ENGINEERS AUSTRALIA

The Independent Review into the Future Security of the National Electricity Market

Engineers Australia Submission

24 February 2017

ENGINEERS
AUSTRALIA

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Executive Summary

Who we are

Engineers Australia is the peak body for the engineering profession in Australia. With over 100,000 individual members across Australia, we represent all disciplines and branches of engineering. Engineers Australia is constituted by Royal Charter to advance the science and practice of engineering for the benefit of the community. Engineers Australia's response is guided by our Charter and Code of Ethics which states that engineers act in the interest of community, ahead of sectional or personal interests towards a sustainable future. Engineers are members of the community and share the community's aspirations for Australia's future prosperity.

Engineers Australia appreciates the opportunity to respond to the Preliminary Report into the Future Security of the National Electricity Market (NEM). We believe that this draft report review presents an excellent overview of the current situation in the electricity sector. Engineers Australia has focused on specific question raised in the preliminary report which will require engineering expertise to navigate going forward. Engineers will play a critical role in the research, development, innovation, production and implementation of many technologies and strategies that will benefit the Australian energy market.

Background

Electricity supply in Australia is fast approaching a watershed as traditional fossil fuel power stations are coming to the end of their economic lives and will be retired, especially given increased market pressure from renewable energies and community expectation regarding the need to address climate change. Having a large variety of natural and emissions free energy resources allows Australia to consider a wider array of options and electricity generation policy should be determined by what Australia is aiming to achieve.

Vision

Engineers Australia believes that electricity generation policy should provide plentiful, affordable, reliable and quality electricity supply to underpin industrial and social objectives, while at the same time reducing emissions to comply with international commitments. The best way to achieve these objectives is through a national transition plan, which establishes a consistent long term policy framework and associated technical rules which provides a stable environment in which investors can bring forward generation using low or zero emission generation technologies.

Strategy

A transition plan should make available all technological options on an equal footing because 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 structured policy environment consistent with energy security, reliability, affordability and emissions reductions targets. It is important that any transition plan or change to energy policy receive bi-partisan support for political stability, while at the same time allowing flexibility in the future. The electricity sector is large and complex, and government must play a direct role in shaping the future direction of the sector. A secure energy future will be reliant on these policy approaches being successfully deployed.

Options

Short term options include setting an ambitious energy efficiency target for Australia, increased interconnection between regions, distributed generation and hot water storage. Energy options which could be deployed in the mid to long term include energy storage, concentrated solar thermal, and pumped hydro. Energy options which would be worthy of consideration in the longer term, along with further research and development, include geothermal and wave energy and nuclear energy (subject to safety and legal restrictions). The national electricity market needs to be flexible to allow new technologies to enter the market as they become more economically viable and allow existing technologies to improve.

Fossil fuels

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.

New ultra-supercritical coal generators and carbon capture and storage have been recently promoted as a technology that can meet Australia's energy ambitions. Ultra-supercritical coal and Carbon Capture and Storage should not be completely discounted as a low emissions options but, to be seriously considered, advocates need to put forward arguments which would validate their claims. This includes how it could keep prices lower, including costs for upgrading and the extra maintenance they require, while also achieving climate reduction targets to 2030 and beyond.

No state generation curtailment and optimal integration of distributed resources

The 28 September 2016 black system event in South Australia has brought the issue of energy security to the top of the energy policy discussion in Australia. Much of these discussions are on energy security in Australia and have predominantly focused on the lack of a traditional baseload power production. Although renewable distributed energy has complexities, Engineers Australia does not believe that this warrants curtailing this form of electricity generation in each region. Instead, these complexities should be resolved in the transition plan we advocate.

The deployment of other low-emission technologies, such as solar PV in Queensland and New South Wales assisted in reducing the risk of outages when the system was put under pressure in those jurisdictions. Further practical experimental and simulation studies are warranted for optimal integration of distributed generation, and these should be based on sound engineering and policy decisions. There should be some caution about how additional renewable energy is implemented in the future, but this is why a transition plan is essential.

Market reform and policies for investment

To allow the market to respond appropriately and flexibly to such challenges, Engineers Australia believes that ongoing market reforms along with assistance mechanisms may be required, and this should be led by the federal government. Energy policy makers should avoid unnecessarily increasing vulnerabilities, threats and risks in both the energy sector and other sectors that affect electricity generation.

For emerging technologies, policies to create initial markets must run alongside research and development programmes, far ahead of widespread deployment of the technologies, and draw on competitive market forces where possible. Many of the large banks, which generally invest in large energy projects, have turned away from fossil fuel investment which may stifle any proposals of retrofitting of existing coal power plants or building of new coal power plants.

Government policies need to promote investment in established and emerging technologies that can provide reliable and affordable electricity supply, but also reduce emissions. For investors of new zero and low emission technologies, governments can initiate change by creating sustainable markets by filling funding gaps, and creating enabling infrastructure for new technology.

Engineering workforce

Engineers Australia believes that the future of Australia's energy supply will be dependent on a strong engineering workforce. Engineers will be essential in the development of energy efficiency measures and emerging technology options, helping to provide reliable energy to Australian consumers while at the same time helping to meet Australia's emission reduction targets.

Consultation Questions 1

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

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

Engineers Australia believes that the timescale for the transformation of the Australian power system to low to near zero carbon dioxide emissions will be several decades and during this time there will continue to be major developments. Current generation technologies are continually improving efficiency, and this includes fossil fuels, nuclear (3rd generation), hydro, wind, solar PV and biomass. At the same time, developments in newer emerging technologies are advancing and could play an increasing part in the future energy mix such as battery storage options, carbon sequestration, geothermal and wave energy.

However, without a national transition plan for the generation and power network sector, Australia puts its energy security and reliability at risk while also facing uncertainties in energy affordability and emission reductions. A transition plan should consider all technology options, because 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.

Most importantly, any transition plan or changes to energy policy needs to have bi-partisan support for political stability, while at the same time allowing flexibility for whatever arises in the future. Flexibility will allow Australia to quickly adjust to any major advances or changes in new technologies, staying up to date with the most affordable, reliable energy options in a carbon constrained energy sector.

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

Innovation in the energy sector will continue to improve, and this will be driven by the need for both generators and consumers to address the ongoing trilemma of security, affordability and environmental outcomes. Innovation could drastically change the electricity grid and the way we use energy, so it is essential that the NEM be designed to allow for innovative changes. A national transition plan should outline the current and predicted costs and effects of all technologies being considered. A major investment in energy systems modelling would provide a vehicle by which the impacts, influences and limitations of new technologies could be tested and assessed. It would also provide a path to assess the effect of new technologies on services and costs.

Research and collaboration is an essential requirement to innovate, and the market should have a mechanism to allow for this. Australia has many experts in universities and research organisations which do not currently collaborate with the power industry as there is no adequate incentive to do this. Programs which do exist for collaboration compete from funds for all other research projects except medical which is governed by the National Health and Medical Research Council. Electricity projects and funding should be separated and not compete against non-electrical projects (beyond ARENA, which is specific). All policy options must be on the table in research and collaboration policy development.

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

The transition to an energy mix which can fulfil the trilemma may take a number of decades to implement. Not only will a wide mix of different energy options need to be considered, but energy policy strategies planning for the short-term should also be implemented. Energy security, reliability, and affordability issues must be front and centre, but so too should be environmental considerations. This means that all options that can provide minimal externalities (environmental damage, health effects, greenhouse gases) must be on the table for consideration.

Furthermore, there needs to be a national organisation established with the responsibility of monitoring developments of all technologies worldwide so that the best innovations can be quickly adopted. What is critical is that the operating regime of any technology is fully understood, modelled and tested when being introduced to the grid. The specialist skills and knowledge of Australian engineers would play a major role in this process.

Energy options which can be deployed in the near to short term:

- *Energy efficiency and optimal integration*: Although energy efficiency is primarily achieved at household and business user ends, it also has ramifications for how the network is managed. It is here that engineers employ the latest digital technology to optimise flows between generators and users, matching forecast demand with supply. As certain parts of electricity supply are monopolistic (mainly in transmission and distribution), reform to regulation in these areas is necessary to complete an energy efficiency program. Implementing an energy efficiency program offers dual benefits: it is an effective way for Australia to reduce its emissions, and it avoids the opportunity cost associated with unnecessary expenditure on energy. To realise the full potential of energy efficiency across the economy, and promote investment in energy efficiency, barriers to energy efficiency efforts need to be addressed. This includes split incentives, information failures, lenders favouring existing and familiar approaches and assigning higher risks to new approaches and other disadvantages experienced by early adopters.

The removal of these barriers, along with more aggressive energy efficiency policies are essential in promoting energy efficiency. Setting an ambitious energy efficiency target for Australia will ensure that electricity users use no more electricity than is necessary and provides immediate response to emission reduction targets in the short term.

- *Increased interconnection*: Studies should be undertaken of the value of constructing new interconnectors, particularly between regions. This would identify opportunities where some regions that may have more synchronous capacity may assist others by providing ancillary services to increase security. The analysis is critical, particularly with the announcements of the retirement of further synchronous generation in the NEM.

- *Hot water storage*: Hot water storage allows consumers to match the high supply of solar power with the peak time of hot water usage. The development of smart meters and devices will be essential in the development of this technology. This technology is already in Australia.

- *Distributed generation:* Distributed generation gives the power back to the consumer by allowing them to charge a battery at the right time, and eliminate the cost and inefficiencies that are generally associated with distribution and transmission.

Energy options which could be deployed in the mid to longer term:

- *Energy storage*: Renewable energy storage technologies such as storing solar energy are already being developed and a market is emerging in Australia for home energy storage[1]. Energy storage holds great potential to benefit the electricity system and has the potential to solve challenges such as smoothing intermittency of renewable generation and managing peak demand[2]. By connecting millions of customer-owned generators and storage systems to each other, they can act as networks which help to match supply and demand[3]. However, without a transition plan, it is possible that grid defection could occur as the affordability of off-grid technologies become more prevalent. Conversely, with large uptake of embedded solar, the grid needs to be able to cope with back feed. Further demand side incentives for users to assist in reducing grid stress should be implemented, but it should be known what level of back feed is acceptable. Large interconnected grids are inherently more secure than a long skinny grid, and mini-grids or micro-grids would be highly beneficial as commercial battery storage becomes an energy option.

- *Concentrated solar thermal:* The advantage of concentrated solar thermal (CST) is that it has the ability to provide dispatchable energy in the same range as traditional

[1] For example, see the Reflow Zcell and Tesla Powerwall.
[2] CSIRO, 2015, *Electrical Energy Storage: Technology Overview and Applications*, prepared for the Australian Energy Market Commission, www.amec.gov.au
[3] Energy Networks Australia, CSIRO, 2016, *Electricity Network Transformation Roadmap: Key concepts report 2017-27*.

baseload electricity, and this can be adjusted based on grid demand[4]. Australia has an ideal climate for CST technology and declining costs will make this technology more attractive as it has the potential to provide a large percentage of Australia's power consumption[5].

- *Pumped hydro:* Although in the early stages of development, pumped hydro is an energy storage system that involves the recycling of water between adjacent upper and lower reservoirs[6]. Pumped hydro couples with transmission generation well, but not with distributed generation. Pumped hydro is already in use at Wivenhoe Power Stations, and new projects announced such as Kidston Project in North Queensland. For pumped hydro to be successfully deployed, the grid would need to be configured and operated in a way that optimises the use of renewable energy.

Energy options worthy of further consideration in the longer term, along with research and development:

- *Geothermal and wave energy*: In Australia, the two types of projects that are under development are enhanced geothermal systems and hot sedimentary aquifers[7]. Geothermal energy holds the potential of providing consistent energy over 24 hours, and can also be used for heating and cooling purposes. Wave energy is an emerging energy source and has the potential to contribute up to 11 per cent of Australia's energy[8].

- *Nuclear energy:* Nuclear power has the ability to provide long term energy security as modern nuclear power reactors are built with sixty-year life spans, and they also have near-zero carbon emissions[9]. Modern build reactors have minimal greenhouse gas and other airborne emissions, high fuel efficiency, minimal and manageable residual waste, built-in proliferation protection and advanced safety protection[10]. The majority of countries with low emissions intensities (such as Sweden, France, Finland) have nuclear power in their energy mix.

  The recent South Australian Royal Commission (SARC) inquiry into the nuclear fuel cycle found that nuclear power should not be discounted as an energy option on the basis of safety, but also found it would not be commercially viable to develop a nuclear power plant in South Australia beyond 2030 under current market rules[11]. This does

[4] Australian Solar Institute, 2012, *Realising the potential of concentrating solar power in Australia*.
[5] Clean Energy Council, 2015, *Concentrated solar thermal*, www.cleanenergycouncil.org.au
[6] Renew Economy, 2016, *No batteries required: pumped hydro for solar energy storage*, www.reneweconomy.com.au
[7] Australian Renewable Energy Agency, 2016, *Geothermal energy* www.arena.gov.au
[8] CSIRO, 2016, *Wave energy in Australia*, www.csiro.au/en/Research
[9] Engineers Australia, 2015. *Submission to the Nuclear Fuel Cycle Royal Commission*. www.engineersaustralia.org.au/about-us/government-submissions
[10] Australian Academy of Technological Sciences and Engineering, 2013. *Nuclear energy for Australia?* Conference report. www.atse.org.au
[11] Nuclear Fuel Cycle Royal Commission, 2016. *Nuclear Fuel Cycle Royal Commission Report.* www.nuclearrc.sa.gov.au

not totally discount the inclusion of nuclear energy in the future of the Australian energy mix, but to pursue it further there are issues which will first need to be addressed which are:

1. Two pieces of Commonwealth legislation that prohibit the licensing of a nuclear power reactor in Australia. A feasibility study would be required, learning from overseas nuclear projects, to see if this legislation should be amended.
2. The ability to generate electricity at a price that generates profits that are large enough to create a return on investment. As there is a wide difference in the costs of projects in different countries, a full feasibility study would be required to establish the cost of a nuclear project in Australia.
3. Public concern over the safety of nuclear energy. There are concerns that the nuclear industry is unsafe and has waste disposal problems, and these concerns cannot be ignored and public debate is essential before any possibility of nuclear energy being used in Australia.

Nuclear has the potential to provide diversity in electricity generation, provide long-term energy security, make a useful contribution to the reduction of greenhouse gas emissions and provide innovation, new industries and jobs. However, for nuclear energy to become an option for electricity generation in Australia, it would need to fully satisfy the three issues outlined above.

Consultation Questions 2

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

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

Engineers Australia agrees that there is great importance in consumer choice. This applies more broadly than just their own personal selections, but must also include market structures and rules to facilitate this. These topics have previously been raised in the Australian Energy Market Commission Power of Choice review with key recommendations put forward. Topics covered in this review including being given choice in selecting service providers for what have historically been monopolistic services (e.g. Residential metering).

Engineers Australia supports the three key reforms put forward in this report being:

1. Rewarding demand-side participation in the wholesale market.
2. Providing appropriate consumer protection arrangements and gradually phasing in efficient and flexible pricing.
3. Introduce competition in metering services and develop a framework for smart meters and their services.

An increasing proportion of customer appliances are ‘smart devices’ that are capable of being remotely controlled with the aid of modern telecommunications. Customer installations can have control agents embedded in the control systems to interactively respond to system demand. Greater attention should be given to sending the appropriate signals to customer installations so that they can be set to optimally utilise the combination of appliances, embedded generation and storage capability to respond to system conditions and reduce maximum demand. At the same time the algorithm would be set to meet the performance objectives within the household.

Consultation Questions 3

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

3.*1 What role should the electricity sector play in meeting Australia's greenhouse gas reduction targets?*

As a major contributor to Australia's greenhouse gas emissions, the electricity sector should also play a proportionate role in the meeting of greenhouse gas emission reduction targets. Australia made significant commitments to reducing global emissions at the 2015 United Nations Climate Change Conference in Paris (Paris COP21), and future decisions about energy supply must comply with this commitment.

Australia has large endowments of oil, gas and coal energy resources, but we cannot continue down the path of dependence on fossil fuels for electricity generation. Having a large variety of natural and emissions free energy resources allows Australia to consider a wider array of options so Australians can access plentiful, affordable, reliable and quality electricity supply to underpin industrial and social objectives, while at the same time reducing emissions to comply with international commitments.

Government policy has the ability to shape the role of the electricity sector in emission reductions, and Engineers Australia believes that this is best achieved through a national electricity transition plan. A national transition plan needs to set out national priorities for the electricity system, ensuring reliability, security, affordability and environmental considerations. All options should be available for analysis and public scrutiny, including existing and emerging technologies, and options such as nuclear energy which are constrained in the public debate by current legislation.

The emissions intensity from electricity generation is determined by the mix of technologies and Australia has a high emission intensity due to the dependence on fossil fuels. Many countries have emissions intensities one third of what is recorded in Australia. As the country does not have extensive hydro resources (such as Norway) or geothermal resources (such as New Zealand) all low emission options need be considered as part of the energy discussion.

A transition plan should also consider the age profile of Australia's largest coal-fired power stations, and the urgent situation of planning for a transition as some generators proactively close these stations. The Australian Electricity Market Operator (AEMO) predicts that there is no new or additional electricity generation needed for the next seven to 10 years[12]. However, it is estimated that as many as three-quarters of Australia's coal-fired power stations are

[12] Australian Energy Market Operator, 2016, *National Electricity Forecasting Report June 2016*. www.aemo.com.au/

operating beyond their original design life[13], and these power stations are responsible for a large portion of Australia's greenhouse gas emissions.

The national electricity generation, transmission and distribution system is a very large and complex system. This system must be properly engineered to meet national objectives. If a national transition plan for these aging power plants is not put forward there is the potential for high emitting power stations to continue to contribute large amounts of Australia's greenhouse gas emissions or, in the case of Hazelwood power station, a number of large capacity power stations could exit the market suddenly with no viable alternative ready to take its place.

Lowering the amount of greenhouse gas emissions from the electricity generation sector will also assist in lowering emissions in other sectors of the economy. Australia's transport sector will in turn see decreases in emissions as a transition to hybrid-fuel and electric vehicles becomes more common.

Engineers Australia believes that the future of Australia's energy supply will be dependent on a strong engineering workforce. Engineers will play a critical role in the research, development, production and implementation of energy efficiency and optimisation measures and emerging technology options, helping to provide reliable energy to Australian domestic and industrial consumers, while at the same time helping to meet Australia's emission reduction targets.

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

Gas is an important part of Australia's energy mix, already making up a large percentage of the energy generation sources, most notably in South Australia, Western Australia and the Northern Territory. With the ability to respond more rapidly to variable grid demands, and with lower emissions than coal, gas has been suggested as a short-term substitute or a transition fuel for aging coal fired power plants[14].

In Australia, gas consumption by gas powered generation is forecast to reduce in the short term, but beyond five years it is expected to rise to support electricity consumption and to replace over 2,000MW of expected coal-fired generation withdrawals[15]. While gas-fired generation will be seen as a substitute or transition fuel for coal, the extent of its use will be dependent on its cost, market framework and on the extent of emission reduction targets.

While gas is a more expensive fuel than coal, open cycle gas turbines are competitive at times of intermediate and peak demand[16]. Gas is effective as a peaking plant with the ability to ramp up quickly, where coal-fired plants are not easily able to adjust to demand. The prospect of gas price increases or shortages has recently made headlines, and this stems from Australia's

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[13] Australian Government, Department of Industry and Science, 2015, *Energy White Paper 2015*, www.ewp.industry.gov.au
[14] Kirkland, J, 2010, Scientific American, *Natural Gas Could Serve as 'Bridge' Fuel to Low Carbon Future.* www.scientificamerican.com
[15] Australian Energy Market Operator, 2015, *National Gas Forecasting Report*, www.aemo.com.au/Gas
[16] Australian Energy Market Commission, 2016, *Australia's Energy Market: Electricity*, http://www.aemc.gov.au/Australias-Energy-Market/Electricity/Generation

domestic market linking to the overseas gas markets. The eastern Australia gas market is increasingly reliant on coal seam gas and shale gas and over the past 10 years the retail price of gas for households has increased by eight per cent a year[17].

A number of stakeholders have called for a gas reservation policy in eastern Australia as they believe linking domestic gas markets to the international export market has distorted domestic prices. Others have pointed to international examples where gas reservation policies can hinder supply. While there is a reservation policy in place in Western Australia the Australian government has stated that it does not support it at the national level.

Serious consideration also must be given to environmental issues that are continually at the forefront of discussion with fracking. Extraction of natural gas through unconventional means such as fracking can be achieved safely if well managed. However, the intersection of environmental concerns, social effects and engineering solutions must be addressed publicly to regain a 'social licence to operate' if Australia is expected to source more energy from gas.

Gas is seen as a lower emissions fossil fuel compared to coal, but the extent to which it will replace coal-fired power stations is dependent on the reduction targets set. The CSIRO eFuture energy modelling tool shows projections to reduce emissions by our set targets do include small to medium percentages of gas[18]. Other studies suggest that portfolios sourcing significant quantities of energy from gas-fired generation in 2030 and 2050 will not achieve the greenhouse gas emission reduction levels required and that the lowest cost, low emission generation scenarios in 2050 source less than 20 per cent of energy from gas with the remaining energy sourced from renewables[19].

Increasing gas fired generation for electricity supply can assist in a transition away from coal fired power stations, however it only remains part of the short to medium solution in a low carbon economy. The role gas plays in the future energy mix will also be determined by energy policy considerations about the role of coal and nuclear energy, as well as the advancements in energy storage.

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

Companies such as large banks, which usually provide the investment into large power projects such as new power stations, are more strictly governing investment in energy projects. Many of the large banks have turned away from fossil fuel investment, which may stifle any proposals of retrofitting of existing coal power plants or building of new coal power plants.

Additionally, there are policy uncertainties in the electricity generation sector which are creating the barriers to further investment. The first is that there is a lack of a transition plan which would send the right signals to potential investors. Delaying a shift away from aging

[17] Australian Government, Department of Industry and Science, 2015, *Energy White Paper 2015,* www.ewp.industry.gov.au

[18] CSIRO, 2016, *eFuture energy modelling*, www.csiro.au

[19] Riesz, J, Vithayasricharoen, P, MacGill, I, 2015. Assessing "gas transition" pathways to low carbon electricity – An Australian case study. *Applied Energy*, Volume 154, 15 September 2015, Pages 794–804.

fossil fuel plants to low carbon options increases the likely risks and costs of a transition in the electricity sector because it can take decades to plan, permit, finance and build new power infrastructure[20].

Given the long term nature of traditional electricity investments, investment decisions in baseload generating capacity are usually made on the basis of long-term fundamentals rather than short term behaviour[21]. If there is ambiguity in policies that will influence Australia's future electricity generation options, it can create uncertainty for investors. To change this, bi-partisan support with long-term direction is required, otherwise there is risk of no further investment. This is not just a lack of policy; it is the policy content itself.

The second barrier to investment is widespread belief that current direct action policies are inadequate to meet Australia's emission reduction target. There has been a long held view by some that the current policy would either need more funding, or need to develop into an emissions trading scheme for Australia to reach its emissions target[22]. Further confusion is compounded as a number of jurisdictions are already putting forward their own climate change policies, partially due to a perception of a lack of federal leadership, which results in many states and territories working on different targets and approaches.

Climate change policies, which target the amount of emissions that a generator can produce can greatly alter expectations that generators may have about future costs or revenues. Uncertainty surrounding this policy, which has undergone substantial changes in recent years, can influence a generator's decision to remain in the market in the hope that it could benefit from little or no changes to government policy. At the same time new low carbon technology generators are affected in respect to their ongoing profitability under the current policy scenarios.

While government tone about the importance of a transition to help tackle climate change has recently become more positive, real action, and a real transition plan, are still missing from the national discourse. Doing nothing is not going to help investment, nor is it an option if Australia is going to follow through with the commitment to Paris COP 21 targets.

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

In the 2015 Australian Energy White Paper, the government states that it does not favour any intervention in promoting the transition away from coal-fired power plants, and that this should be left to the energy market to signal these changes[23]. The paper states that prematurely forcing new technologies in the energy market through policy interventions runs the risk of early adoption coming at a higher cost and lower efficiency than if that product

[20] Stock, A, 2014, The Climate Council, *Australia's Electricity Sector: Ageing, Inefficient and Unprepared.* www.climatecouncil.org.au
[21] International Energy Agency, 2003, *Power generation investment in electricity markets*.
[22] L. Taylor. The Guardian June 27, 2016. *Greg Hunt plays the long game on his glaringly obvious emissions trading scheme*. https://www.theguardian.com/australia-news/2016/may/27/election-2016-greg-hunt-coalition-emissions-trading-scheme.
[23] Australian Government, Department of Industry and Science, 2015, *Energy White Paper 2015*, www.ewp.industry.gov.au

found its way onto the market by a competitive basis. However, the energy market is not a 'real market' as it has some restrictions and biased incentives. These include the 5-minute dispatch while settlement occurs over a 30-minute trading interval, the AEMC adjusted maximum spot price cap, the different types of energy supply that are considered illegal (such as nuclear energy) and subsidised energy via advantageous tariffs creating market distortion.

Engineers Australia believes that, in light of this, some government intervention is warranted to kick start this transition to meet the Paris COP21 agreement targets that were set and to help boost investment in the sector. This will promote investment in emerging technologies that can provide reliable electricity supply, but also reduce emissions. For investors of new zero and low emission technologies, governments can initiate change by creating sustainable markets by filling funding gaps, and creating enabling infrastructure for new technology.

For emerging technologies, policies to create initial markets must run alongside research and development programmes, far ahead of widespread deployment of the technologies, and draw on competitive market forces where possible. Fostering the development and deployment of emerging technologies expands the number of low carbon technologies available at scale on a commercial basis, providing more flexibility and lowering overall cost[24]. Engineers Australia believes that to reduce emissions in the electricity generation sector, all options should be on the table.

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

Greenhouse gas emissions can be reduced if ultra-supercritical generators replaced the current aging and heavily emitting coal generators. Ultra-supercritical coal is a technology which improves the efficiency of coal-fired power stations by changing the steam conditions created in the boiler. Efficiency is increased by designing the unit for operation at higher steam temperature and pressure, which has been made possible by the development of new materials with higher performance capabilities[25].

However, even if these new generators were able to provide a 25 per cent reduction in coal emissions from electricity generation, it is only a fraction of Australia's total emissions and not enough to meet emission reduction targets. Additionally, the country would be locked in to using these power stations for another 30 or 40 years and it might be difficult to reduce the emissions from these stations further without more significant cost.

Carbon capture and storage (CCS) could be implemented with these plants, but this would result in much higher project prices. Carbon Capture and Storage is an enabling technology for reducing emissions from large sources of carbon dioxide emissions such as power plants[26]. This usually involves a transport and storage and network involving pipelines, booster pumps, wells,

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[24] International Energy Agency. 2015. *Energy and Climate Change, World Energy Outlook Special Report*.
[25] CO2CRC, 2015, *Australian Power Generation Technology Report*. www.co2crc.comau/publication-category/reports
[26] CO2CRC, 2015. *Australian Power Generation Technology Report*. www.co2crc.com.au/publication-category/reports

storage site facilities and monitoring facilities. Such a network does not currently exist in Australia.

IEA scenario analysis has consistently highlighted that CCS will be important in limiting future temperature increases[27]. Carbon Capture and Storage plant capital costs are projected to reduce by 2030 as there are likely to be improvements in both base plant efficiency and capture technology[28]. However, if there is a lack of deployment at the global level this can inhibit learning by doing, and not lead to reductions in costs for CCS.

There are also concerns that because of the additional costs associated with building capture plants, transport pipelines and a sequestration plant for CCS, the amount of coal that must be burned to make up for the energy cost of the CCS process itself would more than double[29]. When CCS was first considered as an emissions solution, competition from renewable energy sources such as wind and solar was much weaker than is the case now.

Ultra supercritical coal and CCS should not be completely discounted as a low emissions options, but the fast pace of advancements in renewable technology has dominated the future electricity generation discussion. If these coal technologies are to be considered in a future energy mix, advocates need to put forward arguments in the context of an overall transition plan which would verify their claims that it could keep prices lower, including costs for upgrading and extra maintenance while also achieving climate reduction targets.

[27] International Energy Agency, 2016, *20 years of carbon capture and storage – Accelerating future deployment.* www.iea.org
[28] International Energy Agency, 2016, *20 years of carbon capture and storage – Accelerating future deployment.* www.iea.org
[29] Ellem, G, June 2016, The Conversation, *Carbon capture and storage is unlikely to save coal in the long run*. www.theconversation.com

Consultation Questions 4

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

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

The 28 September 2016 blackout event in South Australia has brought the issue of energy security back into the public discourse, the weather warning prior to the unprecedented weather event on the 28 of September 2016 in South Australia was for wind gusts to 140 km/hr, while the transmission lines were rated to 165 km/hr. After the event it was found that some local areas had experienced tornados, in the case of Wilmington this was assessed at 260 km/hr and destroyed four towers. Additionally, some loss of power could not be avoided, as there were five major faults in less than two minutes, with three lines lost, and six big volt drops. The cost of building towers to withstand this level of wind would be prohibitive and therefore some loss of transmission lines could not be avoided.

The interconnector from Victoria at the time was fully loaded and a large proportion of the wind generation units that were generating at the time were not able to ride through the multiple transient conditions that occurred in a short period of time as a result of the short circuits that occurred on the system. The technical explanation for the units tripping out has not been resolved. In the meantime, however, the number of events that the units will ride through has been increased.

The recent discussion about energy security in Australia after this event have predominantly focused on the lack of a traditional baseload power production, without looking at the issue from a holistic approach. Too often the discussion about energy security in the context of electricity generation is too narrow and can miss the broader issues.

Diversity of energy options

A secure energy future will be reliant on a diversity of energy options including renewable energy production, connectivity between state borders and the development of smart-grids to help strengthen resilience. Baseload power that was supplied by fossil fuelled power stations needs to transition to a mix of energy options that, combined, are capable of providing the equivalent of the demand profile and the frequency support required. If there is going to be fluctuations in energy generation in the future, they will need to be balanced with alternative generation options which have the ability to supply power and frequency support on demand.

The engineering profession can play a lead role in the successful adaptation and implementation of technical solutions that can help minimise major disruptions to power supply, apply synchronous condensers, synthetic inertia and power conversion systems. It is important that work on Australian Standards for new technology be implemented early, so that these solutions are ready for real world application as soon as required. If the market operator is to alter the way that electricity is managed in an extreme weather event, there needs to be a mechanism in the market outlining how this can be achieved.

Vulnerability and resilience

A key goal of the energy security agenda should be to reduce vulnerability and improve resilience of energy supply systems by constantly improving these systems and ensuring integration with critical infrastructure[30]. The current grid's overreliance on aging twentieth-century architecture could create future systemic vulnerabilities.

The big cities get their power primarily from large clustered power producers located away from urban centres and electricity is transmitted over long, high voltage infrastructure. The transmission network plays a critical role by providing a highly reliable energy balance in a wide range of operating conditions and will play a key role in ensuring that power system security can be retained[31]. The potential of smart grid technologies with emerging energy storage systems can increase generation and distribution resilience.

Renewable distributed generation has become more popular as it provides greenhouse emission reduction, can handle grid vulnerability, curbs unnecessary infrastructure investments and enhances grid efficiency. However, it is a complex new area and not enough practical experimental and simulation studies have been engaged to delve into the operational and policy conditions. Without further investigation in this area, we could see implementation of sub-optimal renewable generation practice and policies not being able to cope with increasing demand loads, as we experienced recently in South Australia. As a result, stakeholder engagements for leveraging artificial intelligence and big data approaches need to be sought for digitalising and optimising renewable participated distributed generation, in particular with battery storage, on which engineering and policy decisions should be based on.

Australia's population growth is not forecast to become more widely spread; rather, it shall continue to be sparsely populated with only a concentrated number of energy intensive locations such as cities, mines, smelters, and steelworks. This is conducive to a long skinny transmission network, a structure which typically is of high vulnerability.

Focusing on the strength of energy intensive locations, local network meshing can advance the security of a network with distributed energy resources via distribution and sub-transmission interconnectors or bus-coupling utilising new technologies such as fault current limiting (FCL) ceramic high temperature superconductor (HTS) cable technologies. These interconnectors and bus-couplers do not increase the fault level (an issue usually created with more available sources of generation energising a busbar) but increases the security by reducing the vulnerability (e.g. one FCL HTS interconnector will increase the security of a N-1 substation to N-2). This is an enabling technology, providing a distributed energy resource topology not possible otherwise. The topology created by the distributed interconnectors would reduce the

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[30] Yates, A, and Greet, N, 2014, Engineers Australia, *Energy security for Australia: Crafting a comprehensive energy security policy.*

[31] Energy Networks Australia, CSIRO, 2016, *Electricity Network Transformation Roadmap: Key concepts report 2017-27*.

reliance on interstate interconnectors (making the power system more secure) while featuring the ability to cope with an increased number of smaller sized distributed energy resources that can supply states internally. Moreover, this opens up distributed energy resources to competition, providing both investors and customers a real choice of installation projects and supplies not possible otherwise.

If local network meshing options are to be considered, then true network vulnerability analysis will be required for future network planning accommodating distributed energy resources while reducing network vulnerability. This analysis would include determining where distributed interconnectors would best be located and installed, optimising the spend on the network while providing enhanced network security.

Energy efficiency and other technology options

Policy makers should also give much greater attention to reducing energy consumption through energy efficiency, because reducing total consumption of energy is one of the most cost-effective methods of improving energy security by lessening the demand on the system. Additionally, some consideration should be given to low emission technologies which can also provide baseload, high capacity electricity such as nuclear energy which has already been discussed in section 1.3 of this submission.

Planning for future community energy needs

A comprehensive view of energy security is important because electricity does not sit isolated from other energy considerations in Australia. The looming disruption of transport by electric and autonomous vehicles will shift the reliance from liquid fuels to a decentralised grid. Regulators and Government must plan for this disruption now or risk not being able to meet future demand. Australia cannot wait to be shocked by future events without a plan for a reformed energy grid.

To allow the market to respond appropriately and flexibly to such challenges, Engineers Australia believes that ongoing market reforms along with assistance mechanisms may be required, and this should be led by the federal government. Energy policy makers should avoid unnecessarily increasing vulnerabilities, threats and risks in both the energy sector and other sectors that affect electricity generation.

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

Although renewable distributed energy has complexities, Engineers Australia does not believe that this warrants curtailing electricity generation in each region. Firstly, not only would this not be feasible, but there is no evidence it is currently needed in jurisdictions with existing high levels of synchronous generation such as Queensland.

Although further practical experiments and situational studies are required, and the South Australia security should be investigated, the most likely and fastest way to get greater security is the deployment of other low-emission technologies; solar PV in Queensland and New South Wales have assisted in reducing the risk of outages. The market design must also be appropriate so investment is sensible for future network structure. There must be caution about how additional renewable energy is implemented in the future, which is why a transition plan is essential.

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

AEMO must have adequate information to know how generators will perform and impact the grid and the market. This was most evident in South Australia as there was an obvious knowledge gap in the fault ride-through settings for the wind farms. This would need to be extended to include the aggregated performance of small scale generation, for example rooftop PV inverters also have voltage and frequency settings and if they were all to trip off in one part of the grid this could lead to potential problems.

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

Engineers Australia believes that modern information technology, communications and data analytics can be used to improve supply network efficiency and reliability, in particular when faced with the challenges posed by variable renewable energy sources. Many of these new technologies can be utilised by consumers to help improve energy efficiency and optimisation.

Smart electricity meters offer a range of capabilities to manage and reduce energy consumption, and coupled with mobile device applications they can allow the consumer to be aware of their energy usage and modify behaviour. Smart meters allow differential time-of-day pricing to modify consumer behaviour and reduce peak demand. Social media offers the possibility of engaging customers in times of network stress or catastrophic weather events to switch off non-essential consumption.

Cloud based data gathering analytics can allow demand to be modelled and predicted. Modelling can be used to predict future demand trends based on population growth, demographics, affluence and energy conservation consciousness.

With the proliferation of domestic PV solar systems and the likely proliferation of on-site battery storage, communications technology offers the prospect of real-time monitoring and optimisation of feed-in from multiple sources to maintain network stability. On-site storage including electric vehicle battery packs could be coordinated across the network to balance supply and demand at the local level, to minimise transmission losses and fossil fuel backup generation usage.

Data gathering and analytics would allow the generation capacity of renewable sources to be determined as a function of prevailing weather conditions, and risk management techniques could be applied to predict the probability of adverse events. This would allow contingency measures to be put in place in the event of catastrophic weather, network stress and generation outages. Asset Management systems coupled with equipment health monitoring and risk analysis allows effective management to be undertaken, including predictive maintenance.

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

Modern power grids are cyber-physical systems composed of data communication networks and physical infrastructure. To have high levels of resiliency of the network for continued energy supply, not only vulnerability of the physical system requires attention but that of the data communication network, as well as interactions between these cyber and physical systems. Protection that controls the physical systems are open to attack if the cyber systems are not kept secure. Power system communication network and interacting cyber elements that are open to attack increases the vulnerability of the physical elements, reducing the power system security. Attention to keeping these communication networks secure utilising the latest data science techniques is recommended. Moreover, it is highly recommended investing in the development of specific security methodologies for the Australian power system data communication network and its interacting elements to ensure ongoing power system security.

Consultation Questions 6

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

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

Demand side management techniques have been used within Australia to defer or avoid network infrastructure. The generation stations can control their peak demand by optimising:

- large load which can be utilised during off-peak, such as pumps for filling up tanks
- hot water systems to their customers (distributer, retailer and general)
- all government buildings and upgrading to optimal energy efficient settings.

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

Tariff reform, including structures such as time-of-use or critical peak pricing must consider both the appetite of customers to receive what could be complex billing, and the benefit to energy reliability and security. Where network service providers in Australia have rolled out demand side management programs, direct payments have been used to reward customers while lessening the burden on the network, increasing network reliability. Without cost reflective pricing (CRP), this is often done outside the Retailer's billing systems, and represents a form of "network support payment".

Recent heatwave events have reinforced the need to address the issue of peaking load. This is especially relevant as consumers utilise certain electrical appliances during extreme weather events (such as air conditioning on a hot day) and place a heavy load on the grid. During peak when demand is highest, CRP provides no benefit to customer energy consumption affordability. However, during high demand, security and reliability can only be sustained with CRP that uses automated signalling to control customer load, otherwise user intervention will exacerbate the high demand. Mechanisms such as air conditioning demand manipulation (by way of retail control of thermostat set points and availability), mandating the sale of smart-compatible appliances that can be 'integration-enabled', as well as planning approvals through Greenstar programs to enforce the use of 'integration-enabled' appliances, can all provide overall customer affordability benefits.

'Stepped' technology of new inverter technologies in appliances are more efficient which helps to reduce consumers' energy bills. During heatwaves, older air conditioners that operate above their designed ambient temperature cannot cool the air sufficiently and remain on at all times. A replacement program would reduce demand and market operating price. Current government subsidies provide an advantage to those who can afford to take up these new technologies, but at a cost to the whole community, as only those who can afford it benefit from it. Policies which incentivise inverter technology would be of great advantage during the hot summer months as they have the ability to run all day while remaining efficient, and using less energy.

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