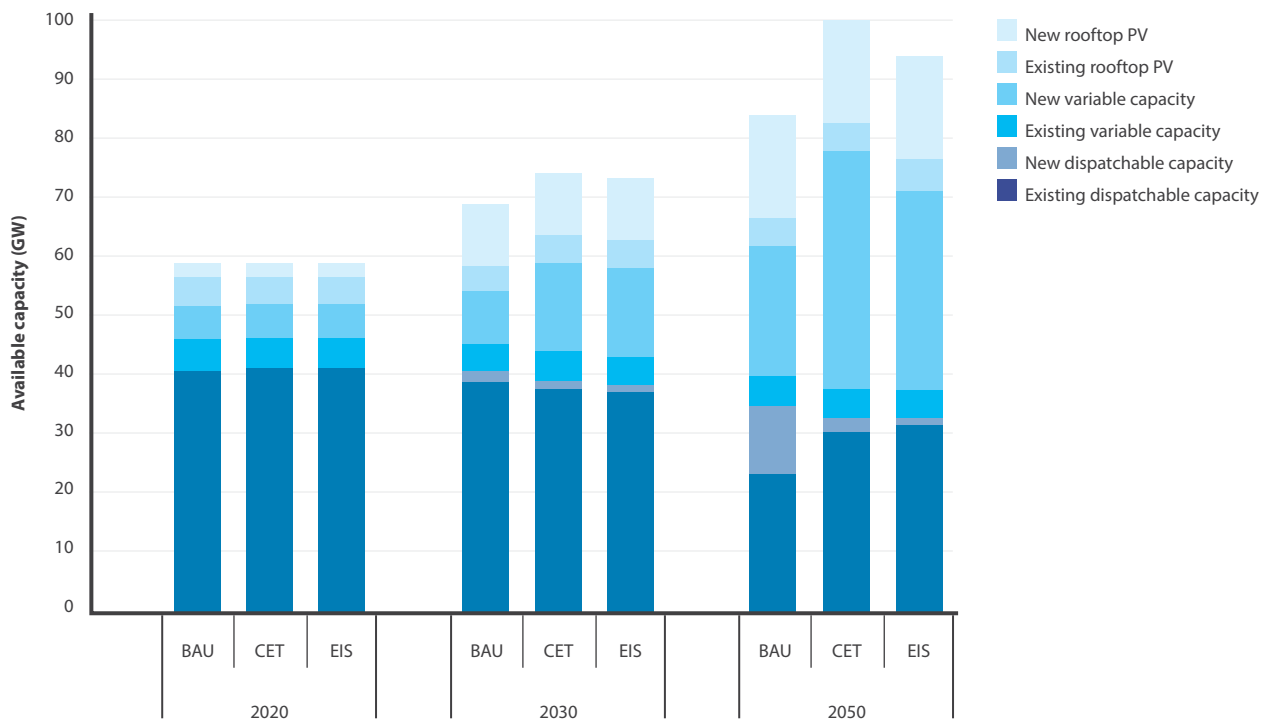
187. Climate Change Authority, *Policy options for Australia's electricity supply sector*, 2016.

Both an EIS and a CET can also be designed to achieve a set emissions reduction target, though they get there in different ways. Overall emissions are the product of total electricity demand and the average emissions intensity of the electricity generated. An EIS is calibrated to achieve a given NEM-wide emissions intensity, with the emissions outcome dependent on actual demand. To keep total emissions from electricity generation in line within the agreed trajectory, the average emissions intensity target would need to be adjusted from time to time. A CET, on the other hand, sets a quantitative target for emissions reduction (based on the quantity of low emissions generation) by setting a trajectory for the number of certificates to be surrendered each year. Again, if demand departs significantly from the forecasts on which the trajectory was based, an adjustment would need to be made to keep total emissions in line with the agreed trajectory. In either case, a predictable set of rules for making such adjustments in a way that does not arbitrarily alter returns on investment would be essential.

Implications for security and reliability

Additional quantitative power systems analysis was commissioned to examine the security and reliability impacts of the scenarios assessed.¹⁸⁸ While acknowledging there are new challenges created by higher VRE penetration, analysis found that sufficient dispatchable capacity would be in place across the NEM to maintain system reliability in all scenarios (see Figure 3.10). There were no differences in terms of security and reliability between the CET scenario and EIS scenario modelled. Specific recommendations to enhance system security are discussed in Chapter 2.

Figure 3.10: Forecast NEM capacity mix, dispatchable, variable, rooftop PV¹⁸⁹



The security and reliability analysis assessed the ability of the forecast generation mix to meet average peak demand events (referred to as a 50 per cent probability of exceedance (POE)). Another consideration for the electricity sector is the ability of the generation mix to meet more extreme peak demand events. This was tested in the modelling through applying a 10 per cent POE load. The sector would be expected to bring forward

188. University of Melbourne, Melbourne Energy Institute, *Power system security assessment of the future National Electricity Market*, 2017.

189. Adapted from Jacobs, *Report to the Independent Review into the Future Security of the National Electricity Market*, 2017.

additional investment in peaking capacity consistent with more extreme demand events. This additional generation would further add to the security and reliability of the system.

The security and reliability analysis focussed on policies that were scaled to achieve a 28 per cent emissions reduction on 2005 levels by 2030. The adoption of a more ambitious target would have larger consequences for energy security as such a target would likely see a higher level of VRE incentivised. The Panel recommends that if a higher national target is to be considered, cost, security and reliability implications should be re-examined.

Recommended approach

According to the modelling undertaken for this Review, there was a small difference in price between the CET (Clean Energy Target) and EIS (Emissions Intensity Scheme) scenarios. The business as usual price outcomes were worse for consumers than under either the CET or EIS scenarios.

In the Panel's view, the single most important characteristic of any emissions reduction mechanism to be adopted by governments is that it is agreed expeditiously and with sufficient broad-based support that investors can be confident it will endure through many electoral cycles.

Experience both here and overseas has shown that mechanisms of this kind rarely operate as originally designed, not least due to rapid and unanticipated changes in consumer markets, technology costs and global commodity prices. The full complexity of influences on real-world decisions cannot be completely anticipated in policy theory. As a consequence, mechanisms with any longevity are subject to adjustment in both target parameters and substantive design features.

There are likely to be some differences in how either scheme would interact with the existing contract market and on whom it would place obligations to negotiate and enter into contracts. The Panel has come to the view that the differences in interaction with the contract market are not significant enough to prevent the implementation of either mechanism. With the right package of policy measures, both mechanisms could support functional and effective contract markets.

For these reasons, the Panel is hesitant to argue definitively that one mechanism, between the EIS and the CET, is superior to the other. The differences in theory may be less significant than how well the chosen scheme is implemented and aspects of its detailed design, such as a predictable process for parameter changes and a robust and proportionate compliance and enforcement regime.

The Panel notes that many stakeholders have expressed strong support for an EIS. The Panel also notes that to date the Australian Government has ruled out implementing an EIS. The Panel does not seek to offer a political resolution of these opposing points of view. However, in the Panel's view a CET, though less widely canvassed than an EIS, has similar ability to achieve the required level of emissions reduction in the electricity sector securely and reliably, with price benefits to consumers relative to business as usual.

An EIS, though widely discussed in recent months in Australia, would be a new scheme and require detailed development and design. By contrast, a CET could build directly on the experience of the Renewable Energy Target and its operations are well understood by participants. The Clean Energy Regulator would be well placed to administer the CET drawing on well-developed skills, procedures and infrastructure such as the Renewable Energy Certificate Registry system.

In terms of the specific emissions reduction target that should be set for the electricity sector, the Panel acknowledges that this is a question for governments. At a minimum, the electricity sector should have a target that reflects a direct application of the 2030 commitment of 26 to 28 per cent reduction on 2005 levels, as per the Paris Agreement. The target should anticipate a continuing emissions reduction trajectory out to 2050. A CET or EIS provides a credible mechanism by which both governments and industry can have confidence that the electricity sector will meet its emissions reduction requirements.

Recommendation 3.2

There is an urgent need for a clear and early decision to implement an **orderly transition** that includes an agreed emissions reduction trajectory, a credible and enduring emissions reduction mechanism and an obligation for generators to provide adequate notice of closure.

- The Panel **recommends** that the Australian and State and Territory governments agree to an emissions reduction trajectory for the National Electricity Market.
- Both a Clean Energy Target and an Emissions Intensity Scheme are credible emissions reduction mechanisms because they minimise costs for consumers, are flexible and adaptable, and satisfy security and reliability criteria. Both mechanisms are shown to deliver better price outcomes than business as usual.

With the additional context that a Clean Energy Target can be implemented within an already well understood and functioning framework, and has better price outcomes, the Panel **recommends** a Clean Energy Target be adopted.

- To support the orderly transition, the Panel **recommends** a requirement for all large generators to provide at least three years' notice prior to closure. The Australian Energy Market Operator should also maintain and publish a register of long-term expected closure dates for large generators.

These recommendations are made in the context of the need for a Generator Reliability Obligation recommended in this chapter and the Energy Security Obligations recommended in Chapter 2.

Phase out policies for coal-fired generators?

It was suggested to the Panel that governments could consider a lifetime limit for existing generators, based on their fuel type or emissions intensity. This measure would be complementary to the notice of closure requirement and would provide additional forward planning and certainty to the electricity sector and to affected communities. A lifetime limit would aid in investment and planning decisions for new entrants looking to enter the market.

A 50 year lifetime limit on coal-fired generators, for example, would allow existing coal-fired generation assets to operate to the end of their expected investment life. A number of large coal-fired generation owners, such as ENGIE,¹⁹⁰ Origin¹⁹¹ and AGL,¹⁹² have previously announced their intention to not invest in new conventional coal assets, while Origin and AGL have also announced specific timeframes by which they plan to divest from coal-fired generation assets. Together, these three companies are the majority owners of more than 60 per cent of the privately-held coal-fired generation capacity in the NEM.¹⁹³ This suggests that a 50 year lifetime limit would not be at odds with the sector's intentions or expectations. At the same time, a lifetime limit would improve planning information and certainty for the sector.

A lifetime limit would also give more forward certainty to workers and communities affected by closures. Forward visibility of when coal-fired generation assets close would give communities and governments greater ability to plan for and manage potential impacts to regional economies.

190. ENGIE media release, <http://www.engie.com/en/journalists/press-releases/2016-integrated-report/>, accessed 3 June 2017.

191. Australian Financial Review, <http://www.theherald.com.au/story/3436819/origin-energy-to-shut-eraring-ditch-coal-assets/>, accessed 3 June 2017.

192. AGL, *AGL Greenhouse Gas Policy*, 2015, p.1.

193. Review taskforce analysis of Australian Energy Council, *2016 Electricity Gas Australia*, 2016, Appendix 1.

Box 3.2 – International coal-fired generation phase out policies

Canada

On 21 November 2016 the Canadian Government announced that it intends to phase out traditional coal-fired generation by 2030. Existing regulations under the *Canadian Environmental Protection Act 1999* mandate that any new coal-fired generator must meet an emissions intensity threshold of 0.42 tCO₂/MWh. New amendments to regulations will see this emissions intensity threshold apply to existing coal-fired generators by 2030, which allows for the potential retro-fit of carbon capture and storage technology. Consultation with provinces, territories and other stakeholders will take place throughout 2017 with final regulations to be published in 2018.¹⁹⁴

United Kingdom

In November 2015, the UK Government announced that it will be requiring conventional coal-fired generators to close by 2025. Under the *UK Energy Act 2013* there is an emissions performance standard for new coal-fired generation equivalent to 0.45 tCO₂/MWh for a plant operating at baseload. Additionally, any prospective new plant must employ CCS on at least 300 MW of capacity and be 'carbon capture ready' on the remainder of capacity. Consultation on the mechanism by which the phase out will be implemented closed in February 2017.¹⁹⁵

Germany

Germany's *Electricity Market Act 2016* mandates the phasing out of 2.7 GW of lignite (brown) coal capacity, a measure that is generally considered necessary for Germany to meet its 2020 emissions reduction goals. Starting in 2019, relevant generators will be paid to cease generating but remain on standby for 4 years, capable of coming back online within 10 days' notice, to provide a strategic reserve.¹⁹⁶

While not explicitly recommended by the Panel, a lifetime limit on some generators could be considered as a way to further aid in achieving an orderly transition.

3.4 Generator Reliability Obligation

Regions with a very high proportion of VRE can present challenges for system reliability. A number of submissions to the Review¹⁹⁷ highlighted that, going forward, there will be a need for more dispatchable capacity to be brought forward to the market to complement an increasing proportion of VRE generators like wind and solar photovoltaic.

194. Government of Canada, Canada Gazette, <http://www.gazette.gc.ca/rp-pr/p1/2016/2016-12-17/html/notice-avis-eng.php>, accessed 3 June 2017.

195. UK Department of Business, Energy and Industrial Strategy, <https://www.gov.uk/government/consultations/coal-generation-in-great-britain-the-pathway-to-a-low-carbon-future>, accessed 3 June 2017.

196. Clean Energy Wire, <https://www.cleanenergywire.org/factsheets/germanys-new-power-market-design>, accessed 3 June 2017.

197. For example AGL, Australian Energy Council, and Business Council of Australia submissions to the Review.

The Panel recommends the adoption of a new Generator Reliability Obligation. This will consist of new obligations for VRE generators connecting to the NEM, to ensure reliability is maintained. As part of this measure, the market bodies should undertake regional reliability assessments to determine the minimum dispatchable capacity required for each region to maintain system security and reliability. How much dispatchable generation is required in any region of the NEM depends on a number of factors. Considerations should include:

- Total VRE generation as a proportion of dispatchable generation.
- Strength of the network.
- Extent of variation in VRE generation.
- Interconnections with other NEM regions.
- The load profile.
- Wholesale and contract market considerations.
- Expected future trends.

In regions where dispatchable capacity approaches the determined minimum acceptable level, new generation projects should be obliged to also bring forward new (i.e. not contracting existing) dispatchable capacity to that region. This obligation should be expressed in terms of a percentage of the new VRE generator's nameplate capacity, able to be dispatched for a required time period. The new capacity should not need to be located onsite, and could utilise economies of scale. Multiple VRE projects could pair with one new large-scale battery or gas-fired generation project, for example.

If technology cost reductions or policies such as more ambitious state and territory based renewable energy targets lead to very high levels of VRE in a particular region, the Generator Reliability Obligation would ensure that adequate dispatchable generation is also brought into the market to maintain reliability.

The Generator Reliability Obligation could also assist in maintaining liquid contract markets in regions by maintaining a level of dispatchable capacity. Implications for the financial markets should be considered when undertaking a regional reliability assessment.

Box 3.3 – Falling costs of technology

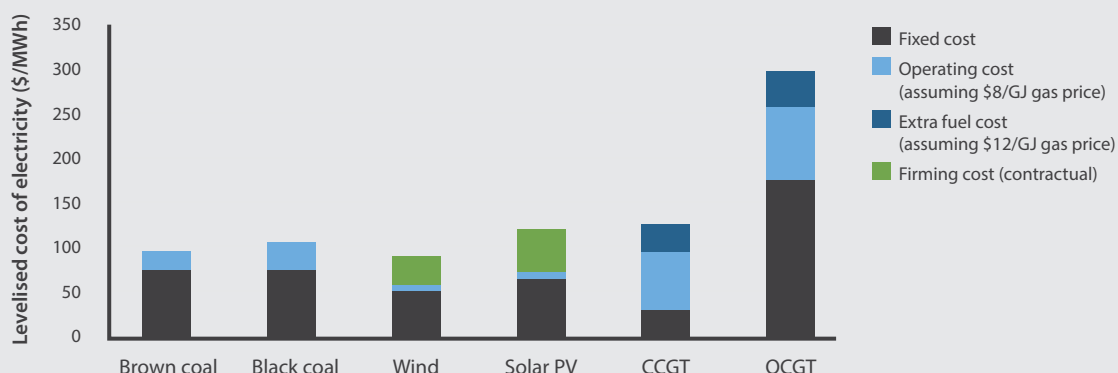
The Panel notes that, even since the Review started, utility scale batteries, wind and solar photovoltaic have declined in cost substantially more than expected.

Origin Energy Limited has agreed to buy all of the power generated by the Stockyard Hill Wind Farm and the associated Renewable Energy Certificates for a power purchase agreement (PPA) of below \$60/MWh.¹⁹⁸

AGL recently outlined its estimates for the cost of different fuels. AGL considers that a new wind farm supported by gas peaking generation (through the 'firming cost') to now be cheaper than new CCGT at a \$8/GJ price. A new solar farm supported by gas peaking generation would also be cheaper than new CCGT at a gas price of \$12/GJ (see Figure 3.11).¹⁹⁹

198. Origin, ASX/Media Release, <http://www.stockyardhillwindfarm.com.au/sites/default/files/pdf/05-17/OEL%20Media%20release%20SHWF%20sale%2020170508.pdf>, accessed 3 June 2017.

199. AGL, <https://www.agl.com.au/-/media/DLS/About-AGL/Documents/Investor-Centre/Presentation-and-speech----A-future-of-storable-renewable-energy.pdf?la=en&hash=79A44C65B8D4D1469B8AD04B9C61CAA64C9CD117>, accessed 3 June 2017.

Figure 3.11: Implied cost of new generation²⁰⁰

Recommendation 3.3

To complement the orderly transition policy package, by mid-2018 the Australian Energy Market Commission and the Australian Energy Market Operator should develop and implement a **Generator Reliability Obligation**.

The Generator Reliability Obligation should include undertaking a forward looking regional reliability assessment, taking into account emerging system needs, to inform requirements on new generators to ensure adequate dispatchable capacity is present in each region.

3.5 Additional reliability measures

The orderly transition policy package and Generator Reliability Obligation discussed above, if implemented and committed to in full, will improve the investment environment, lead to more efficient market outcomes and give confidence that the reliability of the NEM will be maintained through the energy transition. The measures discussed below represent additional reforms that may be warranted to address more specific issues that could arise in the future and have implications for reliability. The Panel recommends market bodies investigate the appropriateness of these measures in relation to existing arrangements.

Out of market strategic reserve

Consideration should be given to the suitability and desirability of an out of market Strategic Reserve mechanism. This could involve equipping AEMO with the power to contract for a targeted level of capacity that would be held in reserve outside the market. If implemented, this policy should be designed as an enhancement or replacement to the existing reliability safety net measure, the Reliability and Emergency Reserve Trader (RERT) mechanism (see Box 3.4), to avoid adding additional complexity and uncertainty for the electricity sector.

200. Adapted from AGL, *A future of storable renewable energy*, 2017, p.6.

Box 3.4 – Reliability and Emergency Reserve Trader mechanism

The primary tool to ensure reliability under the existing framework is the Reliability and Emergency Reserve Trader (RERT) mechanism. The RERT allows the market operator to contract for additional electricity generation reserves, where there is a projected shortfall. The reserves that the market operator contracts with cannot otherwise be available to be bid into the market, and participants are only paid if their contract is executed. From November 2017 onwards, the maximum length of time that the market operator can enter into a RERT contract is 10 weeks ahead of a projected shortfall. Prior to recent revision the maximum contract timeframe was nine months.

Changes to the RERT may be warranted. The relatively short timeframe at which reserves can be contracted prevents AEMO taking steps to address identified capacity shortfalls well ahead of time. This reportedly places the market operator in a sub-optimal negotiating position when trying to negotiate with potential participants.

In addition, because the RERT only pays participants once a contract is executed, it does not currently provide sufficient incentives to encourage the participation of distributed demand response aggregation services. This shortcoming is a key reason changes to the RERT may be warranted. Making better use of demand response in the NEM represents a low cost and as yet under-developed opportunity to maintain reliability.

To avoid interventions crowding out private sector investment or creating other perverse outcomes, there would need to be a clear and transparent set of criteria under which the reserve could be called upon. For example, AEMO may only intervene in cases where the reliability standard is forecast to be breached.

Ramp rates

South Australia is at the forefront of managing the impacts of a high penetration of VRE generation. The Panel understands that AEMO has recommended a series of actions to be implemented in South Australia to address current challenges presented by VRE generators, independent of this Review. The Panel considers these reforms adequate for addressing South Australia's immediate concerns and recommends the measures be further assessed for their suitability in other NEM regions.

Among these new measures is a requirement for active power control facilities to be fitted to all VRE generators. This measure is understood to require VRE generators to control their rate of change of active power (ramp rates), among other things. This may require that VRE generators curtail their power output at times to ensure they meet limitations on power output rates of change. This measure has the potential to provide additional incentives for VRE to install energy storage or partner with other storage companies as a way to capture the potentially lost value of curtailed power output. AEMO should monitor the effectiveness of this new requirement and assess its application more broadly.

Day-ahead markets

The ability for both AEMO and NEM participants to contribute to short-term reliability could be enhanced through greater forward transparency of supply conditions. While the NEM already has mechanisms that provide forward transparency, another approach that is used in other countries is a 'day-ahead market', as discussed in Box 3.5.

Box 3.5 – Case study – international experience on day-ahead markets

Internationally, day-ahead markets are widespread. They exist in most European power markets, including in Germany, Great Britain and NordPool; many are part of an integrated European day-ahead market called the Price Coupling of Regions.²⁰¹ There are also day-ahead markets in the majority of North American power markets, including in the PJM Interconnection, the Electric Reliability Council of Texas (ERCOT) and the California Independent System Operator (CAISO).

In these markets, bids to trade volumes of electricity for each interval in a day are submitted, and financially committed to, the prior day. From the bids a schedule is developed which commits certain generating units to run for given intervals, and instructs how much they must generate ('dispatch'). In developing the schedule, the generation portfolio is optimised based on constraints that reflect expected real-time conditions. The day-ahead market is followed by a real-time 'balancing' market where supply is dispatched to balance residual demand, including based on updated constraints. While participation is usually voluntary, typically a high proportion of electricity trading volumes is settled in day-ahead markets.

In contrast to this 'two settlement' system, the NEM uses a 'single settlement' approach, with no firm day-ahead market. All electricity trades are settled in the real-time market. There is a pre-dispatch process that has similarities to a day-ahead market, but it is not financially binding: up until the start of the relevant five-minute dispatch interval, generators are allowed to resubmit bids ('rebid') to shift volumes between price bands nominated in the original bid.²⁰² The accuracy and validity of the pre-dispatch process depends on factors such as demand forecasts, wind and solar forecasts, changes to constraints, unplanned outages, and the level of rebidding.²⁰³ Aside from rebidding, the same factors also affect the accuracy and validity of scheduling in day-ahead markets.

A key function of day-ahead markets in European and North American power markets is for more efficient coordination of electricity transactions with neighbouring power markets; though this is not relevant to the NEM, as it does not connect to any other power markets. Another beneficial feature of day-ahead markets is their ability to coordinate with fuel markets. In the United States, day-ahead markets assist gas-fired generators in procuring and transporting their gas supplies (referred to as 'gas-electric coordination'). The windows for bidding into these day-ahead markets are synchronised with the windows for procuring gas supply.

More broadly, day-ahead markets may be a more efficient means for the market operator to manage reliability than a pre-dispatch process, to the extent that a pre-dispatch process may be subject to strategic capacity withholding or disorderly bids. However, there is also recognition of the efficiency benefits from the flexibility of securing unit commitment closer to real-time (as occurs in a single settlement system), and in some existing day-ahead markets there is consideration of moving the gate closure closer to real-time. The forward nature of day-ahead markets also enables generators and loads to hedge against exposure to pricing and scheduling risks, and in doing so, can reduce price volatility in the real-time market. The financial markets in the NEM provide a similar function, but in a less transparent way.

201. European Power Exchange, <https://www.epexspot.com/en/market-coupling/pcr>, accessed 3 June 2017.

202. AEMC, *National Electricity Amendment (Bidding in good faith) Rule 2014: Options Paper*, 2014, p.11.

203. AEMO, *Pre-dispatch: procedure document*, 2016.

Importantly, day-ahead markets are also recognised to better facilitate demand-side participation compared to real-time markets. A recent assessment of a day-ahead market for the New Zealand Energy Market noted potential efficiency benefits in this regard.²⁰⁴

For the NEM, any further consideration of a day-ahead market would require detailed cost-benefit analysis, including in relation to the nature of changes to the existing real-time and contract markets, impacts on market participants, and the implementation costs. Introducing a day-ahead market would be a significant reform. Other reforms are more urgent, as discussed elsewhere in this chapter. For further consideration, the Panel recommends that AEMO and the AEMC should work closely with market participants to consider the possible benefits of a day-ahead market in the NEM.

Recommendation 3.4

By mid-2018, the Australian Energy Market Operator and the Australian Energy Market Commission should assess:

- The need for a Strategic Reserve to act as a safety net in exceptional circumstances as an enhancement or replacement to the existing Reliability and Emergency Reserve Trader mechanism.
- The effectiveness of the new licensing arrangements being developed for generators in South Australia and whether they should be applied in other National Electricity Market regions.
- The suitability of a 'day-ahead' market to assist in maintaining system reliability.

204. Electricity Authority of New Zealand, *Comparison of NZEM and Australian NEM*, 2015, pp.16-20.

Chapter 4

MORE EFFICIENT GAS MARKETS

Overview

Gas and electricity markets are closely connected. As ageing coal-fired generation retires, gas-fired generation can provide a low emissions substitute for coal and can also complement variable renewable electricity generation. In recent years, the contribution of gas to electricity generation has declined largely due to higher gas prices and tighter supply availability. Gas market reforms driven by the COAG Energy Council and recent Australian Government initiatives will help to improve both gas supply and affordability.

To improve transparency in all aspects of the gas market, the Panel concludes that:

- AEMO should have better oversight of gas supply contracts for gas-fired generators.
- Governments should work with communities and industry to enable the safe exploration and production of unconventional gas, including ensuring that landowners receive fair compensation.
- Gas industry performance data should be transparent, clear and accessible. This should include seismic activity, fracking fluid composition, aquifer purity and fugitive emissions.

Even with the benefit of these reforms, domestic gas prices, in real terms, are likely to remain higher than historical levels. Improving the efficiency of gas-fired generators, both in their fuel use and flexibility, will help to ensure gas can continue to play a role in electricity generation.

4.1 Electricity and gas markets are linked

Access to a reliable and affordable gas supply is in the interest of all Australians for its direct use for heating, as a feedstock chemical for industrial processes and as a fuel for electricity generation. In the NEM, gas-fired generation can provide a reliable, low emissions substitute for ageing coal-fired generation, and can provide essential security services to complement variable renewable electricity (VRE) generation.

There is an increasing interdependency between gas and electricity (see Figure 4.1). Material changes in the gas market have a subsequent effect on the electricity market – whether it is with respect to supply or to price. The economics of gas-fired generators are being challenged by rising gas prices and tightening gas supply. As coal-fired generators retire, gas-fired generators are likely to set the marginal cost of generation within the NEM, which will flow through to consumers as higher retailer electricity prices. Under these circumstances, access to affordable gas supply will be critical.²⁰⁵

The recent linkage of the east coast domestic gas market to international gas markets has complicated the outlook for gas in the NEM's future generation mix. The three Queensland liquefied natural gas (LNG) projects – Australian Pacific LNG (APLNG), Queensland Curtis LNG (QCLNG) and Gladstone LNG (GLNG) – are driving changes in the domestic gas market. To enable investment in these LNG projects, long-term offtake contracts were committed to major gas users in the Asian region. Domestic users in the east coast gas market now compete for additional gas supplies with prices set at a level that competes with the international market.

Gas prices have increased substantially in recent years, causing affordability stress for vulnerable residential consumers and severe cost escalations for some energy intensive industries. The extent of the price rises is unclear because there is little, if any, transparency in contract prices.

205. GE submission to the Review, p.10.

Efficient gas markets have a central role to play in maintaining energy security and reliability as Australia reduces its emissions in line with international commitments.

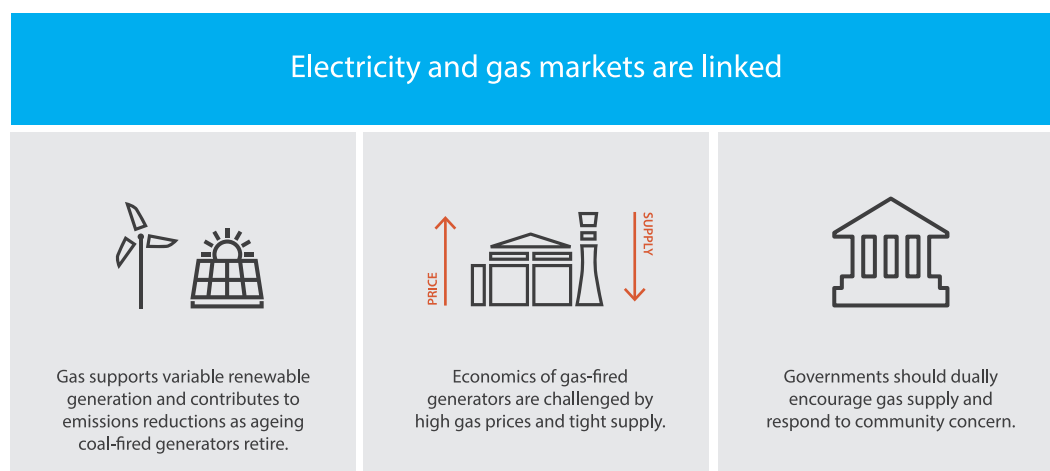
In this context, effective government policy and regulatory settings have a dual role. They should:

- Facilitate new investment and enable the development of Australia's gas resources.
- Address community concern about the environmental and social impacts associated with unconventional gas extraction.

As indicated by Engineers Australia:

Gas is an important part of Australia's energy mix, with the ability to respond more rapidly to variable grid demands, and with lower emissions than coal. However, it only remains part of the solution in a low carbon economy and the on-going role that it plays will be determined by its cost due to price volatility and availability, as well as broader energy policy considerations.²⁰⁶

Figure 4.1: Relationship between electricity and gas markets



4.2 The role of gas in the NEM

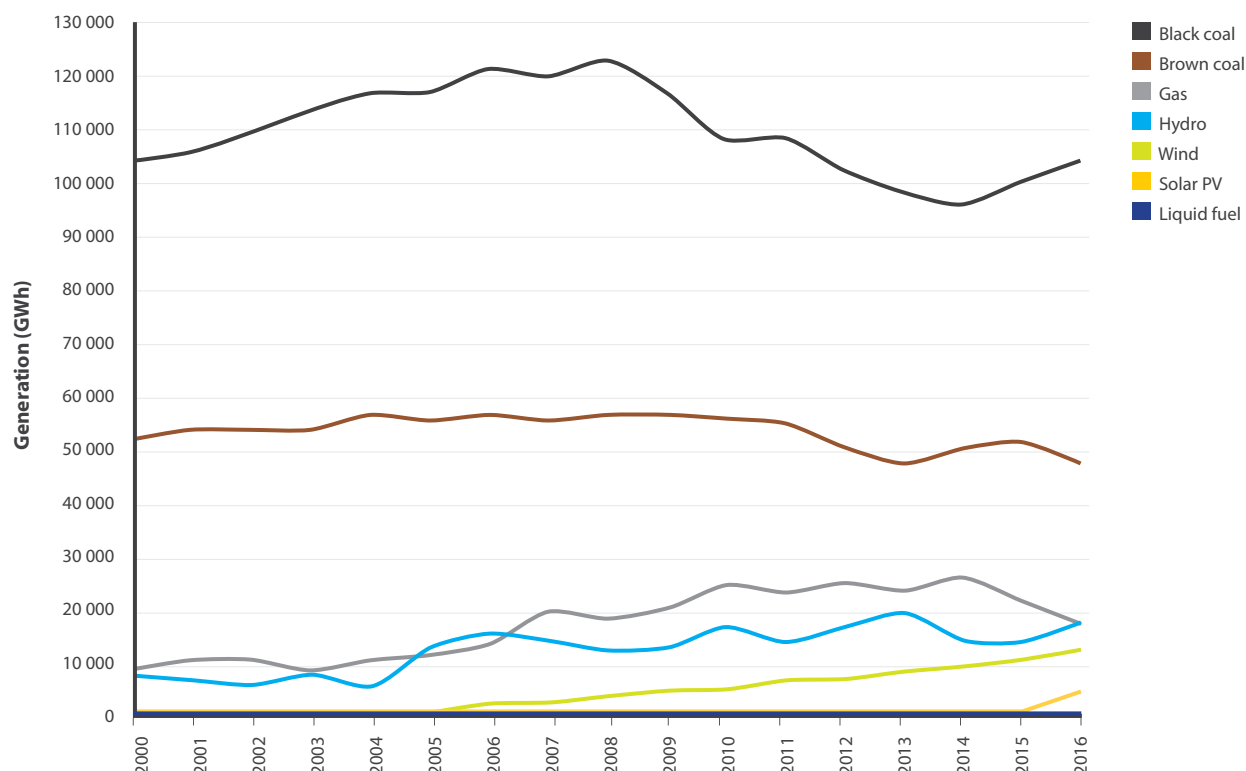
Traditionally, gas-fired generation has been used to meet periods of high demand in the NEM, such as when air conditioning loads are high on hot summer afternoons.

As demonstrated in Figure 4.2, gas-fired generation reached its highest level in 2014 when very cheap gas was available in the domestic market and local prices fell. This encouraged local gas-fired generation, particularly in Queensland, to run, substituting for coal-fired generation and contributing around 13 per cent of electricity energy generation in the NEM.

206. Engineers Australia submission to the Review, p.5.

Since 2014, gas-fired generation output has been in decline due largely to higher gas prices, increases in VRE generation and reduced electricity demand. While gas-fired generation represented around 19.4 per cent of capacity in the NEM for FY2017,²⁰⁷ it contributed only 8.4 per cent of electricity energy generation in 2016. However, as coal-fired generators are retired, more gas-fired generation will be required to substitute for coal and complement VRE generation.

Figure 4.2: NEM generation 2000 to 2016 by fuel type²⁰⁸



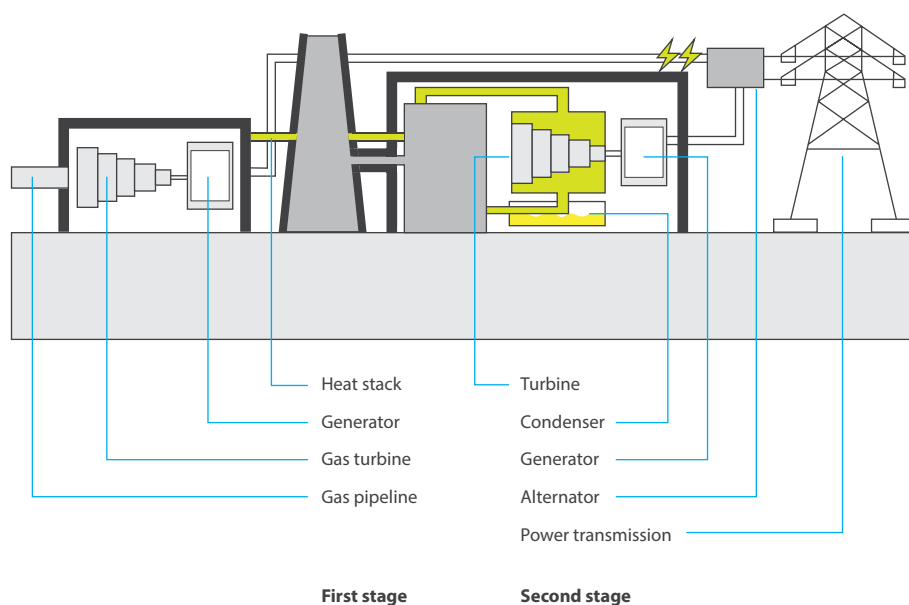
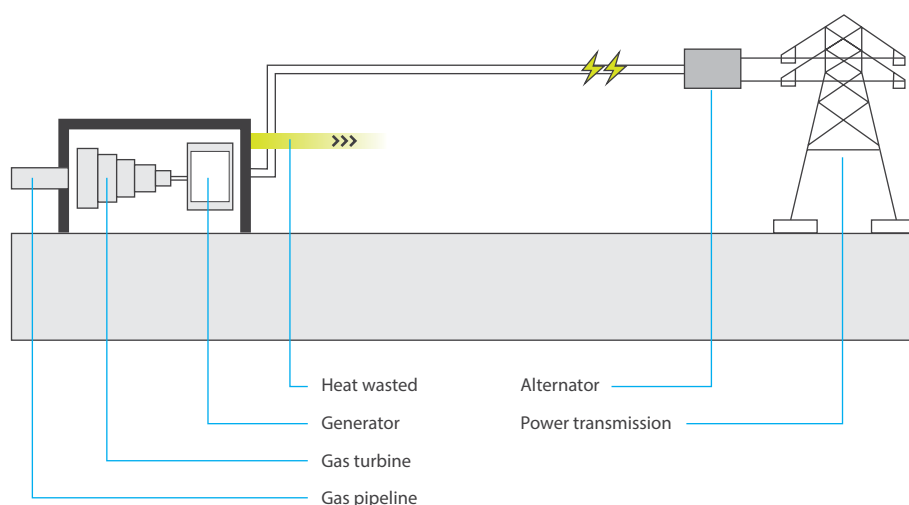
Gas contributes to a secure and reliable NEM

Rapid changes in power output from VRE generation need to be balanced with generation technology that has the ability to increase (ramp up) or decrease (ramp down) power output at the same time. Gas-fired generators have the ability to 'fast ramp'. Most of Australia's coal-fired generators do not. In addition, gas-fired generators are synchronous and provide essential security services, including physical inertia to help dampen rapid frequency changes, fault current to help maintain system strength, and the ability to supply or absorb reactive power to help control voltage. These security services are discussed in more detail in Chapter 2.

In the NEM, the main types of gas-fired generation technology are combined cycle gas turbine (CCGT) and open cycle gas turbine (OCGT) (see Figure 4.3).

207. AER, <https://www.aer.gov.au/wholesale-markets/wholesale-statistics/generation-capacity-and-output-by-fuel-source>, accessed 31 March 2017.

208. NEMwatch review data, accessed 30 May 2017.

Figure 4.3: Gas-fired generation technology²⁰⁹**Combined cycle gas-fired generation****Open cycle gas-fired generation**

CCGT technology captures heat from the exhaust of the first-stage gas turbine to produce steam to drive a second-stage steam turbine. The capture of waste heat improves the thermal efficiency of the plant, thus CCGT generators use less fuel but the trade-off is that they have higher capital costs. CCGT generators offer an intermediate level of flexibility and capital expenditure between coal-fired and OCGT generators. Initial start-up times for CCGT generators can be quite fast to achieve partial output, but reaching full output takes longer. Mothballing and reinstatement times for CCGT generators are shorter than for coal-fired generators but involve more time and cost than for OCGT generators.²¹⁰

209. Adapted from the AER, *State of the Energy Market 2017*, 2017, p.28.

210. Frontier Economics, *Barriers to exit for electricity generators in the NEM*, 2015, p.27.

OCGT technology uses a gas turbine to generate electricity. This technology does not recover heat, and therefore has a lower efficiency and higher fuel use than CCGT. OCGT generators are the most flexible form of fossil fuel generation, in the context of both frequent cycling as well as seasonal or longer shut-downs. This flexibility is due to the versatility of gas turbines and their lack of thick-walled components. The time and cost to mothball and reinstate an OCGT generator is much shorter and lower than for coal-fired generators and CCGT generators.

Recent technological improvements have increased the flexibility of gas-fired generators to provide fast ramp rates and dispatchable capacity. New CCGT generators are able to operate with a high degree of flexibility, including being able to ramp up their output from zero to 100 per cent in less than 10 minutes. Thus, with new generation CCGT the flexibility of traditional OCGT can be had without the higher fuel costs.

In the short to medium term, the NEM is likely to require higher levels of flexible, gas-fired generation to maintain security and reliability. Storage technologies, such as pumped hydro and batteries, will be able to play a role to support reliability as and when they are deployed at scale.

Gas contributes to emissions reduction

As discussed in Chapter 3, Australia's coal-fired generation fleet is ageing and is unlikely to be replaced on a like-for-like basis.

The best gas-fired generation is less than half as emissions intensive than even the most efficient coal-fired plant, including ultra-super-critical coal generation, which is referred to as high efficiency, low emissions (HELE) generation. To compete with new gas-fired generation from the emissions point of view, new HELE generation would need to be fitted with carbon capture and storage (described in Chapter 8).

4.3 Gas markets need to be highly efficient

Domestic gas prices will likely be higher in the future compared with historical levels. If gas is to play an increasing role in affordable electricity supply, gas markets will need to be highly efficient, as gas-fired generation often sets the spot price for the wholesale electricity market when VRE generation is low. Increased wholesale electricity prices will inevitably flow through to higher retail electricity prices for consumers.

Securing firm gas supply as a stand-alone contract is difficult, as it requires a gas producer to commit a large amount of processing and production capacity for the sale of a small amount of commodity. In the past, gas producers were willing to provide relatively high levels of flexibility within gas contracts for modest price premiums.²¹¹ Gas producers are now increasingly seeking to recover the true cost of providing such flexibility. They have a strong incentive to run their processing and production facilities as 'flat' as possible. Coal seam gas (CSG) producers, in particular, have limited ability to vary production on a short-term basis.²¹²

Consequently, it is becoming increasingly difficult, and more expensive, for gas-fired generators to secure firm gas supply contracts if they do not have access to a substantial portfolio.²¹³ This uncertainty could lead to gas-fired generators over-contracting for gas, which they still have to pay for under take or pay conditions, or under-contracting and being unable to generate on a reliable basis.²¹⁴

211. ACIL Allen Consulting prepared for the Australian Energy Council, *South Australian Technical Challenges: integration of renewables*, 2016, p.31.

212. ACIL Allen Consulting prepared for the Australian Energy Council, *South Australian Technical Challenges: integration of renewables*, 2016, p.31.

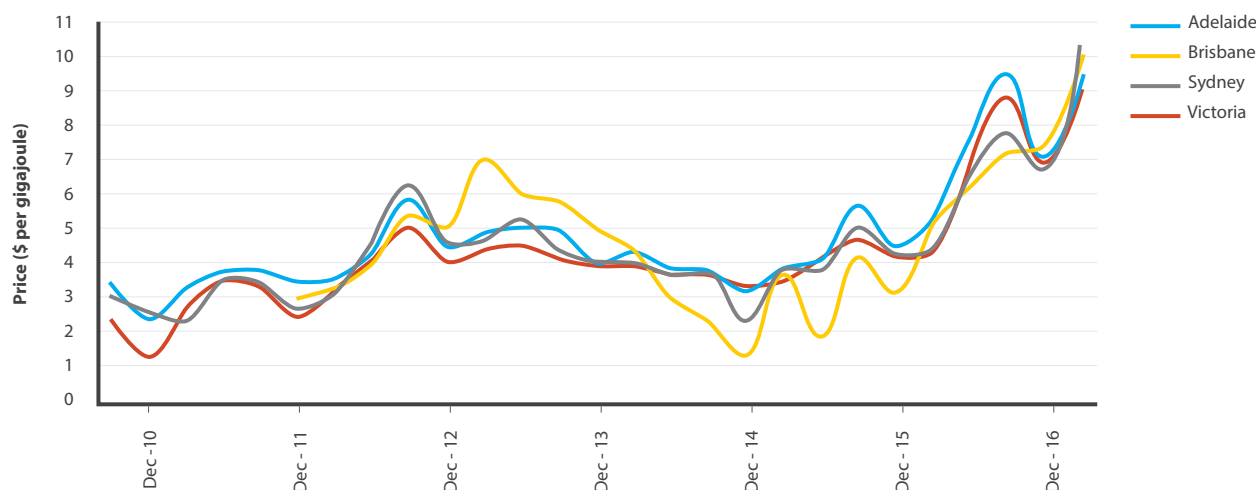
213. ACIL Allen Consulting prepared for the Australian Energy Council, *South Australian Technical Challenges: integration of renewables*, 2016, p.31.

214. Australian Energy Council, *South Australia: Pioneering Australia's Energy Transformation*, 2016, p.9.

If gas-fired generators are unable to obtain long-term supply contracts, they become increasingly reliant on the Short Term Trading Market (STTM) and the Victorian Domestic Wholesale Gas Market to supplement their supply. The volatility in spot gas prices in these markets exposes gas-fired generators to significant fuel price risk, which is bid into the wholesale electricity market.

Figure 4.4 demonstrates the increasing domestic short-term gas prices. At the end of March 2017, spot prices were \$10.10/GJ in Brisbane, \$10.39/GJ in Sydney, \$9.48/GJ in Adelaide and \$9.11/GJ in Victoria.²¹⁵ While spot prices are likely to be influenced by bilateral gas supply contract prices, they do not provide a clear guide to actual supply contract prices; rather they provide an indicator of market conditions.²¹⁶ Anecdotally, compared with levels of around \$3/GJ to \$4/GJ in 2006,²¹⁷ domestic gas supply contracts for large gas users, including gas-fired generators, now range from around \$6/GJ to around \$22/GJ with various onerous contract conditions.²¹⁸

Figure 4.4: Spot prices - by quarter²¹⁹



As demonstrated in Figure 4.5, the fuel cost of generating electricity at a gas price of \$9/GJ is estimated to be in the range of \$60/MWh to \$140/MWh depending on the efficiency of the plant. This does not include any other costs.

215. Australian Energy Regulator, <https://www.aer.gov.au/wholesale-markets/wholesale-statistics/victorian-gas-market-average-daily-weighted-prices-by-quarter> and <https://www.aer.gov.au/wholesale-markets/wholesale-statistics/sttm-quarterly-prices>, accessed 30 May 2017.

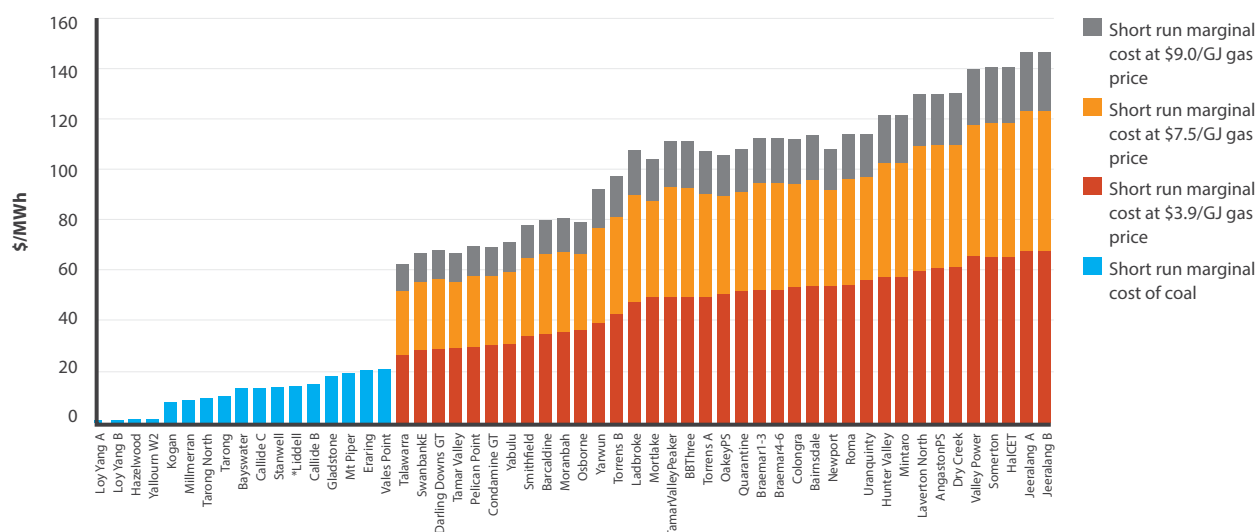
216. ACCC, *Inquiry into the east coast gas market*, 2016, p.88.

217. AER, *State of the energy market 2007*, 2007, p.234.

218. Australian Industry Group, https://www.aigroup.com.au/policy-and-research/mediacentre/releases/letter_to_PM_on_Energy_18_April_2017/, accessed 4 June 2017.

219. Average daily ex ante gas prices (daily gas price calculated before the gas day) for each STTM hub and average daily weighted prices for Victoria.

Figure 4.5: Indicative relative gas price impacts on generation fuel costs²²⁰



For gas-fired generators to operate on a more flexible basis and contribute to a reliable and secure NEM, efficient gas supply and transportation markets that are able to dynamically respond to changing conditions are required.

Recognising the need to address gas supply and competition concerns in the gas market, the COAG Energy Council (the Energy Council) has committed to a comprehensive Gas Market Reform Package. A Gas Market Reform Group has been established to develop and implement the Reform Package. This includes a new information disclosure and commercial arbitration framework for pipelines not subject to regulation under the National Gas Law (whether it be light or full regulation), transportation (pipeline and hub services) capacity trading-related reform, market transparency reforms, and wholesale gas market reforms.²²¹

This work may further benefit gas-fired generators that are looking to use the gas market or bilateral deals to optimise portfolios over the short-term.

Technical efficiency

In the NEM, around 4,900 MW of proposed new gas-fired generation capacity has been publicly announced.²²² Whether the proposed projects are built will depend on a positive investment environment and favourable electricity market conditions underpinned by access to a reliable and affordable gas supply and off-take arrangements.

A gas-fired generator must have sufficient gas available to generate the amount of electricity it has offered to the market. This includes having transportation arrangements in place to deliver the gas to the generation facility. Thus, adequate and flexible contractual arrangements for fuel, pipeline capacity and storage are critical for gas-fired generators. In some international jurisdictions, such as New York State, all gas-fired generators are required to have an alternative on-site fuel source such as diesel, sufficient to run for several days in the case of a gas supply constraint.²²³

220. AGL Investor Day 2016, <https://www.agl.com.au/-/media/AGL/About-AGL/Documents/Investor-Centre/AGL-Investor-Day-2016---Master-Presentation---2717FINAL.pdf?la=en>, accessed 30 May 2017.

221. COAG Energy Council Gas Market Reform Group, <http://gmrg.coagenergycouncil.gov.au/>, accessed 30 May 2017.

222. AEMO, <https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information>, accessed 30 May 2017.

223. New York Independent System Operator, *Dual Fuel Requirements in New York City*, 2014, p.5.

Given the prevailing gas prices, most existing gas-fired generators cannot economically provide dispatchable power at current wholesale electricity prices.²²⁴ Alternatively, gas-fired generators run less often and seek to capture periodic price spikes. In operating as peaking generators, these generators need substantially higher spot prices in order to recover their fixed costs over a lower utilisation rate.²²⁵

Gas-fired generators will increasingly need to switch in and out of service, or ramp up and down while operating, depending on intermittent supply from wind and solar generation. This volatility means less predictability and more starts for gas-fired generators, resulting in higher costs.

The result may be that gas-fired generators close down rather than compete. Across the NEM it is possible that a number of gas-fired generators will become uneconomic when their current gas supply or electricity off-take contracts end. Rather than potential new gas-fired generation capacity being built, this could result in a reduction in gas-fired generation capacity, despite the inherent value of gas to security in a power system dominated by VRE generation.²²⁶

An alternative for investors to consider would be to replace their ageing, inefficient gas turbines with modern turbines at the same site. Improving the efficiency of the gas-fired generator would in some cases halve fuel costs and halve the emissions. By using the same site, existing gas supply pipelines, gas contracts and electricity transmission infrastructure could be used.

4.4 Long-term gas supply certainty is essential

As has been discussed, an increase in gas prices affects both the cost and reliability of electricity supply and is largely a reflection of changes in supply and demand. For gas-fired generation to contribute to electricity supply now and in the future, gas supply certainty is required.

In the past ten years, the east coast gas market has fundamentally changed, introducing new dynamics to the gas market and flow-on effects for the NEM.

Coal seam gas (CSG) exploration has been occurring in Queensland since the late 1970s.²²⁷ The depletion of conventional gas resources and increased LNG prices in the mid-to-late 2000s encouraged further exploration and development.

The surge in international energy prices in 2007, together with the identification of large CSG resources led to three LNG projects in Queensland proceeding to final investment decision based on CSG from the Bowen and Surat basins. A fourth LNG project, proposed by Arrow Energy, has not proceeded. In 2016, the Queensland LNG industry exported around 16 million tonnes with an estimated export value of \$7 billion.²²⁸

However, production from CSG fields carries a greater degree of uncertainty in the development and production phases compared with conventional gas. CSG wells are depleted faster and as a result, wells need to be drilled on a continuing basis to access the gas and to make the development of a CSG field economically viable. This requires a continual investment of capital.²²⁹

The three LNG projects have entered into long-term LNG export agreements, with strict gas delivery conditions, requiring sufficient levels of production to meet export obligations. Whether the LNG projects continue to make investments sufficient to sustain production will depend on the economics of new developments. Some LNG

224. Australian Energy Council submission, p.12.

225. Australian Energy Council submission, p.12.

226. Australian Energy Council submission, p.12.

227. Australian Government Office of the Chief Economist, *Review of the socioeconomic impacts of coal seam gas in Queensland*, 2015, p.14.

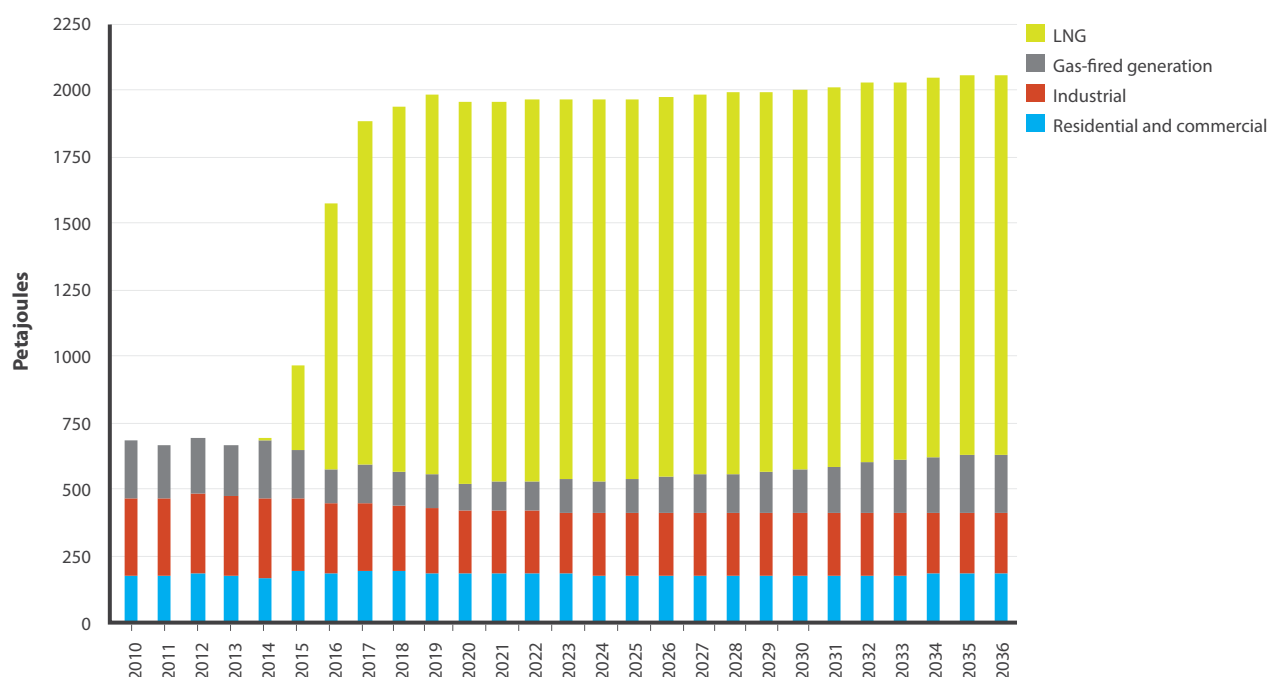
228. Analysis from Australian Government Office of the Chief Economist, *Resources and Energy Quarterly March 2017*, 2017, p.72.

229. Australian Government Office of the Chief Economist, *Review of the socioeconomic impacts of coal seam gas in Queensland*, 2015, p.9.

projects have experienced difficulties in extracting reserves and higher than expected costs of production.²³⁰ Restrictions on exploration and production have also been a significant factor. As a result, significant volumes of gas originally intended for the domestic market are being exported.

As demonstrated in Figure 4.6, compared with the demand from the three LNG projects, the size of the domestic gas market (residential and commercial, industrial and gas-fired generators) is relatively small. In 2016, the annual demand for LNG was more than double that of the domestic market, with gas-fired generators consuming just 22 per cent (121 PJ) of domestic demand (excluding LNG).

Figure 4.6: Total annual gas consumption by sector (historical and forecast) 2011 to 2036, PJ²³¹



AEMO anticipates that unless new production is incentivised, total gas production for the domestic market will decline from 600 PJ in 2017 to 478 PJ in 2021, with most of this decline projected to occur in the offshore Victoria gas fields.²³²

AEMO has projected that in the absence of new sources of supply, the NEM faces a potential shortage of gas for electricity generation between 2019 to 2024.²³³

AEMO notes that constraints on the availability of gas for electricity generation could result in average electricity shortfalls of an estimated 80 to 363 GWh between 2019 and 2021. AEMO predicts that these shortfalls would result in a breach of the NEM reliability standard.²³⁴ This comes at a time when flexible gas-fired generation will be relied on to balance intermittent renewables as some ageing coal-fired generators retire.²³⁵

230. ACCC, *Inquiry into the east coast gas market*, 2016, p.44.

231. AEMO, <http://forecasting.aemo.com.au/Gas/AnnualConsumption/Total>, accessed 30 May 2017.

232. AEMO, *Gas Statement of Opportunities for Eastern and South-Eastern Australia*, March 2017, p.3.

233. AEMO, *Gas Statement of Opportunities for Eastern and South-Eastern Australia*, March 2017, p.3.

234. AEMO, *Gas Statement of Opportunities for Eastern and South-Eastern Australia*, March 2017, p.15.

235. Australian Energy Council, <https://www.energycouncil.com.au/analysis/gas-intervention-but-will-it-increase-supply/>, accessed 30 May 2017.

Other than in Victoria, AEMO does not have the power to direct the flow of gas into or within the NEM to maintain and improve the reliability of gas supply. While AEMO can take short-term operational measures in Victoria, including the controlled interruption of gas demand, ultimately those measures are limited by the available supply of gas and transportation capacity.²³⁶

Gas market reforms

Since this Review commenced, a number of initiatives (in Box 4.1) have been announced to address supply tightness in the east coast gas market and ensure gas-fired generators have access to a reliable and affordable gas supply. LNG proponents have also announced a number of measures to address any supply shortfalls in the short-term, including committing to supply gas-fired generators.²³⁷

Box 4.1 – Current work to improve the east coast gas market

Energy for the Future package: gas supply and affordability measures: as part of the FY2018 budget, the Australian Government announced a number of measures to address supply tightness in the east coast gas market. These include:

- \$19.6 million over four years to accelerate reform through the Gas Market Reform Group to improve transparency and access to gas markets.
- \$30.4 million over four years for new combined geological and bioregional resource assessments to assess the potential impacts on waterways and aquifers in three onshore areas that are underexplored but prospective for unconventional gas.
- \$5.2 million to examine the costs and benefits of constructing pipelines to link Northern and Western Australia gas reserves to the east coast, through Moomba in South Australia.
- \$2.0 million to allow AEMO to improve publication of real time assessment of gas flows and market analysis to make it easier for the market operator, businesses and investors to make informed decisions about gas market operations.
- \$0.5 million in FY2018 to examine the constraints impinging on increased gas supply on the east coast of Australia, including regulatory barriers and inconsistent policies.
- \$6.6 million for the ACCC to conduct a wide-ranging inquiry into gas prices, transport and supply. The ACCC will report regularly on the supply and pricing of gas over the next three years.
- \$28.7 million over four years for measures to increase the supply of gas, including a grants program to accelerate projects and work to improve community and landowner acceptance of gas projects.
- Continual support of the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development in providing advice to Australian governments on the water-related impacts of coal seam gas and large coal mining development proposals, to strengthen the science underpinning regulatory decisions.

236. AEMO, *Gas Statement of Opportunities for Eastern and South-Eastern Australia*, 2017, p.17.

237. Shell has committed to provide 75 PJ of gas to the domestic market in 2017 and will supply 8 PJ to ENGIE's Pelican Point for five months over the peak period and an 18 month agreement with Orica <http://www.shell.com.au/media/2017-media-releases/shell-seals-more-east-coast-domestic-gas-deals.html>, accessed 6 June 2017. Origin is supplying 8 PJ of gas to ENGIE across 2018-2019. <https://www.originenergy.com.au/about/investors-media/media-centre/origin-works-with-engie-to-help-boost-energy-security-in-south-australia.html>, accessed 6 June 2017.

In April 2015, the Australian Government released the Domestic Gas Strategy, which sets out the Australian Government's role and expectations of governments and industry in responsibly developing unconventional gas. Following this, the Energy Council released its Gas Supply Strategy in December 2015. The Energy Council then developed the Gas Supply Strategy Implementation Plan for Collaborative Actions (released in August 2016) which sets out 14 actions for jurisdictions to collaboratively improve efforts on scientific and regulatory issues associated with onshore gas. Energy Council Ministers can agree to additional collaborative actions at any time.

The Australian Government's Australian Domestic Gas Security Mechanism will give the Government power to impose export controls on companies when there is a shortfall of gas in the domestic market.²³⁸

Further consideration by governments is warranted on the future of gas-fired generation if gas is not available at the end of contract periods. Given the current gas market conditions, it is possible that new technologies such as battery storage systems may be more cost-effective in providing security and reliability in the NEM in the near future.

The initiatives driven by the Energy Council and the Australian Government will assist in improving gas supply security and affordability. The Energy Council should recommit to the Gas Supply Strategy Implementation Plan as a matter of urgency.

Over the last several years, a number of large users, including gas-fired generators, have made the commercial decision to on-sell their gas supply to take advantage of high wholesale gas prices.²³⁹ Stanwell withdrew its Swanbank E Power Station and sold its contracted gas.²⁴⁰ ENGIE is also believed to have on-sold some of its contracted supply of gas to GLNG in 2015.²⁴¹ Currently, generators are only required to notify AEMO about whether a generation unit will be physically available at a point in time. There is no requirement to report to AEMO whether a generation unit has sufficient fuel to run.

While managing their supply contract positions is a commercial matter for generators, greater transparency of the fuel resource adequacy of generators (including gas and coal) over the medium term would enable AEMO to plan its response and mitigate any potential fuel shortages in the NEM. In addition, gas producers and major gas consumers should produce and provide to AEMO a rolling monthly look ahead for six months and an outlook for three years. Increased visibility of forward gas supplies will allow AEMO to plan in an informed manner and better assess if there is sufficient fuel available.

Measures announced by the Australian Government and the gas industry to guarantee that gas will be available to meet peak demand period in the NEM include AEMO being given the power to direct the market.²⁴² This should also include AEMO having a last resort power to procure and enter into commercial arrangements with existing gas-fired generators to make them available to maintain reliability in the NEM. However, the right to use this power should only be exercised if certain conditions are not met in the market. Appropriate parameters will need to be established.

238. The Hon Malcolm Turnbull MP media release, <https://www.pm.gov.au/media/2017-04-27/delivering-affordable-gas-all-australians>, accessed 4 June 2017.

239. AEMO submission to the Review, p.29.

240. Stanwell, <http://www.stanwell.com/energy-assets/our-fuel-assets/gas/>, accessed 30 May 2017.

241. EnergyQuest, *Energy Quarterly March 2017 Report*, 2017, p.50.

242. The Hon Malcolm Turnbull MP media release, <https://www.pm.gov.au/media/2017-03-15/measures-agreed-cheaper-more-reliable-gas>, accessed 4 June 2017.

Recommendation 4.1

By end-2017, the Australian Energy Market Operator should require generators to provide information on their fuel resource adequacy and fuel supply contracts, to enable it to better assess fuel availability.

Recommendation 4.2

By mid-2018, the Australian Energy Market Operator should be given a last resort power to procure or enter into commercial arrangements to have gas-fired generators available to maintain reliability of electricity supply in emergency situations.

Ensure appropriate regulatory regimes

While investment in exploration and appraisal has been slowed by falling oil prices, this has the potential to increase again if the oil price rises. The economics of developing any new supply outside established production areas is yet to be fully demonstrated. Increases in domestic gas contract prices are expected to be driven by higher costs of production as new gas is sourced from higher-cost fields.

Increasing gas supply will relieve supply tightness and assist in mitigating gas price rises. This will go some way to improving the economics of gas-fired generation. Without further and extensive investment in undeveloped gas reserves, there may be significant unfilled demand and continuing high prices on the east coast.

For this reason, government and industry should prioritise the exploration and development of gas reserves to build long-term supply certainty, given the timeframe of five or more years to bring new supply to market.

The exploration and development of onshore unconventional gas fields gives rise to a number of socioeconomic challenges.²⁴³ Unconventional gas has a large development footprint as it occurs across a large subsurface area, requiring a range of infrastructure, including gas wells, access roads, pipelines, processing plants and dams.²⁴⁴

Regulation of onshore gas is the responsibility of state and territory governments. In response to community concerns, some governments have put in place restrictive regulations and moratoria on the exploration and development of gas reserves. While it is vital that regulatory regimes are in place to ensure community safety and environmental protections, and to protect landholders' economic interests, regulatory restrictions not based on evidence have long-term detrimental impacts on gas exploration and development and disrupt the flow of gas.

Stakeholders have advised the Panel that these regulatory restrictions have exacerbated the current supply tightness. The interconnected nature of the east coast gas market means decisions made by states in isolation have national consequences and impacts for multiple markets – including the NEM. The consequences of these interventions are now being felt. Any disruptions to the flow of investment will impact the availability of gas for the domestic market, leading to higher prices and consequent risk to the economy and jobs.

For long-term gas supply certainty, governments and industry need to invest in earning community confidence in onshore unconventional gas. In particular, the LNG projects in Queensland will need to continue to develop CSG fields over the long-term. In other states, diversity in gas supply would increase their energy security.

243. Australian Government, *Domestic Gas Strategy*, 2015, p.2.

244. Australian Government Office of the Chief Economist, *Review of the socioeconomic impacts of coal seam gas in Queensland*, 2015, p.18.

One of the key differences between CSG and other mining activities is that CSG wells cohabit with other land uses such as agriculture. There is a strong need for sustainable co-existence between the gas industry, landholders and communities.²⁴⁵

The Australian Government's three principles for the development of CSG are:²⁴⁶

- Agricultural land should only be accessed with the farmer's agreement, and farmers should be fairly compensated.
- There must be no long-term damage to water resources used for agriculture and local communities.
- Prime agricultural land and quality water resources must not be compromised for future generations.

South Australia has announced that 10 per cent of royalties will be provided to landowners whose property overlies an unconventional gas field that is brought into production. In Queensland, landholder and resource companies must negotiate a legally binding Conduct and Compensation Agreement that outlines compensation for landowners for the effects and impacts of authorised activities.²⁴⁷ The Queensland Government has established a Land Access Ombudsman to deal with disputes between landholders and resource companies in relation to Conduct and Compensation Agreements.

The NSW Chief Scientist and Engineer's independent review into CSG activities in New South Wales found that CSG extraction and related technologies are mature and Australia is well equipped to manage their applications.²⁴⁸

The role of governments and industry is then to provide leadership and establish community trust while ensuring legitimate concerns are acknowledged and addressed. Listening to and responding to diverse community segments is absolutely necessary for any new industry wishing to operate successfully within communities.

The Panel considers that governments should avoid blanket restrictions and bans on gas projects and instead encourage the safe exploration and development of the industry. Evidence based regulatory regimes enable the risks of individual gas projects to be managed on a case-by-case basis. A number of submissions to the Review support this approach.

Recommendation 4.3

Governments should adopt evidence based regulatory regimes to manage the risk of individual gas projects on a case-by-case basis.

This should include an outline on how governments will adopt means to ensure that landholders receive fair compensation.

245. Australian Government Office of the Chief Economist, *Review of the socioeconomic impacts of coal seam gas in Queensland*, 2015, p.1.

246. Australian Government, *Domestic Gas Strategy*, 2015, p.2.

247. Queensland Government, *A guide to land access in Queensland*, 2016, p.16.

248. NSW Government Chief Scientist and Engineer, *Final Report of the Independent Review of Coal Seam Gas Activities in NSW*, 2014, p.9.

Improve access to transparent and informative gas industry performance data

Key concerns for communities relate to the potential impacts on aquifers and the use of chemicals as part of the hydraulic fracturing process. Concern has been expressed about information disclosure, the absence of baseline monitoring, inadequate testing of chemical additives, and the recovery and disposal of used hydraulic fracturing fluids.

Not all CSG wells require hydraulic fracturing. Generally, only wells that intersect lower permeability deeper coal seams require hydraulic fracturing. According to the Gas Industry Social and Environment Research Alliance around 20 to 40 per cent of CSG wells in Australia use this technique.²⁴⁹

It is worth noting that Australia has a robust environmental regulatory framework to manage the risks associated with these activities. The Australian Government protects water resources from the impacts of CSG development through the 'water trigger' provisions of the *Environment Protection and Biodiversity Conservation Act 1999*. This Commonwealth regulatory regime is designed to work in concert with state and territory governments, which have primary responsibility for water resources and regulating environmental impacts associated with the resource sector.

The water quality of CSG water varies greatly, though it is generally rich in salts and other minerals. Where properly managed and treated, which typically involves desalination through reverse osmosis,²⁵⁰ CSG water can be reused in a range of different ways including irrigation.²⁵¹

Concern has been expressed that the level of fugitive emissions (from infrastructure leaks and minor venting) associated with unconventional gas production has the potential to diminish the emissions reduction benefits of CSG utilisation for gas-fired generation. However, recent empirical research²⁵² into fugitive emissions of methane from Australian CSG fields, commissioned for the *National Inventory Report 2015*,²⁵³ do not support this concern. In 2013, the Australian Council of Learned Academies looked at international comparative life cycle emissions per MWh by fuel and found that gas emissions were generally significantly lower than coal emissions.²⁵⁴ Ongoing monitoring is required.

While most of the information on the management of risks associated with CSG extraction is available in some form, it is not easily accessible or in a format that can be readily understood. Industry performance data should be transparent, clear and convenient to access by the public.

Types of data that should be publicly available include seismic activity, fracking fluid composition, aquifer purity and fugitive emissions. For example, the University of Texas at Austin's TexNet research portfolio includes a seismic monitoring program²⁵⁵ to monitor impacts of the injection of fluids on underground geological formation. The data are made available on a public web site. In the United States, a not-for-profit publicly

249. GISERA, <https://gisera.org.au/more-information/frequently-asked-questions/how-is-coal-seam-gas-extracted/>, accessed 30 May 2017.

250. Reverse osmosis involves forcing the saline water under pressure against a semi-permeable membrane which allows water molecules to pass through, leaving larger molecules such as salt, behind for further processing.

251. GasFields Commission Queensland, *CSG Water Treatment and Beneficial use in Queensland*, Australia, 2014, p.5.

252. CSIRO prepared for the Department of the Environment and Energy, *Methane, Emissions from CSG Well Completion Activities Report*, 2017; CSIRO prepared for the Department of the Environment and Energy, *Field Measurements of Fugitive Emissions from Equipment and Well Casings in Australian Coal Seam Gas Production Facilities*, 2014.

253. Commonwealth of Australia, *Update on Recent Empirical Evidence on Fugitive Emissions From the Gas Industry*, 2017.

254. Cook, P, Beck, V, Brereton, D, Clark, R, Fisher, B, Kentish, S, Toomey, J and Williams, J prepared for the Australian Council of Learned Academies, *Engineering energy: unconventional gas production*, 2013, p.17.

255. The University of Texas, <http://www.beg.utexas.edu/texnet>, accessed 30 May 2017.

accessible website, FracFocus, provides information about the chemicals used in hydraulic fracturing fluids, which can be found for individual wells in the majority of jurisdictions.²⁵⁶

Robust information from a trusted source, such as an academic institution or not-for-profit organisation, would go some way to increasing transparency and improving community trust of gas exploration.

Recommendation 4.4

By mid-2019, the COAG Energy Council should bring together relevant regulatory and scientific data on gas in an informative and easily accessible format.

256. FracFocus Chemical Disclosure Registry, <http://fracfocus.org/>, accessed 30 May 2017.

Participants include BG Group, BHP Billiton Petroleum, ConocoPhillips Company, ExxonMobil Upstream Research Company, and Shell Oil Company affiliate.

Chapter 5

IMPROVED SYSTEM PLANNING

Overview

A more strategic approach is required for the coordination of generation and transmission investment in the NEM, and to ensure security and reliability are maintained – a view supported by current international practice.

This chapter examines how generation and transmission planning is currently undertaken in the NEM. The Panel concludes that there is a need for strengthened planning in the NEM to address these challenges, including:

- A long-term, integrated plan for the grid that establishes the optimal transmission network design to enable connection of renewable energy resources, including through inter-regional connections.
- Improved coordination of generation and transmission planning and investment.

The Panel also supports work underway to strengthen the Regulatory Investment Test for Transmission. This work would enable more equitable consideration of alternatives to transmission network investment.

5.1 Aligning networks with future generation needs

Transmission networks will need to be reconfigured to support large-scale variable renewable electricity (VRE) development in areas that are remote from the existing grid. Their role in providing a reliable and secure electricity supply is likely to grow over time.²⁵⁷ Increased transmission capacity in regions with high quality renewable energy resources, and interconnectors to allow efficient trade between regions, will support security and reliability. However, this must be balanced against the need to avoid making inefficient long-term investments that impose unnecessary costs on consumers, or crowd out technologies that provide alternatives to network infrastructure.

Structural reform of the electricity sector has made coordination between generators and transmission network service providers (TNSPs) difficult, as their interests do not necessarily align. Aligning the interests of generators and networks in a manner consistent with the long-term interests of consumers is particularly important in the context of the electricity transition and delivering a secure, reliable and affordable electricity supply.

The complexity in decision making should not be cause for inaction. A number of opportunities exist to strengthen the current planning process.

5.2 Network planning

Planning is essential for the effective development of electricity systems. A critical difference between the NEM and the state-based electricity systems of the past is that responsibility for planning and investment decision making is now distributed between market institutions, networks and market participants rather than centralised within vertically integrated, state-owned monopolies.

When planning was undertaken by vertically integrated, state-owned monopolies and the range of energy technologies was more limited, electricity suppliers were able to determine how much new generation capacity they required and optimise its location based on proximity to fuel resources and the cost of connection to the transmission network. The generation mix has changed significantly since the commencement of the NEM.

An overview of planning within the NEM is provided in Box 5.1.

257. AEMO, *National Transmission Network Development Plan*, 2016, p.3.

Box 5.1 – Overview of planning in the NEM

Transmission planning: AEMO provides forecasting information to assist network businesses and generators to make long-term investments in capital assets. This includes the National Transmission Network Development Plan (NTNDP), national electricity and gas forecasting reports, the Electricity and Gas Statements of Opportunities (ESOO and GSOO) and the Medium Term Projected Assessment of System Adequacy.

AEMO's planning role in Queensland, New South Wales, South Australia and Tasmania is restricted to providing information. In Victoria, AusNet Services owns the transmission network but AEMO provides transmission network services and is responsible for transmission system planning, including:

- Undertaking Regulatory Investment Test for Transmission (RIT-T). The RIT-T has a threshold of \$6 million.
- Procuring and providing transmission network services.
- Conducting competitive tenders for the provision of contestable shared transmission services.
- Setting prices for the use of the shared transmission system (transmission use of system charges).
- Working with the transmission system owner to negotiate with parties seeking to connect to the shared transmission system for shared transmission services.
- Directing non-contestable augmentations of the transmission system.

Transmission planning within each NEM region is generally undertaken by the local TNSP, with the exception of Victoria, where AEMO performs the planning role and procures augmentations on a contestable basis, despite not owning the network. Interconnector planning involves multiple TNSPs, thereby creating a coordination challenge. TNSPs are also responsible for connecting new generators and large loads to the network so they can participate in the market.

Distribution planning: Distribution network planning is undertaken by distribution network businesses in response to local area needs, asset management policies and state-based distribution reliability standards. Where distribution network augmentations are required, distribution businesses looking to have new investment included in their regulated asset base are required to undertake a Regulatory Investment Test for Distribution (RIT-D), which operates in a similar manner to the RIT-T. The RIT-D has a threshold of \$5 million.

Generation investment: The location of new generation assets within the network is determined by investors and based on a combination of resource location, access to land and water and proximity to transmission infrastructure, as well as market, commercial and financing considerations.

The purpose of planning should be to ensure the system delivers the quality of electricity services required by consumers now and into the future. The COAG Energy Council (the Energy Council), policymakers and the community must have confidence that the system is working well and that emerging issues, risks and opportunities are being identified and managed or capitalised on as appropriate.

Looking forward, the framework within which the NEM operates should enable institutions, networks, market participants and consumers to identify and manage the risks arising from the transition and to capitalise on the opportunities it creates. Planning, particularly for transmission lines, is needed to recognise and respond

to emerging trends, provide a clear direction for the system as a whole, remove uncertainty where possible, and test that the market provides signals that incentivise appropriate, timely and efficient investments and innovation.

A more strategic approach to transmission planning

The long-lived nature of investment in the electricity system means that investments made today will significantly shape the network of the future. Incremental planning and investment decision making based on the next marginal investment required is unlikely to produce the best outcomes for consumers or for the system as a whole over the long-term or support a smooth transition. Proactively planning key elements of the network now in order to create the flexibility to respond to changing technologies and preferences has the potential to reduce the cost of the system over the long-term.^{258,259}

Without a well-planned approach to navigate this transformation, Australia's energy system will be unable to efficiently and securely integrate the diverse technologies, large-scale renewable energy sources and customer owned distributed energy resources. This will potentially result in the costly duplication of energy investments.²⁶⁰

Energy Networks Australia and CSIRO

Stakeholders have identified a range of whole-of-system benefits that can be realised through greater strategic planning of transmission infrastructure including:

- Creating more options for reliability through the development of a diverse mix of large-scale generation capacity in a range of locations through the grid, including the development of new renewable energy zones.
- By enabling the connection of large-scale renewables and large-scale backup generation and storage, such as gas, grid-scale batteries and pumped hydro, the transmission system can be a critical enabler of significant emissions reductions.
- Ensuring the transmission system is able to contribute to the preservation of network security and stability, including through inter-regional provision of security services.
- Ensuring reactive power control, and in future by procuring necessary inertia and fast frequency response.
- Increasing affordability by ensuring consumers are able to access the benefits of a competitive wholesale market.^{261, 262, 263}

Planning frameworks need to be capable of facilitating the efficient development and connection of new renewable energy zones, some of which may be remote from the current transmission network. In order to maintain secure, reliable and affordable supply, these will need to be developed before significant amounts of older coal-fired generation begin to exit.

AEMO's current transmission planning provides limited guidance regarding prospective resource zones for solar, wind, or pumped hydro storage. TNSPs' annual planning reports generally only discuss the location of renewable energy resources in each region at a high level.

258. Garnaut, R, *Climate Change Review Update 2011*, 2011, p.33.

259. Pfeifenberger, J. and Chang, J., *Well-planned electric transmission saves customer costs: Improved transmission planning is the key to the transition to a carbon constrained future*, The Brattle Group, 2016, p.3.

260. Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Key Concepts Report*, 2016, p.i.

261. TransGrid submission to the Review, p.4.

262. ElectraNet submission to the Review, p.2.

263. Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Key Concepts Report*, December 2016, p.iii.

The Australian Renewable Energy Mapping Infrastructure (AREMI), which identifies and maps renewable energy resource zones across NEM regions, is a useful resource. The use of this information would enable improved consideration of new sources of supply in both generation and transmission planning processes.

AEMO, supported by TNSPs and other relevant stakeholders such as the renewable energy industry, should collaborate to determine the optimal transmission network design to enable the connection of renewable energy resources, including through inter-regional connections. They should develop an integrated grid plan for the NEM transmission network.

The integrated grid plan should:

- Identify and map prospective renewable energy zones across all NEM regions, including but not limited to wind, solar, pumped hydro, and geothermal resources.
- Identify transmission network routes to efficiently connect the renewable energy zones to the existing network, including routes for interconnectors that pass through these areas.
- Include a high-level assessment of the relative economics of different zones, taking into account the quality of the resource, approximate cost of connection, network impacts and other relevant considerations. This will enable the classification of zones according to how prospective they are and inform future decisions about the order in which to develop the transmission network.

The plan should be released as a publicly available resource to enable investors to make informed decisions about where to plan new renewable generation capacity. Although it may be many years until particular renewable energy zones are connected due to reasons of commercial attractiveness and economic efficiency, an integrated grid plan will send a clear signal to investors about the future of the transmission network. Augmentations in line with the integrated grid plan would be evaluated through the RIT-T process or its successor.

The plan should be reviewed on a regular basis to ensure that it remains current and reflects changing circumstances. It may be appropriate to update the plan annually at first and reduce the frequency of reviews in the future as greater certainty emerges.

The integrated grid plan would build on the AEMC's May 2017 connections and planning rule change designed to achieve a more coordinated and integrated approach to transmission planning. The AEMC rule change requires TNSPs to include additional information in their annual planning reports and undertake joint planning on investments in other transmission networks to deliver market and reliability benefits in their own network. It also requires the AER to develop a guideline to support consistency across transmission annual planning reports.²⁶⁴

Recommendation 5.1

By mid-2018, the Australian Energy Market Operator, supported by transmission network service providers and relevant stakeholders, should develop an integrated grid plan to facilitate the efficient development and connection of renewable energy zones across the National Electricity Market.

264. AEMC, *Transmission Connection and Planning Arrangements – Final determination*, 2017.

Coordination of renewable generation and transmission investment

The location of the best renewable energy resources will be a critical part of the transmission planning process because of their remoteness from the existing network. Significant investment may be required to enable the connection of large-scale renewable energy generation in areas that are not currently well serviced by the transmission network.

This issue has already emerged internationally where jurisdictions have made a strategic policy choice to facilitate large-scale renewable energy generation, including Germany, the United Kingdom and Texas, USA (Box 5.2).

Box 5.2 – Coordinating renewable generation and transmission network planning – lessons from overseas

Germany: In 2009, Germany passed the *Grid Expansion Acceleration Act* to encourage the optimal development of transmission infrastructure to support the transition to a clean energy supply. Recognising that renewable energy resources are typically remote from the existing grid, the legislation establishes a process that determines where and when to expand the transmission network to facilitate high levels of renewable energy penetration.²⁶⁵

United Kingdom: The UK has established a mechanism known as *Transmission Investment for Renewable Generation* to fund projects to connect renewable energy generation. It operates outside the primary price control process and includes expenditure allowances to reinforce the network to support renewable energy projects.²⁶⁶ The UK also has a Transmission Investment Incentives scheme, which provides a mechanism for funding transmission investment projects that may be required to accommodate future generation and demand patterns associated with meeting the Government's low carbon and renewable energy targets.²⁶⁷

Texas, USA: In 2005, the Texas Legislature passed a directive to establish Competitive Renewable Energy Zones. The Texas Public Utilities Commission instructed the Electric Reliability Council of Texas (ERCOT) to identify areas with potential wind capacity and build the associated transmission infrastructure to allow the area to be developed.²⁶⁸ The costs of the development were passed through to consumers.²⁶⁹

Within the NEM, different generation and transmission planning processes create a number of coordination challenges with respect to the location of new large-scale renewable generation and transmission infrastructure. Generators have limited incentive to take on the risk of investing in areas with high quality renewable energy resources, unless they are close to the existing transmission network.

265. Bundesnetzagentur, *Grid Expansion in Germany: What you need to know*, 2014.

266. OFGEM, <https://www.ofgem.gov.uk/electricity/transmission-networks/critical-investments/transmission-investment-renewable-generation>, accessed 8 May 2017.

267. OFGEM, <https://www.ofgem.gov.uk/electricity/transmission-networks/critical-investments/transmission-investment-incentives>, accessed 8 May 2017.

268. US Department of Energy, https://energy.gov/sites/prod/files/2014/08/f18/c_lasher_qer_santafe_presentation.pdf, accessed 3 June 2017.

269. Clark, J. 2013, <https://gwujeeel.files.wordpress.com/2013/07/miso-ercot-cost-allocation-methods.pdf>, accessed 3 June 2017.

Generators need to trade off the benefits that are likely to accrue from locating near a quality resource against the cost of connecting to the transmission network.²⁷⁰ The further removed the resource is from the network, the less likely it is that a generator will seek to exploit it.

In the event that a resource that is remote from the existing network is of sufficient quality that a generator is prepared to pay the cost of connection, they have an incentive to build the minimum capacity necessary to support their needs. That is, generators are unlikely to pay for the construction of a transmission line that is of sufficient scale to enable other generators to connect in the same area. If other generators subsequently move into the same area, there is a risk that the network would become congested and would need to be upgraded or duplicated. This would come at a significantly higher cost than if the network had been built to an appropriate scale in the first place.

TNSPs have an incentive to extend the network into new areas because the size of their asset base is a key driver of their returns. The regulatory framework is designed to ensure they are only able to earn a regulated return on efficient investments. A TNSP could extend the transmission network in order to facilitate new generation investment but would be unlikely to do so unless it was able to include it in its regulated asset base. Given the cost involved and the risk that the anticipated generation investment might not materialise, it is unlikely such an investment would pass a RIT-T. As such, it would only be built if a TNSP was prepared to carry the risk of the investment.

The AEMC previously investigated the regulatory framework for the connection of large-scale renewable energy assets in its *Scale Efficient Network Extensions* rule change process. The AEMC found that there is a trade-off between building transmission capacity in anticipation of future generation, and the risk that these investments might not materialise. This would result in stranded assets, which consumers would still be required to pay for. The AEMC concluded that decisions of this nature should be made by market participants who have the information, ability and incentive to manage the asset stranding risk.

Consistent with this position, the AEMC made a rule commencing from 1 July 2011 that required TNSPs to undertake, on request, specific locational studies to reveal to the market potential opportunities for efficiency gains from the coordinated connection of expected new generators in a particular area.²⁷¹ The AEMC identified that the key advantage of the rule was that it provided a framework to capitalise on scale efficiencies without forcing anyone to carry the risk and cost of stranded assets.²⁷² To date, this rule has not been used to develop a scale efficient network extension.

The AEMC, as part of its Transmission Frameworks Review, proposed the Optimal Firm Access model as a potential solution to the problem of coordinating generation and transmission investment. In 2015, the AEMC concluded that although Optional Firm Access may be beneficial in future, its costs outweighed its benefits at that time.²⁷³

In lieu of Optional Firm Access, in February 2016, the Energy Council commissioned the AEMC to undertake a *Review of the drivers of change impacting transmission networks* and report on a biennial basis. The AEMC will examine the issues that could affect future transmission and generation investment and, if necessary, assess whether change to the transmission regulatory framework to increase commercial drivers of transmission and generation development is warranted to meet the National Electricity Objective. The first review is currently underway. Key drivers of change under consideration include government policies, regulations and international agreements, and technological developments and new business models.²⁷⁴

270. AEMC, *Draft Stage 1 report – Reporting on the drivers of change that impact transmission frameworks*, 2017, p.8.

271. AEMC, *National Electricity Amendment (Scale Efficient Network Extensions) Rule 2011*, 2011, p.1.

272. AEMC, *National Electricity Amendment (Scale Efficient Network Extensions) Rule 2011*, 2011, p.i.

273. AEMC, *Optional Firm Access, Design and Testing, Final Report Volume 1*, 2015, p.i.

274. AEMC, *Draft Stage 1 Report: Reporting on drivers of change that impact transmission frameworks*, 2017, pp.i-5.

A way forward

The Panel considers that there may be a future role for governments in facilitating considered and targeted investments in network infrastructure to enable the efficient development of renewable energy resources. This would be necessary if it becomes clear that it is not possible to resolve the coordination problem between generators and TNSPs under the current regulatory framework. It would likely require governments to make decisions on particular transmission investments.

To this end, AEMO, in consultation with TNSPs, should develop a list of potential projects, consistent with the proposed integrated grid plan. Projects would need to be defined in reasonable detail, including approximate costs of network augmentations to enable their development. The list would need to be updated regularly to ensure it enables governments to make the best decisions.

The AEMC should develop a rigorous framework to enable the evaluation of these projects, including guidance for governments regarding the circumstances that would warrant government intervention to facilitate specific transmission investments. This should minimise the risk of consumers bearing the cost of unnecessary transmission infrastructure.

Recommendation 5.2

By mid-2019, the Australian Energy Market Operator, in consultation with transmission network service providers and consistent with the integrated grid plan, should develop a list of potential priority projects in each region that governments could support if the market is unable to deliver the investment required to enable the development of renewable energy zones.

The Australian Energy Market Commission should develop a rigorous framework to evaluate the priority projects, including guidance for governments on the combination of circumstances that would warrant a government intervention to facilitate specific transmission investments.

Coordination of transmission planning between regions

TNSPs have identified a need for greater coordination of planning for interconnectors between NEM regions. Interconnectors play a vital role in the NEM by allowing the transfer of electricity and system security services between regions. They also have the potential to enable efficient investment in renewable generation across the NEM.²⁷⁵ TNSPs are concerned about regional inconsistencies in transmission planning, particularly between Victoria and other regions. They are also concerned that TNSPs in adjacent regions have different interests that may result in investment decisions that are not in the best interests of the system as a whole.²⁷⁶

AEMO currently undertakes a range of national transmission planning activities in its role as the National Transmission Planner, but does not have the power to ensure that investments are undertaken that meet the needs of the whole system.²⁷⁷ The AEMC has a last-resort planning power to ensure timely and efficient inter-regional transmission investment if other mechanisms to incentivise the planning of this investment fail.²⁷⁸ The AEMC may require network businesses to apply the RIT-T to augmentation projects that are likely to relieve a forecast constraint on a national transmission flow path, or to potential transmission projects identified by

275. Tamblyn, J., *Feasibility of a second Tasmanian interconnector*, 2017, p.v.

276. AusNet Services Submission to the Review, p.8; Energy Networks Australia supplementary submission to the Review, p. 12.

277. AusNet Services submission to the Review, p.8.

278. AEMC, <http://www.aemc.gov.au/Markets-Reviews-Advice/Last-resort-planning-power-2016-review#>, accessed 10 April 2017.

the AEMC. At present, the last resort planning power rests with the AEMC rather than AEMO because AEMO's transmission decision making role in Victoria creates a conflict of interest.

Energy Networks Australia (ENA) has proposed two possible solutions to the coordination of national transmission planning based on the options identified through the AEMC's Transmission Frameworks Review.

- Extending AEMO's current role as the National Transmission Planner to include determining whether an interconnector investment is needed. It would do this by conducting an independent evaluation of the RIT-T carried out by the project proponent – one of the regional TNSPs. If AEMO determined that an interconnector was required it would direct the relevant TNSP to build it. Responsibility for procurement would remain with the project proponent.
- Modifying the current model to require that AEMO, as the National Transmission Planner, and TNSPs agree on issues of national significance for the transmission network. AEMO would endorse the TNSPs' Transmission Annual Planning Reports and the TNSPs would endorse AEMO's National Transmission Network Development Plan. Where agreement could not be reached, AEMO and TNSPs would publish a statement outlining areas of disagreement and the reasons for their position. The AER would decide whether to provide allowance for revenue for these investments as part of TNSPs' revenue determinations.

The options proposed offer the potential for greater coordination without significant changes to the current role of TNSPs in most regions. They also contemplate a greater role for AEMO in planning and decision making processes, which may provide greater confidence to the AER about the efficiency of proposed interconnector investments.

ENA argues that for either option to work, responsibility for transmission planning would need to be made nationally consistent. This would require that in addition to giving AEMO a greater national planning role, conflicts with its role in Victoria would have to be resolved.²⁷⁹

- AEMO's role as the provider of transmission network services in Victoria would need to be transferred to AusNet Services.
- Regulatory oversight of AusNet Services regarding transmission augmentation would need to be made consistent with that in other regions.
- The composition of AEMO's board would need to change to address the potential conflict of interest that arises because generators and retailers appoint AEMO's directors, who then take national transmission planning decisions with investment consequences.

ENA's argument that reform of AEMO's role in Victoria would be required to make these options work is consistent with the AEMC's findings on this issue.²⁸⁰

AEMO proposed an alternative approach for increasing coordination. AEMO's proposal involves extending its role as the National Transmission Planner to include responsibility for transmission planning within all jurisdictions, as it currently does in Victoria. This would provide a consistent national approach and clear accountability for national transmission planning. It would enable a single body with no direct financial interest to determine the best combination of inter-regional, intra-regional transmission and non-network solutions to meet the needs of the system as a whole. It would also remove incentives for over-investment.

This approach has been examined many times before but has not been acted upon. This is due to questions about whether not-for-profit planning undermines incentive-based economic regulation.²⁸¹ The AEMC, in its Transmission Frameworks Review, did not support this approach. It concluded that it would not enhance

279. Energy Networks Australia supplementary submission to the Review, p.12-13.

280. AEMC, *Transmission Frameworks Review: Second Interim Report*, 15 August 2012, p.vi.

281. AEMO submission to the Review, p.32.

efficiency due to the lack of financial incentive on AEMO and the separation of operational and investment decisions.²⁸²

Successful implementation of either ENA's or AEMO's models would require one or more states to fundamentally change the way they allocate responsibilities for transmission planning. Adopting either of the approaches proposed by ENA would require transmission planning in Victoria to be brought into line with other jurisdictions. Adopting AEMO's proposal would require the role of TNSPs to be redefined in all other regions. This is a significant barrier to progress.

As the transition unfolds, it is likely that AEMO's role in transmission planning will need to increase in order to ensure that the development of the transmission network is consistent with the needs of the NEM as a whole. The proposed integrated grid plan and potential 'priority projects', which could include interconnectors, are a step in this direction and provide for greater cooperation between AEMO and regional TNSPs on transmission planning issues.

In future, there may be merit in the creation of a single, national transmission planner with a whole-of-system focus. AEMO would be the logical choice to fulfil this role. Governments would need to reach a resolution on an acceptable approach in order for this to occur.

The Panel believes governments should give further consideration to whether AEMO should play a greater role in the transmission planning and decision making process, including how this could be done in the context of its Victorian role. However, recommending a stronger, mandatory role for AEMO in inter-regional or intra-regional transmission planning, beyond the integrated grid plan and future priority projects, will require further careful consideration. This would need to occur as part of a separate piece of work to this report.

Recommendation 5.3

The COAG Energy Council, in consultation with the Energy Security Board, should review ways in which the Australian Energy Market Operator's role in national transmission planning can be enhanced.

5.3 Network regulation

In designing the NEM, governments sought to capture the benefits of competition. The NEM's wholesale and financial markets are designed to provide incentives for efficient investment in electricity generation. In contrast, and in recognition of their natural monopoly characteristics, electricity transmission and distribution networks are planned and their revenues regulated to incentivise network businesses to make investments that support efficient, secure and reliable electricity supply, while preventing over-investment and excessive prices.²⁸³

Network incentives

Electricity networks are natural monopolies. Even with advances in technology, it is unlikely to be economically efficient for a competitor to duplicate the assets needed to provide the service. This means that economic regulation is needed so that network service providers do not use their market power to earn excess profits, reduce reliability or refuse to serve some consumers.

282. AEMC, *Transmission Frameworks Review, Second Interim Report*, 2012, p.79.

283. Based on network reliability standards determined by states and territories.

Economic regulation in the NEM works by allowing network service providers to recover the efficient costs of delivering network services in a manner that meets all of their regulatory obligations, for example reliability standards. Network service providers develop proposals regarding the level of expenditure required to meet these obligations and the resulting level of revenue that needs to be recovered from consumers through network tariffs. These proposals are reviewed by the AER, which can approve the revenue proposals or substitute its own assessment of the efficient level of revenues.

Once the regulated revenue is set, there are incentives for network service providers to limit their spending within each regulatory period (generally five years). If a network service provider spends less than the amount that the AER determined to be an efficient estimate of capital expenditure (capex) or operating expenditure (opex), it retains some of the savings and passes the remainder on to consumers through reduced network charges in the next regulatory period.²⁸⁴ Provided it is at or below the level approved by the AER, capex is rolled into the regulatory asset base at the start of the next regulatory period, and the network service provider earns revenue on that asset base over the economic life of the assets based on a regulated rate of return.

There has been significant debate about whether the current network regulatory regime is effective in incentivising efficient investment given the scale of network expenditure in recent years. A package of reforms to the network regulatory framework were made in 2013 to address these concerns.

Reducing incentives for network over-investment

The potential cost impact of network investment is a critical consideration for the development of a future NEM, particularly given that significant investments are likely to be required to connect new renewable energy resources to the grid. Keeping investment to efficient levels is particularly important in light of widespread community and stakeholder concern about the scale of recent network investments. Many stakeholders question the efficiency of recent network investments and suspect that there has been a significant degree of over-investment. They are particularly concerned about the impact these investments have had on costs for consumers.

Limited Merits Review

Network businesses and affected consumers can use a process known as the Limited Merits Review to seek review by the Australian Competition Tribunal of AER revenue and other determinations. The grounds for review are that the determination involved an error of fact, an incorrect exercise of discretion, or an unreasonable decision having regard to all the circumstances. The Tribunal can choose to reject an application, substitute the AER's decision with its own determination, or remit the decision to the AER for new determination.²⁸⁵ Most of the AER's decisions have been appealed.

Concerns about the effectiveness of the Limited Merits Review process led the Energy Council, in 2013, to implement a range of reforms to improve the operation of the regime so it focused on outcomes in the long-term interests of consumers.²⁸⁶ Despite these reforms, the scale of the revenues at stake mean that network businesses still have a strong incentive to challenge the AER's determinations.

In 2016, NSW and ACT distribution networks successfully appealed the AER's revenue determinations in the Australian Competition Tribunal. The AER appealed to the Full Federal Court against the Tribunal's decision. In May 2017, the full court upheld most aspects of the Tribunal's decision.

284. The Capital Expenditure Sharing Scheme and Efficiency Benefit Sharing Scheme mean that networks retain around 30 per cent of any underspend, and customers receive 70 per cent of the benefit. Networks are penalised similar amounts for any overspends.

285. COAG Energy Council, *Review of the Limited Merits Review Regime: Consultation Paper*, 2016, p.4.

286. Standing Council on Energy and Resources, *Energy Market Reform Bulletin*, 2013.

The Energy Council, in 2016, reviewed the Limited Merits Review regime to assess its effectiveness and considered a range of reforms, including the option of abolishing it altogether. The Energy Council was unable to reach a consensus on the need to abolish the regime but agreed, in principle, to further reforms, including:²⁸⁷

- Tightening and clarifying the grounds for review.
- Higher financial thresholds for leave, which apply to individual grounds for review.
- Reviews to be conducted on the papers, rather than through expensive and adversarial oral hearings.
- Reviews to be conducted within a strict timeframe.
- A strengthened requirement for review appellants to demonstrate that overturning the regulator's decision would not be to the serious detriment of the long-term interests of consumers.
- More flexible arrangements for consumer participation in reviews.
- Introduction of a binding rate-of-return guideline, with relevant elements of the regulator's decision not subject to merits review.
- Removing opportunities for gaming by limiting the timeframes in which material can be submitted to the AER.
- Costs of reviews, including those of the AER, to be borne by network businesses.

At the time of writing, work to develop the detail of the reform package is ongoing and subject to final agreement by ministers.

Detailed analysis of the Limited Merits Review regime and the case for its reform or abolition is beyond the scope of this Review. However, the Panel notes that the proposed reform package would deliver a range of benefits, including a clearer focus on whether the AER has made errors rather than differences of professional opinion and better decisions in the long-term interests of consumers.

The Panel considers that the proposed package of reforms should be finalised and implemented as soon as practicable in order to deliver better outcomes for consumers.

Recommendation 5.4

By end-2017, the COAG Energy Council should finalise and implement the proposed reforms to the Limited Merits Review regime.

More equitable consideration of alternatives to network investment

New technologies and business models, including those deployed within the distribution network, are changing the nature of transmission and distribution investment. As the range of technologies offering alternative solutions to network investment grows and matures, transmission and distribution infrastructure is less likely to be replaced on a like-for-like basis given the growing range of alternatives to network investment available. Where there is a high degree of uncertainty, the efficient investment choice may be a short-term solution that addresses near-term risks without locking in longer term costs. This may allow options to be kept open until long-term investment decisions can be made with greater certainty.

287. COAG Energy Council 2016, *Meeting Communique: 14 December 2016*, 2016.

The AEMC has released a draft rule change to increase the transparency of network investment decisions and ensure that all capital investments, including replacements, are treated consistently. Specifically, the draft rule change:

- Specifies that information on all planned asset retirements in distribution and transmission networks, including the reasons for the retirements, is to be included in the distribution and transmission annual planning reports.
- Specifies that information on planned de-ratings that result in a constraint on a network, including the reasons for these, is to be included in the annual planning reports.
- Requires TNSPs to report consistently on transmission network needs and the options for addressing them, irrespective of whether they are identified in the context of network replacements or augmentations.
- Extends the RIT-T and RIT-D processes to network replacement expenditure decisions.
- Requires asset management reporting to be included in the transmission annual planning reports.
- Clarifies that the RIT-T is to be retaken where there is a material change in circumstances.
- Specifies that distribution annual planning reports will need to include information on investments in information technology and communications systems related to the management of network assets.²⁸⁸

If implemented, the rule change should assist with the identification of efficient alternative solutions to network investments, and will also improve coordination of generation and transmission investment by improving information sharing.²⁸⁹

Strengthening the Regulatory Investment Test for Transmission

The RIT-T aims to identify the option that best addresses the needs of the network and maximises economic benefits with respect to generation, transmission, distribution and consumption of electricity. Its purpose is to achieve the National Electricity Objective by ensuring that transmission networks are only able to earn a regulated rate of return from consumers on efficient investments, thereby minimising the risk of consumers paying for unnecessary investments.

The RIT-T is intended to be a transparent and consultative planning process that allows for the objective evaluation of transmission investments against credible network and non-network alternatives. Interested parties are able to propose alternative solutions and have them evaluated, notionally on an equal footing. The RIT-T identifies several classes of market benefits that can be considered but allows for the inclusion of additional benefits if approved by the AER. It models expected future outcomes under a range of scenarios.

The RIT-T is self-administered by each TNSP as the central planner for their part of the network. The AER's role is limited to ensuring the legislative requirements for the RIT-T are adhered to and resolving disputes between interested parties. It can also be asked to decide whether a preferred option satisfies the RIT-T.²⁹⁰ The AER has not had to resolve a dispute to date.²⁹¹ The AEMC has reported that the number of RIT-Ts being undertaken is growing as TNSPs grapple with changing patterns of generation investment.²⁹²

288. AEMC, <http://www.aemc.gov.au/getattachment/046018e3-a446-4f5b-86f0-67afb90c48e/Information-sheet.aspx>, accessed 28 April 2017.

289. AEMC, *Draft Stage 1 Report: Reporting on drivers of change that impact transmission frameworks*, 2017, p.51.

290. COAG Energy Council, *Review of the Regulatory Investment Test for Transmission*, 2017, pp.9-11.

291. COAG Energy Council, *Review of the Regulatory Investment Test for Transmission*, 2017, p.14.

292. AEMC, *Draft Stage 1 Report: Reporting on drivers of change that impact transmission frameworks*, 2017, p.11.

Some stakeholders have raised concerns about transmission planning through the RIT-T.

Key concerns raised by TNSPs centre on the fact that it does not capture all the benefits of transmission, notably:

- It does not capture the consumer benefits from increased competition, such as when low cost electricity is made available to consumers in a region with a scarcity of generation.
- It does not capture the environmental benefits of transmission, such as its capacity to enable increased renewable energy generation and lower emissions.
- It does not capture broader economic benefits beyond the NEM.²⁹³

The key concern raised by non-TNSPs was that self-administration of the test by TNSPs enables them to use the RIT-T process to favour network investments over non-network solutions.

The Energy Council's review of the RIT-T was published in February 2017. The review assessed whether the RIT-T remains fit for purpose in the current electricity market. It considered the appropriateness, effectiveness and efficiency of the test, with a focus on the balance between timeliness and rigour; its ability to capture the full costs and benefits of transmission projects; whether it is appropriate to facilitate strategic interconnection investment decisions; and the effectiveness of the current governance arrangements surrounding the test.²⁹⁴

The RIT-T review found that the current framework allows TNSPs to consider competition but, consistent with the National Electricity Objective, is confined to looking at costs and benefits that occur within the electricity sector only. It found that environmental and other non-market benefits can also be considered.²⁹⁵ The review also found that providers of non-network solutions faced barriers to participation in the RIT-T process, including a lack of information and engagement by TNSPs.²⁹⁶

Ultimately, the Energy Council review found that the RIT-T remains an appropriate mechanism to ensure that transmission augmentations are in consumers' long-term interests but recommended a number of refinements to improve its operation in light of the transition, including:

- Reviewing the RIT-T application guidelines to better reflect the net system benefits of option values created by transmission projects, including with respect to maintaining system security, and achieving renewable energy and emissions reduction goals.
- Ensuring that non-TNSPs are involved in the RIT-T process and transmission annual planning reports.
- Exploring the merits of increasing the AER's oversight of the RIT-T process to address concerns about:
 - Network businesses' incentives to select projects that increase their regulated asset base ahead of non-network options.
 - The current rules that allow the capital costs of projects to be incorporated in a network's regulated asset base, thereby contributing to their regulated rate of return, regardless of outcomes of a RIT-T assessment.

The changes to the RIT-T process are designed to address the issues raised by stakeholders in their input to that review. As such, the reforms proposed by the Energy Council should be given an opportunity to work before further changes are made. However, the RIT-T should be subject to further review within three years to ensure the reforms have been effective and are delivering appropriate outcomes.

293. Transgrid submission, p.14; Spark Infrastructure submission, p.12.

294. COAG Energy Council, *Review of the Regulatory Investment Test for Transmission – Final Report*, 2017, p.4.

295. COAG Energy Council, *Review of the Regulatory Investment Test for Transmission – Final Report*, 2017, p.33-34.

296. COAG Energy Council, *Review of the Regulatory Investment Test for Transmission – Final Report*, 2017, p.23.

Distribution network regulation

The energy transition will also affect the distribution networks that transport electricity from connection points on the transmission network to consumers throughout urban and regional areas. Like transmission networks, there has been significant investment in distribution infrastructure in recent years. Much of this was undertaken on the basis of inaccurate demand forecasts, and the cost of these investments are flowing through to consumers. The combined value of distribution network assets is \$68 billion. This is more than three times the value of transmission networks.²⁹⁷

The role of distribution networks are changing. Significant amounts of VRE generation is being connected within distribution networks. Rather than being a vehicle for the one way delivery of electricity from generators to consumers, they are becoming platforms for trading in a range of electricity services. This is discussed further in Chapter 6. In this context, it will be important to ensure that the RIT-D remains fit for purpose and is effective in identifying the most appropriate investment to meet the needs of the network. The RIT-D commenced in 2014. It has not been in place for long enough to warrant review at this stage. It would be appropriate to review it in three years' time, in parallel with the review of the RIT-T.

Recommendation 5.5

By mid-2020, the COAG Energy Council should commission a further review of the Regulatory Investment Test for Transmission to ensure the suite of reforms implemented following the 2017 COAG Energy Council review have been effective in addressing stakeholder concerns.

A review of the Regulatory Investment Test for Distribution should be conducted at the same time.

5.4 Improved demand forecasting

Demand forecasting is likely to become more important and more difficult as the network transforms. It will be particularly important for efficient and timely investment in 'lumpy' infrastructure assets, such as new generation or network infrastructure.

Under-estimation of demand may contribute to under-investment, possibly resulting in security and reliability issues, while over-estimation of demand may contribute to inefficient and wasteful over-investment that drives up costs for consumers. The Panel has heard that recent investments in network assets were informed by inaccurate forecasts, which contributed to the networks being overbuilt, with consequent impacts on electricity bills.

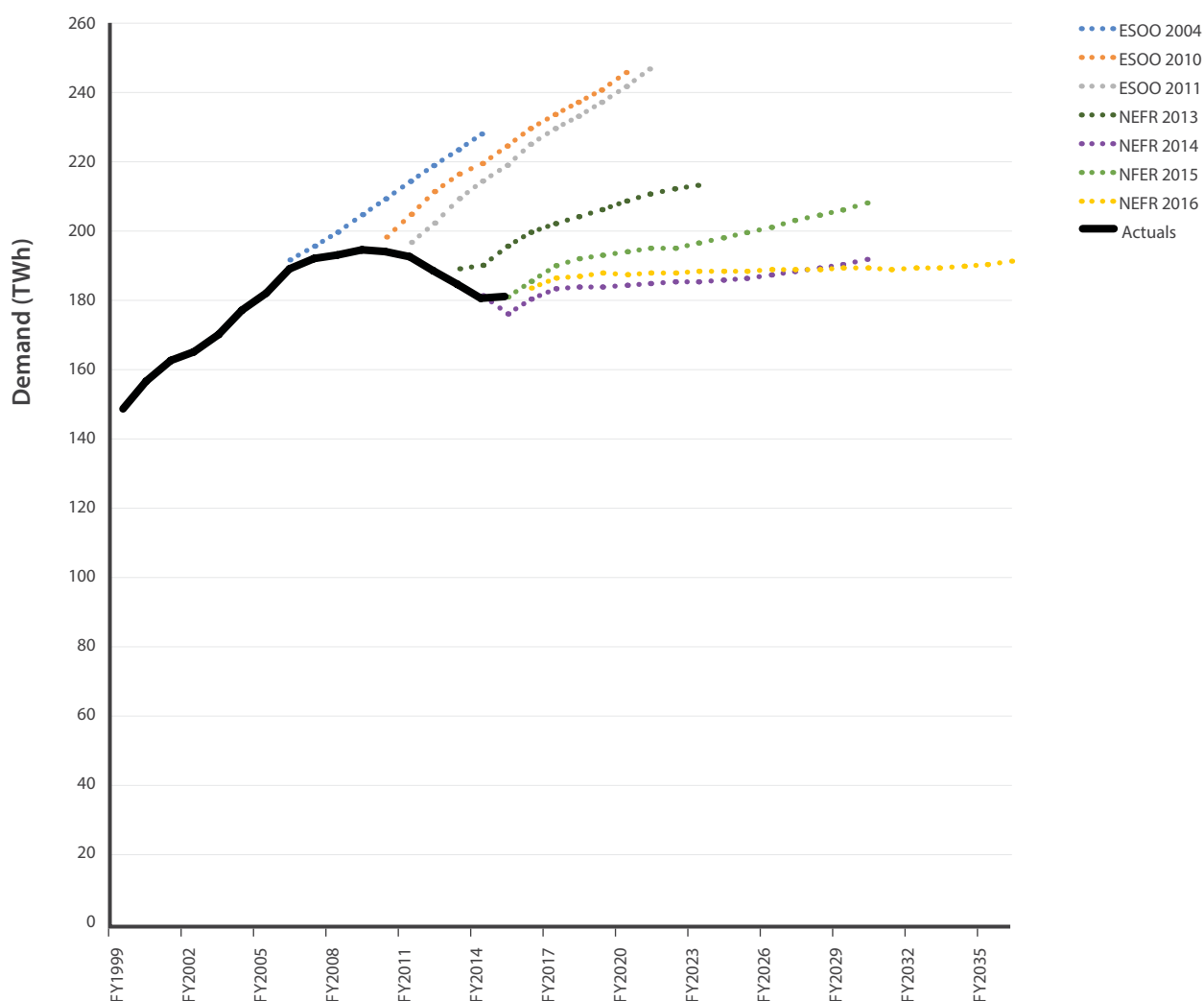
Credible demand forecasts are essential to the operation of the NEM. Demand forecasts underpin all planning and investment decisions. Better informed demand forecasts reduce the likelihood of incorrect or inadequate responses to emerging risks and opportunities. Large demand forecasting errors have contributed to a number of problems in the NEM.

From the commencement of the NEM until the late 2000s, electricity demand increased with population and economic growth. From the late 2000s, demand moderated and then declined. Electricity forecasters did not anticipate the structural shift in electricity demand that would occur as a result of increased penetration of rooftop solar photovoltaic, changing industrial consumption, consumers' responses to rising electricity prices, energy efficiency initiatives, and changes in the economic environment.²⁹⁸ Further, it took several years to recognise that the changes in actual demand were part of a structural shift. This is demonstrated in Figure 5.1.

297. AER, *State of the Energy Market*, 2017, p.98.

298. AEMO, *National Electricity Forecasting Report*, 2012, p.iii.

Figure 5.1: Forecast and actual electricity demand



AEMO has established a work program to improve the accuracy of its long-term demand forecasts, including moving from ‘top-down’ to ‘bottom-up’ models with finer resolution within regions, increasing stakeholder engagement, increased use of meter data, and increasing transparency of data, models and advice.²⁹⁹ AEMO is currently establishing a new performance assessment framework for its forecasts.³⁰⁰ The Panel supports this initiative to drive continuing improvements over time.

Collaboration with the CSIRO as it develops its Energy Use Data Model (EUDM) is likely to further strengthen AEMO’s modelling capabilities. The EUDM will provide detailed information about changing electricity consumption patterns, including peak loads and daily load shapes, and demographic, technological, and environmental factors interact to shape behaviour.

299. AEMO, *NEFR Delivery plan and proposed improvements*, 2016, pp.7-8.

300. AEMO, *Forecast accuracy report 2016*, 2016, p.12.

5.5 Dealing with the financial risk of stranded assets

As the NEM evolves, there is a risk that existing network assets will no longer be required or will not be required to the same degree, due to the closure of existing generators or consumers.

This possibility raises the question of how stranded assets should be handled. Some stakeholders have called for the value of network assets to be written down, either voluntarily or compulsorily, where there has been over-investment in capacity to meet peak demand or major structural changes to the load.^{301, 302} Network service providers are opposed to compulsory write-downs.³⁰³

Voluntary write-downs of asset values would have the effect of lowering prices for consumers, and reducing the size of the regulated asset base without increasing the risk profile of the investment. Compulsory write-downs are problematic. Writing down the asset values would increase creditors' perceptions of risk, resulting in a higher Weighted Average Cost of Capital for future projects or refinancing, leading to potentially higher costs for consumers over all. The issue of historical network over-investment is beyond the scope of this Review, and it is not possible to examine this issue in detail. However, given that there is a reasonable likelihood that some assets will be stranded in the future, there is merit in a future examination of the most appropriate method for handling this issue in the long-term interests of consumers.

301. Hugh Grant submission to the Review, p.5.

302. Carbon Markets and Energy, *Privatisation and the regulatory valuation of electricity distribution network service providers in New South Wales: A report for the Public Interest Advocacy Centre*, 2014, p.3.

303. Crawford. G., 2014, *Written-Down Value: Assessing proposals for electricity network write-downs*, Energy Networks Association, 2014, p.3.

Chapter 6

REWARDING CONSUMERS

Overview

The uptake of new technologies is putting residential, commercial and industrial consumers at the centre of the electricity market. Distributed energy resources, such as rooftop solar photovoltaic and battery storage systems installed at commercial and residential premises, energy efficiency improvements, and demand response by consumers can all be harnessed to improve the reliability and security of the electricity system. Consumers of all sizes should be rewarded for taking those actions, which will benefit them individually and also help reduce overall system costs, leading to savings for all consumers.

Achieving this outcome requires action. The retail electricity market must operate effectively and serve consumers' interests. Improved access to data is needed to assist consumers, service providers, system operators and policy makers. Increased use of demand response and changes to the role of networks and how they are incentivised are required to unlock these benefits. Governments also need to take steps to ensure that all consumers, including low income consumers, are able to share in the benefits of new technologies and improved energy efficiency.

6.1 Consumers are at the centre of the NEM

Australians are keen adopters of new energy technologies. The uptake of new technologies and new, often digitally enabled, ways of providing services to consumers is an integral part of the transformation of the NEM.

An increasing proportion of investment in new generation assets comes from individual consumers. In the NEM, consumers have installed more than 1.44 million rooftop solar photovoltaic systems.³⁰⁴ AEMO forecasts that by 2036 the annual electricity generation from rooftop photovoltaic solar will increase by 350 per cent from current levels.³⁰⁵

Battery storage is poised to be the next major consumer-driven deployment of energy technology. Upfront costs for solar photovoltaic systems with storage are currently high, with long payback periods for most consumers. Bloomberg expects the average payback period for residential consumers to fall below 10 years in the early 2020s, with around 100,000 battery storage systems to support rooftop solar photovoltaic generation predicted to be installed by 2020.³⁰⁶

Innovative companies are starting to develop and market home energy management systems that coordinate and automate a consumer's appliances, generation and storage equipment. Energy efficiency improvements, particularly in homes with modern appliances and building technologies, can reduce peak demand.

For larger consumers, building energy management systems able to respond to outside control signals are becoming more common. Given appropriate incentives and market opportunities, voluntary load reductions by commercial and industrial users could serve as an alternative to involuntary load shedding to address supply shortages.

304. Clean Energy Regulatory, <http://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations>, accessed 1 June 2017.

305. AEMO, *National Electricity Forecasting Report*, 2016, p.3.

306. Bloomberg New Energy Finance, *Australia behind-the-meter PV and storage forecast, 2017*, Research note for subscribers.

Consumers currently benefit directly from installing these technologies through avoiding the wholesale cost of energy, transmission and distribution costs, but residential and small business consumers are not currently rewarded for their contribution to reducing peak demand.

A vision for consumers in an active demand-side of the market would be one where:

- Consumers across the spectrum share in the benefits associated with new technologies.
- Consumers have the information they need, in a manner they can understand, so that they can make informed decisions about their electricity use and investment in equipment.
- In the short-term, distributed energy resources (DER) are coordinated to provide real-time services including energy, ancillary services and network support.
- In the medium-term, improved price signals show the value of services across the supply chain and new technologies and consumer tools supporting demand-side solutions and consumer choice achieve mass scale.
- In the long-term, improvements in energy efficiency reduce electricity demand and generation capacity, reducing costs for consumers.

Missing these opportunities risks over-investment in new large-scale generators and network assets, leading to higher costs. This particularly affects consumers who are not able to invest in their own alternatives to grid-supplied electricity or energy efficiency. Higher costs of electricity from the grid could see more and more consumers having little or no need for grid-supplied energy, concentrating the burden of the cost of the grid on a much smaller group of remaining consumers.

Despite this environment of change, consumers still expect electricity to be safe, reliable and affordable. The current regulatory arrangements for the NEM are unlikely to be able to meet those expectations without reforms.

The impacts of new technologies also mean that the energy market bodies – AEMO, the AER and the AEMC – will face new challenges. It will be critically important that they be more dynamic and responsive.

6.2 An effective retail electricity market

Consumers need to be confident that the retail sector, their first point of contact with the electricity market, is working for them and meeting their needs. Surveys by the AEMC and Energy Consumers Australia have found that while the majority of residential consumers are satisfied with their services and their retailer, they are not convinced they are getting value for money.³⁰⁷

Activating demand-side resources needs consumers who trust the market and expect it to work in their favour, so that they are willing to engage with retailers and the emerging energy services sector.

Effective competition is a key driver of productive, efficient and innovative markets. Competition also allows consumers to take greater control. But there are indicators that the retail market in the NEM may not be as effective as it could be.

The retail market needs to:

- Provide real value to consumers from their choice of providers and products.
- Support service innovation that unlocks technology and simplifies choice for consumers.
- Open up new opportunities for all consumers, including vulnerable and less-engaged consumers.
- Deliver prices that reflect costs and risks, including reasonable returns for the provider.

307. AEMC, *Retail Competition Review*, 2016, p.i; Energy Consumers Australia, *Energy Consumer Sentiment Survey Findings: December 2016*, 2017, p.2.

Several studies have found that the retail market is not offering the same value or benefits to consumers as other markets. For example, the Grattan Institute argues that the retail electricity market for small consumers is characterised by profit margins that are higher than in other retail electricity markets overseas, a lack of innovation, and confusing product offerings, with a consequent lack of engagement by consumers.³⁰⁸

It is difficult to make accurate assessments of the effectiveness of the retail electricity market due to the lack of publicly available information about retail prices. Public reports such as the Grattan Institute report and the AEMC's annual retail competition review rely on information about prices being publicly offered by retailers (without knowing how many consumers are on each offer) or limited information that is voluntarily shared by retailers. The AER has extensive gathering powers but to date it has not used them in relation to retail pricing information.

Comparing offers from different retailers is also complicated by differences in how prices are structured and marketed. For example, prices may include several different components, and may be marketed as a discount of 'x' per cent without it being clear to the consumer what base the discount is from. Marketing by retailers should be much clearer and state the standard price from which any discounts apply.

A number of reviews and inquiries are currently considering issues related to the effectiveness of electricity retail competition. Most significantly, the Australian Government has announced an inquiry into the electricity retail market by the Australian Competition and Consumer Commission (ACCC). The Terms of Reference for the inquiry require the ACCC to scrutinise a number of issues, including the cost drivers of electricity prices and any impediments to consumer choice, including a lack of transparent information. The ACCC has extensive information gathering powers. In the course of this inquiry the ACCC should consider whether the AER has sufficient information gathering powers and functions to gather retail price information on an ongoing basis. Three special reviews will report this year (Table 6.1).

Table 6.1: Current special reviews of the electricity retail market

Special Review	Body	Timing
Electricity supply and prices inquiry	ACCC	Preliminary report in September 2017; final report in June 2018
Review of electricity and gas retail markets in Victoria	Victorian Government	Final report to the Minister by May 2017
Market monitoring report (one-off report for FY2017)	Queensland Competition Authority	By 31 October 2017

The following reports are published annually, half yearly or quarterly (Table 6.2).

Table 6.2: Periodical energy market reports

Periodical report	Body	Timing
Retail energy competition review	AEMC	Published annually
Residential electricity price trends report	AEMC	Published annually
Retail energy market performance reporting	AER	Quarterly updates and a report published annually

308. Grattan Institute, *Price shock: Is the retail electricity market failing consumers?*, 2017, p.3.

Periodical report	Body	Timing
State of the Energy Market	AER	Quarterly updates and a report published annually
Victorian Energy Market Report	Essential Services Commission of Victoria	Published annually
Monitoring of the NSW retail electricity market	NSW Independent Pricing and Regulatory Tribunal	Published annually
Energy retail offer prices in SA: Ministerial report	Essential Services Commission of South Australia	Published annually
Comparison of Australian Standing Offer Energy Prices	Office of the Tasmanian Energy Regulator	Report updated every 6 months

Recommendation 6.1

As part of its inquiry into the electricity retail market, the Australian Competition and Consumer Commission should make recommendations on improving the transparency and clarity of electricity retail prices to make it easier for consumers to:

- Understand and compare prices.
- Be aware when the terms of their offer change or their discounts expire.
- Make more informed decisions about investing in rooftop solar photovoltaic, batteries or energy efficiency measures.

The Australian Competition and Consumer Commission should also consider whether the Australian Energy Regulator requires further powers to collect and publish and share retail price data.

Large consumers also face particular issues in relation to the availability and price of long-term retail contracts. Many commercial and industrial businesses prefer to enter into retail contracts that offer a specified electricity price for a defined period, for example two to three years, providing greater certainty regarding one of their key input costs and assisting them to make business decisions.

The price and availability of these retail contracts largely depends on the price and availability of equivalent wholesale market forward contracts. As discussed in Chapter 3, there has been a significant increase in the level and volatility of wholesale spot prices in recent years, which has led to significant increases in contract prices in electricity financial markets. At the same time, the current level of uncertainty in the market means that many commercial and industrial consumers are reluctant to enter into longer term contracts. The recommendations in Chapter 3 are designed to ease these concerns, and should lead to less risk and a greater availability of long-term wholesale and retail contracts for large consumers.

Large industrial consumers are particularly sensitive to reliability and affordability issues, due to their high electricity consumption and, in some cases, uninterruptible loads. Unexpected power losses have the potential to cause considerable damage to industrial infrastructure, imposing costs of repairs, and of lost production

while repairs are underway.³⁰⁹ Some industrial consumers are turning to contingency options to ensure a reliable electricity supply,³¹⁰ which could include emergency back-up generators or self-generation.

Recommendation 6.2

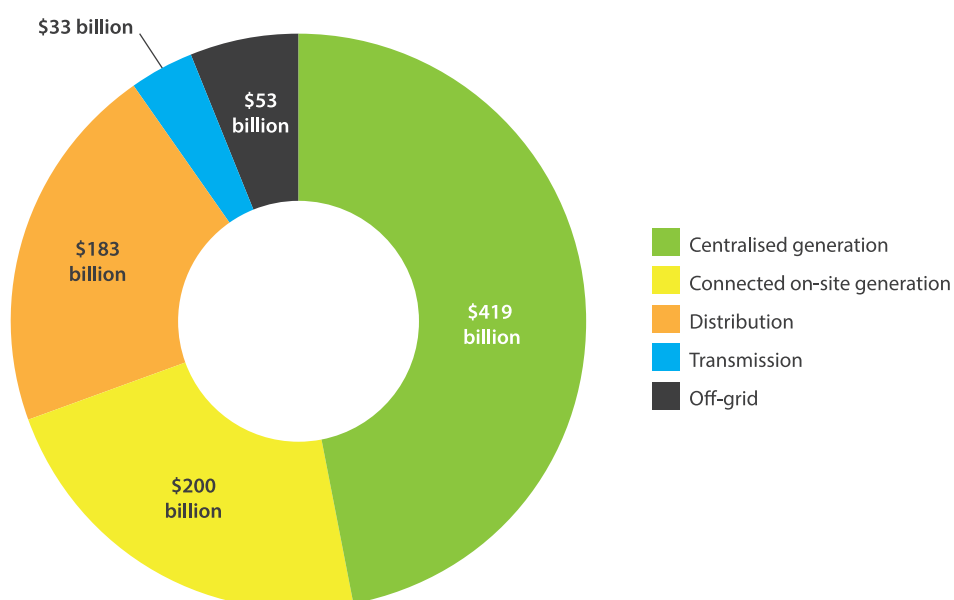
The Energy Security Board's annual *Health of the NEM* report to the COAG Energy Council should include the impact of changes in the market on the price and availability of long-term retail contracts for commercial and industrial consumers.

6.3 Maximising choice and accessibility

A limited number of highly engaged consumers already spend time finding the best deals in the market. However, many consumers find the market confusing or do not want to actively engage. Consumers need more transparency and clarity regarding pricing. A greater number of options, such as DER orchestration, are also needed for less actively engaged consumers and low income consumers to access demand-side products without requiring significant time, expertise or money.

Work by Energy Networks Australia and CSIRO gives a sense of these challenges and opportunities.³¹¹ As demonstrated in Figure 6.1, their modelling shows that consumers and their agents will determine how more than \$200 billion in system investment is spent by 2050, with millions of customer-owned generators supplying 30 to 45 per cent of Australia's electricity consumption.

Figure 6.1: Forecast total expenditure in the electricity system to 2050³¹²



309. BHP Billiton submission to the Review, p.5; Australian Aluminium Council submission to the Review, pp.6-7.

310. Cement Industry Federation submission to the Review, p.3.

311. Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Final Report*, 2017, p.i.

312. Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Final Report*, 2017, p.9.

An emerging energy services sector is packaging benefits from DER into products and services for consumers. While it looks like many of these new businesses are selling batteries, distributed generation and energy management systems, what they are really doing is navigating the energy market and finding value to share with consumers. An active energy services sector will be important to support security and reliability in the NEM.

There is a debate about who is best placed to develop offerings to consumers using new technologies – the competitive retail sector or regulated network businesses. Service providers, whoever that may be, should have incentives and the ability to maximise revenue by finding opportunities along the whole supply chain in cooperation with consumers and other energy businesses.

An active and competitive energy services sector requires improved access to a broad range of data and information, robust consumer protections that apply to new technologies and business models, and measures to enable all consumers to share in the benefits of new technologies.

Access to data and information

Consumers require access to data, particularly their electricity consumption data, to help them make more informed decisions about retail offers, their investment choices (such as solar photovoltaic systems, batteries and energy efficient appliances) and fuel choices. The electricity retailer Powershop has noted that its experience indicates some consumers value information and will respond to it, even in the absence of cost savings. Some consumers will change their usage in response to information about other benefits of doing so, such as reducing emissions or helping the community avoid involuntary load shedding.³¹³

Service providers, including a range of new technology providers, require increased access to electricity consumption and other data, in order to assist consumers and find ways to help them save money. Improved data access can also assist governments, policy makers and others to better understand the market and the impacts of changes in the market.

Consumers should have access to their electricity consumption data in real time. They should also have control over who, if anyone, can access that data.

Box 6.1 – Case study – Easy access to energy consumption data under the Green Button initiative

Green Button is an industry-led initiative in the United States that allows electricity consumers easy access to their energy usage data in a consumer-friendly and computer-friendly format. Consumers can use the Green Button website to download their detailed usage data and share it with authorised service providers. Service providers can analyse the data for consumers or provide regular information on their usage. Energy companies offer apps so consumers can view the data, and third party developers can also build apps that consumers can use with their downloaded data.³¹⁴

The Green Button system may not necessarily be applicable to data access in the NEM, but it is a useful example of the type of systems that have been adopted in other markets.

313. Paper submitted to the Review by Powershop on 6 April 2017 following a roundtable of retail and technology stakeholders.

314. See <http://www.greenbuttondata.org/>, accessed 6 June 2017.

Improving consumers' access to data is an action under the COAG Energy Council's (the Energy Council's) National Energy Productivity Plan. Currently, there are very limited data available for residential and small business consumers on their electricity consumption, other than in Victoria. This is due to most of these consumers having meters that only measure the electricity used between manual meter reads, which usually occur every three months.

An increased uptake of digital meters that can measure a consumer's electricity usage every five or 30 minutes is critical to achieving many of the benefits discussed in this chapter. As discussed in the Preliminary Report, Victoria already has digital meters following a government mandated deployment. The AEMC has new rules providing for competition in metering services, which will enable all consumers to receive new digital meters from 1 December 2017.

Large consumers are more likely to have good access to information about their own consumption, as they have digital meters that record detailed consumption information. There are also a number of service providers that can assist them to interpret and act on that information.

Under a recent change to the National Electricity Rules, consumers and their authorised representatives can obtain their consumption data from their electricity retailer or distributor free of charge up to four times a year. However, several practical barriers limit consumers' ability to easily access and use this information. For example, they may face onerous requirements to verify their identity, may receive their data in a variety of formats, and may receive their data up to 10 days after making their request. This is a long way from an ideal in which data are available immediately in a form that suits the consumer, for example to input into an app or website. Ultimately, energy retailers, third party energy service providers and behind-the-meter automation software will play an important role in removing complexity for consumers.

Recommendation 6.3

By mid-2020, the COAG Energy Council should facilitate measures to remove complexities and improve consumers' access to, and rights to share, their energy data.

There are also benefits available from improved access to data and information extending beyond electricity consumption. In particular, improved data on retail prices can help address the issues noted above about difficulties in assessing the effectiveness of the retail electricity market, resulting in better informed policy decisions.

The Energy Security Board should develop and implement a new data strategy for the NEM. One of the aims of the data strategy should be to enhance the availability of data that can support changes in the market, including data that can assist the use of DER to reduce overall system costs and improve reliability and security. This recommendation is set out in more detail in Chapter 7.

Appropriate consumer protections

Price rises over recent years have made electricity less affordable for all consumers and resulted in particular affordability problems for low income and other vulnerable consumers.

The National Energy Retail Law and National Energy Retail Rules contain a number of protections for electricity consumers. A key protection for vulnerable consumers is the requirement for retailers to develop and maintain a consumer hardship policy that sets out their approach to identifying and assisting consumers who are having difficulties in paying their electricity bills. Governments also offer a range of concession programs to assist consumers.

The AER monitors compliance with the National Energy Retail Law and Rules and also publishes an annual report on the performance of the retail energy market. The AER also publishes quarterly data collected from energy retailers on a range of indicators, including energy debt levels, consumers in hardship programs and disconnection levels.

The AER's FY2016 annual retail energy market report observes that:³¹⁵

- Electricity bills make up a significant proportion of income for low income households, with a typical low income household spending around 4 to 9 per cent of its disposable household income on electricity bills depending on jurisdiction (before government concessions).
- The proportion of consumers in hardship programs ranges from less than 1 per cent in NSW, Queensland, the ACT and Tasmania, to 1.8 per cent in South Australia.
- Disconnection levels increased in FY2016 in several jurisdictions, with the highest rate of disconnections being in South Australia where 1.4 per cent of electricity consumers were disconnected for non-payment.

Continued AER reporting of this information will be increasingly important as the market continues to transition. Further, as part of its annual *Health of the NEM* report discussed further in Chapter 7, the Energy Security Board should identify any emerging affordability issues for consumers.

Recommendation 6.4

The Energy Security Board's annual *Health of the NEM* report to the COAG Energy Council should report on affordability issues and proactively identify emerging issues.

A number of stakeholders have raised concerns that the current energy sector consumer protections in the National Energy Retail Law and Rules do not adequately cover new technologies and new business models. When those documents were drafted, they assumed that consumers would be supplied by an authorised electricity retailer and would receive all of their electricity supply from the grid. Now, many consumers are receiving services from people other than authorised retailers who are selling rooftop solar photovoltaic or battery services to consumers as a full or partial substitute for grid-supplied electricity.

In addition to ensuring that consumers have the information and tools to engage in the new market, there is also a need to ensure they can do so with confidence that there is a comprehensive consumer protection regime to back them up when things go wrong. While consumers currently enjoy specific energy-market protections under the National Energy Customer Framework (NECF), these protections are based on the traditional energy market model, where consumers are grid connected and transact with an authorised retailer. This means that NECF protections, such as access to dispute resolution through an ombudsman scheme, do not extend to many new 'behind the meter' products and services that are emerging.

*The changes that are underway in the market ultimately imply a need for a significant re-design of the [National Energy Customer Framework and the Australian Consumer Law] framework itself.*³¹⁶

Energy Consumers Australia

315. AER, *Annual report on the performance of the retail energy market: 2015-16*, 2016, pp.10-11.

316. Energy Consumers Australia submission to the Review, p.14.

The Energy Council's Energy Market Transformation Project Team published a consultation paper in August 2016 on the extent to which energy-specific consumer protections should apply to new forms of electricity supply, including distributed generation.

It is also important that safety requirements are updated so that they remain appropriate for new technologies such as battery storage. In its recent report on policy and regulatory reforms to unlock the potential of energy storage in Australia, the Clean Energy Council notes that there is currently no legally enforceable Australian Standard for the safety of lithium ion batteries and no requirement that consumers use an accredited installer for the installation of battery storage devices.³¹⁷ The Clean Energy Council report makes a series of recommendations to address these issues.

Recommendation 6.5

By mid-2018, the COAG Energy Council should accelerate its work on applying consumer protections under the National Energy Retail Law and National Energy Retail Rules to new energy services, and also consider safety issues as part of that work.

Enabling all consumers to share in the benefits of new technologies

Investments in DER and improved energy efficiency can be expensive, but falling costs and payback periods mean that an increasing number of consumers along the income spectrum are making these investments.

Retailers or other service providers can provide simple and automated services that allow consumers to benefit with zero effort. However, retailers can present highly variable prices to consumers who want them, for example commercial and industrial consumers who want to be rewarded for brief periods of demand reduction.

However, low income or vulnerable consumers are unlikely to invest in energy efficiency and demand management due to high upfront costs and imprecise benefits. Other consumers have limited opportunities because they rent or occupy high-density buildings. It is important that these consumers are not excluded from the possible benefits of the energy transition.

One way to do this is to make sure that the distributed resources owned by other consumers are being used in a way that provides benefits not only to the owner but also to the whole electricity system. This would result in lower costs for all consumers as the total costs of building, operating and maintaining the electricity system reduces over time.

There are also targeted programs that support investment in distributed generation, energy efficiency and other demand-side services for low income consumers. For instance, in New South Wales, Queensland, and South Australia, governments and industry are involved in the installation of solar photovoltaic systems on public housing. The Victorian Government is also offering low interest loans to low income consumers for rooftop solar photovoltaic as well as other energy efficient appliances or improvements.

Other mechanisms could be considered by governments to ensure that low income consumers are not left behind.

317. Clean Energy Council, *Charging Forward: Policy and regulatory reforms to unlock the potential of energy storage in Australia*, 2017, p.5.

Recommendation 6.6

The COAG Energy Council should engage with relevant portfolio areas including housing, and with state, territory and local governments, to identify:

- Opportunities to accelerate the roll out of programs that improve access by low income households to distributed energy resources and improvements in energy efficiency.
- Options for subsidised funding mechanisms for the supply of energy efficient appliances, rooftop solar photovoltaic and battery storage systems for low income consumers.

6.4 Rewarding consumers for improving reliability and security

Demand response by consumers plays a relatively small role in the NEM when compared with a number of other countries. New mechanisms could unlock the value of demand response actions by commercial and industrial consumers to the wholesale market. For residential consumers, the key challenge is how to coordinate millions of solar panels, storage systems, load management devices and other technologies in a way that best utilises the multiple services they can provide to improve reliability and security, and reduce costs.

Demand response involves consumers temporarily changing their usage of electricity at times of peak demand in response to signals to do so. There are a number of different types of demand response, each with different consumer motivations and impacts on consumers' energy consumption.

Demand response can improve reliability and reduce wholesale prices

Using demand response to incentivise consumers to reduce their demand at peak times is often cheaper, and faster to implement, than building new generation and networks to meet the peak.

Even small amounts of demand response can avoid costly, involuntary load shedding. It allows consumers to assess the value of consuming electricity versus compensation for reducing consumption. By contrast, involuntary load shedding imposes the full cost of being shed on certain consumers with no compensation or prior warning.

Box 6.2 – Case study – How demand response can reduce the risk of involuntary load shedding and save consumers money³¹⁸

A recent demand management trial conducted by Mojo offered consumers savings if they voluntarily reduced their demand during the February 2017 heatwave in NSW. This occurred at a time when the wholesale market was forecast to hit the market price cap of \$14,000 per MWh and AEMO had advised of a risk of involuntary load shedding.

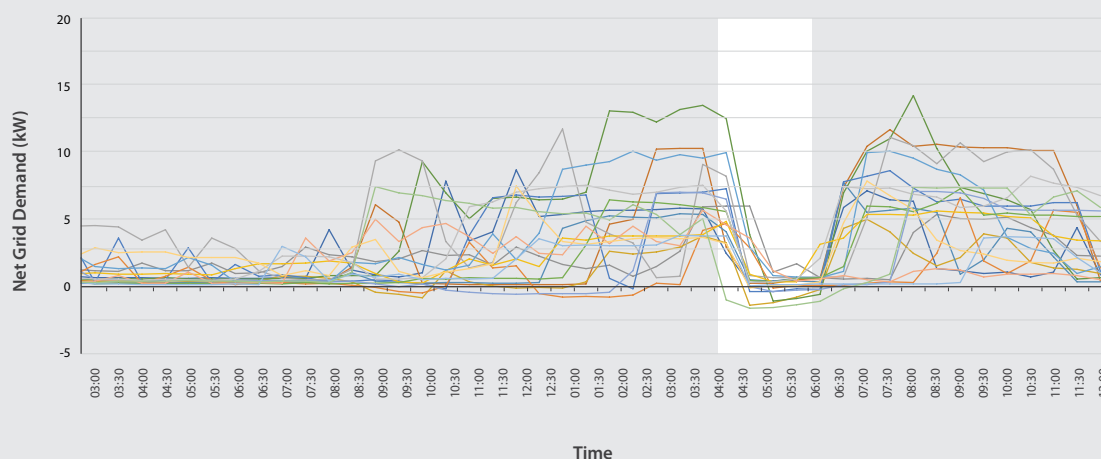
In the trial, Mojo texted 500 of its NSW consumers who had smart meters in the early afternoon of 10 February 2017 asking if they wanted to receive a credit of at least \$25 on their bill to reduce their energy use between 4 and 6 pm that day. Mojo states that a high proportion of consumers responded positively and participated by turning off or down their air conditioners and pool pumps. Smart meter data was used to measure the value of their response in reducing Mojo's

318. Mojo submission to the Review, pp.6-7; Australian Financial Review, <http://www.afr.com/news/sydney-family-paid-to-turn-off-power-on-40-degree-day-20170228-gung61>, accessed 4 June 2017.

wholesale market exposure during that period. Consumers' demand reductions allowed Mojo to save on wholesale energy costs and Mojo shared those savings with consumers, with each customer receiving between \$25 and \$140.

Figure 6.2 shows the load profiles of the top 10 per cent of Mojo's demand response customers and shows the dramatic reduction in their consumption between 4 and 6pm.

Figure 6.2: Demand response by Mojo customers on 10 February 2017



While some residential consumers are responsive to price signals, evidence from other countries suggests that this is difficult to maintain over time. Demand response is best achieved when the consumer is not required to manually respond, but the demand reduction is orchestrated by a service provider who has an agreement with the consumer covering the terms under which their demand can be curtailed or shifted. The service provider can then manage the load over many consumers aggregating a total amount of load that can have a material impact on the reliability of the NEM or a specific local distribution area.

Box 6.3 – Case study – Network business demand response programs

Some network businesses have begun to use new technologies to offer programs that help reduce peak demand and network costs, with consumers rewarded for participating.

For example, Energex offers a PeakSmart program for air conditioners, which enables these devices to reduce their energy consumption during periods of high demand. Air conditioners at participating households are fitted with a signal receiver.³¹⁹ At times of high demand on the network, a signal is sent from the Energex control centre, which reduces the device's energy consumption for a brief period of time. Households can claim a rebate of up to \$400 off the cost of the air conditioner for participating in the program.

319. The signal receiver is a Demand Response Enabling Device, known as DRED.

There are currently low levels of demand response in the NEM. A 2016 survey for the AEMC suggested there is only around 235 MW of demand response under contract to retailers, mostly involving exposure to the wholesale market spot price.³²⁰ The same report estimated that 2,000 MW of load in the NEM is price responsive – that is, those consumers would be willing to reduce demand in response to a cost saving.³²¹

A 2014 report for the Australian Government suggested that, with a realistic incentive of a 5 to 15 per cent reduction of a company's annual electricity bill, 1,700 MW of demand response could be available from industry.³²² Interviews undertaken for that report identified a number of barriers to industry offering demand reduction, notably a lack of incentives and mechanisms to do so, a lack of expertise within the companies interviewed, and the fact that management priorities within these companies are focussed elsewhere.

In 2015, the Energy Council submitted a rule change request to the AEMC proposing the introduction of a wholesale market demand response mechanism and the unbundling of ancillary services from energy services to enable different parties to offer each service to a single consumer. The AEMC decided not to introduce the proposed mechanism on the basis that it would be costly to implement and that consumers can already contract with retailers and specialist providers, and can choose to be exposed to the wholesale market spot price through their retail contract.³²³ As discussed below, the AEMC made a different rule to the rule requested by the Energy Council in relation to the ancillary services unbundling part of the request.

ARENA and AEMO have recently announced plans to trial a new demand response initiative. The three-year program will be trialled in South Australia and Victoria to pay consumers to temporarily reduce their demand to help manage peak demand. Consumers that participate in the trial will receive payments funded by ARENA to be on standby to reduce their demand when requested by AEMO.³²⁴

Given the potential value of demand response to address reliability constraints and reduce wholesale prices, increased mechanisms should be available for demand-side resources to offer these services to the market. If unscheduled participation in the wholesale market as proposed in the 2015 rule change is not appropriate, there are other options in use around the world, including demand response participation in reliability markets in New York and Texas. The important thing is that a suitable option capable of unlocking the vital benefits of demand response is chosen.

Recommendation 6.7

The COAG Energy Council should direct the Australian Energy Market Commission to undertake a review to recommend a mechanism that facilitates demand response in the wholesale energy market. This review should be completed by mid-2018 and include a draft rule change proposal for consideration by the COAG Energy Council.

320. Oakley Greenwood prepared for AEMC, *Current Status of DR in the NEM: Interviews with Electricity Retailer and DR Specialist Service Providers*, 2016, p.3.

321. Oakley Greenwood prepared for AEMC, *Current Status of DR in the NEM: Interviews with Electricity Retailer and DR Specialist Service Providers*, 2016, p.22.

322. Climateworks Australia prepared for the Department of Industry, *Industrial demand side response potential: Technical potential and factors influencing uptake*, 2014, p.3.

323. AEMC, <http://www.aemc.gov.au/Rule-Changes/Demand-Response-Mechanism>, accessed 4 June 2017.

324. AEMO press release, <https://www.aemo.com.au/Media-Centre/ARENA-and-AEMO-join-forces-to-pilot-demand-response-to-manage-extreme-peaks-this-summer>, accessed 22 May 2017.

The ability of demand response to provide system security benefits

Demand response can also improve power system security by providing fast response services to manage changes in frequency. Compared to some overseas markets, the NEM currently has very little demand response participating in frequency control markets.³²⁵

This may change following a rule change made by the AEMC in November 2016, which is intended to reduce barriers to using demand response to provide frequency control services.³²⁶ The rule change establishes a new type of market participant – a market ancillary service provider – who can offer ancillary services loads into frequency control markets. This will allow parties other than the consumer's retailer to offer ancillary services demand response to consumers, which is expected to facilitate the entry of new providers for these services. This rule commences on 1 July 2017.

The orchestration of distributed energy resources

DER and demand response provide a range of services that are valued by different parties in the electricity supply chain. For example, a battery could be used by a consumer to reduce their retail bill, by a network business to reduce network peak demand, or by a participant in the wholesale market to provide energy or ancillary services. A battery could also be used as a source of backup power to avoid blackouts, or as a way to improve power quality to reduce voltage and frequency fluctuations. A single battery could potentially be used to provide all of these services at different times.

Energy Networks Australia and CSIRO estimate that by 2050, just considering the network benefits from DER, the increased uptake of consumer-owned generation has the potential for (in real terms):³²⁷

- \$16 billion in network investments being avoided.
- Residential consumers saving more than \$400 per year compared to the business as usual. Though any material reductions are likely to occur over the longer term.
- Industrial, commercial and residential consumers receiving a total of \$2.5 billion per year in payments for providing grid support services.

The efficient use of all of these services requires coordination and cooperation between a range of parties, for example, across generation, networks and retail. This can be challenging, especially when it involves not just optimising the use of one large battery, but instead coordinating the efficient use of thousands of small batteries located at consumers' houses. To get the full value of DER, their dispatch needs to be coordinated or 'orchestrated' so that it is sufficiently material.

There are a variety of ways that this orchestration can occur. Using a large number of households with solar panels and storage devices as an example:

- The devices could be owned by the consumers, who could contract with an aggregator whose role is to coordinate the output of the devices. The aggregator could trade energy and ancillary services on the wholesale market (or partner with a generator who does so) and enter into agreements with network businesses to supply network support services. The aggregator could use the prices of each of these services and the value to the consumer of self-consumption of energy to determine which service to supply at any time.
- The devices could be owned by the consumer's retailer, or the retailer could supply them to the consumer at a discount in return for the consumer allowing the retailer to control the devices in certain

325. EnerNOC submission to the Review, p.26.

326. The Australian Energy Market Commission, <http://www.aemc.gov.au/Rule-Changes/Demand-Response-Mechanism#>, accessed 4 June 2017.

327. Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Final Report*, 2017, p.iv.

circumstances. As above, the retailer could trade energy and ancillary services and enter into network support agreements with network businesses.

- The devices could be owned by a transmission or distribution network business, or a related entity of the business. The network business could use the device to provide network support services as an alternative to augmenting the network. The network could also enter into agreements with a third party to use the devices to trade energy and ancillary services.

There is currently limited use of these types of arrangements in the NEM, with their deployment mainly being limited to small-scale trials. One example of such a trial is set out in Box 6.4.

It is important that network prices better signal the value of these services in reducing network costs, and that the wholesale market values new services that emerging technologies can provide such as very fast frequency response services.

Box 6.4 – Case study – Orchestration of solar and storage to provide multiple services³²⁸

AGL Energy has launched a Virtual Power Plant trial in South Australia with funding from ARENA. Over the next three years, AGL plans to have 1,000 smart, connected energy storage devices installed at homes and small businesses in Adelaide. Less than six months into the trial more than half the systems have been sold and a substantial fraction of these are already installed and operational.

When aggregated, the batteries will act like a 5 MW peaking power station that can be called upon to provide services to the grid. The project will demonstrate at a commercial scale the value that DER can provide to three groups of people:

- Consumers can use the batteries to self-consume more of their solar power by storing energy produced during the day that might otherwise be exported at a low price per kWh to the grid, saving them money over purchasing electricity at a high price per kWh.
- Retailers can benefit from reduced wholesale energy costs during peak periods, and through using the battery to sell frequency control services into the wholesale market.
- In the future, networks can benefit from reducing network peak demand and voltage management services, potentially avoiding future network infrastructure expenditure.

Importantly, all consumers stand to benefit from such an arrangement through reduced network costs and improved reliability and security.

6.5 Rewarding network providers for avoiding costs

Until recently, the role of networks was to transport electricity from large generators to consumers. Networks will continue to deliver this service, but it will only be one of a number that consumers want. In a network that makes efficient use of DER, the network connection is the access point for users who want to both consume and produce energy and related services.

Network businesses should be rewarded for providing the services that consumers want. Currently, there are concerns that the regulatory framework favours capital investments, resulting in too much expenditure on network assets and too little expenditure on non-network alternatives. The regulatory framework should encourage network businesses to utilise new technologies where they are cheaper than building poles and

328. AGL submission to the Review, pp.5-6.

wires. Such 'non-network' solutions could include purchasing services provided by DER or utilising individual power systems³²⁹ or microgrids³³⁰ as alternatives to a traditional grid connection.

The AER is currently developing a demand management incentive scheme to provide an additional incentive for demand-side projects, and an innovation allowance for research and development into non-network solutions that have the potential to reduce long-term network costs.

Electricity networks are natural monopolies and are regulated accordingly. Even with advances in technology, it is unlikely to be economically efficient for a competitor to duplicate the assets needed to provide the service. Economic regulation is important for the uptake of demand-side resources because it shapes the incentives and obligations on networks to provide services to consumers.

Network incentives

There is a long-standing question about the 'power' of the underlying incentives in network regulation. The power of an incentive refers to its financial impact on a business, for example the extent to which it leads to greater profits. A number of submissions argued that the power of the incentive to undertake capital expenditure (capex), which goes into the regulatory asset base and earns a regulated rate of return, is greater than incentives to undertake operating expenditure (opex) on non-network options such as embedded generation or demand management programs. If this is true, it would be a powerful influence on network business behaviour, leading to a preference to select capex options over alternatives that rely more on opex, even if the opex options would result in lower long-term prices for consumers.

The relative power of the financial incentives in network regulation should be an empirical question. It is recommended that the Energy Council or the AEMC commission financial modelling to assess the relative power of the incentives in distribution network regulation. If this modelling shows that there is a bias in favour of capex, in spite of reforms like the new capital expenditure sharing scheme and demand management incentive scheme, this would signal a need to look at alternative models of economic regulation for network service providers. To deliver the network services that consumers will want in future at the lowest cost, distribution network businesses should be indifferent to spending opex or capex.

The Energy Council has already begun work on some of these issues. The Energy Council has asked the AEMC to monitor developments in the electricity market, including decentralised energy, and the need for any changes to the regulatory approach.³³¹ In December 2015, the Energy Council agreed to undertake work on optimising network incentives and considering the merits of different approaches to incentivising efficient network investment, but no documents have yet been published on this work. It should be completed as a priority or transferred to the AEMC.

The AEMC is also considering some of these issues as part of the current rule change request on the contestability of energy services, including whether there would be merit in moving to a regime where network businesses' revenues are based on a single estimate of their efficient total expenditure (totex) rather than having separate treatment of capex and opex.³³²

329. An individual power system is a system that supplies electricity to an individual customer and that is not physically connected to the national electricity system or to any other customer. Typically, it includes a combination of solar photovoltaic, batteries and a diesel generator.

330. Microgrids are smaller grids that can disconnect from the large traditional grid to operate autonomously while the main grid is down, for example, the proposed Moreland microgrid in Victoria.

331. AEMC, <http://www.aemc.gov.au/Markets-Reviews-Advice/Electricity-Network-Economic-Regulatory-Framework>, accessed 6 June 2017.

332. AEMC, <http://www.aemc.gov.au/Rule-Changes/Contestability-of-energy-services-demand-response>, accessed 6 June 2017.

Recommendation 6.8

By mid-2018, the COAG Energy Council or the Australian Energy Market Commission should commission financial modelling of the incentives for investments by distribution network businesses, to test if there is a preference for capital investments in network assets over operational expenditure on demand-side measures.

If this work demonstrates that there is a bias towards capital expenditure, the COAG Energy Council should direct the Australian Energy Market Commission to assess alternative models for network incentives and revenue-setting, including a total expenditure approach. This should be completed by end-2019.

Networks as platforms

In a 'platform' model of network service provision, network businesses are provided with revenue for delivering a platform for consumers to trade energy and other services between each other and with networks, retailers and other market participants.

International jurisdictions are testing different approaches to a platform model of network regulation. For example, New York's *Reforming the Energy Vision* approach overlays a Distributed System Platform Provider, which makes use of the distribution network's assets.³³³ The Distributed System Platform Provider earns revenue by coordinating distributed resources to provide services to the electricity network. Utilities also continue to earn revenue to provide the underlying assets, but there is an expectation that over time the Distributed System Platform Provider revenues would expand to the point that they can replace the traditional capex and opex revenue requirements.

Preliminary work has begun to consider these issues in the NEM, including Energy Networks Australia and CSIRO's *Electricity Network Transformation Roadmap*³³⁴ and the AEMC's ongoing Distribution Market Model project.³³⁵

A key part of networks' role as a platform provider will be to provide clear signals about the location of network constraints and the amount that networks are willing to pay consumers, retailers or other providers of services that can avoid or defer those network constraints.

Electricity networks have good information about the costs of providing services and the value of non-network investments, but it can be difficult for consumers and service providers to get this information. There is information about emerging constraints in network planning reports, but this does not clearly show the value of avoiding network investments. Information about value is revealed in the Regulatory Investment Tests, but these happen on timeframes that make it difficult for service providers to plan ahead.

Service providers are starting to overcome these barriers. For example, in response to a Regulatory Investment Test for Distribution, Greensync has contracted with United Energy to provide a demand-side solution to a network constraint on the Mornington Peninsula in Victoria, including resources dispatched from United Energy's control centre.

New AEMC rules introduced in 2016 require all distribution businesses to publish an annual system limitations report that shows the location of network constraints and information to help providers of non-network solutions estimate the amount that network businesses would be willing to pay for a non-network solution that removes the constraint, such as by reducing network peak demand at that location. This information must be

333. New York State Energy Planning Board, *The Energy to Lead 2015: New York State Energy Plan Volume 1*, 2015.

334. Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Final Report*, 2017.

335. AEMC, <http://www.aemc.gov.au/Markets-Reviews-Advice/Distribution-Market-Model>, accessed 3 June 2017.

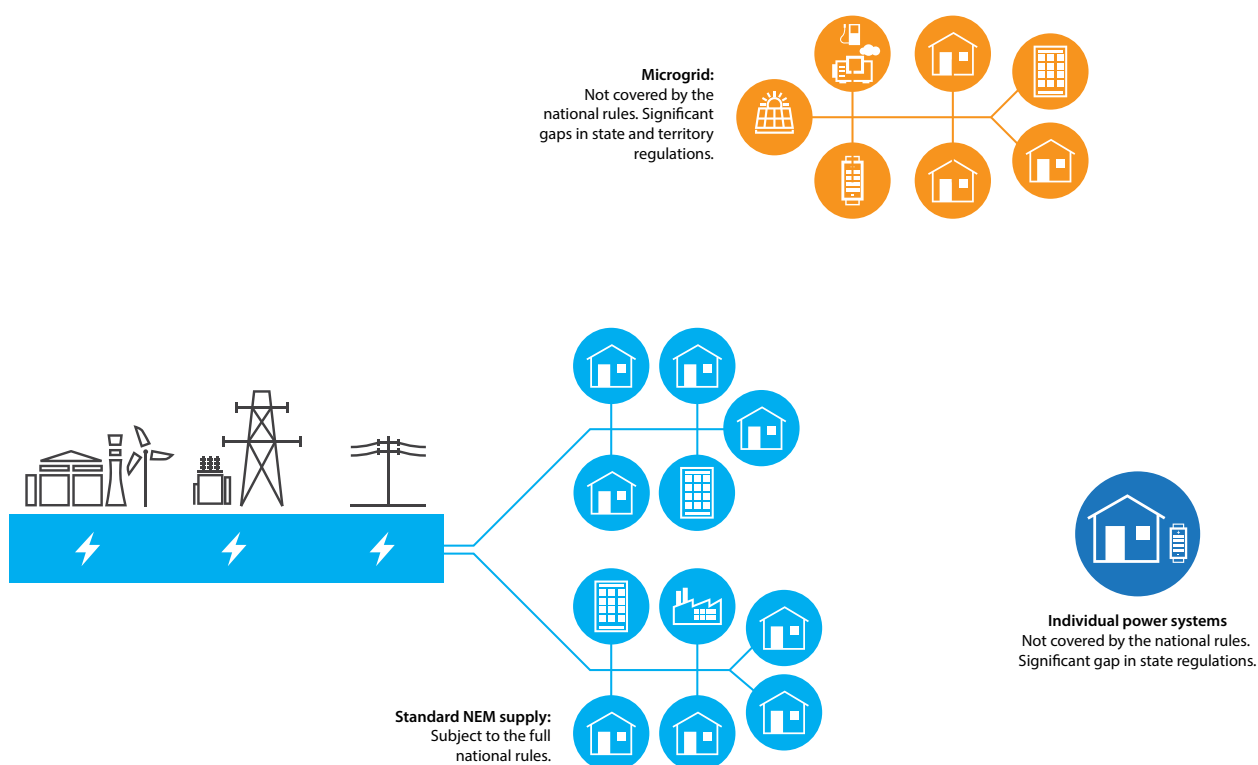
published in a common format determined by the AER.³³⁶ These new reports will be published by 31 December 2017 and will go some way to improving access to this information. In addition, several maps of network opportunities and constraints have been developed, as discussed in Chapter 5.

Increased adoption of open platforms for signalling network value are likely to lower transaction costs for energy service providers seeking to mediate between consumers and the electricity market.

New technologies as an alternative to traditional grid connections

Individual power systems and microgrids using technologies such as solar photovoltaic and storage have the potential to provide more reliable and lower cost alternatives to a traditional connection to the interconnected distribution network. However, a number of submissions identified current regulatory barriers that prevent the adoption of these technologies. Individual power systems and microgrids are not currently regulated under the national frameworks and are subject to separate state and territory legislation, with significant gaps in regulation in some jurisdictions.

Figure 6.3: How microgrids and individual power systems are currently regulated³³⁷



336. Local Generation Network Credits rule change, available at <http://www.aemc.gov.au/Rule-Changes/Local-Generation-Network-Credits>, accessed 30 May 2017.

337. Adapted from AEMC submission to COAG Energy Council, *Consultation paper on stand-alone energy systems*, 2016.

Modelling conducted by Energeia for the *Electricity Network Transformation Roadmap* found that new regulatory arrangements would be required to allow innovative service delivery options for up to 27,000 new rural connections between now and 2050. Almost \$700 million could be saved by supplying these connections, usually farms, with an individual power system, but current regulations would require the use of a more expensive conventional grid connected service.³³⁸

The Energy Council's Energy Market Transformation Project Team published a consultation paper in August 2016 on how these systems could be regulated and whether there is value in regulating them under the National Electricity Rules and National Energy Retail Rules.³³⁹

The AEMC is also currently considering a rule change request from Western Power that seeks to remove some of the barriers to distribution network businesses using individual power systems as an alternative to a grid connection, particularly in rural areas.³⁴⁰

Recommendation 6.9

By mid-2018, the COAG Energy Council should direct the Australian Energy Market Commission to undertake a review of the regulation of individual power systems and microgrids so that these systems can be used where it is efficient to do so while retaining appropriate consumer protections.

The Australian Energy Market Commission should draft a proposed rule change to support this recommendation.

6.6 Improved energy efficiency

Energy efficiency can contribute to improving reliability and affordability and reducing emissions through:

- Reducing demand, which can reduce the costs of delivering infrastructure to meet reliability standards.
- Reducing consumer bills through direct savings and also through downward pressure on long-term costs in the energy system.
- Avoiding fossil fuel generation and reducing the investment needed in new infrastructure to meet a given emissions target.

Energy efficiency activities are driven by a wide range of consumer choices and can require coordination of many small decisions and investments to have impact. There are also many well recognised barriers to the uptake of energy efficiency by consumers, such as information failures and transaction costs. For these reasons, there remains a large potential for accessing untapped energy efficiency improvements.

Many successful energy efficiency activities, such as minimum energy efficiency standards for appliances and buildings, can have a strong impact on energy consumption and costs. Average household electricity use in Australia has been falling for the last decade, despite increasing numbers of appliances, due in part to energy efficiency standards. For example, modern refrigerators and air conditioners use significantly less energy than older models, and combining them with modern homes with improved insulation further reduces energy consumption.

338. Energy Networks Australia, <http://www.energynetworks.com.au/energeia-modelling-roles-and-incentives-microgrids-and-stand-alone-power-systems>, accessed 3 June 2017.

339. COAG Energy Council, *Stand-alone energy systems in the Electricity Market: Consultation on regulatory implications*, 2016.

340. AEMC, <http://www.aemc.gov.au/Rule-Changes/Alternatives-to-grid-supplied-network-services>, accessed 3 June 2017.

The energy efficiency of new buildings has an even longer-term effect as most buildings built today will be standing long after 2050. ‘Split incentives’ can result in cost-effective measures not being undertaken voluntarily, with builders more likely to be focused on short-term costs while building owners and tenants manage long-term energy costs.

Some energy efficiency improvements can be delivered in the short-term. In particular, large industrial energy savings projects to reduce electricity peak demand, or to reduce gas use to free it up for other uses, including electricity generation, could have strong reliability benefits in the short-term while also reducing the energy bills of large consumers.

Substantive opportunities have been identified in the large consumer sector for cost-effective investment in energy efficiency measures. While the most energy-intensive users have a strong commercial incentive to manage energy closely, industrial energy users may not invest in these projects to the most efficient levels without some form of support or intervention because some of the benefits accrue to the wider energy system, for example through improved reliability.

There are currently a number of government programs targeting improved energy efficiency. For example:

- In December 2015, the Australian Government and the Energy Council published the *National Energy Productivity Plan 2015-2030*. The National Energy Productivity Plan sets out a high-level framework and initial steps to attain the target of a 40 per cent improvement in energy productivity by 2030.³⁴¹
- Energy savings schemes currently exist in New South Wales, Victoria, South Australia and the Australian Capital Territory. These schemes encourage uptake by creating demand for energy savings measures, and a market of service providers who identify household and business consumers who can benefit and offer services to support the uptake of these measures.
- In December 2016, the South Australian Government launched the South Australian Energy Productivity Program, which includes funding for large businesses to undertake energy audits and implement energy efficiency measures.

The other area in which government actions could assist is to improve the availability of energy efficiency advice for consumers. There are a number of barriers in this area, including the growing complexity of consumer options, the lack of trust consumers currently have in energy retailers delivering value for money, and barriers to third parties accessing consumers’ energy usage data.

A range of recent pilots with both small business (through the Energy Efficiency Information Grants) and vulnerable consumers (through the Low Income Energy Efficiency program) have provided research to improve the way advice is provided to these sectors. Governments could build upon this research to target improvements in these sectors and ensure affordability benefits reach those who most need them.

Despite these existing programs, a large number of submissions called for more to be done on energy efficiency and there appears to be considerable scope for greater use of energy efficiency to improve reliability, security and affordability.

341. “Energy efficiency” is a subset of “energy productivity”. Energy productivity brings together a range of activities that improve the value consumers get out of their investment in energy, including energy efficiency, broader competitive or market efficiencies (like managing peak energy use to save costs) or switching fuels where it is more efficient. This Review focusses on energy efficiency rather than the other broader aspects of energy productivity, many of which are covered in wider discussion of demand and retail activities.

Recommendation 6.10

Governments should accelerate the roll out of broader energy efficiency measures to complement the reforms recommended in this Review.

Chapter 7

STRONGER GOVERNANCE

Overview

A strong and resilient system of governance will be central to ensuring a secure and reliable low emissions future. Good governance requires trusted, capable, empowered and accountable institutions. We need energy market bodies to respond in a coordinated and timely way to rapid changes that will occur in the NEM. To do this they will need clear strategic direction from the COAG Energy Council and to have shared accountability for whole-of-system outcomes.

To help achieve this, the Panel recommends that the COAG Energy Council endorse a national strategic energy plan for the NEM informed by the Blueprint in this report and agree to the formation of a new Energy Security Board to coordinate action.

The Energy Security Board will provide a single point of responsibility and accountability. It will drive implementation of the recommendations of this report, and release an annual *Health of the NEM* Report. The Energy Security Board will draw on the expertise of market bodies and coordinate how they exercise their separate accountabilities to keep pace with the rate of change. More rapid rule-making processes will help keep pace with the rate of change in the NEM.

7.1 Clear strategic direction and shared accountability

Best practice governance is required to facilitate well-functioning energy markets and public confidence in the NEM. Strong governance arrangements provide clarity about strategic direction, roles and responsibilities and accountability for outcomes. They also ensure that the right institutions are doing the right work.

The current NEM governance arrangements have a number of strengths. The framework manages to balance complex federal responsibilities with strong market institutions. It has delivered sound and predictable outcomes. Despite this, as with the NEM itself, reform is needed to make our governance more resilient, better coordinated and reflective of the pace of change in energy markets. Stakeholders identified governance as one of their most common concerns during the Panel's consultation process.

Australia's energy market bodies have a leading role to play in helping steer the NEM through the energy transition. They can be better supported in this role by clear strategic direction from governments on the integration of energy and emissions reduction policy. Stakeholders have expressed concern about the absence of policy leadership from the COAG Energy Council (the Energy Council). Implementation of the orderly transition plan outlined in this report is important in this regard. Governments can further strengthen these arrangements by recommitting to the principles that underpin the NEM.

A new Energy Security Board (ESB) should drive implementation of this report, as agreed by governments. This will enable the Energy Council – the NEM's peak governance body – to focus on matters of national strategic importance. The ESB will draw on the expertise of market bodies and coordinate how they exercise their separate accountabilities to keep pace with the rate of change.

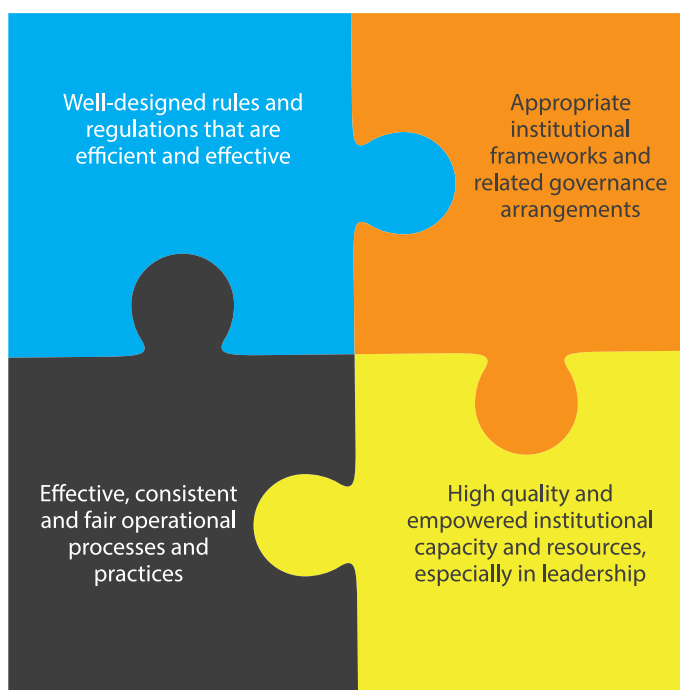
Present arrangements complicate the question of accountability for system outcomes in the NEM, largely because of our federal arrangements and allocation of regulatory and operational responsibilities. When high-profile events occur in the NEM and amid the intense debates that follow, it is difficult for the community to understand who is responsible and accountable.

While not a conventional board in every sense, the ESB would bring the energy market bodies and regulators together to take a whole-of-system view. It will help them speak to governments with one voice and governments speak to them collectively about the NEM. It integrates interlocking responsibilities for overall national energy security. Finally, in implementing the blueprint, it will facilitate better planning, coordination, and action between governments, the Energy Council, and market bodies and regulators. It will lead to clearer reporting and accountability on whole-of-system outcomes. Governments, industry and consumers will all benefit from better and more transparent data about system performance, investment and resource opportunities.

The essential elements of good governance

The term ‘energy governance’ applies to both the energy system as a whole and its overarching policy and legal framework, as well as the individual institutions within it and how they function. The necessary elements of better regulatory outcomes are described in Figure 7.1.

Figure 7.1: Elements of good governance³⁴²



342. Adapted from OECD, *OECD Best Practice Principles of Regulatory Policy: The Governance of Regulators*, 2014, p.22.

Appropriate institutional frameworks and related governance arrangements are an important focus of this Review. In this context, principles of good governance that the Panel considers relevant for the NEM include:

- clarity of purpose and functions
- accountability and transparency
- well-designed rules
- maintaining trust and independence
- appropriately skilled board and staff
- effective information management.³⁴³

Given these principles, the Review has identified that the following issues require particular attention:

- coordination between the market bodies, and between market bodies and the Energy Council
- clarity about accountabilities for energy system outcomes
- timing of the rule change process.

Current NEM governance arrangements

Energy market governance occurs within the context of Australia's federal system of government. Currently, states and territories have primary responsibility for energy policy. The Commonwealth has primary responsibility for emissions reduction policy (based on its constitutional responsibility for external affairs, including meeting Australia's obligations under international agreements such as the United Nations Framework Convention on Climate Change).³⁴⁴

The Australian Energy Market Agreement (AEMA) was created to provide a framework for cooperation between the Commonwealth, State and Territory Governments. Through the AEMA, governments agreed to implement a national legislative framework for the energy market. This national legislative framework is contained in the National Electricity Law (NEL) and the National Electricity Rules (the Rules).

The Energy Council sits at the peak of energy system governance. The AEMA provides that the Energy Council is "*the national policy and governance body for the Australian energy market including for electricity and gas*".³⁴⁵ The responsibilities of the Energy Council include policy oversight of, and future strategic direction for, the NEM, but do not extend to direct engagement in the day-to-day operation of the NEM.³⁴⁶ The Energy Council is supported by a Senior Committee of Officials comprised of representatives from portfolio agencies in each jurisdiction.

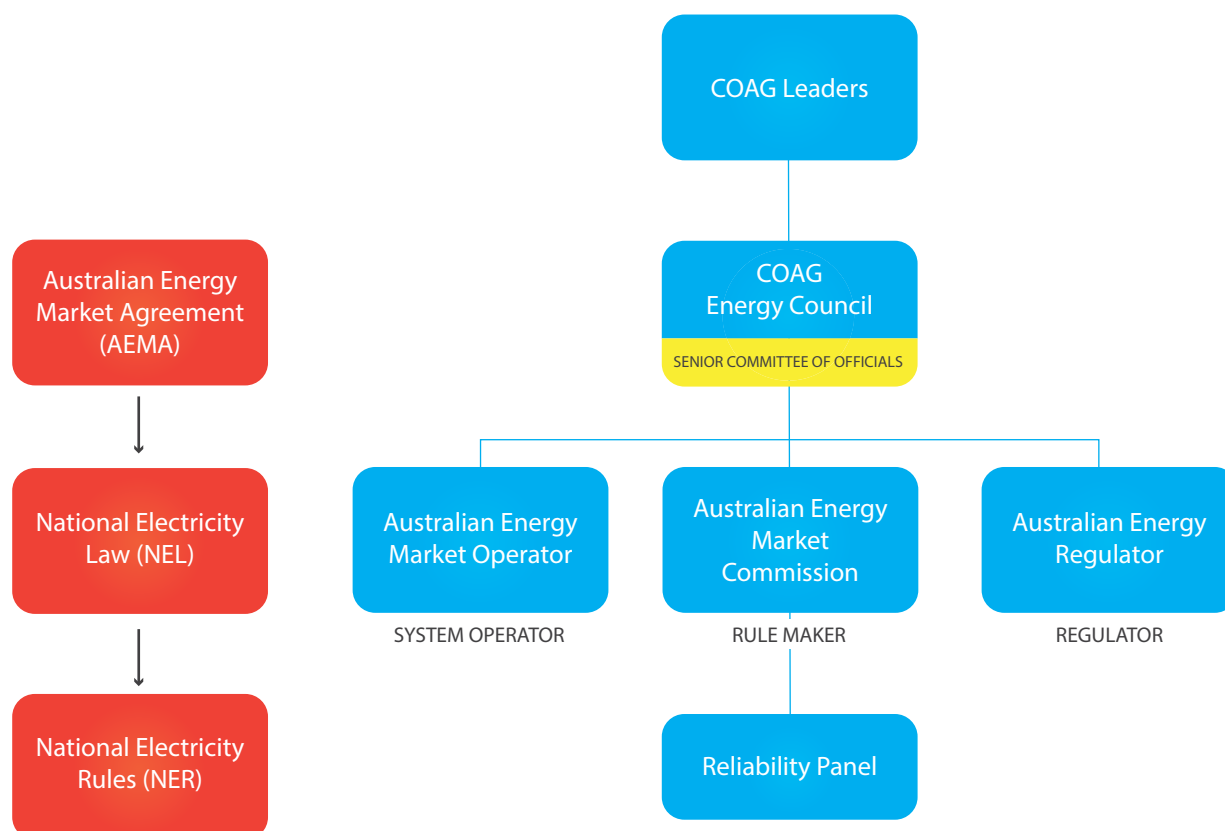
Responsibilities for rule-making, market operation and market regulation functions are divided between three energy market bodies – the AEMC, AEMO, and the AER respectively. Each body is constituted and funded differently, and subject to different legislative arrangements. The independence of market bodies from governments is intended to provide confidence that the market will not be subject to political interference. There is also an efficiency dimension. Appointing the AEMC as the independent rule maker prevents the delays and costs that would occur if every state and territory was required to deliberate on and implement rule changes. These arrangements are illustrated in Figure 7.2. They are explained in more detail in Box 7.1.

343. Australian National Audit Office, *Better Practice Guide: Administering Regulations Achieving the Right Balance*, 2014, pp.11-28.

344. The Commonwealth Energy Minister also has responsibility under the *Liquid Fuel Emergency Act 1984* to prepare for and manage a prospective liquid fuel supply emergency.

345. AEMA, Cl. 4.1.

346. AEMA, Cl. 4.3(b); Cl. 4.5.

Figure 7.2: NEM governance framework

Several other agencies have been established with functions that affect the NEM. These include:

- The Clean Energy Regulator, which is responsible for administering the Renewable Energy Target and other national schemes to measure and manage greenhouse gas emissions.
- The Australian Renewable Energy Agency, which funds innovation and shares knowledge to accelerate the shift to renewable energy.
- The Clean Energy Finance Corporation, which provides finance for clean energy projects.

Separately, Energy Consumers Australia has been established by government as an organisation to help understand and represent the interests of all consumers to government. The institutions involved in NEM governance need to be able to respond and adapt in a timely way to rapid changes in energy markets in order to ensure a secure and reliable supply of electricity. For this to occur there needs to be coordination between all elements of the governance arrangements and shared accountability for system outcomes. It is for this reason the Panel considered the need for a coordination mechanism through the ESB. The ESB will need to maintain a working relationship with all of these agencies to ensure it has a full picture of any emerging issues.

Box 7.1 – NEM Governance

The **Australian Energy Market Commission (AEMC)** is responsible for rule-making and energy market development at a national level. If requested, the AEMC may make rules in relation to the operation of the NEM and national electricity system. The AEMC may conduct a review at the request of the Energy Council or by self-initiation. A review may be conducted in such manner as the AEMC considers appropriate. The AEMC cannot be directed in the performance of its functions

and the rules it makes cannot be disallowed by parliament. The Energy Council may issue a Statement of Policy principles to guide the AEMC's rule-making power; though this power has only been used once. AEMC commissioners are appointed by the South Australian Governor in accordance with a resolution of the Energy Council.³⁴⁷

The **Reliability Panel** is part of the AEMC's institutional arrangements to monitor, review and report on the safety, security and reliability of the NEM. Its responsibilities are set out in the NEL and its work program is prescribed by the Rules. It may request rule changes relating to its functions. The Panel has an ongoing obligation to review market parameters regarding power system security and reliability and also provides advice at the request of the AEMC. It determines standards and guidelines which are part of the framework for maintaining a secure and reliable power system, such as connection and performance standards.

The **Australian Energy Regulator** (AER) is responsible for regulation and compliance at a national level, including in respect of the NEL and the Rules. The AER operates under the *Competition and Consumer Act 2010 (Cth)*. The AER has an independent board made up of one Commonwealth member and two state or territory members. It shares staff, resources and facilities with the Australian Competition and Consumer Commission and is funded by the Commonwealth.

The **Australian Energy Market Operator** (AEMO) is responsible for the day-to-day operation and administration of both the power system and electricity wholesale spot market in the NEM. AEMO's electricity functions are set out in the NEL. It is incorporated as a company limited by guarantee under the *Corporations Act 2001 (Cth)*. It recovers operating costs through fees paid by market participants. Members are made up of Australian governments (60 per cent) and industry participants (40 per cent). The AEMO board is appointed by the Energy Council based on a Board Selection Panel Report that has been approved by members.

The **National Electricity Law** (NEL) is contained as a schedule to the *National Electricity (South Australia) Act 1996* and applied in other jurisdictions through legislation agreeing that the NEL and the Rules operate in that jurisdiction. Any changes to the NEL must be agreed by all jurisdictions through the Energy Council and are then subject to the South Australian legislative process. This kind of cooperative federal scheme operates in other fields of regulation such as competition law. States have ultimate responsibility for a matter but they delegate it to a lead legislator to ensure national consistency. The NEL establishes a **National Electricity Objective** (NEO), which guides the market bodies in executing their respective responsibilities.

Any person – apart from the AEMC – can propose a change to the **National Electricity Rules**. But the AEMC has the power to make a preferable rule, different to the one initially proposed, if it will (or is likely to) better contribute to the achievement of the NEO.³⁴⁸

Previous reviews of NEM governance arrangements

NEM governance arrangements have been reviewed on several occasions. The findings of the Productivity Commission's 2013 review of electricity network regulation and the 2015 Review of Governance Arrangements for Australian Energy Markets (the "Vertigan Review") are of most significance to this Review.

347. AEMC Establishment Act 2004 (SA) s13(1a).

348. NEL, s91A.

The Productivity Commission observed that:

*Reform appears to have been frustrated by complex processes, constant and overlapping reviews, and a lack of agreement by relevant governments about either the reforms themselves or the need for more timely progress to a genuinely NEM-wide approach to energy regulation.*³⁴⁹

It described the situation as sometimes descending into “paralysis by analysis”³⁵⁰ and urged the Energy Council to change its processes to accelerate reform.

The Vertigan Review found that the structure and division of market responsibilities in the NEM was “fundamentally sound” and that “Australian energy market governance is amongst best practice internationally.”³⁵¹ Nevertheless, it made a range of recommendations to improve NEM governance. A number of these have not yet been implemented, including:

- the appointment of additional AEMC and AER commissioners
- expedited rule change processes
- a comprehensive review of the Rules
- structural separation of AER from the ACCC
- a new Statement of Role for AEMO.

Recent events have highlighted that in addition to implementing these recommendations, action is required to further strengthen NEM governance.

7.2 Coordination and accountability for system outcomes

NEM institutional arrangements are characterised by a division of responsibilities between governments and market bodies. The Energy Council is responsible for coordination of these arrangements and for providing strategic direction.³⁵² The Vertigan Review identified that a “strategic policy deficit” had led to diminished clarity and focus in roles, fragmentation and a diminished sense of common purpose.³⁵³ It observed that the Energy Council and the Senior Committee of Officials appeared to lack a focus on strategic direction and were not providing effective and active policy leadership to the energy sector. Its recommendations to address the strategic policy deficit included:

- formally delegating management of the Energy Council’s work program to the Senior Committee of Officials
- seeking input from the AEMC on the strategic direction and priorities of the Energy Council.

The Energy Council accepted these recommendations. It delegated management of its work program to the Senior Committee of Officials, to undertake more of the operational processes, to allow the Energy Council to focus on strategic direction and priorities of the market.³⁵⁴ It also agreed to task the AEMC with providing targeted strategic advice to inform its energy market strategy and priority setting, although as the Vertigan Review acknowledges, the AEMC already publishes a report on ‘Strategic Priorities for Energy Market Development’.³⁵⁵

349. Productivity Commission, *Electricity Network Regulation Frameworks: Inquiry Report, Volume 1, No.62, 9 April 2013*, 2013, p.36.

350. Productivity Commission, *Electricity Network Regulation Frameworks: Inquiry Report, Volume 1, No.62, 9 April 2013*, 2013, p.36.

351. Vertigan M, Yarrow G, and Morton E, *Review of Governance Arrangement for Australian Energy Markets: Final Report*, 2015, p.7.

352. AEMA, Cl. 4.3.

353. Vertigan M, Yarrow G, and Morton E, *Review of Governance Arrangement for Australian Energy Markets: Final Report*, 2015, p.7.

354. COAG Energy Council response to *Review of Governance Arrangements for Australian Energy Market – Final Report*, December 2016, p.1.

355. Vertigan M, Yarrow G, and Morton E, *Review of Governance Arrangement for Australian Energy Markets: Final Report*, 2015, p.43. The Panel noted that the paper was regarded as a statement by the AEMC of its own priorities and there was no process for it to be influential in the work of the Energy Council.

The Panel considers more needs to be done to ensure a clear strategic focus for the Energy Council's work. For the Energy Council and Senior Committee of Officials to demonstrate greater strategic focus, there needs to be a clear strategic plan.

The Energy Council should develop a strategic energy plan to guide market bodies and the operation and evolution of the NEM in coming years. In its international consultations, the Panel observed the importance of a strategic plan in navigating the energy transition (see Box 7.2).

Box 7.2 – Strategic planning around the world

Worldwide, all countries are facing similar opportunities and challenges through the energy transition. Many jurisdictions have a strategic plan in place to actively manage their power system through this transition. Some examples are:

- New York State's 'Reforming the Energy Vision' strategy aims for a clean, resilient, and affordable energy system, and sets out 2030 targets for emissions reductions, the renewable share of electricity generation and energy efficiency in buildings. The strategy is being enacted through the New York State Energy Plan, which provides a comprehensive roadmap of initiatives to achieve the targets.
- Denmark has a strategic plan in the form of its Energy Agreement. This establishes a framework for climate and energy policy with a view to a zero emissions energy system by 2050. The current Energy Agreement runs from 2012 to 2020 and is a multilateral policy, supported by all parties in Parliament bar one. An Energy Commission has been established to come up with recommendations for the next steps in Denmark's green transition, to be built into the next Energy Agreement.
- Germany has undergone a process to transform its electricity market into an 'electricity market 2.0', capable of integrating renewable energy into the market in a way that guarantees a secure, low-cost electricity supply. The German Government identified the short, medium and long-term measures necessary for this transformation, with some implemented through a new Electricity Market Act. It has also initiated a process to shape the transition from the electricity market 2.0 to the broader 'energy market 2.0'.

The new strategic energy plan should contain elements of this report's blueprint and provide clarity and direction for market bodies and participants, including on the alignment of emissions reduction and energy policy.

Recommendation 7.1

By mid-2018, the COAG Energy Council should develop and maintain a strategic energy plan informed by the Panel's blueprint to guide the operation and evolution of the National Electricity Market.

Roles and responsibilities of market bodies

The division of responsibilities in the NEM is widely accepted and supported by many energy market participants but it can lead to complexity and minimal joint accountability for system outcomes. As noted previously, NEM governance arrangements have their strengths. Reallocating or consolidating³⁵⁶ responsibilities would not be the best use of time and resources given the urgency of the challenges confronting the NEM. It would distract from the critical task of implementing the blueprint, in which the market bodies will need to play a central role.

Empowering market bodies to take necessary actions

The roles and responsibilities of market bodies are set out in the AEMA, the NEL, the Rules, and other legislation establishing these bodies.

Under the NEL, both AEMO and the AEMC have broad discretionary powers in connection with the performance of their statutory functions.³⁵⁷ The bodies are given this discretionary power so they are able to respond to unforeseen circumstances. This discretionary power is important in a rapidly changing market.

AEMO has expressed a concern that its statutory discretionary power is limited by the detail contained in the subordinate Rules. In its submission to the Review, AEMO highlighted that the NEL and the Rules fail to allocate clear responsibility for certain aspects of power system security. For example, AEMO highlighted that no agency had been assigned explicit responsibility in either the NEL or the Rules for *“tracking emerging risks in relation to the power system, and promoting adaptation to the overall system security framework”*.³⁵⁸ It also proposed streamlining the Rules by taking out technical access standards and placing them in procedures under constant review by AEMO.

AEMO should have the powers it needs to ensure secure and reliable supply, and uncertainty regarding its role and responsibilities addressed as a priority. If AEMO considers that its existing powers are insufficient, it should make the case for change and propose amendments to the Rules or request that the Energy Council amend the NEL. Alternatively, it should take action under its broader mandate to ensure the secure operation of the system.

The Vertigan Review noted that there was a degree of confusion around AEMO’s role in market development. AEMO has a statutory function to *“promote the development and improve the effectiveness of the operation and administration of the wholesale exchange”*, but the AEMA clearly states that market development is the responsibility of the AEMC.³⁵⁹ It recommended that the Energy Council clarify AEMO’s role in relation to market development by issuing AEMO with a ‘Statement of Role’. This recommendation should be implemented as a matter of priority. As highlighted by the valuable work being done on power system security by AEMO, the market operator needs to strongly contribute to future market development by the AEMC.

The need for a new body

Implementing the blueprint will require a greater level of coordination between market bodies. The Energy Council will require clear advice from market bodies about how the market is changing and how those changes should be managed. The market bodies will need to take a whole-of-system perspective and work together to advise the Energy Council on how best to respond to emerging issues.

Shared accountability for NEM outcomes will be important. At present, market bodies have a shared objective – to promote the National Electricity Objective – but there also should be a shared accountability for meeting it. Energy Networks Australia, in a supplementary submission to the Review, stated:

356. The Parer Review in 2002 recommended that the rule-making and regulator responsibilities be consolidated in one body.

357. NEL, ss.29(2) and 49A.

358. AEMO submission to the Review, p.35.

359. Vertigan M, Yarrow G, and Morton E, *Review of Governance Arrangement for Australian Energy Markets*, Final Report, 2015, pp.79-83.

In the absence of clear roles for market institutions, the Council or its individual members has dealt with energy security in an 'ad hoc' and sporadic manner, while the overall strategic accountability for energy security has not been tasked to institutions.³⁶⁰

In discussions with the Panel about the need for greater whole-of-system oversight and accountability the market bodies proposed a 'forum' comprised solely of market bodies. Market bodies announced the establishment of the 'Market Bodies Forum' on 7 June 2017. However, a forum comprised solely of market bodies does not go far enough. It will not be able to implement the blueprint and drive the change required in the NEM. The Panel recommends a stronger approach as outlined below.

Energy Security Board will implement the blueprint

The Energy Council should establish a non-statutory body – the Energy Security Board. Establishing the ESB as a non-statutory body in the first instance will enable it to begin performing its functions as quickly as possible within the existing legal framework. The need for the ESB to have statutory powers should be considered as part of a subsequent review of its performance.

The ESB will provide whole-of-system oversight for energy security and reliability and will have primary responsibility for the implementation of the blueprint. It will provide better alignment of channels of information, policy, and strategic advice flowing between the Energy Council and the market bodies. The current fragmented institutional arrangements will not be able to do this effectively and coordinate the actions of market bodies in a rapidly changing market. The ESB will strengthen the Energy Council's ability to focus and make decisions on broader structural and strategic policy issues.

An important responsibility of the ESB will be to publicly report on the *Health of the NEM* in a way that allows both ministers and the general public to clearly understand the pressures within the system, and actions being taken to respond to them. Such a reporting regime will provide greater confidence to the Energy Council that they can delegate responsibility to the ESB and market bodies. Similarly, there will be greater transparency for the general public about emerging risks and actions being taken in response.

There are a number of precedents in Australian energy markets for this approach. The National Grid Management Council was established in 1991 by COAG to oversee and coordinate efforts in the transition to a national market. There is now a similar need to oversee the transition occurring in the NEM.

Accountability and organisational structure

The ESB will be accountable to the Energy Council. It will keep ministers informed and help them focus on strategic policy and provide clear direction to market bodies. Members of the ESB will act in the interests of the NEM as a whole.

The Panel considers that the new ESB should be comprised of the Chairs of the AEMC and the AER and the Chief Executive of AEMO, plus an independent Chair supported by an independent Deputy Chair. The independent Chair and Deputy Chair will play an important role on the ESB by bringing an outside perspective and a "fresh set of eyes" to ESB deliberations. This is consistent with the ASX Corporate Governance Principles.³⁶¹ The inclusion of an external Chair and Deputy Chair, a whole-of-system focus and the ESB's proposed processes and reporting are features that are common in boards across the private and public sectors. Clean energy technology and regulatory bodies – the CER, ARENA and CEFC – along with Energy Consumers Australia should be invited to attend and contribute to meetings where issues relevant to their responsibilities are being discussed.

The ESB will operate by the delegated authority of the ministers (through the Energy Council) and its power will derive from being endorsed by ministers. Under the proposed two-tier model, the role of the Energy Council will be to provide direction to the ESB. The ESB Chair will facilitate meetings of the Board.

360. Energy Networks Australia supplementary submission to the Review, p.5.

361. ASX Corporate Governance Principles, 3rd edition, 2014, p.14.

The Chair should attend Energy Council meetings with the heads of the market bodies to enable ministers to seek further information and provide direction. The independent Chair and Deputy Chair will bring a diversity of skills and experience to enhance NEM governance. They should be appointed by the Energy Council based on clear identification of relevant skills and experience in the energy sector.

The ESB should have a budget provided by the Energy Council to allow it to engage a secretariat with experience in national and international energy markets. The budget should also cover the salary of the Chair and Deputy Chair, and operational requirements. Market bodies should be encouraged to second staff to the secretariat, as should State, Territory and Commonwealth Governments.

Terms of reference of the ESB should include:

- Implementing this Review's Blueprint according to the timeline recommended in this report.
- Providing advice to the Energy Council as required on developments in the NEM and proposed steps to be taken to address potential threats to reliability and security.
- Providing advice on governments' action affecting the NEM.
- A procedure for individual Board members to advise other members immediately on becoming aware of an emerging risk that is relevant to the responsibilities of the other members or the system as a whole.
- A process of notification for where a Board member's action could impact on the performance of responsibilities by another member or the system as a whole, or where the action may have implications for the overall response to an emerging situation, the first member will ensure sufficient notice of the proposed action is provided.
- A process to respond to an emerging risk or broader system stress by coordinating between the members of the Board, where more than one member has responsibility for responding to the situation.
- Providing an annual *Health of the NEM* public report to the Energy Council describing the performance of the system, the actual and emerging risks and progress against the Statement of Expectations issued by the Energy Council.

The ESB should be established as a matter of urgency by the Energy Council. After a period of three years, the Energy Council should review its performance and future. At this time, the Energy Council should consider including the ESB in any new AEMA and developing legislation to give the new body statutory recognition and functions.

The ESB will likely need to be located within an appropriate existing institution to help provide administrative support. The Panel considers that one of the energy market bodies would be best placed to provide this support. The Panel considers that AEMO would be well-suited for the location of the ESB.

Given the present responsibility of the Reliability Panel to monitor, review and report on the safety, security and reliability of the NEM and produce an Annual Market Performance Review, its future role will require further consideration once the ESB is established. Important matters to consider will be that it has a broad representation of market participants and stakeholders and that most of the Panel's guidelines are developed to assist AEMO to perform its power system security and reliability functions. The ESB should consider the most efficient arrangement for the Reliability Panel to operate as a matter of priority and introduce and make recommendations to the Energy Council.

Recommendation 7.2

The COAG Energy Council should immediately agree to establish an **Energy Security Board** to have responsibility for the implementation of the blueprint and for providing whole-of-system oversight for energy security and reliability.

- The Energy Security Board should be provided with the necessary funding to operate.
- The Energy Security Board should be comprised of an independent Chair, supported by an independent Deputy Chair, with the Chief Executive of the Australian Energy Market Operator and the Chairs of the Australian Energy Regulator and the Australian Energy Market Commission as members.
- Administrative support for the Energy Security Board should be provided by the Australian Energy Market Operator.

A new AEMA required to reaffirm national commitment

In a federal system, different levels of government have different priorities and pressures. The AEMA reflects a cooperative framework to deliver long-term collective benefits to outweigh any short-term pressures on parties to act unilaterally. Under the AEMA, governments agreed not to take any action *“that would limit, vary or alter the effect, scope or operation of the Australian Energy Market Legislation without the agreement”* of the Energy Council.³⁶²

In recent times the commitment of governments to this national approach to energy policy has been tested. One complicating factor has been that the AEMA explicitly recognises that it does not prevent parties from developing policies relating to environmental (including emissions reduction), energy efficiency (including demand management) and planning issues within their own jurisdictions. Compounding this situation is the fact that the parties also agreed in the AEMA to establish a framework for further reform to *“address greenhouse emissions from the energy sector”*.

In these circumstances, it is appropriate to develop a new intergovernmental agreement to reaffirm Australian governments’ commitment to the NEM and a national, integrated approach to energy and emissions reduction policy. The existing AEMA is not legally binding, nor would be the new agreement. However, the process of reaching and signing a new intergovernmental agreement would reinforce to governments the importance of taking a uniform national approach to energy markets. The new agreement should also recognise Australia’s international commitment to reduce emissions and governments’ commitment to align efforts to meet this target with energy market frameworks. While parties may wish to continue with State and Territory-based emissions reduction and energy efficiency policies, they should agree that this be done in a way that aligns with energy market frameworks.

A new mechanism required to assess governments’ actions that affect the NEM

Consistent with the views expressed in the Chapter 2 and Chapter 3, any emissions reduction targets by government that are more ambitious than a national target to reduce emissions to 26 to 28 per cent on 2005 levels by 2030, will be assessed in the context of the security and reliability obligations recommended in this Review, including regional impacts. The ESB should also be consulted for views on security, cost and reliability impacts of new or adjusted targets.

362. AEMA, Cl.6.7.

In its submission to the Review, the Australian Energy Council proposed the development of “*clear and rigorous criteria for assessing proposals by jurisdictions who seek derogations*” as a useful mechanism to ensure the costs and benefits of such choices are transparent.³⁶³ Market bodies proposed a similar mechanism to the Review to ensure better transparency of the consequences of governments’ unilateral actions. This would involve amending the AEMA to require any jurisdiction seeking to take a unilateral action that falls within the scope of the AEMA to notify the Energy Council prior to taking the action. The notification would explain the nature of the proposed action and its impact on the effectiveness of the national energy frameworks and expected outcomes. Market bodies would then provide advice to the Energy Council on the impacts of the proposed action taking into account the objectives of the AEMA. This advice would be published.

This proposal has merit. It will ensure greater accountability and transparency to the community on the likely impacts of a government’s unilateral action. The ESB would be well placed to provide this advice and should be required to do so within 28 days of receiving a notification from a jurisdiction. If a jurisdiction does not notify the ESB of its intention to undertake a unilateral action but the ESB becomes aware that such a change is being seriously considered, it should advise the Energy Council.

Recommendation 7.3

By mid-2018, COAG leaders should agree to a new Australian Energy Market Agreement that re-commits all parties to:

- Taking a nationally consistent approach to energy policy, that recognises Australia’s commitment in Paris to reduce emissions and governments’ commitment to align efforts to meet this target with energy market frameworks.
- Notifying the COAG Energy Council if they propose to take a unilateral action that falls within the scope of the Australian Energy Market Agreement prior to taking the action.
- Within 28 days of notification, the Energy Security Board will provide advice to the COAG Energy Council on the impacts of the proposed action taking into account the objectives of the Australian Energy Market Agreement.

Energy Council annual reporting

Transparency is essential for ensuring accountability and enabling the performance of a body to be properly assessed. The Energy Council was previously required to provide an annual status report to COAG but this formal report back mechanism was removed in 2014. The Energy Council is now required to report to COAG only when it believes there is a matter deserving of leaders’ attention. Since 2014, the Energy Council has not provided a formal report to COAG despite the significant events of the last three years that have given rise to this Review. In light of this, the Panel considers that a formal report back mechanism should be reinstated. The Energy Council should annually update leaders on emerging issues of concern and strategic priorities for each coming year.

Recommendation 7.4

By end-2017, the COAG Energy Council should commence annual public reporting to COAG leaders on its priorities for the next 12 months and progress against the strategic energy plan.

363. Australian Energy Council submission to the Review, p.39.

Performance indicators

Market bodies report publicly on their performance through their annual reports. This reporting can be strengthened through greater use of outcomes-based performance indicators. The Energy Council currently issues a Statement of Expectations to the AER and the AEMC, which are then required to provide an annual Statement of Intent outlining how they will meet these expectations.

The most recent Statement of Expectations issued in 2013 provides limited strategic direction to the market bodies and little guidance regarding the measurable system outcomes that the Energy Council expects the market bodies to help achieve. The Key Performance Indicators (KPI) focus on:

- progress on work program
- expenditure against budget
- engagement with stakeholders
- improving capabilities.

As a result, the most recent Statement of Intent from the AEMC contains process-related KPIs, such as timeliness for rule changes and budget management.³⁶⁴ The outcome-based strategic priorities specified by the AEMC include:

- strengthening consumer participation while continuing to promote competitive retail markets
- promoting development of efficient gas markets
- developing market arrangements that encourage efficient investment and flexibility.

While these are appropriate priorities they provide no quantifiable way of measuring performance. The statements should give a clearer indication of the Energy Council's priorities and expectations for the NEM and include performance-based outcome KPIs. This would include emphasising Energy Council's expectation of collaboration between the market bodies.

The Energy Council should also provide the new ESB with a similar Statement of Expectations and an outcomes-focused "Statement of Role" to AEMO. The AER currently has two Statements of Expectation to which it is expected to respond – one from the Energy Council and one from the Australian Government. These should be consolidated into one new Statement of Expectation. Consistent with the *Public Governance, Performance and Accountability Act 2013* these energy market bodies' Statements of Expectations should be refreshed every three years and responded to annually by a Statement of Intent.

Market bodies' KPIs also do not include any reference to whole-of-system outcomes. The ESB - advised by the market bodies - should report to the Energy Council against whole-of-system performance indicators to enable better shared accountability for NEM outcomes. These shared KPIs would enable market performance to be assessed by the Energy Council and allow it to give appropriate directions to the ESB and market bodies.

Health of the NEM Report

At present, the outcomes being delivered by the NEM are reported through a vast array of publications by market bodies, state governments and private companies. The most significant of these are the AER's annual *State of the Energy Market* report and annual market performance reviews by the Reliability Panel. There is no single document that consolidates and synthesises the key information. An important responsibility for the ESB will be to provide an annual *Health of the NEM* report to the Energy Council that provides an assessment of the performance of the NEM, the market bodies' performance against shared KPIs, and any significant opportunities and risks in the NEM that require attention and how the ESB proposes to deal with them. Given the complexity

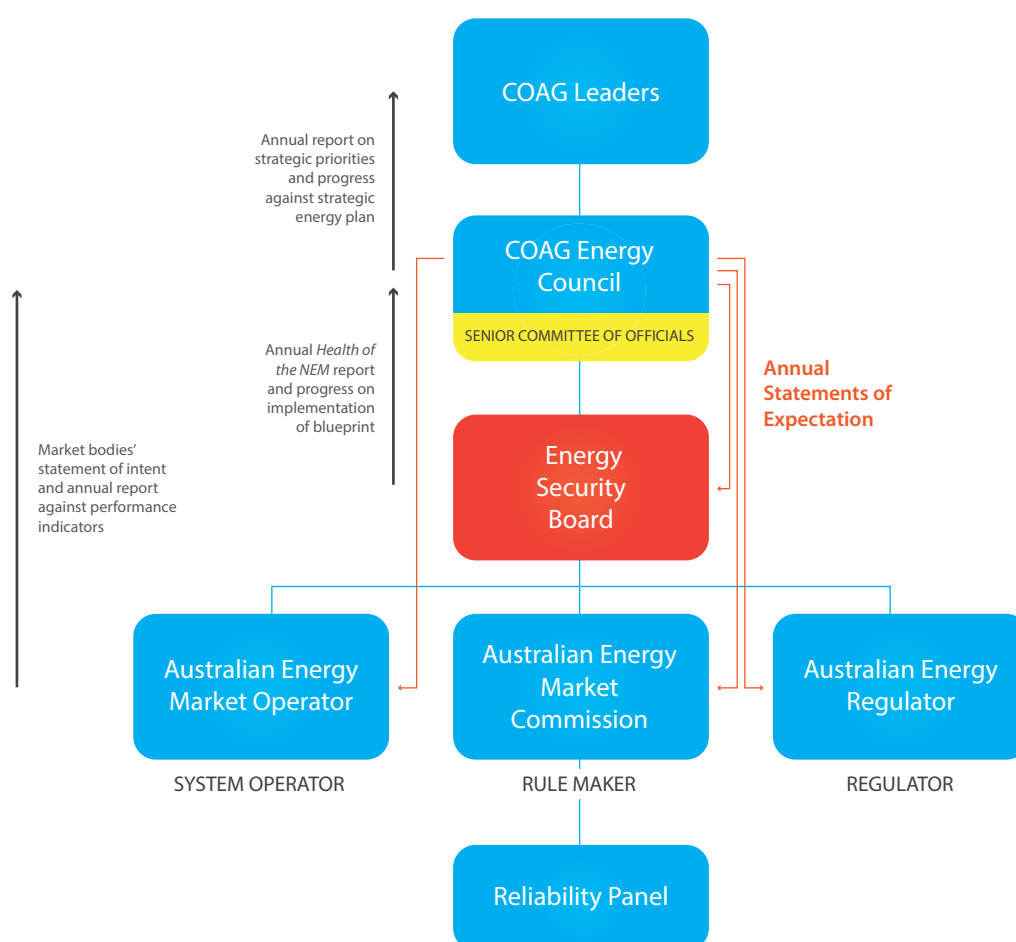
364. AEMC, <http://www.aemc.gov.au/getattachment/51d50777-9999-4c37-af83-71d65812f511/Statement-of-Intent-of-the-Australian-Energy-Marke.aspx>, accessed 3 June 2017.

of the NEM and emerging risks, the ESB Chair also has a role to play in publicly explaining and communicating electricity market issues to the community.

The *Health of the NEM* Report should be provided to the Energy Council on an annual basis. It would draw on the work of the AER and the Reliability Panel and other reports, as required. It should also include details about the progress of implementation of the blueprint. This will ensure greater public transparency of NEM outcomes, key risks and actions, and their joint ownership by market bodies.

The aim of this public reporting scheme is to provide greater visibility of market bodies performance and integrated understanding of system wide issues. The proposed accountability and reporting framework is illustrated in Figure 7.3.

Figure 7.3: Proposed NEM accountability and reporting framework



Recommendation 7.5

By mid-2018, the COAG Energy Council, in consultation with the Energy Security Board, should issue new Statements of Expectations to the Australian Energy Regulator and the Australian Energy Market Commission, and a Statement of Role to the Australian Energy Market Operator containing a comprehensive set of outcomes-based performance indicators.

Recommendation 7.6

By end-2017, the Energy Security Board should provide an inaugural, annual *Health of the NEM* Report to the COAG Energy Council describing:

- The performance of the system.
- Performance against whole-of-system key performance indicators.
- Opportunities for market development including actual and emerging risks.
- Progress against a Statement of Expectations.

7.3 Responding to changes in the market

Stakeholders have expressed concerns about the ability of market governance arrangements to respond effectively to the rapid changes in the NEM. Concerns principally focus on the Rules, including:

- The complexity and prescriptive nature of the rules and the fact that they have failed to keep up with changes in the NEM.
- The time taken end-to-end for the rule change process being too long.
- The role of the National Electricity Objective in the rule change process.

Complexity of the Rules

The Rules provide much of the detail about, and prescribe procedures for, the operation of the NEM. They are divided into chapters on different issues and for most market participants only a few chapters have direct relevance. Over time, the Rules have grown in length and detail, having been amended on average about once every six weeks. The length and breadth of the issues covered mean that very few people are familiar with every aspect of the Rules.

The level of detail in the Rules is partly due to the complexity of the electricity market. Market participants may prefer the certainty of prescriptive rules over the uncertainty that may arise from a more principles-based approach. On the other hand, it is also true that unnecessary regulation and complexity can create additional costs for market participants, act as a barrier to change and impede innovation.

In its submission to the Review, AEMO proposed a streamlining of the Rules; it argued that the current “*hierarchical regulatory layers*” in NEM frameworks were time consuming to change, creating uncertainty and risk for investors. It proposed using the upper regulatory levels to define role and policy principles with broad expression, with detailed processes and settings within the control of market bodies.

Industry change is taking place at an increasing pace, with technology and business models far less predictable than they were at NEM commencement. An effective response to this rapid industry evolution requires innovation in the management of regulatory reform.³⁶⁵

AEMO

There may be potential to streamline the Rules. The Energy Council has accepted a recommendation of the Vertigan Review that the AEMC conduct a comprehensive review of the Rules, but this recommendation has not been implemented. Rather, the Energy Council requested the AEMC to provide advice, from a high-level, issues-based perspective, on matters covered under the Rules that may require further consideration. While this

365. AEMO submission to the Review, p.35.

advice will be of assistance, there remains considerable value in a comprehensive audit of the Rules to ensure they remain fit-for-purpose.

A comprehensive review of the Rules would be a lengthy process and would need to be carefully managed to avoid creating uncertainty. The Panel notes that the AEMC is specifically empowered under the NEL to conduct a review into the *“operation and effectiveness of the Rules”* or *“any matter relating to the Rules”*.³⁶⁶ The Energy Council is also similarly empowered under the NEL to seek a review of the Rules.³⁶⁷ These provisions evidence governments’ intention at the time the NEL was passed to conduct a review of the Rules at some time in the future. Given that considerable resources and effort required, it could be undertaken over an extended period and feed into the review of the ESB in three years’ time.

Recommendation 7.7

The COAG Energy Council should request that the Australian Energy Market Commission, or alternatively the Energy Security Board or other suitable body, complete by end-2020 a comprehensive review of the National Electricity Rules with a view to streamlining them in light of changing technologies and conditions.

Rule change process

One of the main concerns expressed by stakeholders to this Review is the length of time for decisions to be taken in response to rapid changes in the NEM.

The rule change process and timeframes are set out in Part 7, Division 3 of the NEL. The standard timeframe under the NEL for consultation and making a rule change is 130 working days – around six months. This includes one round of public consultations after an initiation notice and another round following a draft determination. In practice, the end-to-end process takes considerably longer. The AEMC provided the Panel with data relating to rule change proposals dealt with between FY2013 and FY2016. The average time from a rule change being submitted to the AEMC to its finalisation is just over a year.

Since FY2013 rule change proposals submitted by government and non-market participants have taken longer to finalise. The discrepancy arises because the clock only commences when the AEMC publishes a notice of its intention to consider a rule change, rather than on the date when the rule change request is made. The AEMC is required to verify that the request is made in a proper form, is not misconceived, and is not already addressed by an existing rule or another request. It also may request further information from a proponent before starting the rule change process. The AEMC also has the power to extend the length of the rule-making process if it considers that a rule change request raises issues of *“sufficient complexity or difficulty”* or if *“there is a material change in circumstances such that it is necessary”*.³⁶⁸ In FY2015, the AEMC commenced about 47 per cent of rule changes within four months of receipt and extended about 32 per cent of rule changes.³⁶⁹

The amount of time taken to process a rule change proposal is significantly influenced by its content and nature. Some rule changes from government and non-market participants have contained broad proposals which, if made, would have had a significant impact on the market and raise a complex range of issues. The complexity of

366. NEL, s.45.

367. NEL, s.41(1).

368. NEL, s.107.

369. AEMC, Annual Report 2015/2016, 2016, p.52.

a rule change request will affect the amount of time to deal with it; further work may be required to clarify the nature and terms of the rule change proposed. For this reason, proponents can help achieve a timely rule change process by clearly defining and drafting their proposals.

Proposed rule changes arising from an AEMC review requested by the Energy Council take the longest to be dealt with. There are also no statutory timeframes for reviews to be completed, considered by the Energy Council, and any subsequent request for a rule change arising from the review to be made.³⁷⁰

There have been significant delays in the Energy Council submitting a rule change arising from an AEMC review it has commissioned. In practice, it takes around 14 months between the AEMC finalising a review, and the Energy Council submitting a rule change request. In some cases it has taken up to two years.

Rule change proposals submitted by the Energy Council can sometimes differ from those recommended by the AEMC in a review. In a number of cases, the AEMC declined to make the rule change requested, despite recommending that rule change in its initial review. In those cases, as the Vertigan Review highlighted, the length of time taken to make a decision meant that the market had moved on without resolution of the policy issue being addressed, *"to the point where the issue had lost relevance"*.³⁷¹ While there may be valid reasons in each case for not making the rule change proposed, the time and cost expended by all parties, sometimes for little tangible outcome, raises the question whether a quicker resolution of rule change processes could be achieved.

Rule change proposals

Some stakeholders have suggested that the AEMC should be able to initiate rule changes. This would address time taken by the Energy Council to initiate rule change proposals. The AEMC does not support such a change. It argues that it is not appropriate for the rule-maker to also propose rule changes. Others noted that the prohibition on the AEMC initiating rule changes is an important check and balance on a significant rule-making power. If changes are required then there is nothing stopping AEMO or the AER proposing them. In future, the ESB could propose rule changes via the Chair. There is also nothing preventing other interested parties submitting a rule change proposal arising from an AEMC review, where this has not yet been done by the Energy Council.

Balancing complex issues

In addressing concerns about the duration of the rule change process, the AEMC stated in its submission to the Review that a *"considered and consistent approach to reform is desirable as inappropriate regulatory or policy decisions, or policies that change too often have significant consequences for markets"*.³⁷² Rule changes that are complex and have significant implications for the market – such as the proposed five-minute settlement rule – require careful consideration.

*We are aware of a perception held by some stakeholders that this process unnecessarily extends the time period before words (policy recommendations) are converted to action (rules), particularly where extensive analysis and consultation has already occurred as part of a completed AEMC review. However, matters that are considered in reviews are not trivial. They may involve multiple rules, proposed changes to the Law, affect multiple and diverse stakeholders, or have a non-energy policy component, such as understanding the potential consequences for financial markets in response to the failure of a large market participant.*³⁷³

AEMC

370. To deal with this problem, the AEMC has suggested that the Energy Council respond to reviews within six months to enable rule changes proposed to be dealt with under the fast-track or standard rule-making process.

371. Vertigan M, Yarrow G, and Morton E, *Review of Governance Arrangement for Australian Energy Markets: Final Report*, 2015, p.45.

372. AEMC submission to the Review, p.9.

373. AEMC submission to the Review, p.13.

AEMO's submission stressed that the rules and the process to change them need to keep pace with the rate of change:

The regulatory framework has to pre-empt investment change. However in the NEM, regulatory change can take upwards of a year to define, and several years to effect. Uncertainty and risk for investors, inefficiency for the market, and risks for power system security can flow from this slow regulatory change.³⁷⁴

There is clearly scope to prioritise streamlining the rule change process. The AEMC's rapid progression of rule change proposals through the System Security Market Frameworks Review provides a model. If additional resources are required to enable this to occur, the Energy Council should consider increased funding following appropriate advice from the ESB. Achieving timelier rule changes also requires a commitment by all involved to play their part to speed up the process.

Expediting the rule-change process

Under the NEL, rule change proposals can be fast-tracked or expedited in certain circumstances.

Under the fast-track process, the AEMC may make a rule change in four months by issuing a draft rule upon commencing the process, where there has been a previous public consultation by an electricity market regulatory body or Energy Council-directed AEMC Review (s.96A). There is no requirement to hold the 'first round' public consultation on notification of the rule change request. The fast-track process has not been used since 2009. In large part, this is due to uncertainty about what constitutes previous public consultation. The AEMC believes the delay between when it recommends a rule change as part of a review and when it receives a request from the Energy Council is generally too long to enable it to make use of the fast-track process.

Under the expedited process, a rule change can be made in six weeks if it is either "non-controversial" or "urgent". A rule change is considered to be urgent if it deals with a matter that is "imminently prejudicing or threatening" the effective operation or administration of the wholesale market or the safety, security or reliability of the NEM. The expedited rule change process is used by the AEMC, but not for the majority of rule change proposals. Since FY2013, no rule changes were put to the AEMC as urgent and none were expedited on that basis. The most recent rule change made on an urgent basis was in 2009 in relation to the Reliability and Emergency Reserve Trader mechanism to enable it to operate during a period of high demand. However, a number of rule change requests have been expedited on the basis that they were non-controversial.

The Vertigan Review also recommended a number of reforms to expedite the rule-making process and ensure proper consideration of rule change proposals. These included recommending the AEMC develop a staged review process for more complicated matters to reduce duplication in the consultation process and shorten the time taken. It also supported an AEMC proposal to develop a single-step review process for specific or contained issues. This would involve the AEMC including a draft rule change with its review final report. An expedited rule change process for less complex rule changes, with legislative changes to allow for an increased timeframe range of six to eight weeks for the process, was also proposed. These proposals should be implemented as soon as possible.

In a joint submission to the Review, market bodies acknowledged the AEMC could make use of the expedited rule change process for a broader range of matters. They also committed to work together to establish a clear understanding about the level and nature of previous public consultation required to trigger the fast-track process, to enable this to be used more frequently. They suggested that all rule change proposals resulting from an Energy Council-directed review should occur through the fast-track procedure. They also proposed that the AER and AEMO develop guidelines and procedures concurrently with a rule change process where they will be required to implement new arrangements.

374. AEMO submission to the Review, p.34.

If a rule change is requested by the Chair of the ESB, AER or AEMO with an indication that it is urgent, the AEMC should consider this is sufficient to constitute an “urgent rule” for the purposes of the expedited process under the NEL.

The Vertigan Review also recommended that the AEMC implement a ‘start the clock’ provision upon receipt of a rule change. This recommendation was not accepted by the Energy Council. Nevertheless, there is scope to improve the end-to-end rule change process and opportunity for the fast-track and expedited processes to be used more frequently. The ESB should prioritise working with the market bodies and the Energy Council to achieve this, including developing a protocol for dealing with proposed rule changes arising from an AEMC review.

Trialling rule change proposals

There is merit in trialling new regulatory approaches on a “sand-boxed” basis. In many cases, nothing prevents this occurring already under the existing regulatory framework, apart from a willingness of market participants to trial innovative approaches. However, market participants appear reluctant to trial new approaches if they are not explicitly allowed by the Rules.

Where a trial is explicitly prevented by the Rules, the use of time-limited rules could be considered to enable it to occur. The AEMC would need to be empowered to make such rules. This should be further considered by the ESB and advice provided to the Energy Council. As detailed in Chapter 2, the AEMC should be requested to review and update the regulatory framework to facilitate trialling proof-of-concept technologies.

Recommendation 7.8

Recommendations of the Vertigan Review to expedite the rule-making process should be implemented by end-2017.

Recommendation 7.9

The Energy Security Board should prioritise work with energy market bodies, the COAG Energy Council, and other relevant stakeholders to further optimise the end-to-end rule change process.

National Electricity Objective

The overarching objective of the NEL is the National Electricity Objective (NEO). The NEO is much more than just an objects clause for the NEL. It guides and constrains energy market bodies in the discharge of their powers and functions, and ensures performance is focussed on the long-term interests of the consumer. Importantly, when considering whether to make a new rule or when conducting a review, the AEMC is required to consider whether this is consistent with the NEO.

The AEMC explains in detail how it interprets the NEO in its guide for stakeholders, *Applying the Energy Objectives*. This guide explains that the NEO is an economic concept and is intended to focus the operation of the NEM and market bodies on efficiency in the long-term interests of consumers. Importantly, this “recognises that there is an inherent trade-off between consumers today, and consumers in the future”.³⁷⁵

The absence of any reference to emissions reduction does not mean that such issues cannot be taken into account by market bodies. Rather, they can only be taken into account if they are consistent with or contribute to the achievement of the NEO. The non-inclusion of any environmental or emissions reduction objectives in the NEO has been a point of contention since its formulation.

375. NEL, s.96.

In submissions to this Review, the AER, AEMO and the AEMC argued against the inclusion of any reference to environmental considerations in the NEO. They argued the inclusion of such considerations would create multiple, potentially competing objectives, which they would be required to reconcile in their decision making with little practical guidance. The AEMC argues that keeping the NEO focussed on an economic objective enables market bodies to focus on the efficient operation of the market in the long-term interests of consumers. This contributes to greater predictability and transparency of the rule-making process.³⁷⁶ This view was echoed by a number of market participants.

There were equally strong views in support of amending the NEO to include environmental considerations. Supporters of an amended NEO argue that non-inclusion results in an absence of “*price signals to foster research, development and deployment of renewable energy, energy efficiency or demand management*” in the NEM.³⁷⁷ In its submission to the Review, the Total Environment Centre, supported by a number of environment groups and the City of Sydney, argued that by treating emissions reduction as an externality, the NEO has been partly responsible for economically inefficient investment, and has hindered emissions reductions in the NEM. In particular, the submission cited the AEMC’s approach to demand management, optional firm access and local generation credits. It argued the AEMC should include the long-term cost of climate change as part of its consideration of the “long-term interests of consumers”.³⁷⁸

The Panel considers that what is likely to have a bigger impact on market bodies’ decisions are clear and effective emissions reduction policies, including agreement by jurisdictions on a national emissions reduction trajectory and mechanism (see Chapter 3). In developing these policies, energy market bodies will be well placed to provide advice to the Energy Council on their practical impact on the NEM. While a number of other countries have an environmental objective in their regulatory frameworks and have experienced no adverse consequences, they also have different regulatory approaches. In the long run, amending the NEO risks greater uncertainty in market bodies’ decision making processes.

Nevertheless, the Panel considers that there would be value in the Energy Council providing a Statement of Policy Principles to the AEMC under section 8 of the NEL to provide clearer policy guidance and clarity on the application of the NEO in the rule-making process. Given that the core of the NEO is the long-term interests of consumers with respect to, among other things, “reliability and security of supply of electricity”, this could include guidance to the AEMC on how issues of emissions reduction and environmental sustainability can be taken into account. This would not require a change to the NEL.

Recommendation 7.10

By mid-2018, the COAG Energy Council should issue a Statement of Policy Principles to the Australian Energy Market Commission to provide further clarification and policy guidance on applying the National Electricity Objective in the rule-making process.

As the market transitions, the Energy Council will benefit from the advice and engagement of market bodies and the ESB in its consideration of matters related to emissions reduction. Alignment of emissions reduction and energy policy may also be assisted by input from the CER, ARENA and the CEFC. They should be invited, along with energy market bodies and the ESB Chair, to attend Energy Council meetings to provide ministers with advice and input into relevant policy discussions.

376. AEMC, *Applying the energy objectives*, 2016, p.3.

377. Wright, G, *Reforming the National Electricity Objective: March 2013*, 2013, p.5.

378. Total Environment Centre submission to the Review, p.10.

7.4 Other issues limiting effective governance

Resourcing of market bodies

Well-resourced market bodies are a key element of a properly functioning NEM, particularly at a time of rapid market transition. Recommendations in this report have clear resource implications so the Review considered whether market bodies have sufficient financial resources to adequately perform their existing functions and those recommended by the Panel.

The Vertigan Review recommended that the funding mechanisms for the AER and the AEMC should be reviewed *“to promote the ‘national’ character of each institution and to align with the principle that their funding be more closely reflective of resource and/or workload causation”*.³⁷⁹ It also found that the AEMC and the AER should both be funded by all jurisdictions in a manner determined by the Energy Council. Given the recommendations in this report, the Energy Council will need to ensure they are appropriately funded to implement the Blueprint.

The requirement for an increase in funding for the AER is particularly pressing. The necessary level of funding will be determined in part by whether another recommendation of the Vertigan Review is implemented – the structural separation of the AER from the Australian Competition and Consumer Commission (ACCC). However, even without this separation, the current level of AER funding is inadequate. Compared to 2005, the AER now enforces more than three times as many laws and rules, monitors more than four times as many market participants, regulates more than four times as many networks, and is responsible for monitoring 58 retailers. Although the AER’s staffing has doubled over the same period, this has not been sufficient to keep pace with the additional workload. The Australian Government has provided the AER with an additional \$8.0 million in FY2018 on top of its existing budget of around \$41 million to ensure it is sufficiently resourced, pending further analysis of resourcing requirements.

In recent years, the Energy Council and the AEMC have conferred new roles upon the AER in response to rapidly changing market conditions, including in relation to network regulation, market monitoring and enforcement and consumer education. For example, the AER is now required to monitor wholesale markets to determine whether there is effective competition within the market and to identify factors that may be impacting detrimentally on the efficient functioning of the market. Given stakeholder concerns about market manipulation last summer during periods of high demand, the AER will have a critical role in providing market analysis to the ESB and the Energy Council.

The AER’s funding and resourcing has not kept pace with its additional responsibilities, making it difficult to perform its functions effectively. This should be remedied as a matter of priority. The AER’s role is likely to continue growing as the energy market evolves so its resourcing will need to be reviewed regularly to ensure it remains an effective regulator.

The OECD Best Practice Principles for Regulatory Policy state that a regulator should be funded at an adequate level to enable it, operating efficiently, to effectively fulfil legislated obligations and the objectives set for it by government.³⁸⁰ The AER needs stable and sustainable long-term funding if it is to be an effective and best practice regulator. Governments and all stakeholders need to have faith in the credibility and legitimacy of the regulator. Better funding of the AER will increase its oversight and responsiveness. Recommendations in this Review will provide improved accountability for this additional funding. The new ESB also needs to be appropriately funded.

379. Vertigan M, Yarrow G, and Morton E, *Review of Governance Arrangement for Australian Energy Markets*, Final Report, 2015, p.9.

380. OECD, *OECD Best Practice Principles for Regulatory Policy: The Governance of Regulators*, 2014, pp.98-103.

Recommendation 7.11

The COAG Energy Council should ensure that the Australian Energy Regulator and the Energy Security Board are adequately funded to undertake their responsibilities, including implementing the blueprint.

Human resources

Financial resources are only part of the picture. It is important that the market bodies attract and retain personnel with the requisite skill and experience in energy markets. For example, high turnover in staff can create a loss in important corporate memory and historical understanding of issues arising in energy markets.

It is also important that the market bodies have leadership that understands all aspects of the challenges confronting them – economic, engineering, regulatory and legal – and develops a proactive culture of responding to them. The Review has undertaken an analysis of the backgrounds of the boards of energy market bodies to determine whether this is the case. In analysing the boards of the market bodies, it was evident to the Panel that market bodies possess strong skills in certain aspects of energy markets but need additional skills in other areas; particularly, power system engineering. This was especially the case in relation to AEMO. In consultations, network operators expressed concern that the current AEMO board only has representation from generation and retail companies, and there is little networks expertise.

The boards of market bodies should be appointed on a skills basis, rather than on a representative basis. The Panel notes that the AEMO constitution only requires a minimum of three board members with industry experience. Given the changes underway in Australian energy markets and the challenges to reliability and security, the Panel considers that this is insufficient and the number should be increased. The AEMO board skills matrix contained in its constitution should be refreshed to include the broader range of skills required by the market operator.

One barrier to appointing independent directors with appropriate experience is the requirement under AEMO's constitution that independent directors cannot have been employed or retained by a member company in the previous three years. This requirement has the effect of limiting the already small pool of candidates with experience and skills in energy markets. This limitation on independent directors is consistent with the ASX Corporate Governance Principles.³⁸¹ However, in light of the need to increase the skills base on the AEMO board and the limited pool of candidates, the Panel considers that the three-year cooling off period for independent directors should be reduced to six months. While this may give rise to a greater risk of conflicts of interest, the Panel considers that this can be dealt with under current safeguards and procedures. The six-month cooling off period should also apply to candidates for the independent chair and deputy chair of the ESB.

Recommendation 7.12

By end-2017, the Australian Energy Market Operator should update its Constitution by developing a new skills matrix for directors that will ensure appropriate representation of professional power systems engineering or equivalent expertise.

Recommendation 7.13

The three-year cooling off period for independent directors of the Australian Energy Market Operator should be reduced to six months.

381. ASX Corporate Governance Council, *Corporate Governance Principles and Recommendations*, 2014, p.16.

Incumbency bias

A number of submissions to the Review complained of an “incumbency bias” in favour of the status quo on the part of energy market bodies to the detriment of consumers and new market participants.

*The welfare of the incumbent industry has always been a priority – in the case of energy networks, at enormous expense to consumers.*³⁸²

Alan Pears

For AEMO, the perception of incumbency bias is re-enforced by its funding model, which relies, in part, on industry co-contributions.

*While supporting AEMO’s activities, these funding arrangements make no provision for adaption or innovation. Further, AEMO’s governance arrangements may create a bias toward status-quo rather than innovation and adaption to technological change.*³⁸³

Clean Energy Council

There was a similar concern that the AEMC rule change process favours market participants over energy users.

*Consumers feel they have little influence on the market current[ly] where consumer involvement is all about “advisory committees” which it seems are little more than “tick the box” activities.*³⁸⁴

Energy Users Association of Australia

The perception of incumbency bias is difficult for market bodies to address while at the same time ensuring that board members and senior staff have the necessary skills and industry experience to perform their roles. Market bodies have robust procedures to prevent actual and perceived conflicts of interest among staff and board members. AEMO directors have a legal duty under the *Corporations Act 2001 (Cth)* to act in the best interest of the company and disclose conflicts of interest.³⁸⁵ Concerns about incumbency bias can be addressed by ensuring a thorough selection process and board appointments that take into account the diversity of skills and experience required in energy markets. Concentration of board representation from a small number of sectors should be avoided.

Market bodies can also ensure all stakeholders are given a full opportunity to be heard through conducting broad consultation processes. This would build stakeholder confidence and trust. As highlighted by the Grattan Institute, market bodies would also benefit from having a better insight into consumer preferences and the value they place on the competing trilemma objectives.³⁸⁶ In this regard, the Vertigan Review recommended expanding the board of the AEMC to five commissioners to allow it to expand its stakeholder engagement, particularly with consumers. Legislation to implement this recommendation should be prioritised. Energy Consumers Australia also plays an important role in the AER regulatory determination process in promoting the long-term interest of consumers. At the same time, market bodies must be vigilant to ensure that consultation processes do not unnecessarily delay decisions being made.

382. Alan Pears submission to the Review, p.6.

383. Clean Energy Council submission to Review, p.43.

384. Energy Users Association of Australia submission to Review, p.10.

385. Under its constitution, a Director is considered an Independent Director if the Director is a non-executive Director who is not a member of management and is free of any business or other relationship that could materially interfere with the exercise of their unfettered and independent judgment or could reasonably be perceived to do so. In particular, independent directors cannot be associated directly with a member of AEMO or been employed or contracted to a member in the last three years.

386. Grattan Institute submission to Review, p.9.

Structural separation of the AER from the ACCC

The structure and governance of the AER has received significant attention in recent years, including from the Vertigan review and the Harper Review of Competition Policy. In considering this issue, Vertigan was persuaded that the roles of the ACCC and the AER were significantly different and this influenced the skills and organisational culture required. The AER's primary role is as an economic regulator while the ACCC is more focused on compliance and enforcement of competition and consumer law.

Network regulation in particular requires a distinctive blend of skills and a particular culture, since in this activity the regulator is very frequently substituting its own economic decisions in relation to matters that would normally be settled by a market. This is very different from, say, the legislative task of establishing rules or the enforcement of competition law. In other words acting as a substitute for and serving as a complement to market exchange and initiative are different roles".³⁸⁷

Vertigan Review

The Harper Review of Competition Policy³⁸⁸ also found that the culture and analytical approach required to regulate an industry differed from those required of a competition law enforcement agency. It recommended the creation of a single, cross-sectoral Access and Pricing Regulator to strengthen analytical capacity for economic regulation and provide consistency across regulatory frameworks between sectors. A cross-sectoral regulator would also avoid the possibility of an industry-specific regulator being susceptible to 'capture' by the regulated industry.

In contrast, the Vertigan Review recommended that the AER become a dedicated regulatory body for the energy sector with full management and financial autonomy of the ACCC. This was seen to be necessary because of the challenges faced by the sector and the particular skills and culture required.

The [Vertigan] Panel considers that the key issue for the AER's organisational structure is to facilitate the desired culture within the AER. In the Panel's view, establishing the AER as a stand-alone body will encourage it to adopt a culture that vigorously pursues and promotes information discovery, and adapts and adjusts to the new challenges that are being set for the energy sector, consistent with its role as an economic regulator, as opposed to the ACCC, which is predominantly an enforcement body across the economy as a whole.³⁸⁹

Vertigan Review

Careful consideration needs to be given to the relationship between the AER and the ACCC in the context of structural separation, and how this could be preserved through good information sharing, liaison and cooperation. Structural separation could result in a loss of synergies with the ACCC, including access to specialist legal and economic expertise. The significant additional costs associated with establishing and operating a new, standalone body, should be factored into a sustainable funding arrangement for the AER.

On balance, the Panel has reached the same conclusion as the Vertigan Review. The AER's role is highly technical and sector specific. While the ACCC also carries other sector-specific regulatory responsibilities, the AER as a separate energy agency would reflect the energy-specific responsibilities of the other energy market bodies and energy regulators in similar countries. The structure, governance and funding arrangements of the AER are a longstanding concern for key stakeholders, and a decision on structural separation should be resolved, but not without clarity on a sustainable funding arrangement.

387. Vertigan M, Yarrow G, and Morton E, *Review of Governance Arrangement for Australian Energy Markets: Final Report*, 2015, p.63.

388. Harper, I et. al. *Competition Policy Review: Final Report*, 2015, p.80.

389. Vertigan M, Yarrow G, and Morton E, *Review of Governance Arrangement for Australian Energy Markets: Final Report*, 2015, p.68.

Information management in the NEM

The availability of timely and accurate information is critical to good governance. It underpins decision making across all areas of the NEM, including market operation, investment, policy development and regulatory enforcement.

Existing data management systems, processes and regulations have struggled to keep up with changes in how data are generated and used. They are no longer fit for purpose. Data gathering and sharing arrangements are focused primarily on the traditional needs of the market bodies and market participants such as generators, retailers, traders and network service providers. New technologies, such as smart meters, smart grids and distributed energy resources (DER), are creating a huge range of challenges in how current data systems work, as well as new opportunities to use data to better manage the NEM. Current data sharing arrangements, including in operational systems, create barriers for new service providers, limiting competition and innovation. There are also gaps in data that are not being gathered in an effective way or at all.

No single organisation has a complete view of the NEM. In the face of the rapid changes in the NEM, this situation is no longer adequate, and can result in costs to consumers from less visibility of emerging threats and sub-optimal forecasting, planning and policy-making. To support a smooth transition to a low emissions future NEM, additional, authoritative information is needed to engage a wider set of stakeholders, and to better enable innovation, investment, and performance tracking.

There is a wide range of information in the public domain.

- The market bodies publish reports and other information. For instance, the AER publishes an annual *State of the Energy Market* report, along with supporting datasets related to the wholesale and retail sectors. AEMO releases a significant number of raw data files that cover a variety of operational characteristics.
- There are a number of commercial software applications available that repackage the raw data provided by AEMO, allowing subscribers to query and extract the information of interest.
- There are also a range of other organisations which gather data and publish reports and datasets relating to the NEM.

However, there are barriers to accessing certain types of information. These barriers include privacy concerns, an inability to obtain information in a particular format or timeframe, costs involved in sharing information, and commercial interests. Additionally, there are challenges in how data and information about the NEM is stored and accessed. While there is a lot of publicly available information, there is no central repository or 'single source of truth'. Information is dispersed across reports and datasets published by various market bodies and agencies, making it difficult to piece together. No datasets published by the market bodies are presently available on data.gov.au, the Australian Government's official data platform.

Critical data needs

Through this Review, the Panel has identified some key data needs that should be addressed.

- There is a lack of transparency of information about electricity prices and consumer bills. This issue was discussed in Chapter 6.
- Existing arrangements for sharing electricity consumption data are not effective. Consumers struggle to access their own consumption data in an effective way and to be able to share it with service providers. This issue was discussed in Chapter 6.
- A lack of visibility of DER, including what is installed and how it is operating, is challenging AEMO's ability to manage power system security. This issue was discussed in Chapter 2.
- A recognised gap in data used for NEM forecasting and planning is the limited information on energy consumption and the changing drivers of energy demand. For instance, as a result of current net-settlement arrangements between retailers, no single entity (including AEMO) has access to a complete set of energy consumption data.

An Energy Use Data Model is currently being developed to help address this issue. It will link existing and new datasets relating to electricity consumption, and convert them into a useable and meaningful form on a publicly accessible online platform (while maintaining privacy and confidentiality of the underlying data). A range of stakeholders are already involved in bringing together datasets for the Energy Use Data Model, including AEMO, who will use it as a critical new input to demand forecasting.

The Energy Use Data Model project by CSIRO has been necessary as bringing together these data sets has previously been hindered due to regulatory and governance constraints on the data. Government intervention was required. Issues remain in ensuring that appropriate levels of data access, sharing and transparency are achieved, for example, to be able to link energy consumption data to activities behind-the-meter. A range of regulatory changes may need to be considered. On the basis of the current pilot version, which is already demonstrating strong value, the Australian Government announced in the FY2018 budget forward funding to develop the project over the next four years.

For the Energy Use Data Model to be ongoing, permanent funding, governance, and its role within the market need to be resolved.

- Another key data constraint relates to planning of new development and capacity in the NEM. Networks have a large amount of information on network capacity and constraints and future network investment needs. Improved availability of that data for service providers, generators and large consumers would enable them to make more efficient decisions as to where to locate and how to use generation and distributed energy resources in a way that avoids or defers network constraints and therefore reduces long-term network costs for all consumers.

Some online platforms have been developed to try to improve access to this type of information; though the availability and granularity of this information varies significantly between different network areas. ARENA's Australian Renewable Energy Mapping Infrastructure (AREMI) Program provides authoritative spatial data regarding the availability of renewable energy resources and network infrastructure.³⁹⁰ AEMO prepares an interactive map that allows users to explore the forecast supply and demand characteristics and emerging transmission network constraints. Additionally, some network operators publish their own network capacity maps.

The data within these different mapping platforms is complementary. In particular, the use of AREMI data in transmission planning would enable users to obtain an integrated view of the opportunities and constraints across the NEM and enable improved consideration of new sources of supply in both generation and transmission planning processes. This is also discussed in Chapter 5.

A data strategy to support the strategic plan for the NEM

Section 7.2 outlines the need for a strategic plan for the future NEM. Integral to this, but currently absent, is a data strategy. A data strategy will ensure an adequate evidence base is available for the development of the strategic plan, as well as provide the ability to track the key performance indicators of the NEM and refine the plan as needed in the future. Moreover, it will enhance the availability of data and information to support the market in adapting to rapidly changing conditions. This strategy will also help inform the *Health of NEM* report.

The data strategy should address barriers to accessing information by balancing the needs for particular types of information (including to support emerging services and competition) with the open government data principles. The Australian Energy Council's submission to the Review raises some considerations in this regard.³⁹¹

390. See <https://nationalmap.gov.au/renewables/>, accessed 6 June 2017.

391. Australian Energy Council submission to the Review, p9-10.

It is recommended that the ESB, in collaboration with the AER, be given responsibility for developing and implementing the data strategy. In the longer term, the Panel considers that the AER could take permanent ownership of it, given the complementarities with the *State of the Energy Market Report*.

The Panel recommends the strategy be developed in a phased approach.

Phase 1: The initial program of work should include:

- A rigorous gap analysis, to be undertaken in consultation with industry and other relevant stakeholders. It should consider whether additional measures are needed in terms of market bodies' powers to collect and share information (for example, whether there is a need for a formalised agreement between market bodies and government agencies explicitly detailing information sharing arrangements); the effectiveness of data sharing in operational systems in terms of managing future challenges and supporting innovation; and the publication of other relevant data sets.
- An initiative to develop a catalogue of energy market data and publications. This will help overcome the barrier of not knowing what information is available, who publishes it, and where to get it. Data.gov.au should be considered as the platform for this resource.

Phase 2: A medium-term program of work to enhance and consolidate existing data platforms and disseminate up-to-date information in three ways:

- A dashboard that provides transparency on the performance of the NEM against security and reliability, affordability and emissions reduction objectives, allowing progress to be tracked. The dashboard would be a 'single source of truth' for this information. It should be easy to navigate, and combine high-level information with the ability to drill down to specific areas.
- An ongoing Energy Use Data Model. This will support AEMO with demand forecasting as well as helping new entrants to assess market opportunities.
- A mapping platform that provides a single view into the NEM in terms of generation, networks and consumption, to allow new opportunities to be more easily understood. It should combine the features of the Energy Use Data Model, AREMI and AEMO's interactive map of planning information to provide detailed spatial information regarding predicted generation opportunities, network constraints, expansion plans and support requirements. All network operators should be incentivised to maintain up-to-date information about constraints and opportunities that are forecast to occur in their network.

Phase 3: A longer-term process whereby stakeholders can request access to non-public data for research and development purposes. This process will ensure that unanticipated future needs can be met and future innovation supported. It must consider the benefits of the work that the data would enable, the potential risks to privacy, security, and any existing commercial confidentiality agreements, and the costs of making it available.

Recommendation 7.14

By end-2018, the Energy Security Board, in collaboration with the Australian Energy Regulator, should develop a data strategy for the National Electricity Market.

- The initial design of the data strategy must be developed in consultation with industry bodies and consumer bodies, and be consistent with open government data principles.
- The Energy Security Board must report to the COAG Energy Council on the completion of the first stage. This should include costs for design and implementation for initial set up, plus indicative costs for ongoing maintenance of the key deliverables under the data strategy.
- The first phase of the data strategy must be completed by end-2017, with the functionality of the components of the strategy reviewed annually to ensure that they continue to be fit-for-purpose.

7.5 Conclusion

With a commitment to the Blueprint and coordination provided by the ESB as recommended in this chapter, Australia will return to having a world-leading electricity system. Australians can and should expect no less. The combination of AEMC, AEMO, AER, CER, ARENA and CEFC gives the NEM a powerful platform across market development, regulation, operations and innovation. Strong governance arrangements will empower these institutions to implement the Blueprint and proactively manage emerging issues in the energy transition.

Chapter 8

BEYOND THE BLUEPRINT

Overview

The other chapters of this report deliver a blueprint for a NEM that provides a secure, reliable and affordable source of electricity, and reduces its emissions over time in line with international commitments.

This chapter will broadly explore some high-potential technologies and projects that could be considered by government and investors, **which are beyond the scope of the blueprint**, but may have a place in a future NEM. These cover generation, storage and system security technologies, among others.

8.1 A range of possible technological futures

The manner in which technologies develop, and costs change, is likely to evolve over the medium and longer term. There are a range of possible technological futures for the electricity generation mix. No single technology can supply all electrical services, and there are benefits to a diversified generation mix.

The technologies discussed in this section could support emissions reduction as well as security and reliability objectives, but require further innovation and deployment. In some cases they may need to overcome barriers such as lagging standards and regulation to become feasible. It is intended that the future NEM should be conducive to any of these technologies, in line with the principle of technology neutrality. Whether the technologies are commercial or practical remains to be proven by the initiative of governments and investors.

Development of technologies will take time and require strong and ongoing policy support. The Australian Renewable Energy Agency (ARENA) plays an important role in this process by providing grants to accelerate the development of promising technologies towards commercialisation. Private investment in projects may also be supported by other types of government grants, tax concessions, or Clean Energy Finance Corporation (CEFC) debt.

8.2 Generation technologies

This section discusses electricity generation technologies. Technologies that involve a synchronous generator are particularly useful for power system security because they provide physical inertia to help dampen rapid frequency changes, increase fault current to help maintain system strength, and have the ability to supply or absorb reactive power to help control voltage.

Biomass

Biomass is plant and animal derived organic materials, which are grown, collected or harvested for energy.³⁹² Biomass generation is regarded as renewable when the resource consumed in the energy conversion process is replenished by an equivalent amount of biomass.³⁹² Biomass can be used directly to fuel a synchronous generator to provide power that can be dispatched when required, and other services that support power system security.

392. Bioenergy Australia submission to the Review, p.2.

Electricity generation from biomass is a mature technology.³⁹³ However, unless the biomass is a waste stream, it is unlikely to be economically competitive with other forms of generation. Biomass can also be used as a substitute for coal in coal-fired power stations. Often this is achieved by 'co-firing' biomass (typically wood pellets) and coal together, though in the United Kingdom a large power station has converted two 645 MW generation units to run completely on biomass, with a third unit also in the process of being converted.³⁹⁴

In Australia, the most common sources of biomass for electricity generation are bagasse (sugar cane residues) and wood waste. Other sources include food waste, agricultural waste and energy crops.³⁹⁵ ARENA is funding a project to deliver a national database of biomass resources, mapping out their location, volume and availability alongside parameters such as network and transport infrastructure.³⁹⁶ The CEFC sees particular opportunities in energy production, including electricity generation, from urban waste, organic waste from livestock production and food processing facilities, and plantation forest residues.³⁹⁷ Future waste management strategies may provide a further option for sources of biomass for energy generation.

Australia possesses some competitive advantages that support the wider use of biomass, including an environment and climate suitable for growing energy crops, and expertise in relevant sciences and industries.³⁹⁸ A limitation of biomass is that it has a relatively low energy content per unit of volume, meaning that large volumes are needed, and it is typically not economically viable to transport such volumes over long distances.³⁹⁹ It has also been suggested that some aspects of the regulatory framework may present barriers to investment in biomass generation, including the absence of a stand-alone sustainability standard for bioenergy, and 'overregulation' by state environmental protection agencies.⁴⁰⁰

High-efficiency, modular systems, such as diesel generators, offer a technology pathway to substantially increase the efficiency of electricity generation from a range of fuels. Current research is developing low cost fuels from coal and biomass that are suitable, with appropriate fuel injection and engine modifications, for use in diesel engines at scales up to approximately 100 MW. For distributed coal and biomass applications, Direct Injection Carbon Engine (DICE) technologies offer reductions in CO₂ emissions of up to 50 per cent over conventional applications through efficiency gains alone.⁴⁰¹

Waste to energy

Biomass works best economically when the feedstock is a waste stream. In response to shrinking landfill resources and increasing disposal costs, waste-to-energy processes for municipal and industrial waste streams are being considered. Municipal and industrial waste streams often have significant organic (renewable) components. Not only does this provide dispatchable generation and low emissions, but it deals with a separate environmental problem – what to do with the waste.

Waste can be gasified or combusted directly for electricity generation, although the latter requires strict emissions management (relating to potentially toxic and particulate emissions). Direct production of power using advanced combustion technologies is widely practiced internationally, and increasingly, alternative fuels production and power generation through waste gasification processes are being considered for their viability.

393. Bioenergy Australia submission to the Review, p.1.

394. Drax Group plc, <https://www.drax.com/about-us/>, accessed 4 June 2017.

395. Clean Energy Council, *Clean Energy Australia Report 2016*, 2016, p.34.

396. ARENA, <https://arena.gov.au/project/the-australian-biomass-for-bioenergy-assessment-project/>, accessed 4 June 2017.

397. Clean Energy Finance Corporation, *The Australian bioenergy and energy from waste market*, November 2015, p.3.

398. ARENA, <http://arena.gov.au/about/what-is-renewable-energy/bioenergy/>, accessed 6 June 2017.

399. International Renewable Energy Agency, *Renewable Energy Technologies: Cost Analysis Series Volume 1 Power Sector*, 2012, p.i.

400. Bioenergy Australia submission to the Review.

401. David Brockway submission to the Review.

Gas alternatives

As discussed in Chapter 4, gas-fired generation has an important role in contributing to the security and reliability of the NEM and emissions reduction. Over time, as Australia transitions to lower emissions generation, natural gas may be replaced by zero emissions fuels such as hydrogen and biogas. The potential of hydrogen and biogas to be used in place of natural gas in existing electricity infrastructure (combustion gas turbines) is being explored,^{402, 403} and there is recognition of the opportunity for innovation in biogas and hydrogen applications.^{404, 405}

Biogas includes fuels such as biomethane or biopropane, extracted from renewable sources including landfill, wastewater and agricultural waste.

Hydrogen can be produced by two very different means. In the first, hydrogen and oxygen are produced via the electrolysis of water. The only by-product is oxygen. The electrolysis process is powered by electricity that may be from renewable sources (for example, solar or wind generators) or non-renewable sources (for example, coal or gas-fired generators).

In the second, hydrogen is produced from gasification or particle oxidation of hydrocarbon fuels such as methane (natural gas), coal, heavy fuel oils or refinery residues and petroleum coke. The most common process used in Australia is steam reforming of natural gas, in which high-temperature steam reacts with methane in the presence of a catalyst to produce CO₂ and hydrogen. The by-product is CO₂.⁴⁰⁶ For the hydrogen formed from methane or coal to be considered zero or low emissions, the CO₂ by-product would have to be captured and sequestered, but it is currently expensive to do so.

The use of hydrogen instead of batteries for storage of electricity, or to supplement or ultimately replace natural gas for heating, is discussed later in this chapter.

Carbon capture and storage

Carbon capture and storage (CCS) technology can contribute to lower emissions, by reducing CO₂ emissions from coal or gas-fired generators. Fossil fuel generators equipped with CCS are synchronous generators, providing power that can be dispatched when required and other services that support power system security. The Australian Power Generation Technology Report notes that “*while CCS technologies are not very mature, coal with CCS is more slightly mature than gas with CCS*”.⁴⁰⁷

CCS technology works by capturing CO₂ at a major emission source such as a coal or gas-fired power station and compressing it to a dense supercritical state so that it may be transported (by pipeline) to a site where it can be injected into a deep underground rock formation and permanently stored. Alternatively the CO₂ may be used in such applications as enhanced oil recovery, a longstanding petroleum industry practice.⁴⁰⁸ CCS can reduce emissions from power stations by around 85 per cent.⁴⁰⁹ The process of capturing CO₂ reduces the efficiency of power generation by up to 25 per cent.⁴¹⁰ Transporting and storing the CO₂ involves the development of large-scale infrastructure. CCS technology can be installed with a new power station, or in some cases, retrofitted to an existing power station.

402. Ministry of Economy, Trade and Industry Japan, http://www.meti.go.jp/english/press/2014/0624_04.html, accessed 3 June 2017.

403. Energy Networks Australia, *Gas Vision 2050: Reliable, secure energy and cost-effective carbon reduction*, 2017, p.14.

404. Energy Networks Australia submission to the Review.

405. ARENA, <https://arena.gov.au/about/funding-strategy-investment-plan/renewables-for-industrial-processes/>, accessed 3 June 2017.

406. Office of Energy Efficiency and Renewable Energy, <https://energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming>, accessed 3 June 2017.

407. CO2CRC, *Australian Power Generation Technology Report*, 2015, p.iv.

408. Carbon Capture and Storage Association, <http://www.ccsassociation.org/what-is-ccs/storage/enhanced-hydrocarbon-recovery/>, accessed 3 June 2017.

409. IEA, <https://www.iea.org/publications/freepublications/publication/essentials1.pdf>, accessed 5 June 2015.

410. IEA, *20 Years of Carbon Capture and Storage: Accelerating Future Deployment*, 2016, p.53.

Not all CCS is associated with electricity generation. It could be the solution to eliminating emissions from many industrial processes, such as steel making, cement manufacturing and urea production. In Australia, the world's largest CO₂ storage project will be commissioned in 2018 as part of the Gorgon LNG project.

Deployment globally is important for the efficiency improvements derived from 'learning-by-doing'.⁴¹¹ Existing large-scale CCS projects at the Boundary Dam power station in Canada and the Petra Nova power station in the United States have contributed valuable knowledge and experience on the deployment of CCS technology in the power sector.⁴¹² Both projects were retrofits to existing power stations.⁴¹³ A project where CCS technology is intimately integrated into a new-build natural gas generator is under development in the United States.⁴¹⁴ The 25 MW demonstration plant is scheduled to be commissioned by the end of 2017.⁴¹⁵

It may be possible to retrofit some, but not all, of Australia's existing coal-fired power stations with CCS technology. Retrofitting CCS technology to existing brown coal-fired plants can involve some significant challenges, including limited space, process heat and cooling water availability, and limitations of the existing steam turbines.⁴¹⁶

CCS fitted to new build coal-fired generators would be expected to use high efficiency, low emissions (HELE) technologies such as supercritical coal, ultra-supercritical coal or integrated gasification combined cycle (IGCC). The world's first large-scale IGCC generator with CCS has been built in Kemper County, Mississippi (though is not yet fully operational).^{417, 418} Cost projections for the project increased three-fold from original estimates.⁴¹⁹

CCS technology is currently not covered by ARENA funding, however, it is anticipated to be eligible in the future for CEFC funding. In May 2017, the Australian Government announced it would remove a legislative prohibition on CEFC to allow loans for CCS projects.⁴²⁰ In its submission to the Review the CEFC notes that CCS *"is likely to be needed as part of the global mix of technologies to meet long-term emissions reduction goals, but is unlikely to play a significant role in reducing Australia's electricity sector emissions in time to meet our 2030 Paris Agreement commitments"*.⁴²¹ In the absence of government measures to encourage CCS uptake, this is likely to be the case.

Hydroelectricity

Australia has large, established hydroelectric (hydro) schemes, particularly in Tasmania, New South Wales and Victoria. Hydro generators are synchronous generators, providing power that can be dispatched when required and other services that support power system security. Large-scale hydro can have a significant local environmental impact due to the need to modify natural water courses. As a result, there is limited potential for new large-scale hydro in Australia.

411. CO2CRC, *Australian Power Generation Technology Report*, 2015, p.vi.

412. Oxford Institute for Energy Studies Cornot-Gandolfe, S, *The role of coal in Southeast Asia's power sector and implications for global and regional coal trade*, 2016.

413. Global CCS Institute submission, p.6.

414. NetPower, <https://netpower.com/technology/>, accessed 31 May 2017.

415. NetPower, <https://netpower.com/news-posts/net-power-breaks-ground-on-demonstration-plant-for-worlds-first-emissions-free-low-cost-fossil-fuel-power-technology/>, accessed 31 May 2017.

416. CO2CRC, *Retrofitting CCS to coal: enhancing Australia's energy security*, 2017, p.1.

417. Energy Light Power, <http://www.elp.com/articles/2017/02/kemper-county-igcc-power-plant-makes-electricity.html>, accessed 3 June 2017.

418. Mississippi Power, <http://mississippipowernews.com/2017/05/31/mississippi-power-releases-media-statement-on-kemper-facility/>, accessed 4 June 2017.

419. Carbon Capture & Sequestration Technologies at MIT, <https://sequestration.mit.edu/tools/projects/kemper.html>, accessed 4 June 2017.

420. The Honourable Josh Frydenberg MP, <http://www.environment.gov.au/minister/frydenberg/media-releases/mr20170530a.html>, accessed 3 June 2017.

421. Clean Energy Finance Corporation submission to the Review, p.6.

However, many of Australia's hydro generators are more than 40 years old⁴²² and can be modernised to increase their efficiency and capacity. There may be opportunities to increase their generation capacity through refurbishment and turbine upgrades. The Snowy Mountains Scheme has already been upgraded to a capacity of 4,100 MW, from its original capacity of 3,756 MW.⁴²³ Some potential refurbishments and upgrades to Tasmania's hydro schemes are currently being investigated.⁴²⁴

Additionally, there is potential for new, small-scale hydro generation. Small-scale hydro generators can be added to existing structures such as small dams, weirs, water or sewage treatment plants or water supply pipelines.⁴²⁵ To date the total contribution in Australia from small-scale hydro generation is not significant.

The use of pumped hydro for energy storage is discussed later in this chapter.

Nuclear

For many countries, nuclear power provides a secure, affordable and zero emissions electricity supply.^{426, 427} In Australia, the establishment of nuclear power would require broad community consultation and the development of a social and legal licence. There is a strong awareness of the potential hazards associated with nuclear power plant operation, including the potential for the release of radioactive materials. Any development will require a significant amount of time to overcome social, legal, economic and technical barriers.⁴²⁸

Nuclear generators are synchronous generators, providing services that support power system security. Different nuclear power technologies allow application at different scales. Large, traditional nuclear power plants are limited to large-scale applications, which the Australian Nuclear Science and Technology Organisation notes makes it "*difficult to envisage [traditional nuclear power plants] being established on the NEM given current grid structure*".⁴²⁹

Small modular reactors (SMRs) are a more flexible technology, with faster construction and delivery times.^{430, 431} SMRs have a smaller generating capacity (up to 300 MW), and are designed to allow for modular construction.⁴³² SMRs are also expected to have a strong safety case based on their smaller size and factory construction. The reactors are capable of providing dispatchable and synchronous electricity, benefiting system security.^{433 434} Projects underway internationally include in the United States, where the design of modules with the capacity to provide 50 MW of electricity each are undergoing licence review.⁴³⁵ The first SMR plant under this project is

422. Hydro Tasmania submission to the Review.

423. Snowy Hydro submission to the Review, p.5.

424. Hydro Tasmania, <https://www.hydro.com.au/about-us/news/2017-04/supporting-australia%E2%80%99s-energy-transition>, accessed 3 June 2017.

425. NSW Department Planning and Environment, <http://www.resourcesandenergy.nsw.gov.au/energy-consumers/sustainable-energy/hydro>, accessed 3 June 2017.

426. Australian Nuclear Association submission to the Review.

427. Australian Nuclear Science and Technology Organisation submission to the Review.

428. Australian Academy of Technology and Engineering submission to the Review.

429. Australian Nuclear Science and Technology Organisation submission to the Review.

430. Australian Nuclear Science and Technology Organisation submission to the Review.

431. Australian Nuclear Association submission to the Review.

432. International Atomic Energy Agency Annual Report, *Nuclear Technology Review 2016*, 2016, p.24.

433. SMR Nuclear Technology submission to the Review.

434. Australian Nuclear Science and Technology Organisation submission to the Review.

435. NuScale Power, <http://www.nuscalepower.com>, accessed 6 June 2017.

expected to be commissioned in the mid-2020s. The UK Government has launched a competitive program to identify the best value SMR.⁴³⁶ In China, work is underway to launch a demonstration SMR project of 125 MW.^{437, 438}

Further nuclear power research and development is occurring in ‘Generation IV’ and fusion technologies. Research and development of Generation IV technologies aims to use fuel more efficiently, reduce waste production, be economically competitive, and meet stringent standards of safety. Research and development of fusion and Generation IV technologies are being progressed in internationally collaborative work that includes Australia.⁴³⁹ Fusion technology could offer electricity without high-level radioactive waste; however current progress in research and development suggests the technology is unlikely to be commercialised for a number of decades.^{440, 441}

8.3 Energy storage technologies

Electricity cannot be stored in its own right – it must be consumed as it is generated. However, electricity can be converted into other forms of energy that can be stored, such as the chemical energy stored in batteries.

Energy storage technologies can provide solutions to many of the reliability and security challenges facing the NEM as it transitions to a more variable, non-synchronous and distributed generation mix. From a reliability perspective, electricity can be stored at times when electricity is cheap and supply is high, including when excess electricity is being produced by variable renewable electricity (VRE) generators. It is then discharged at times of peak demand, or times of low supply from VRE generators. Storage technologies can also support power system security, by storing or discharging energy in a way that provides services such as frequency control (including ‘fast frequency response’) and voltage control.

The amount of energy that can be stored, and the efficiency losses associated with storage, differs across technologies (see Figure 8.1 for a comparison of some energy storage technologies). Some technologies, such as pumped hydro, have the capacity to store large amounts of energy (multiple GWh), while others, such as batteries, can store small to medium amounts of energy (hundreds of kWh or MWh). The rate that each system can discharge its energy is the power. Depending on the requirement, different combinations of power (MW) and energy (MWh) can be implemented. With current technology, no single storage medium has the characteristics to meet all the requirements for energy that the grid demands. A mix of storage solutions will likely be required to address all applications.

436. UK Government, <https://www.gov.uk/government/publications/small-modular-reactors-competition-phase-one>, accessed 31 May 2017.

437. China National Nuclear Corporation, https://www.iaea.org/INPRO/13th_Dialogue_Forum/011_CNNC_s_ACP100_SMR-Technique_Features_and_Progress_in_China.pdf, accessed 31 May 2017.

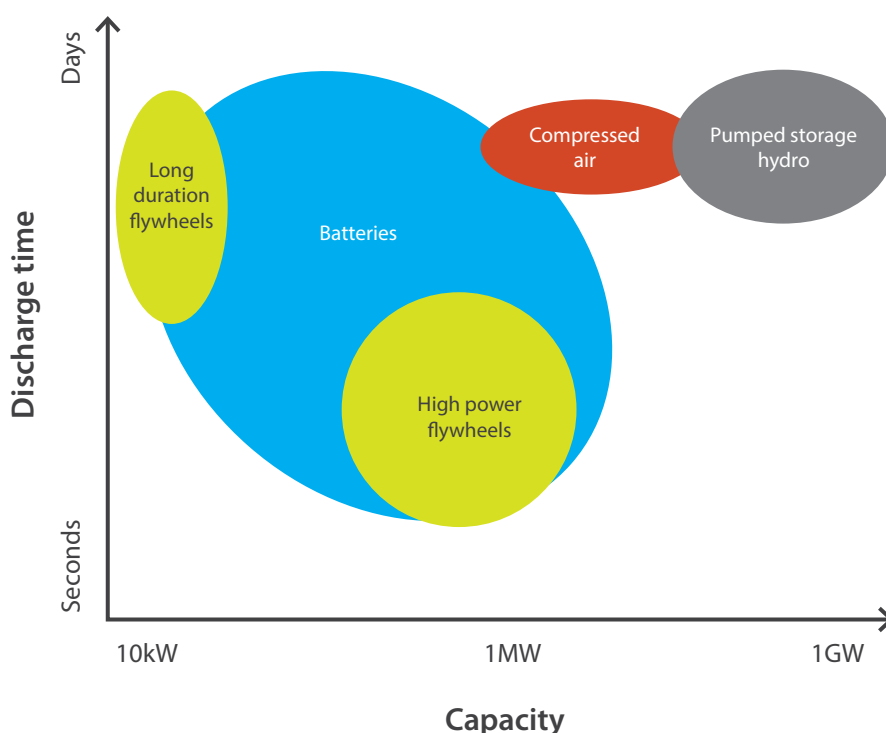
438. International Atomic Energy Agency Annual Report, *Nuclear Technology Review 2016*, 2016, p.25.

439. Australian Nuclear Science and Technology Organisation submission to the Review.

440. Australian Nuclear Science and Technology Organisation submission to the Review.

441. International Atomic Energy Agency Annual Report, *Nuclear Technology Review 2016*, 2016, p.30.

Figure 8.1: Energy storage technologies⁴⁴²



Batteries

Batteries operate as energy storage devices that, when required, convert chemical energy into electrical energy. There are a large range of battery types based on different physical designs and chemistries such as lead-acid, nickel metal hydride, lithium ion and flow batteries, such as zinc-bromide. The characteristics of each type vary in terms of their power density (power to weight), voltage, allowable charge and discharge rates, cycle life and efficiency.

A substantial advantage of batteries is their scalability. They can be deployed from household scale (kWh) up to grid-scale (MWh and GWh), and can also be packaged for off-grid use by household, remote area, and commercial consumers. Another advantage is their rapidly falling prices and increasing availability.

The use of batteries is enhanced by their relatively fast discharge time, particularly when compared with large pumped hydro and thermal storage. This also means that when coupled with appropriate power conversion electronics, batteries are capable of providing a fast frequency response (FFR) service to support power system security. In Great Britain, the system operator has procured 200 MW of FFR from large-scale battery storage.⁴⁴³

A disadvantage of batteries is their relatively limited life, which is in most cases less than 15 years. Some batteries are made from hazardous materials, making disposal and recycling difficult. Batteries are also sensitive to climatic conditions and require cooling in hot environments.⁴⁴⁴

Lithium ion batteries are highly flexible, with lower weight and volume than other technologies. Lithium ion batteries are being deployed for applications such as electric vehicles and grid power quality. Lithium ion batteries typically have high round-trip efficiency, between 85 to 98 per cent, with a typical discharge time from

442. Adapted from U.S Department of Energy, *Quadrennial Energy Review: Second Instalment*, 2017, chapter IV, p.14.

443. NationalGrid, <http://www2.nationalgrid.com/Enhanced-Frequency-Response.aspx>, accessed 3 June 2017.

444. CSIRO prepared for AEMC, *Electrical Energy Storage: Technology Overview and Applications*, 2015, p.3.

seconds to hours, but energy can be stored for longer periods.⁴⁴⁵ They also have a very long lifetime compared to other battery technologies, with 5,000 or more charge cycles.⁴⁴⁶

The potential for batteries to become widespread in Australia depends both on ongoing innovation in technology and changes to market mechanisms to reward investment. Regulatory reform could assist in rewarding consumers for additional services provided by battery storage.⁴⁴⁷ As discussed in Chapter 6, new approaches to aggregate and coordinate the efficient use of thousands of small-scale battery storage systems will be needed to derive the full value of the various services they can provide.

Pumped hydro

Pumped hydro storage systems operate by pumping water from a storage reservoir at a lower elevation to a storage reservoir at a higher elevation, and later releasing it through turbines to generate electricity. They can be developed off-river using existing or purpose-built reservoirs.

Pumped hydro storage systems are the most mature electrical energy storage systems available. They are also the largest, capable of operating at hundreds of MW or even GW power levels for six hours or more.⁴⁴⁸ They are dispatchable with rapid response times, which means they are well placed to balance electricity demand and provide backup for VRE generation. This means they can help VRE generators to meet their Generator Reliability Obligation. Because pumped hydro is synchronous, it can also provide essential security services, including frequency response, voltage control and black start services.

The round-trip efficiency of pumped hydro is relatively high, typically in the range of 70 to 85 per cent.⁴⁴⁹ Evaporative losses are the main cause of reduced efficiency (the extent of this varies according to local climate).

Pumped hydro is also cost effective. Facilities can pump water to the higher reservoir when prices are low and supply it when they are high, such as in response to demand spikes. This may also moderate prices in the wholesale market.

There are already pumped hydro storage systems in Australia, including a 600 MW system at Tumut 3 Power Station in NSW and a 500 MW system at Wivenhoe Power Station in Queensland.⁴⁵⁰

ARENA has funded a project to assess the potential for additional pumped hydro storage on a large-scale, including the potential for pumped hydro to help complement VRE generators. The project will produce an atlas of prospective sites in Australia.⁴⁵¹

In March 2017, the Australian Government announced a study to assess whether it is viable for the existing Snowy Mountains Scheme to be extended to include up to 2,000 MW of large-scale pumped hydro storage capacity. It would connect two reservoirs with an underground tunnel and generation and pumping capacity. There would be little net additional use of water.⁴⁵²

Hydrogen

Hydrogen is a secondary fuel, that when produced using renewable primary energy sources or using coal or natural gas as the source and applying CCS to the associated CO₂ emissions, can provide a low emissions alternative to conventional fuels for vehicles, space heating or power generation.

445. AECOM prepared for ARENA, *Energy Storage Study: Funding and Knowledge Sharing Priorities*, 2015, p.24.

446. CSIRO prepared for AEMC, *Electrical Energy Storage: Technology Overview and Applications*, 2015, p.30.

447. Tesla submission to the Review.

448. CSIRO prepared for AEMC, *Electrical Energy Storage: Technology Overview and Applications*, 2015, p.90.

449. CSIRO prepared for AEMC, *Electrical Energy Storage: Technology Overview and Applications*, 2015, p.92.

450. AECOM prepared for ARENA, *Energy Storage Study: Funding and Knowledge Sharing Priorities*, 2015, p.74.

451. ARENA, <https://arena.gov.au/projects/atlas-pumped-hydro-energy-storage/>, accessed 3 June 2017.

452. Snowy Hydro media release, <http://www.snowyhydro.com.au/news/expanding-pumped-hydro-storage/>, accessed 5 June 2017.

While Australia's domestic market for hydrogen in vehicles is small, the use of hydrogen is increasing in countries such as Japan, South Korea and Europe, although at a far lower rate than the uptake of battery electric vehicles. Japan has developed a roadmap for hydrogen and Japanese businesses are looking at Australian coal resources to supply that hydrogen.⁴⁵³ Projects being developed around the world for hydrogen supply to Japan include renewable-based hydrogen from solar, hydro, geothermal and wind power electrolysis of water as well as through gasification of natural gas and coal (with CCS).

Traditionally, transportation and storage of hydrogen has been a challenge as its low density at ambient temperature means it typically requires high-pressure storage and transport facilities.

Converting hydrogen into ammonia for transportation provides one solution to the transport challenge. Ammonia can be stored and transported either as a liquid under modest pressure, or as a gas at ambient temperatures. Worldwide, the shipping and distribution of ammonia is a mature industry. However, a large amount of energy is lost during the process of converting hydrogen to ammonia for transport, and then back to hydrogen at the point of use. The conversion process reduces the overall efficiency of hydrogen as an energy source. If the original source of electricity is inexpensive or excess renewable energy, this efficiency loss becomes less of a barrier, particularly if the end-use of the hydrogen is for high value purposes, such as a zero emission transportation fuel used in either fuel cell vehicles or direct combustion.

In Australia, there are technologies under development that increase the practicality of storage, transport and conversion of hydrogen from ammonia. CSIRO has recently announced a new metal membrane technology that can be used to separate ammonia into hydrogen and other components at the point of use. The technology could provide an opportunity to increase the use of hydrogen in Australia and to export Australian renewable energy to the world. Associated initiatives include the direct use of ammonia as a fuel in stationary energy systems, or potentially large scale transport applications such as ships and locomotives, using ammonia fired turbines, high temperature fuel cells, or direct combustion engines. The South Australian Government announced in March 2017 it will investigate hydrogen projects through its \$150 million battery storage and renewable technology fund,⁴⁵⁴ and the Panel understands ARENA is also exploring the potential of hydrogen.

Another application for hydrogen is to replace or augment methane (natural gas) for residential, commercial and industrial space heating. The city of Leeds in the UK is investigating this possibility. If the use of hydrogen for space heating can be successfully scaled up and the hydrogen is produced from renewable primary energy sources, there would be substantial potential to reduce emissions from heating buildings.

Existing gas infrastructure can tolerate approximately 10 per cent hydrogen content without requiring pipeline or burner upgrades, which would be an effective and relatively low cost way of decarbonising the gas network, albeit only a little.

Concentrated solar power and thermal storage

Concentrated solar power uses large arrays of mirrors (heliostats) to concentrate sunlight onto a 'receiver' where heat energy is collected. Once collected, a range of technologies can be used to store the energy. Thermal storage is the predominant technology currently used. It operates by heating a fluid (molten salt or other heat transfer medium) with the energy from the concentrated solar power array. The energy is stored by maintaining the fluid at a high temperature, and can be released when needed to make steam to run a synchronous generator.⁴⁵⁵

There are various types of thermal storage technologies, having characteristics to suit different applications. The power storage capacity of thermal storage systems can be very large, with the biggest operating solar plant

453. Ministry of Economy, Trade and Industry Japan, http://www.meti.go.jp/english/press/2014/0624_04.html, accessed 3 June 2017.

454. Government of South Australia, *Our Energy Plan*, 2017.

455. ANU Solar Thermal Group submission to the Review, p.1.

being the Ivanpah plant in California that has a peak operating capacity of 377 MW. Storage discharge rates range from hours to days.⁴⁵⁶

There are currently no commercial scale concentrated solar power plants in Australia. The Australian Government has budgeted up to \$110 million for an equity investment, if required, to accelerate and secure delivery of a solar thermal project in Port Augusta, South Australia.⁴⁵⁷

In a submission to the Review, the ANU Solar Thermal Group highlighted the cost-effective integration of electricity generation and energy storage as a key benefit of concentrated solar thermal technology. Advanced turbine systems, such as those utilising supercritical CO₂ as the operating fluid, offer pathways for step change improvements in cost and efficiency for solar thermal generation. Solar thermal technology also has the advantage of being useable in a hybrid system with other types of generation, such as fossil fuels or biomass, increasing the efficiency of the system. In the future, hybrid systems with renewable energy may emerge as an option for transition of existing generation assets or solutions in their own right.

ARENA has requested information on potential solar thermal projects, recognising the technology has the potential to deliver dispatchable energy that could benefit the grid during periods of high demand.⁴⁵⁸ However, even with the value that a dispatchable steam turbine brings to the stability and reliability of the electricity system, solar thermal generation and storage is not yet economically viable.

ARENA is supporting Australian solar thermal research, technology development and demonstration through the Australian Solar Thermal Research Initiative which represents a coordinated program comprising six Australian universities and CSIRO.

Flywheels

Flywheel energy storage systems convert electricity to kinetic energy (the energy of an object in motion), in the form of a large rotating cylinder. When electricity is needed, power electronics use the flywheel's speed of rotation to release power.⁴⁵⁹

There are different types of flywheel systems, with varying power storage capacities (from multiple kW to tens of MW). Flywheels are capable of achieving a high round-trip efficiency of more than 90 per cent.⁴⁶⁰ The power conversion electronics of a flywheel system can also provide system security services.^{461, 462, 463} A disadvantage of flywheels is that for their size and cost, they store relatively little energy.⁴⁶⁴

There have been four small flywheel energy storage systems (of up to 1 MW in capacity) deployed in Australia.⁴⁶⁵

Compressed air energy systems

Compressed air energy storage systems use electricity to compress air (releasing heat in the process), to be stored in underground reservoirs or surface vessels. The energy is released when the compressed air expands and combines with another fuel, typically gas, to drive a synchronous generator.

456. BrightSource, http://www.brightsourceenergy.com/ivanpah-solar-project#.WTT__tV95hE, accessed 5 June 2017.

457. Australian Government, http://www.budget.gov.au/2017-18/content/bp1/download/bp1_bs7.doc, accessed 3 June 2017.

458. ARENA, <http://arena.gov.au/about/funding-strategy-investment-plan/solar-thermal/>, accessed 3 June 2017.

459. Energy Storage Association, <http://energystorage.org/energy-storage/technologies/flywheels>, accessed 3 June 2017.

460. CSIRO prepared for AEMC, *Electrical Energy Storage: Technology Overview and Applications*, 2015, p.80.

461. The Centre for Low Carbon Futures, http://www.lowcarbonfutures.org/sites/default/files/Flywheel_final_0.pdf, accessed 3 June 2017.

462. Energy Storage Association, <http://energystorage.org/energy-storage/technologies/flywheels>, accessed 3 June 2017.

463. CSIRO prepared for AEMC, *Electrical Energy Storage: Technology Overview and Applications*, 2015, p.81.

464. CSIRO prepared for AEMC, *Electrical Energy Storage: Technology Overview and Applications*, 2015, p.82.

465. AECOM prepared for ARENA, *Energy Storage Study: Funding and Knowledge Sharing Priorities*, 2015, pp.74-75.

The main advantage of compressed air energy storage is a high storage capacity (MW-scale). Additionally, it does not produce any hazardous waste, and the heat released can be used for other purposes. However, it has a relatively low round-trip efficiency, of less than 50 per cent, because the compressed air needs to be reheated prior to its expansion.⁴⁶⁶ A higher round-trip efficiency of up to 70 per cent may be achieved through an ‘adiabatic’ process (which uses heat released from the compression process to reheat the compressed air prior to its expansion), but this technology is still under development,⁴⁶⁷ with plans for a demonstration plant to be built in Germany.⁴⁶⁸ Another disadvantage is geographical limitations, including specific geological characteristics and the large footprint required for an underground storage facility.⁴⁶⁹ However, Australia has many sedimentary basins where compressed air energy storage would be technically feasible.

Only two compressed air energy facilities are currently in operation today – one each in Germany and the United States, where compressed air is used to increase the efficiency of gas turbine power plants. These facilities store the compressed air in salt caverns.⁴⁷⁰ The CSIRO notes that “a significant amount of work is required to deploy and demonstrate the technology in Australian conditions before a market can form”.⁴⁷¹

8.4 Electric vehicles

Uptake of electric vehicles is likely to increase, associated with the combined impact of declining battery prices and introduction of high range and low price electric vehicles⁴⁷² into the market. Currently, electric vehicles only constitute about 0.3 per cent of Australia’s electric vehicle sales.⁴⁷³ Globally, there were an estimated 1.26 million electric vehicles at the end of 2015.⁴⁷⁴ The right mix of incentives for the uptake of electric vehicles along with a decarbonised electricity grid could help to achieve significant emissions reductions in Australia’s transport sector, which in 2015 accounted for about 18 per cent of Australia’s emissions (or 93 million tonnes of carbon dioxide equivalent).⁴⁷⁵

Electric vehicle uptake could significantly change electricity usage patterns in Australia. Electricity consumption by electric vehicles is estimated to reach nearly 4 per cent of total electricity consumed by FY2036.⁴⁷⁶ Electric vehicle charging can be relatively easily managed to reduce negative impacts on the electricity grid. If properly managed, electric vehicle charging could improve grid utilisation and be a flexible demand absorbing load during periods of high VRE output (less spilled energy).⁴⁷⁷

It is possible, in principle, for electric vehicles to be used as distributed energy storage facilities, releasing energy back to the grid at peak times, and also helping in addressing the management of frequency, reactive power and voltage to improve grid security and reliability. However, the Panel is not aware of any cases where the use of electric vehicles in this way has commenced commercially.

466. CSIRO prepared for AEMC, *Electrical Energy Storage: Technology Overview and Applications*, 2015, pp.85-86.

467. Energy Storage Association, <http://energystorage.org/compressed-air-energy-storage-caes>, accessed 3 June 2017.

468. RWE Power, *Adiabatic Compressed-Air Energy Storage For Electricity Supply*, 2010.

469. CSIRO prepared for AEMC, *Electrical Energy Storage: Technology Overview and Applications*, 2015, pp.85-86.

470. CSIRO prepared for AEMC, *Electrical Energy Storage: Technology Overview and Applications*, 2015, p.85.

471. CSIRO prepared for AEMC, *Electrical Energy Storage: Technology Overview and Applications*, 2015, p.86.

472. Tesla, https://www.tesla.com/en_AU/model3, accessed 3 June 2017.

473. AEMO, *AEMO Insights August 2016: Electric Vehicles*, 2016.

474. International Energy Agency, *Global EV Outlook 2016: Beyond one million electric cars*, 2016.

475. Department of the Environment and Energy, *Australia’s Emissions Projections 2016*, 2016, p.6.

476. AEMO, *AEMO Insights August 2016: Electric Vehicles*, 2016.

477. Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Efficient capacity utilisation transport and building services electrification*, 2016 p.44.

8.5 System security technologies

Chapter 2 discusses some key services that are required to support power system security, such as frequency control services. While many of those services can be sourced from generation or storage technologies, they can also be sourced from other technologies, including synchronous condensers and power conversion electronics.

Synchronous condensers

A synchronous condenser is a machine similar to a synchronous generator or motor, having a large rotating mass that spins at a speed proportional to the grid frequency. It does not produce electricity. Instead its benefit is that, as a synchronous technology, it provides physical inertia to help dampen rapid frequency changes, fault current to help maintain system strength, and the ability to supply or absorb reactive power to help control voltage. Operating a synchronous condenser consumes only a very small amount of energy.

Synchronous condensers can be purchased as new, or reconfigured from decommissioned synchronous generators (such as coal-fired generators). Converting a decommissioned synchronous generator to a synchronous condenser may be an economical alternative to purchasing a new synchronous condenser. Cost-savings are achieved through re-using the existing generator machinery, foundation and building, auxiliary systems and grid connections. However, as system security needs are often location-specific, the viability of such a conversion will depend on the location of the decommissioned generator.

It is also possible to make modifications to synchronous generators that are still in operation, enabling them to be switched between generator mode and synchronous condenser mode. This approach has been employed in Tasmania, where there are 14 hydro generators capable of operating in synchronous condenser mode.⁴⁷⁸

Synchronous condensers are a mature technology. There are a limited number of synchronous condensers in place throughout the NEM, though many have either been retired or are close to retirement, and traditionally were designed for voltage control rather than to provide inertia and fault level contributions.⁴⁷⁹ Their future potential depends less on innovation, than on the creation of better incentive frameworks to value the security services they provide.

Power conversion electronics

Power conversion electronics convert electricity to have different characteristics.⁴⁸⁰ Power conversion electronics are used at many points in the grid, including when converting from DC to AC (or vice versa) for certain transmission lines, generators, storage systems and loads. Power conversion electronics associated with VRE generators and loads convert DC to AC and are called an inverter.

Inverters can be designed and configured so that electricity is sent out from a DC generator (such as solar photovoltaic) or consumed by a load in a way that it provides security services. While generators connected to the power system via inverters are typically not able to provide the same level of inertia associated with synchronous generators, some systems can provide synthetic inertia and other system security services.⁴⁸¹ All technologies using inverters have the potential to provide some frequency response, and in some cases, FFR.⁴⁸² The characteristics and practicality of this function vary between different technologies.⁴⁸³ Wind turbines can provide an inertia-based FFR (also known as synthetic inertia) using the kinetic energy in their rotors. If their

478. Hydro Tasmania and TasNetworks, *Managing a High Penetration of Renewables: A Tasmanian Case Study*, 2016, p.3.

479. AEMO, *South Australian Fuel and Technology Report: South Australian Advisory Functions*, 2017, p.62.

480. CERN, <http://cds.cern.ch/record/987498/files/p13.pdf>, accessed 20 May 2017.

481. General Electric's submission to the Review, p.6.

482. US Department of Energy, <https://energy.gov/sites/prod/files/2016/06/f32/GIGA%20Project%20Summary.pdf>, accessed 20 May 2017.

483. General Electric International, *Technology Capabilities for Fast Frequency Response*, 2017, p.2.

generation is curtailed below full capacity they can then provide FFR by increasing generation quickly when needed.⁴⁸⁴ Both wind and solar photovoltaic are able to provide reactive power and voltage control if designed to do so.⁴⁸⁵

A recent example in Australia is Stage 2 of the Hornsdale Wind Farm in South Australia which has been licensed with higher connection standards than required under the National Electricity Rules. In accordance with the licence conditions, the wind turbine inverters installed have the capability to provide frequency control services to the NEM. In addition, the wind farm is designed to better withstand high rates of change of frequency.⁴⁸⁶

8.6 Conclusion

The evolution of power generation, storage and integration technologies continues in Australia and globally. The maturity level and rate of development of these technologies in terms of cost, scalability and operability will vary depending on levels of ongoing investment, the ability to integrate and undertake controlled trials of new developments under realistic conditions and sustained demonstration at scale.

Their inclusion as part of the energy system requires consideration of operating characteristics and other externalities such as emissions intensity, flexibility, scalability and dispatchability and future potential.

It is important that there is ongoing oversight of development progress both nationally and internationally and that appropriate incentives, urgency, support and planning mechanisms exist to ensure timely development of these future options.

484. AEMO, *Wind Turbine Plant Capability Report*, 2013, p.10.

485. AEMO, *Wind Turbine Plant Capability Report*, 2013, pp.30-38.

486. ESCOSA, <http://www.escosa.sa.gov.au/projects-and-publications/projects/electricity/electricity-generation-licence-application-hwf-2/electricity-generation-licence-application-hwf2>, accessed 20 May 2017.

LIST OF ACRONYMS

AC	Alternating current
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
COAG	Council of Australian Governments
CCGT	Combined cycle gas turbine
CCS	Carbon capture and storage
CET	Clean Energy Target
CO ₂	Carbon dioxide
CO ₂ -e	Carbon dioxide equivalent
CSG	Coal seam gas
DC	Direct current
DER	Distributed energy resources
DNSP	Distribution network service provider
EIS	Emissions Intensity Scheme
ESB	Energy Security Board
FFR	Fast frequency response
GJ	Gigajoules
GW	Gigawatt
GWh	Gigawatt-hours
kW	Kilowatt
kWh	Kilowatt-hours
LNG	Liquefied natural gas
MW	Megawatts
MWh	Megawatt-hours
NEL	National Electricity Law
NEM	National Electricity Market
OCGT	Open cycle gas turbine
PJ	Petajoules
TNSP	Transmission network service provider
VRE	Variable renewable electricity

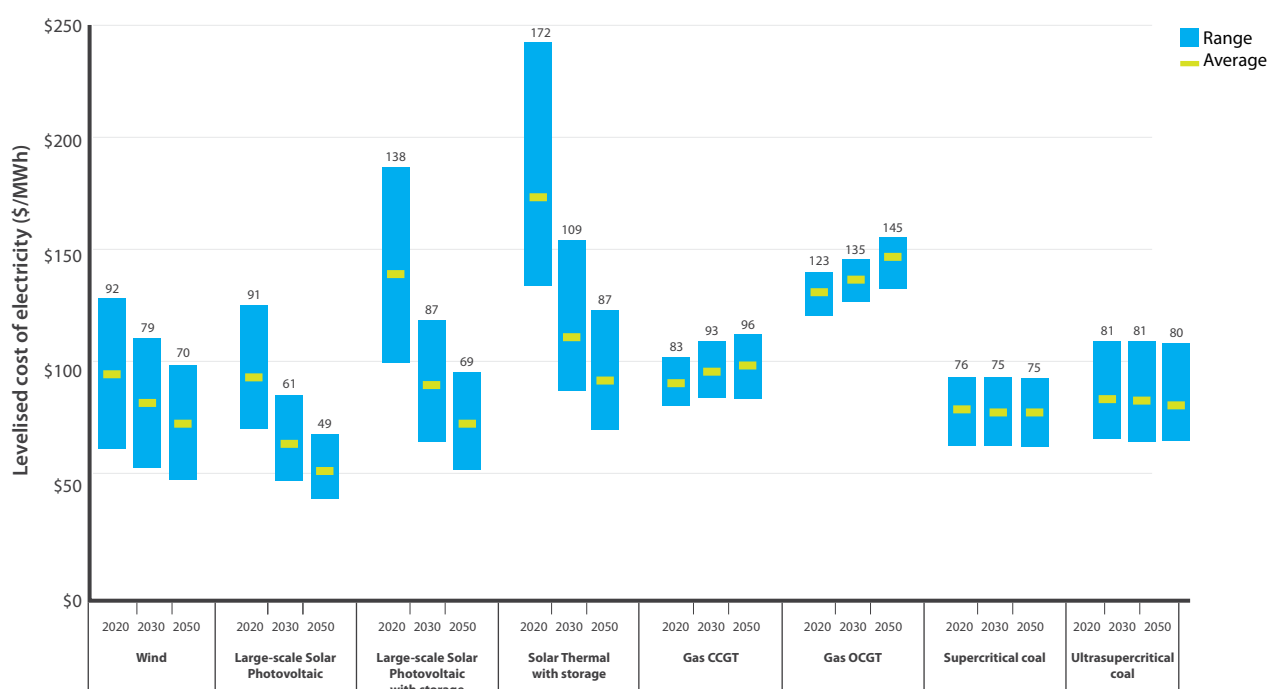
APPENDIX A – LEVELISED COST OF ELECTRICITY

The levelised cost of electricity (LCOE) is a measure of the average cost of producing electricity from a specific generating technology. It represents the cost per megawatt-hour (MWh) of building and operating a generating plant in order to breakeven over an assumed financial life. Key inputs to calculating the LCOEs include capital costs, fuel costs, fixed and variable operating and maintenance (O&M) costs, financing costs, and assumed usage rates for each technology type. The LCOEs do not include transmission or distribution costs.

Figure A.1 shows the estimated LCOE for key technologies based on input assumptions used by Jacobs in its modelling of the electricity sector.

It is important to note that actual investment decisions are affected by the specific technological and regional characteristics of a project and the level of profit the project expects to earn, which involve numerous other factors not reflected in the LCOE values.

Figure A.1: Levelised cost of electricity⁴⁸⁷



Notes:

Numbers in Figure A.1 refer to the average.

For each generation technology shown in the chart, the range shows the lowest cost to the highest cost project available in Jacobs' model, based on the input assumptions in the relevant year. The average is the average cost across the range of projects; it may not be the midpoint between the highest and lowest cost project.

Large-scale Solar Photovoltaic includes fixed plate, single and double axis tracking.

Large-scale Solar Photovoltaic with storage includes 3 hours storage at 100 per cent capacity.

Solar Thermal with storage includes 12 hours storage at 100 per cent capacity.

Cost of capital assumptions are consistent with those used in policy cases, that is, without the risk premium applied.

The assumptions for the electricity modelling were finalised in February 2017 and do not take into account recent reductions in technology costs (e.g. recent wind farm announcements).

487. Adapted from Jacobs, *Report to Independent Review into the Future Security of the National Electricity Market*, 2017.

APPENDIX B – EMISSIONS INTENSITY TABLE

Estimated Operating Emissions for New Power Stations⁴⁸⁸

Generation type	Estimated operating emissions as generated ⁴⁸⁹ (kg CO ₂ -e/ MWh)
Subcritical brown coal	1,140
Supercritical brown coal	960
Subcritical black coal	940
Supercritical black coal (HELE) ⁴⁹⁰	860
Ultra-supercritical brown coal	845
Ultra-supercritical black coal (HELE) ⁴⁹¹	700
Open cycle gas turbine (OCGT)	620
Combined cycle gas turbine (CCGT)	370
Wind	0
Hydro	0
Solar PV	0
Average NEM electricity grid emissions intensity	820⁴⁹²

488. Commonwealth, *A Cleaner Future for Power Station - Interdepartmental Task Group Discussion Paper*, 2010 p.6.

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

490. CSIRO, *Low Emissions Technology Roadmap*, June 2017, p.49

491. CSIRO, *Low Emissions Technology Roadmap*, June 2017, p.49

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

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- Melbourne: Wednesday, 08 February 2017 and Thursday, 09 February 2017
- Hobart: Tuesday, 14 February 2017
- Sydney: Wednesday, 15 February 2017

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