ENGINEERS AUSTRALIA

The Future of Australian Electricity Generation

2017

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The Future of Australian Electricity Generation

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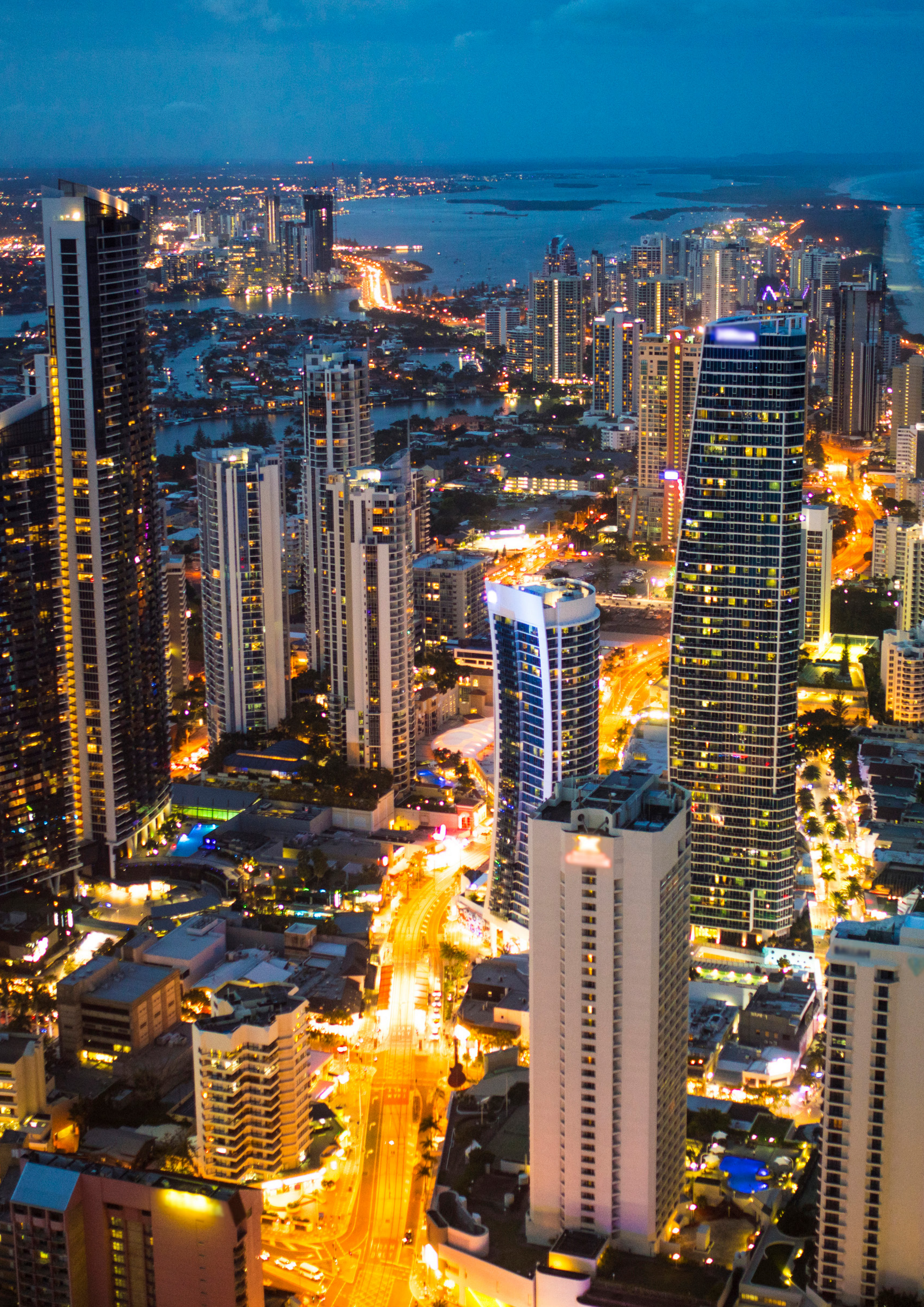
We are the global home for engineering professionals renowned as leaders in shaping a sustainable world.



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Executive Summary

Engineers Australia accepts the comprehensive scientific basis regarding climate change and has addressed this in its sustainability and climate change policies[1]. Electricity supply in Australia is fast approaching a juncture due to traditional fossil fuel power stations coming to the end of their economic lives, increased market pressure from renewable energies and community expectation regarding the need to address climate change. In recent years there have been falls in the demand for electricity due to industry restructuring, greater public awareness of energy conservation, the use of behind the meter renewables, energy efficiency and altered consumer behaviour. These factors are also responsible for projected modest growth in demand over the next 20 years.

Electricity supplied by Australia's current and planned power stations are expected to produce enough energy in the market for the next seven to 10 years. However, Australia's largest capacity coal fired power stations are operating near or beyond their expected commercial lives, and these power stations are responsible for a large portion of Australia's greenhouse gas emissions. They will need to be replaced with low-emissions generation in an orderly way.

Australia has large endowments of oil, gas and coal energy resources, but it does not necessarily mean that we should 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 and electricity generation policy should be determined by what Australia is aiming to achieve. 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.

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. It is time for government energy policy makers to put forward a national transition plan, so Australia can begin to lower emissions and exploit new technologies.

A transition plan should consider all options, and transforming Australia's electricity generation is not a matter of choosing just one technology for the future. 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. A secure energy future will be reliant on these policy approaches being successfully deployed.

1: Engineers Australia, www.engineersaustralia.org.au

Coal fired power stations may be expected to contribute a significant amount of electricity generation in the immediate future, but they will come under increased pressure from climate target constraints, community expectations and renewable energy advancements.

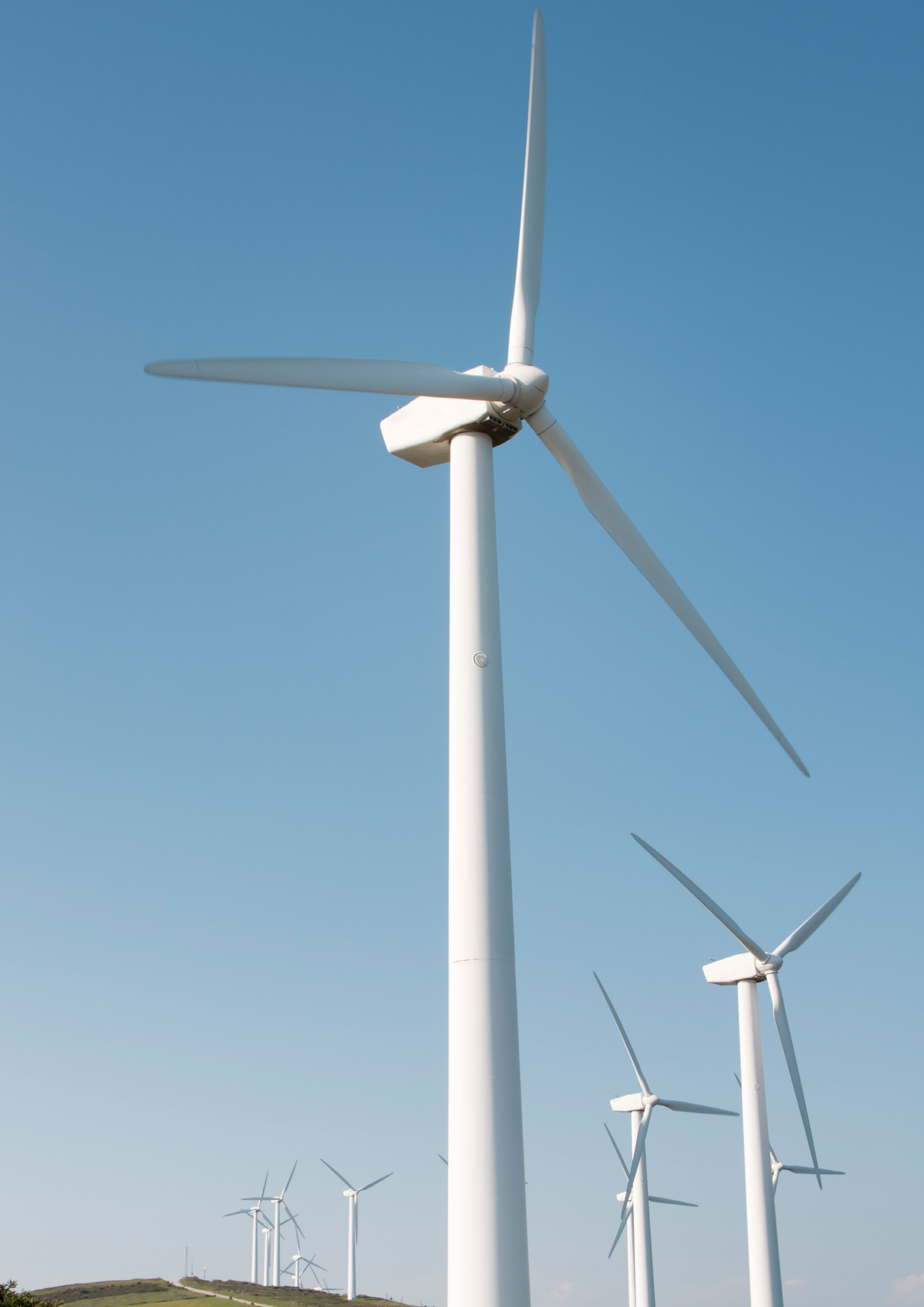
Gas already plays an important part in Australia's energy mix in a number of states, and has been widely suggested as a short-term substitute for coal. This is because gas has lower emissions than coal and has the ability to respond more rapidly to grid demands. Nuclear energy has also been suggested as it has the potential to provide long-term energy security and reduce emissions. However nuclear energy must first prove to be cost effective and satisfy existing community concerns about safety and proliferation.

Renewable electricity generation options including solar PV and wind generation are already influencing the electricity market, and other options are continuing to develop such as solar-thermal, hydro, geothermal, bio-mass, waste gas and wave and tidal energy. Currently rooftop solar PV is the most influential renewable energy to which consumers have direct access and wind energy is currently the lowest cost, low emission, technology which can be rolled out on a large scale.

The emergence of battery storage options and greater use of pump storage will become more prevalent in the next decade as technology development improves, opening up the possibility to transition from reliance on centralised electricity generation to distributed energy generation and storage.

There are also other wide reaching policy approaches that could influence the electricity market, and help to reduce emissions. Energy efficiency policies can be implemented with immediate effect, with the potential to effectively reduce emissions. Additionally, information and data analytics can be used to improve supply network efficiency and reliability, and can assist in managing consumption.

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 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.



Introduction

Access to a reliable, affordable, quality electricity supply is crucial to Australia's continued industrial and commercial prosperity, and to the standard of living currently enjoyed by Australians. Australia has historically used a diverse range of its energy resource base for electricity supply, with the majority powered by coal and gas. In more recent times, Australia has increasingly used a variety of renewable energy resources including wind, solar, geothermal, ocean, hydro and bioenergy.

In the coming decade, Australia will need to reconsider its energy supply mix as a number of large capacity fossil fuel power stations reach the end of their economic lives, and Australia's post Paris COP21 commitments need to be addressed. To overcome the potential loss of a large amount of generation from the grid, and to meet emission targets, Australia will need to further diversify its energy supply and look at increasing low emission options.

Engineers Australia believes there is great value in advancing Australia's renewable energy options as there are promising developments in this sector and the cost competitiveness of new products usually improves as the production of the technology becomes more efficient and economies of scale become apparent. Engineers Australia believes that Australia should also pursue energy efficiency policies as they can have an immediate effect on energy productivity and on reducing emissions.

To prepare for the required change in the energy sector, a national transition plan is essential to provide a clear direction for the nation, provide certainty for investors and consumers, and reduce risk and unnecessary costs to the energy sector. Government policy intervention, clearly laid out through a national transition plan, has the ability to shape the future of Australian electricity generation, considering all options which can help meet emission reduction targets.

This document highlights the current issues facing the electricity generation industry in Australia, and calls on government to create a transition plan to steer Australia in the right direction. Without a clear plan, Australia risks losing a large portion of its generating capacity in a short period without any alternatives in place, while at the same time undermining its Paris COP21 commitments. Reliability and resilience of supply, transmission and distributions of an interconnected electricity grid needs to be considered in any transition plan.

Australia's energy future will require the expertise of Australia's engineering profession. Engineers have the critical skills that can prosper in a future economy with reduced emissions, and engineers will be vital to a successful transition.

A national transition plan is essential to provide a clear direction for the nation.

Demand Drivers

The organisational structure of Australia's electricity supply system has recently come under increased scrutiny as there has been widespread rises in electricity retail prices, while the demand for electricity fell between 2010 and 2015[2]. However, the increase in retail prices does not fall entirely on the shoulders of retailers or network operators as the retail prices that consumers pay for electricity is the aggregate of wholesale, transmission and distribution, and retail prices. When governments structurally separated the energy supply industry in the 1990s, generation and retail were in separate corporations. Since then some retailers and generators have tended to vertically integrate to form 'gentailer' structures, as a way of managing the risk of price volatility in wholesale energy markets[3].

The retail sector of the supply chain is a market, some regulated and some unregulated, which allows consumers to choose which retailer they would like to supply their energy. Retailers that are regulated are allowed to make a 'reasonable' margin, ranging from three to 10 per cent depending on the state[4]. While retail customers are free to choose their electricity provider, all states except Victoria provide a standard contract price. The set price allows retailers to cover three sets of costs: costs associated with buying electricity from the wholesale market, costs in transmitting and distributing electricity from the generators, and retail costs.

Wholesale prices in the National Electricity Market (NEM) are determined every five minutes, and averaged over each half hour period to get a spot price. Energy markets can be extremely volatile over short periods due to the need to instantaneously and continually match the supply with demand which fluctuates from one period to the next. However, over a longer time period they become more stable. Retailers purchase significant volumes of electricity in the wholesale market and sell smaller packages on to consumers. Retailers 'hedge' their exposure to market fluctuations via long term contracts and/or owning and operating their own generation as gentailers.

The price retailers pay in the wholesale spot market is highly volatile, while the price they receive from customers is largely fixed over designated time periods, exposing retailers to higher degrees of risk[5], however this is not the case for gentailers. Settlement in the wholesale market occurs through the Australian Electricity Market Operator (AEMO), it is then packaged with transportation charges (for

2: Nelson, T & Orton, F, 2016. Australia's National Electricity Market: Optimising Policy to Facilitate Demand-Side Response The Australian Economic Review, vol. 49, no. 2, pp. 146-168
3: AMEC, KPMG, 2013. National Electricity Market: A case study in successful microeconomic reform
4: Reserve Bank of Australia, How are Electricity Prices set in Australia? www.rba.gov.au
5: The Energy Efficiency Exchange, 2016, The Wholesale Price of Energy www.eex.gov.au

use of network infrastructure) for sale to consumers[6]. Ultimately the consumer pays for it all through their electricity bill.

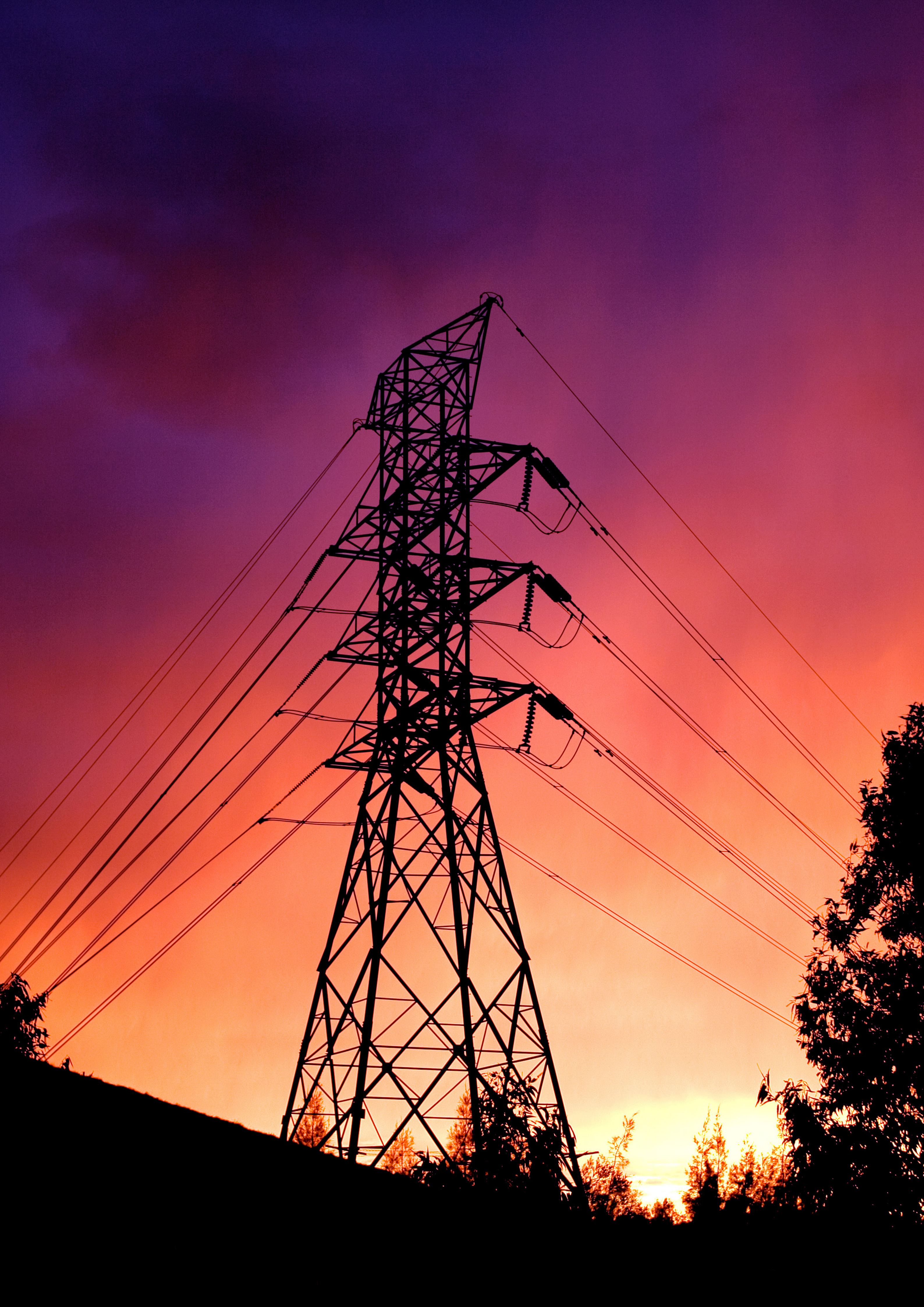
Between 2006 and 2013, the average Australian household power bill increased by more than 85 per cent[7] and this price increase included the three sets of costs the retailer covers. Transmission charges usually make up about 10 per cent of retail prices, while distribution charges make up about 35 to 50 per cent[8]. Electricity price increases can be driven by rising network charges, reflecting the need to expand network capacity (based on demand growth forecasts at the time), replacing aging assets, meet higher reliability standards set by government policy and to cover higher input and borrowing costs. The AER has generally reset the weighted average cost of capital (WACC) down in recent determinations[9].

The extensive networks of electricity poles and wires in a low population density country like Australia means that network services in a particular region can be most efficiently provided by a single monopoly supplier. As natural market competition prices cannot apply, governments need to impose regulation on these networks to meet the long term interests of consumers, and provide reasonable profits to business owners. The regulator imposes a maximum price that an electricity network can charge for services.

If there is poor regulation of electricity markets, there is the potential for overinvestment or unnecessary maintenance which can be disadvantageous to consumers who could be forced to pay more for reliable electricity. Recently, high public scrutiny of high electricity prices led to a senate references committee report in 2015 to investigate the causes of the large price increases. The Interim report found that price increases that have been experienced by consumers were a result of past under-investment, institutional arrangements and regulatory design[10].

Future advancements in technology could lead to large numbers of end users having the ability to generate and store their own electricity. If more consumers become energy self-sufficient, there is the potential for some network infrastructure to become underutilised. Stakeholders and policy makers will need to develop policies which provide greater engagement in this area aiming for a more national approach.

6: Australian Energy Market Commission, 2016, Australia's Energy Market: Electricity, http://www.aemc.gov.au/Australias-Energy-Market/Electricity
7: Wood, T, January 2014, The Grattan Institute, The end of the gold-plated electricity network. https://grattan.edu.au/news/the-end-of-the-gold-plated-electricity-network/
8: Reserve Bank of Australia, How are Electricity Prices set in Australia? www.rba.gov.au
9: Australian Energy Regulator, October 2015, Final Decision: Energex determination 2015-16 to 2019-20 overview
10: The Senate Environment and Communications References Committee, April 2015, Performance and management of electricity network companies, Interim report



Australia's Wholesale Electricity

Australia has an abundance of both fossil fuel and natural energy resources which have underpinned national prosperity over the past 50 years. The energy sector is a major contributor to the Australian economy, accounting for approximately six per cent of the economy in 2014-15[11]. It is expected that domestic and international demand for Australia's energy resources will continue to rise over the next few decades, but the rate of this growth is expected to slow[12].

Domestic energy is supplied to the east and south of Australia through the NEM. The NEM connects five market jurisdictions being NSW and the ACT combined, Victoria, Queensland, South Australia and Tasmania. Currently, Western Australia and the Northern Territory are controlled by individual state arrangements, although AEMO operates the south west interconnected system (SWIS) in WA. Projections from the AEMO show electricity consumption remaining relatively flat for the next 20 years, despite a projected growth in the Australian population[13].

This projected flattening of growth is primarily due to changes in electricity demand, rather than any reduction in supply. Reduction in demand over the last five years, and projected stagnant growth can be partially attributed to industry restructuring and industries exiting which has made remaining industries less power intensive. There has also been greater public awareness of energy conservation, which has directed consumers to energy efficiency schemes and renewable energy products such as rooftop PV, which has also contributed to falling network demand.

Wholesale electricity refers to Australia's electricity generation sector. Historically coal, oil, and gas have been the dominant energy sources for fuel consumption in Australia and this is reflected overwhelmingly in Australia's largest power stations.

In 2014-15 electricity generation from fossil fuel resources comprised 88 per cent of the total electricity produced by Australian businesses, and renewable energy accounted for the remaining 12 per cent[14]. Table 1 shows the percentage of fuel type used for electricity generation in each state and territory and a total for Australia.

TABLE 1:
State and Territory energy source percentages

Fuel Type	NSW & ACT	VIC	QLD	SA	TAS	WA*	NT**
Coal	62.9	50.7	65.5	0.0	0.0	36.0	0.0
Gas	13.7	19.9	26.1	61.7	6.4	59.0	98.3
Solar	1.4	0.0	0.0	0.0	0.0	0.0	0.0
Wind	4.1	10.2	0.1	34.7	11.1	2.0	0.0
Water	16.9	18.7	5.3	0.1	82.3	0.0	0.0
Biomass	0.8	0.4	2.9	0.5	0.2	0.0	0.0
Other	0.3	0.0	0.0	3.0	0.0	4.0	1.7

Source data: AEMO 2016 Statement of Opportunities. Percentages shown only take into account existing generation at the time of release. The Statement of opportunities showed a number of proposed power stations for gas, solar and wind. Rooftop domestic solar not included.

*WA refers to the SWIS system only
**NT data sourced from Electricity Gas Australia 2012-13

11: Australian Government, Department of Industry, Innovation and Science, 2015, Energy in Australia, www.industry.gov.au/oce
12: Australian Government, Department of Industry, Innovation and Science, November 2014, Australian Energy Projections to 2049-50
13: Australian Energy Market Operator, 2016, National Electricity Forecasting Report June 2016. www.aemo.com.au/
14: Australian Bureau of Statistics, 2016, Energy Use, Electricity Generation and Environmental Management, Australia, 2014-15 www.abs.gov.au

Australia's electricity supply is historically characterised by a dependence on fossil fuel energy, which has been the dominant source of fuel type for electricity generation. As demonstrated in Table 1, coal continues to provide the majority of electricity generation in New South Wales, Victoria and Queensland.

Natural gas use for electricity generation has grown and accounts for a large percentage of generation in South Australia, Western Australia and the Northern Territory. The percentage of gas as a fuel type for generation is expected to continue to grow as the consumption of liquefied natural gas (LNG) is boosted over the next 30 years due to the increased use of gas in industries[15]. Currently hydro-generation is the highest renewable energy electricity generator and this is most notably so in Tasmania.

Currently in Australia, the total megawatt capacity supplied by existing power plants is enough to fuel peak demand in summer and in winter in all the states which make up the National Energy Market (NEM) as well as Western Australia[16]. AEMO has predicted that there is no new or additional electricity generation needed for the next seven to 10 years to meet the projected demand[17].

If this projection is realised without any compensation reduction in peak demand, electricity sector capacity utilisation will fall and will change the economics of remaining in business for generators and may create circumstances for early exits by some[18]. The prediction by AEMO may already be in question, as we have already seen the announced closure of one of Australia's largest power stations, Hazelwood. The age, and the emission levels of many of Australia's highest capacity power stations must be considered more closely.

Table 2 (page 16) shows the top 20 electricity power stations in Australia, ranked by total capacity[19]. Key points that can be seen from this table are:

- The majority of Australia's largest capacity power stations are powered by black and brown coal, highlighting Australia's historical dependence on fossil fuels for electricity generation.
- A large portion of these power plants were commissioned in the 1970s and the 1980s. As a result, many of these power plants are reaching the end of their commercial lives and some are already working beyond it.
- If these aging plants were to be removed from the grid in quick succession, there is the potential to see as much as 7,654.3 MW in capacity removed.
- The power plants that have been commissioned more recently do not have the same MW generation capacity as the older power plants.

Electricity generation in Australia as part of the energy supply industry has become characterised by aging power stations and old technology. The economic life span of a traditional fossil fuel fired power plant is generally accepted to be around 40 years of age[20]. It is estimated that as many as three-quarters of Australia's coal-fired power stations are operating beyond their original design life[21], and some have had 'life extension' refits.

15: Australian Government, Department of Industry, Innovation and Science, 2014, Australian Energy Projections to 2049-50
16: Australian Energy Market Operator, 2016, National Electricity Forecasting Report June 2016. www.aemo.com.au/
17: Australian Energy Market Operator, 2014, No New Power Generation Needed for Next 10 Years. http://www.aemo.com.au/News-and-Events/News/2014-Media-Releases/No-New-Power-Generation-needed-for-the-next-10-Years
18: Energy Networks Australia, CSIRO, 2016, Electricity Network Transformation Roadmap: Key concepts report 2017-27
19: This is the most recent list of Australian power stations available.
20: T Woody. 2013. Quartz. Most coal-fired power plants in the US are nearing retirement age. http://qz.com/61423/coal-fired-power-plants-near-retirement/
21: Australian Government, Department of Industry and Science, 2015, Energy White Paper 2015, www.ewp.industry.gov.au

The decision facing governments, policy makers and investors will not only be when these older plants will need to be replaced, but what technology they should be replaced with. Old technologies and aging electricity generation plants have implications beyond the electricity supply industry and could become a drag on national productivity as a whole. As there is no or modest forecasted growth in electricity demand, there is also no incentive for any new generators to enter the market unless an existing operator closes.

There are many wind and other renewable power station projects planned for the near future, and this has been driven by the Renewable Energy Target (RET) scheme. There have also been some proposed fossil fuel power plants which have large megawatt capacity and existing plants with approval for additional capacity, however it is questionable if these projects will proceed due to the current demand conditions, as well as community concerns of adding further emissions from coal fired generation.

Policy makers must realise that a fresh approach is essential and any decision on replacing aging plants needs to be made with consideration of Australia's global commitments to emissions reductions. Australian energy policy is constrained by, and must now be linked to, the Paris COP21 agreement and an emissions reduction target of 26 to 28 per cent on 2005 levels by 2030[22].

The existing major generators are powered by fossil fuels and are high emitters of greenhouse gases, with electricity generation being responsible for the largest source of emissions in Australia, accounting for 35 per cent of total emissions in the year 2015[23]. Although emissions have declined from peaks in 2008-09, 2015 saw a 1.8 per cent increase in emissions from 2014 levels[24].

These emission levels leave the electricity generation sector incompatible with international emission reduction commitments that Australia made in Paris COP21. A transition plan to a new energy paradigm is essential if Australia is to remain internationally competitive, and reduce emissions.

A transition plan to a new energy paradigm is essential if Australia is to remain internationally competitive.

22: Australian Government, Department of Environment, 2015, Australia's 2030 climate change target, www.environment.gov.au
23: Australian Government, Department of Environment, 2015, Quarterly Update of Australia's National Greenhouse Gas Inventory: December 2015. www.environment.gov.au
24: Ibid.

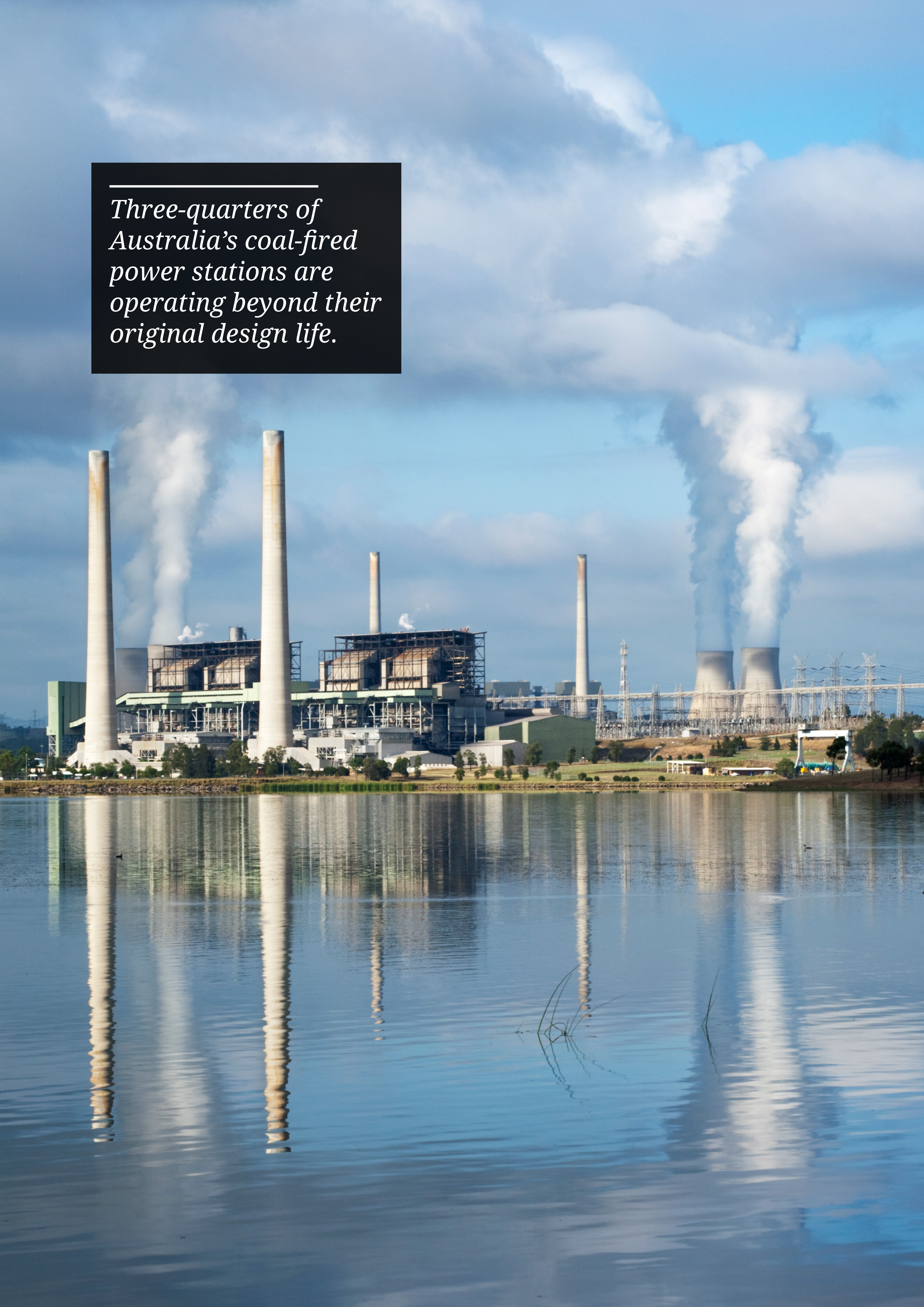
TABLE 2:
The top twenty power plants in Australia ranked by total capacity (MW) 2012-13

Number	State	Power station	Plant type	Primary fuel type	Commissioning year	Total capacity (MW)
1	NSW	Eraring	Steam	Black Coal	1982-84	2780
2	NSW	Bayswater	Steam	Black Coal	1982-84	2640
3	VIC	Loy Yang A	Steam	Brown coal	1984-87	2209.1
4	NSW	Liddell	Steam	Black Coal	1971-73	2000
5	VIC	Hazelwood	Steam	Brown coal	1964-71	1743.3
6	QLD	Gladstone	Steam	Black Coal	1976-82	1680
7	NSW	Tumut 3	Hydro	Water	1973	1500
8	VIC	Yallourn W	Steam	Brown coal	1975, 1982	1480
9	QLD	Stanwell	Steam	Black Coal	1993-96	1460
10	NSW	Mt Piper	Steam	Black Coal	1993	1400
11	QLD	Tarong	Steam	Black Coal	1984-86	1400
12	NSW	Vales Point B	Steam	Black Coal	1978	1320
13	SA	Torrens Island	Steam	Natural Gas	1967, 1977	1280
14	VIC	Loy Yang B	Steam	Brown coal	1993-96	1026
15	NSW	Wallerawang C	Steam	Black Coal	1976-80	1000
16	VIC	Murray 1	Hydro	Water	1967	950
17	WA	Muja	Steam	Black Coal	1981, 1986	854
18	QLD	Millmerran	Steam	Black Coal	2002	851
19	QLD	Callide C	Steam	Black Coal	2001	810
20	QLD	Kogan Creek	Steam	Black Coal	2007	750

Source data: Electricity Gas Australia 2012-13[25]

25: Note that a number of power stations have closed or announced future closure since the release of Electricity Gas Australia 2012-13 including Hazelwood, Morwell, Playford and Redbank.

Three-quarters of Australia's coal-fired power stations are operating beyond their original design life.



Future Electricity Considerations

Coal and gas may be expected to contribute a significant amount of electricity generation in the immediate future, but they will come under increased pressure from climate target constraints, community expectations and renewable energy advancements. Transforming Australia's electricity generation is not a matter of choosing one technology for the future, it is using a combination of existing and emerging technologies and this must coincide with new policy approaches. Without a suitable approach to navigate an energy transition, Australia's energy system will be unable to efficiently and securely integrate the diverse technologies, large scale low carbon energy sources and consumer owned energy resources[26].

Energy security

Energy security is defined by the International Energy Agency (IEA) as the uninterrupted availability of energy sources at an affordable price[27]. Increasingly, energy security is a contested concept and different stakeholders have different perceptions of what energy security is, and how it can be achieved[28]. Challenging the narrow definition of energy security will enable planners of the future Australia electricity supply to assess and adapt to a wider range of vulnerabilities.

Energy security for the electricity generation sector is a multi-dimensional concept, which touches on issues across the social, political, economic and environmental spectrum. Too often the discussion about energy security in the context of electricity generation is too narrow and can miss the broader issues.

The 28 September 2016 blackout event in South Australia has brought the issue of energy security back into the public discourse, and the Australian government has since publicly spoken about energy security priorities for state governments[29]. The recent discussions about energy security have predominantly focused on the lack of a traditional baseload power production, without looking at the issue from a holistic approach.

Firstly, a secure energy future will be reliant on a diversity of energy options including renewable energy production, connectivity between state borders so energy can be traded, and the development of smart-grids to help strengthen resilience. This means the discussions about energy security should not only be about traditional baseload power production, but also the ability of households, businesses and government to accommodate energy market supply disruptions[30].

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 traditional baseload power. 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 on demand.

26: Energy Networks Australia, CSIRO, 2016, Electricity Network Transformation Roadmap: Key concepts report 2017-27
27: International Energy Agency. 2016. What is energy security? www.iea.org/topics/energysecurity/subtopics/whatisenergysecurity/
28: Yates, A, and Greet, N, 2014, Engineers Australia, Energy security for Australia: Crafting a comprehensive energy security policy
29: Frydenberg, J. 2016, Ministers agree to independent review to develop a national energy security blueprint, media release, 7 October, viewed 20 October 2016, www.joshfrydenberg.com.au/guest/mediareleases/
30: Hepburn, S, 2016, South Australian blackout: renewables aren't a threat to energy security, they're the future. www.theconversation.com

To maintain electricity system security, parameters such as system inertia, frequency and system voltage need to be controlled into narrow ranges to avoid major disruptions to power supply which may be experienced with an influx of renewable energy sources[31]. There are technical solutions that can be applied to increase grid security and reliability including synchronous condensers, synthetic inertia, power conversion systems and fast interruption of loads to correct demand and supply imbalances[32]. The engineering profession can play a lead role in the successful adaptation and implementation of these technical solutions.

Secondly, 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[33]. The current grid's overreliance on aging twentieth-century technology based on centralised power generation and interconnected distribution architecture will 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, vulnerable, 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[34]. The potential of smart grid technologies with emerging energy storage systems can increase generation and distribution resilience.

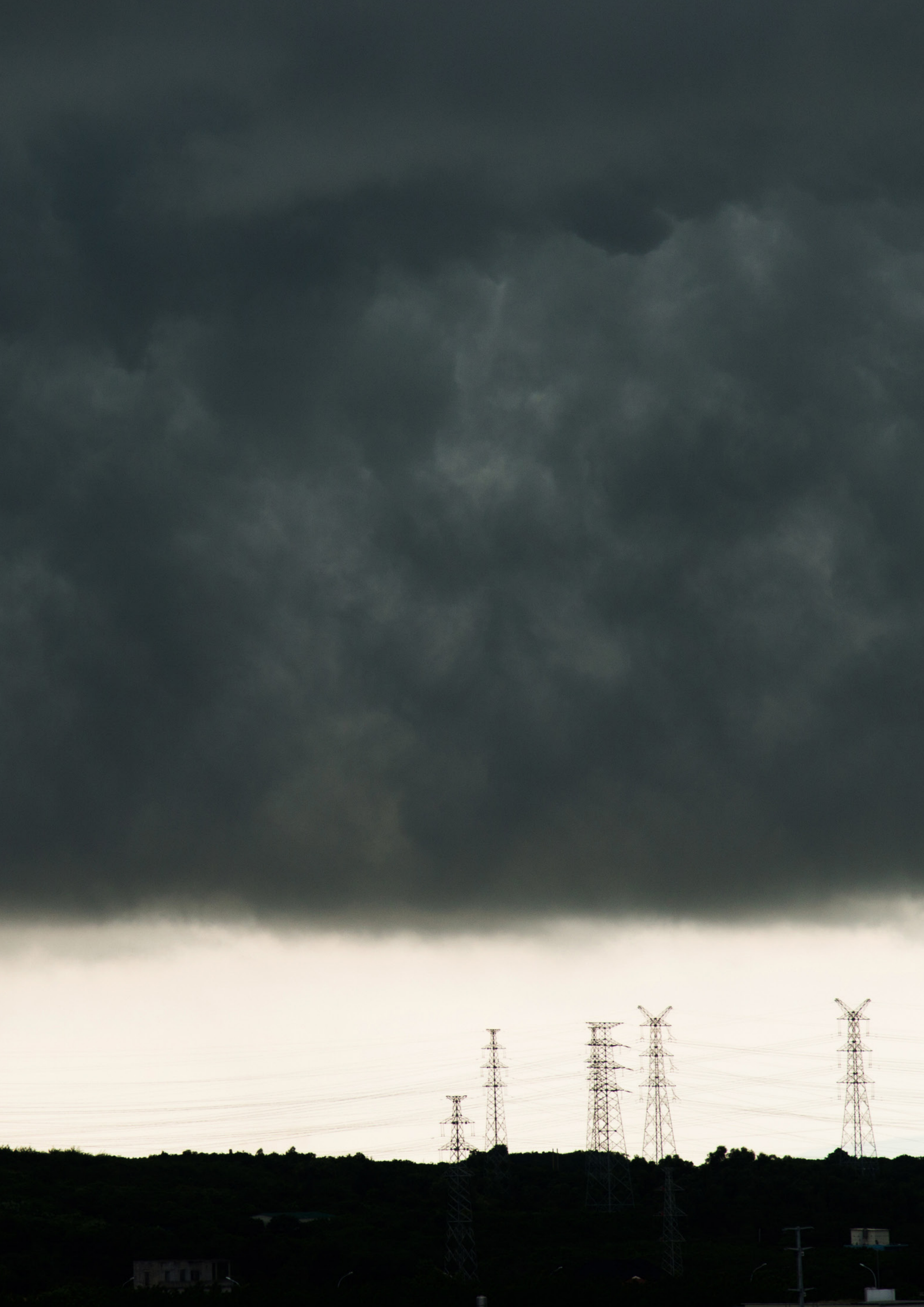
Thirdly, policy makers should also give much greater attention to reducing energy consumption through energy efficiency, as reducing total consumption of energy is one of the most cost-effective methods of improving energy security. By consuming less energy, it reduces vulnerability to both demand and supply shocks, it reduces the national energy bill, and improves environmental security through reducing emissions.

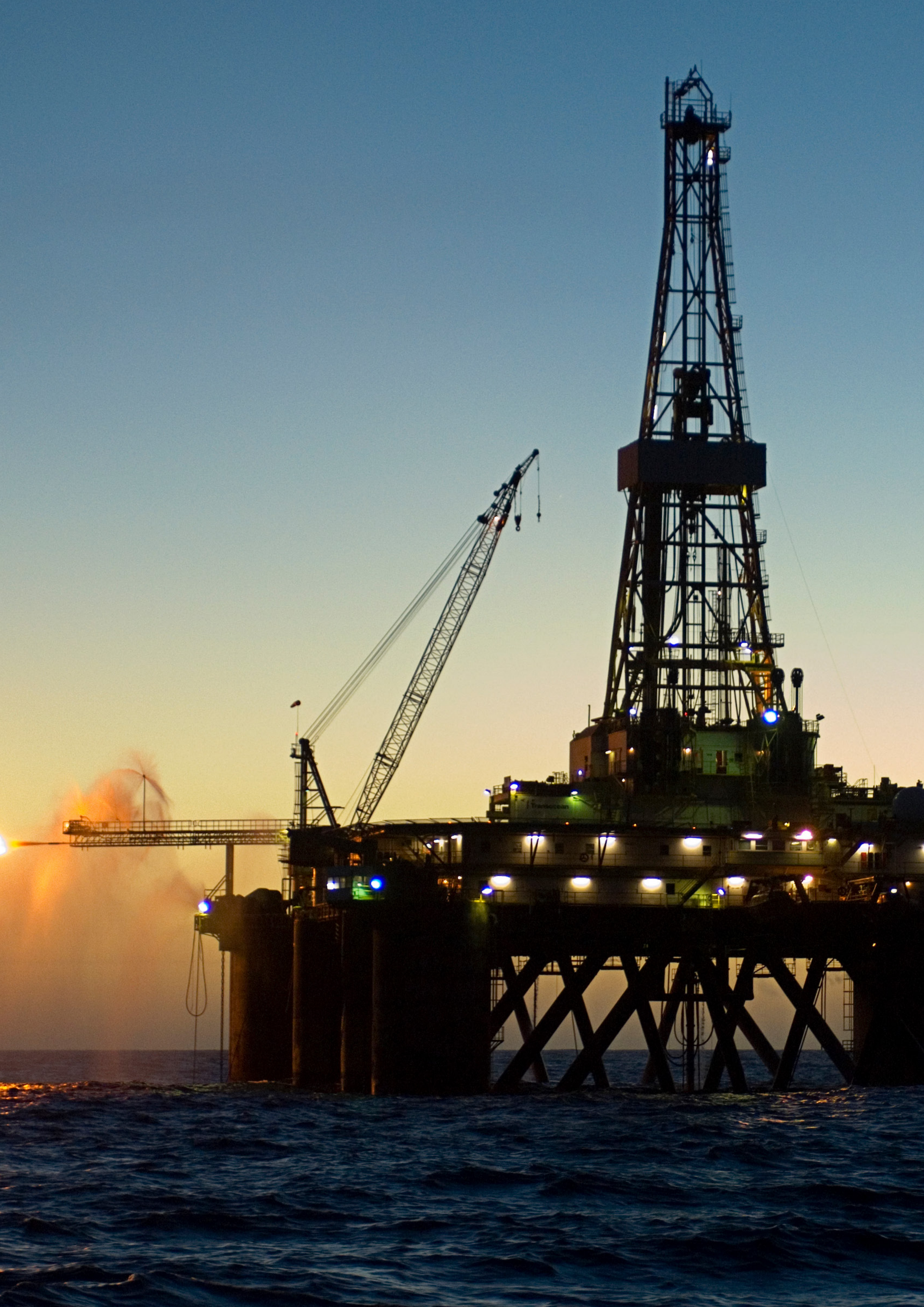
To meet these challenges there will also need to be significant investment required to maintain reliability while transforming the sector, with this investment driving associated price pressures. Investing in energy infrastructure is an expensive and long-term proposition. To develop this infrastructure, energy producers need to have security of demand to justify the investment. Once the upfront investment is made, producers are concerned about demand shocks resulting in idle plant and equipment, and hence decreasing their financial returns.

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.

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.

31: Finkel, A, December 2016, Independent review into the future security of the national electricity market: preliminary report.
32: Ibid.
33: Yates, A, and Greet, N, 2014, Engineers Australia, Energy security for Australia: Crafting a comprehensive energy security policy
34: Energy Networks Australia, CSIRO, 2016, Electricity Network Transformation Roadmap: Key concepts report 2017-27





Gas

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 lower emissions than coal, gas has been suggested as a short-term substitute for aging coal fired power plants[35].

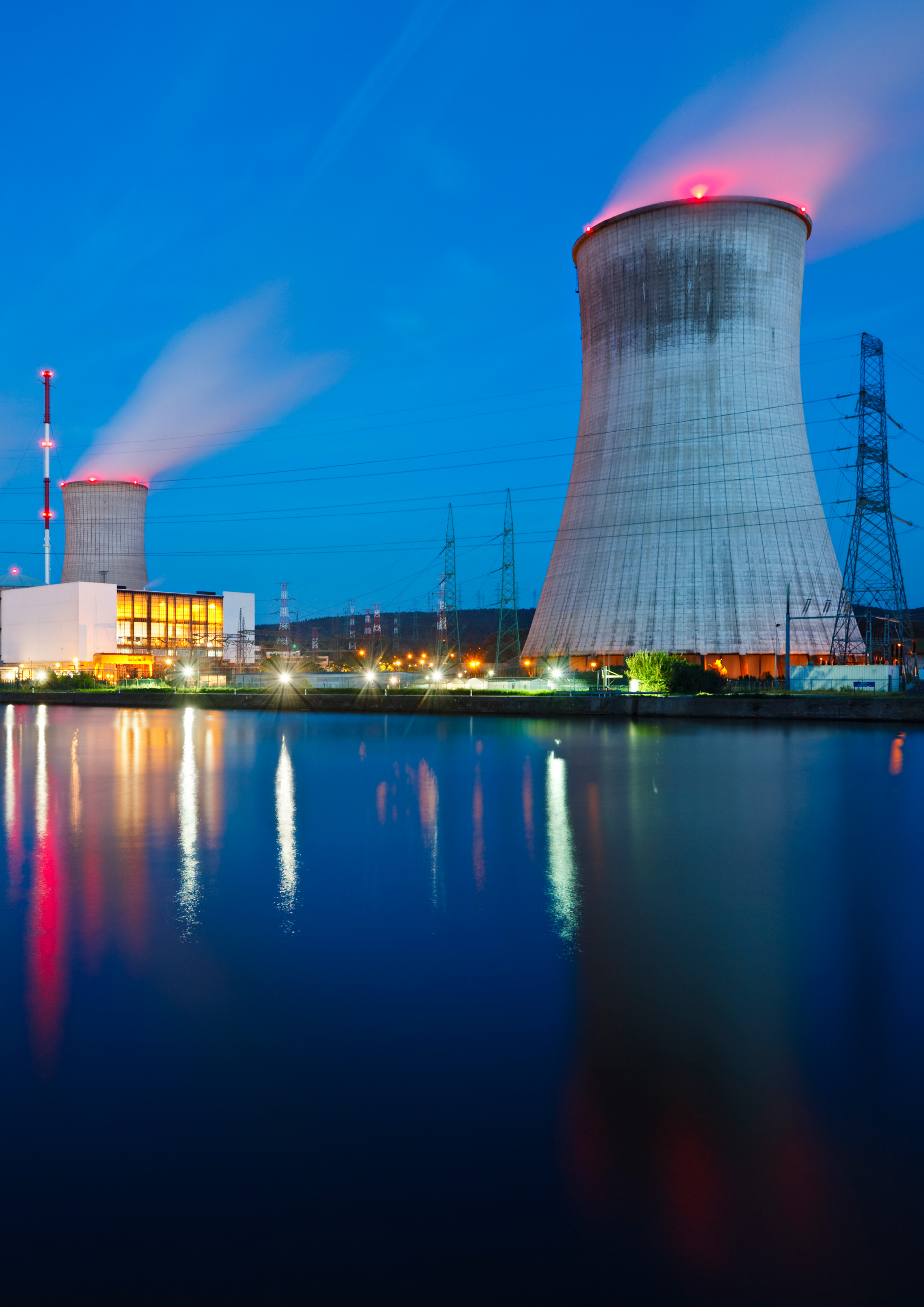
In Australia, gas consumption by gas powered generation is forecast to reduce in the short term, but beyond five years it is expected to rise to support electricity consumption and to replace over 2,000 MW of expected coal-fired generation withdrawals[36]. While gas fired generation will increasingly be used to complement intermittent generation from renewables, the extent of use will be dependent on the cost of gas, and on the environmental policy considerations of emissions reduction[37].

While gas is a more expensive fuel than coal, open cycle and combined cycle gas turbines are competitive at times of intermediate and peak demand[38]. 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 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[39].

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 while 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.

In the power sector, using gas instead of oil for supplying electricity during peak times of demand, and for captive off-grid electricity generation, has the potential to save a further AU$520 million annually by 2030 while also reducing carbon dioxide emissions by one million tonnes per year[40]. However, results 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[41]. 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. 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 solution in a low carbon economy.

35: Kirkland, J, 2010, Scientific American, Natural Gas Could Serve as 'Bridge' Fuel to Low Carbon Future. www.scientificamerican.com
36: Australian Energy Market Operator, 2015, National Gas Forecasting Report, www.aemo.com.au/Gas
37: Heyning, C and Segorbe, J, McKinsey and Company, The role of natural gas in Australia's future energy mix, McKinsey Australia and Energy Insights June 2016
38: Australian Energy Market Commission, 2016, Australia's Energy Market: Electricity, http://www.aemc.gov.au/Australias-Energy-Market/Electricity/Generation
39: Australian Government, Department of Industry and Science, 2015, Energy White Paper 2015. www.ewp.industry.gov.au
40: Heyning, C and Segorbe, J, McKinsey and Company, The role of natural gas in Australia's future energy mix, McKinsey Australia and Energy Insights June 2016
41: Riesz, J, Vithayasrichareon, 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



Nuclear energy

Electricity generation from nuclear power has been recognised by many nations as an energy source that provides secure, reliable energy as nuclear power is a baseload, high capacity technology[42]. To generate constant reliable electricity on a large scale, nuclear energy has been seen as a real alternative to fossil fuels as it is considered to be suitable for major industrial and commercial loads.

Nuclear power also 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[43]. 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[44].

There has been an international effort in the USA, China, Russia, South Korea, and Argentina to develop smaller, decentralised power stations with small modular reactors (SMRs)[45]. SMRs have the potential to enable capacity to match growing demand more closely and are designed to be multipurpose as they can also be used for desalination or to supply process heat.

Australia already has input to the international nuclear fuel cycle, as a large supplier of uranium fuel, and as an experienced operator in research reactors. The Australian government through the latest Energy White Paper has acknowledged the wide variety of views on nuclear energy in Australia and it also has stated that the Australian Government will consider the outcomes of the South Australian Royal Commission (SARC) into the Nuclear Fuel Cycle[46].

Although SARC found that nuclear power should not be discounted as an energy option on the basis of safety, SARC found it would not be commercially viable to develop a nuclear power plant in South Australia beyond 2030 under current market rules[47]. This does not totally discount the inclusion of nuclear energy in the future of the Australian energy mix, as there are recommendations for the South Australian government to promote the development of national energy policies that include nuclear. To pursue nuclear energy in South Australian and Australian energy policies, there are a number of issues that would first need to be addressed.

Firstly, a major legal obstacle to the deployment of nuclear power in Australia lies in two pieces of Commonwealth legislation that prohibit the licensing of a nuclear power reactor in Australia:

- Environmental Protection and Biodiversity Conservation (EPBC) Act 1999, section 140A
- Australian Radiation Protection and Nuclear Safety (ARPANS) Act 1998, section 10.

There are also specific prohibitions in three states: NSW, QLD and VIC.

SARC has recommended that the South Australian Government pursue removal at the federal level of existing prohibitions on nuclear power generation to allow it to contribute to a low-carbon system.

The second issue is that any additional electricity generator coming into the electricity market would need the ability to generate electricity at a price that generates profits that are large enough to create a return on investment. Large nuclear power is generally characterised by large upfront capital costs, however, SMRs do have a lower initial capital cost and flexibility of additional modules being added as demand increases.

42: Engineers Australia, 2015. Submission to the Nuclear Fuel Cycle Royal Commission. www.engineersaustralia.org.au/about-us/government-submissions
43: Ibid.
44: Australian Academy of Technological Sciences and Engineering, 2013. Nuclear energy for Australia? Conference report. www.atse.org.au
45: Engineers Australia, 2015. Submission to the Nuclear Fuel Cycle Royal Commission. www.engineersaustralia.org.au/about-us/government-submissions
46: Australian Government, Department of Industry and Science, 2015, Energy White Paper 2015, www.ewp.industry.gov.au
47: Nuclear Fuel Cycle Royal Commission, 2016. Nuclear Fuel Cycle Royal Commission Report. www.nuclearrc.sa.gov.au

If Australia is to attract capital investment for nuclear energy, governments would need to create the right investment climate by considering total system costs rather than just the levelised cost of energy (LCOE)[48], or introduce an emissions reduction scheme that allows all low emissions technologies to be considered. Estimates provided in a 2012 Australian Energy Technology Assessment (AETA) undertaken by the Australian Government Bureau of Resource Research Economics (BREE) suggested that nuclear energy was readily competitive with other forms of low emissions generation[49].

However, a new collaborative report[50] has found that nuclear technology has become more expensive, with cost projections changing considerably from the previous 2012 estimates. The Australian Power Generation Technology Report found that based on the LCOE alone, nuclear was recorded as being more expensive than the majority of wind and solar energy options, and comparable to coal with carbon capture and storage[51]. 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.

SARC has recommended that the South Australian government collaborate with the Australian government to monitor and report on commercialised nuclear reactor designs that may offer economic value for nuclear power generation in the future. SARC considers 2030 to be the earliest that a nuclear power plant could reasonably be expected to start operation in South Australia. Nuclear electricity generation will depend on network demand at that time, and the extent to which renewable energy generation, energy storage and electric vehicle technologies have developed.

The third issue is public concern over the safety of nuclear energy. There are concerns that the nuclear industry is unsafe and has waste disposal problems[52]. These concerns cannot be ignored and public debate is essential before any possibility of the option of nuclear energy being used in Australia.

Developing community confidence in nuclear technology and safety is a clear first step and this will require transparent communication and open public debate over an extended period at all levels. This requires an effective public engagement strategy, addressing issues in an open and transparent manner. SARC found that while acknowledging the severe consequences of nuclear accidents, there is sufficient evidence of safe operation and improvements such that nuclear power should not be discounted on this basis.

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 current issues outlined: government policy and legislation, cost, and community acceptance. The scope and timing of any nuclear energy policies would be highly influenced by policy measures to reduce greenhouse gas emissions in the energy sector.

48: Australian Academy of Technological Sciences and Engineering, 2013. Nuclear energy for Australia? Conference report. www.atse.org.au
49: Ibid.
50: CO2CRC, 2015. Australian Power Generation Technology Report. www.co2crc.com.au/publication-category/reports
51: Ibid.
52: Australian Academy of Technological Sciences and Engineering, 2013. Nuclear energy for Australia? Conference report. www.atse.org.au

Ultra supercritical coal-fired generation and carbon capture and storage

The Australian government stated in its 2015 Energy White Paper that coal is expected to continue to play a vital role in providing low cost energy[53]. The paper also states that the capacity to store carbon will be vital if Australia will have continued reliance on coal-fired power stations, and needs to reduce emissions.

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[54].

Greenhouse gas emissions can be reduced if ultra-supercritical generators replaced the current aging and heavily emitting coal generators. Predictions on the assumptions made in the Australian Power Generation Technology report show that replacing all of Australia's coal-fired power stations with new ultra-supercritical stations could see a reduction of 16 per cent in coal emissions[55]. If Australia waited for further advancements in this technology this could increase to as much as a 25 per cent reduction[56].

However, even a 25 per cent reduction in coal emissions from power stations is only a small 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 unable to reduce emissions further.

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[57]. This usually involves a transport and storage and network involving pipelines, booster pumps, wells, 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[58]. 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[59]. 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 the additional costs associated with building capture plants, transport pipelines and a sequestration plant for CCS would more than double the amount of coal that must be burned to make up for the energy cost of the CCS process itself . 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 while also achieving climate reduction targets.

53: Australian Government, Department of Industry and Science, 2015, Energy White Paper 2015, www.ewp.industry.gov.au
54: CO2CRC, 2015, Australian Power Generation Technology Report. www.co2crc.comau/publication-category/reports
55: Molyneaux, L, January 2017, The Conversation, Is clean coal power the answer to Australia's emission targets. www.theconversation.com
56: Ibid.
57: CO2CRC, 2015. Australian Power Generation Technology Report. www.co2crc.com.au/publication-category/reports
58: International Energy Agency, 2016, 20 years of carbon capture and storage – Accelerating future deployment. www.iea.org
59: Ibid.

Renewable technologies

With Australia committing to strong emission reduction targets, new emerging renewable electricity generation and storage technologies will put increasing pressure on traditional coal and gas fired power plants. There are already a number of emerging low carbon technologies which have been at the forefront of public discussion, further expanding Australia's electricity generation options.

Firstly, there are increases in renewable electricity generation options which are already in commercial use, or are in the development phase. This includes solar PV, solar thermal plants, wind, hydro, geothermal, bio-mass, waste gas and ocean wave and tidal energy. Currently rooftop PV is the most influential renewable energy generation to which consumers have direct access. Deployment of distributed solar PV has been rapid, with more than 1.5 million distributed solar PV systems now installed across the country[60].

Additionally, residential and commercial uptake of rooftop PV is expected to increase in the coming decades, adding to the projected reduced electricity consumption from the market[61]. If the right policies are introduced it is expected that consumers using rooftop solar panels and batteries will produce between 30 to 50 per cent of Australia's electricity needs by 2050[62]. Large-scale solar PV (defined as greater than 5MW) remains in its infancy however 12 new projects were announced at the end of 2016 with 482 MW (AC) capacity costing over $1 billion[63].

Wind power generation is currently the lowest cost, low emissions technology available that can be rolled out on a large scale[64]. In 2015 Australia's 76 wind farms generated a combined capacity of 4187 MW[65]. Industry observers are expecting to see advancements in the industry, with taller towers for access to greater wind speeds, larger rotators for lower wind locations, and improved reliability and efficiency to reduce cost[66]. The 28 September 2016 blackout event in South Australia raised concerns about wind power providing a reliable energy supply comparable to coal. This led the COAG Energy Ministers to agree to an independent review of the national electricity market to take stock of its security and reliability, with the review being led by the Chief Scientist, Dr Alan Finkel.

It is expected that renewables such as wind and solar will be assessed in terms of security and reliability of power supply. Renewable energy has historically had some difficulty integrating to the pre-existing power grid, as the original grid was not designed to accommodate a large number of dispersed resources, but large generators usually situated outside of major populated areas. Renewable energy such as wind and solar are inherently intermittent as they rely on natural sources which can create challenges in adjusting power output depending on prevailing weather conditions.

To compensate for the growing percentage of renewable generators, there has been discussion about adjustments to the NEM which may be required so it can adapt to the influx of renewable energy, which would allow the system to cope better with intermittency[67]. Additionally, different strategies could be incorporated such as increasing generators over a geographically dispersed area and increasing the number of generators to assist with intermittency issues[68]. Power system security and reliability can also be improved by investing in assets such as interconnectors which allow connected regions to access more installed capacity across the grid, allowing trading between regions and back-up capacity when needed[69].

60: CO2CRC, 2015. Australian Power Generation Technology Report. www.co2crc.com.au/publication-category/reports
61: Australian Energy Market Operator 2016. National Electricity Forecasting Report June 2016. www.aemo.com.au/
62: Energy Networks Australia, CSIRO, 2016, Electricity Network Transformation Roadmap: Key concepts report 2017-27
63: Australian Renewable Energy Agency, September 2016, Historic day for Australian solar as 12 new plants get support. https://arena.gov.au/media/historic-day-australian-solar-12-new-plants-get-support/
64: CO2CRC, 2015. Australian Power Generation Technology Report. www.co2crc.com.au/publication-category/reports
65: Clean Energy Council. 2015, Wind energy in Australia, 2015 in focus, https://www.cleanenergycouncil.org.au/technologies/wind-energy.html
66: CO2CRC, 2015. Australian Power Generation Technology Report. www.co2crc.com.au/publication-category/reports
67: Ludlow, M, 14th August 2016, Australian Financial Review, More gas, interconnectors on COAG energy agenda, www.afr.com
68: Fares, R, 2015, Scientific American, Renewable Energy Intermittency Explained: Challenges, Solutions, and Opportunities, www.scientificamerican.com
69: Finkel, A, December 2016, Independent review into the future security of the national electricity market: preliminary report

The predictive output of wind and solar energy may also improve as both solar and wind power depend on natural systems which can be modelled and forecast with reasonable accuracy[70]. Modelling against weather forecasts could help predict supply capacity and forecast demand, to allow efficient management of backup generation.

Furthermore, renewable energy storage technologies such as storing solar energy are already being developed, and a market is emerging in Australia for home energy storage[71]. 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[72]. 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[73]. There are challenges which must be addressed before their full benefits will be realised, however none of the challenges are considered insurmountable.

Improvements in electricity management and storage which could further advance the use of renewable energies includes the development of energy storage, micro-grids and demand management systems. As Australia's transmission electricity grid is typified by being long, thin and stretched out to remote regions[74], these technologies are able to adjust both the supply of electricity to the grid and demand for electricity from the grid.

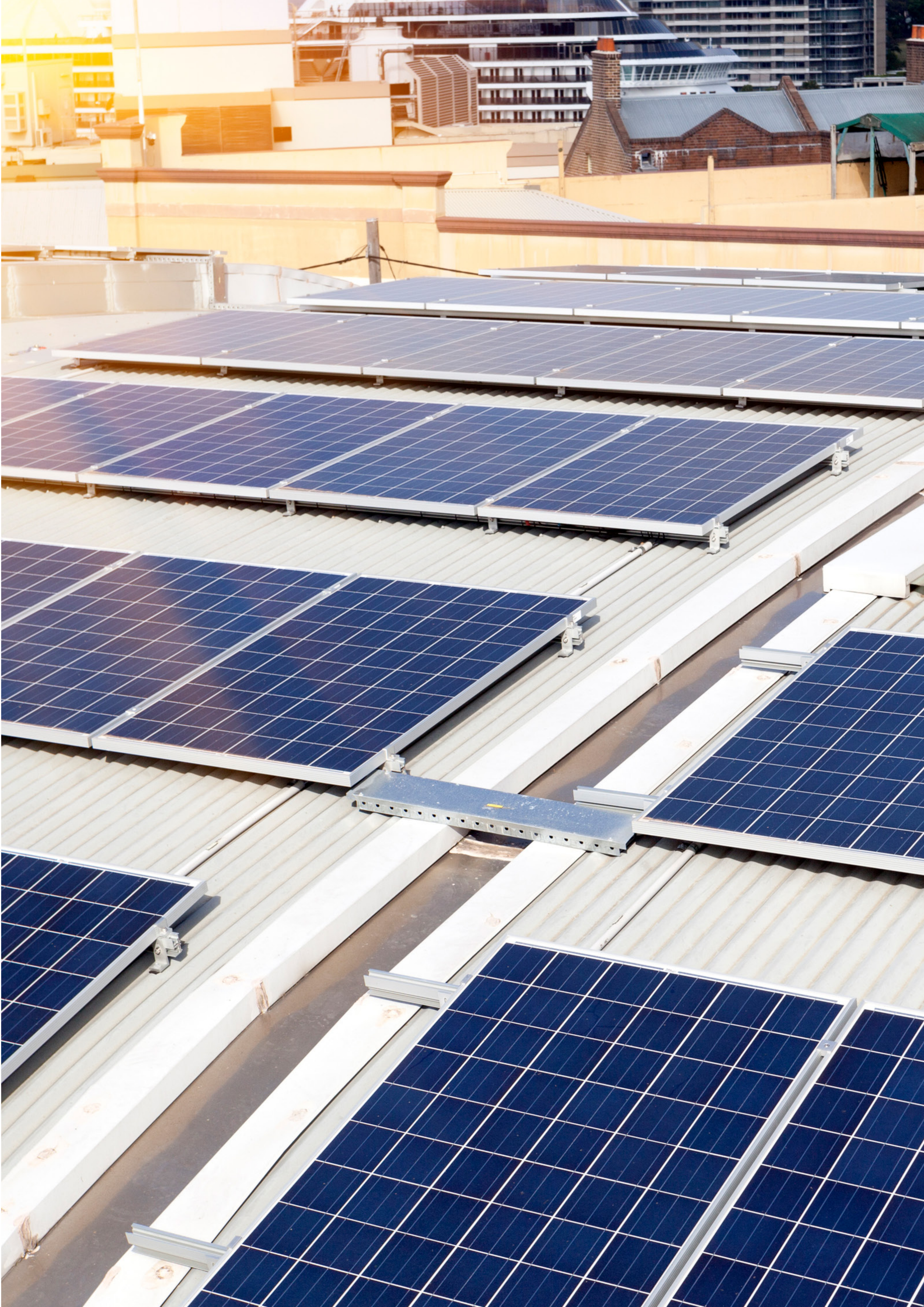
The result may ultimately be the transition from almost complete reliance on centralised electricity generation to a more shared system with distributed electricity generation. Battery storage technology will enable households to access lower cost energy, and AEMO is already forecasting an increase in the uptake of battery storage options beginning in 2017 and then accelerating in the mid-2020s when it is believed the technology will become more economic to the average consumer[75]. Battery storage on a large scale may only be an emerging technology, but it has the potential to make a real lasting change in the electricity generation market.

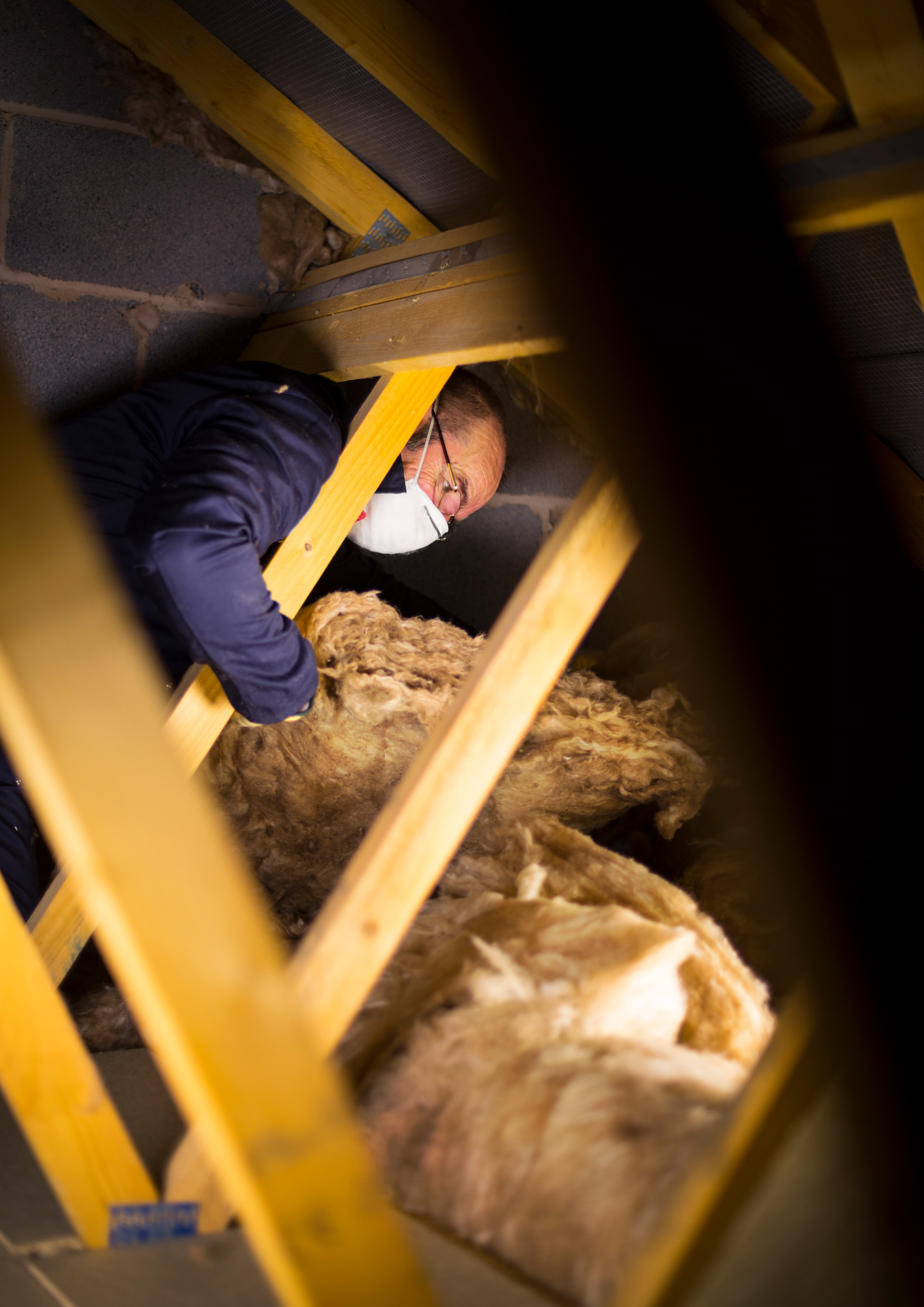
Case study: Combining solar power and battery storage

The Australian Renewable Energy Agency (ARENA) is providing $17.4 million funding support to a solar energy plant which will also include lithium-ion battery storage, located in far north Queensland. The project consists of a 13MWp/10.8MWac solar power PV, with 41,440 solar panels and 1.4MW/5.3MWh storage option which has been designed to provide a consistent power supply[76]. By using storage technology along with the solar PV, there is the possibility of solar power supply after sundown and during peak usage times without having to access the grid[77]. It will produce enough electricity to power the equivalent of over 3,000 homes day and night, and will connect to one of the most remote NEM substations in Australia.

This project adds to ARENA's portfolio of fringe-of-grid projects, which showcases the ability of renewable energy to enhance the reliability of energy supply in regional areas. This project is aiming to be the first in the world to test a concept known as 'islanding' from the main electricity grid, with the aim to power the whole town independently for several hours[78]. This project trial demonstrates the potential for communities to be removed from the grid for long periods, and providing energy reliability in remote areas. If this model is adopted throughout Australia and storage technologies continue to advance it has the potential to change the traditional generation and distribution infrastructure in Australia.

70: Fares, R, 2015, Scientific American, Renewable Energy Intermittency Explained: Challenges, Solutions, and Opportunities, www.scientificamerican.com
71: Reflow Zcell, Tesla Powerwall.
72: CSIRO, 2015, Electrical Energy Storage: Technology Overview and Applications, prepared for the Australian Energy Market Commission, www.amec.gov.au
73: Energy Networks Australia, CSIRO, 2016, Electricity Network Transformation Roadmap: Key concepts report 2017-27
74: Australian Government, Department of Industry and Science, 2015, Energy White Paper 2015, www.ewp.industry.gov.au
75: AEMO 2015. 2015 National Electricity Forecasting Report June 2015. www.aemo.com.au
76: Conergy, 2016, Conergy starts construction on Australia's first grid-connected utility-scale solar and battery storage project. www.conergy.com.au
77: Australian Renewable Energy Agency, 2016, World first to combine big solar and storage. www.arena.gov.au
78: Ibid.





Energy efficiency

Energy efficiency has already played a big part in reducing the demand in energy consumption. However, much of this improvement has been led by consumers and other energy users who have made energy choices in their own interests, rather than because of political leadership. Engineers Australia believes the political attention given to higher energy bills tells Australians only half the story because it neglects the potential of energy efficiency to reduce those bills.

Consumer choices have already made significant contributions to the reduction in electricity consumption as consumers have been increasingly seeking energy efficient products and appliances. This has also been influenced by Commonwealth and state household energy programs including solar hot water, ceiling insulation and home energy rating schemes. This trend is expected to continue in the coming decades as consumer preferences and behaviours continue to change[79]. Although there is an expected increase in the use of electrical appliances in households as the population increases, less energy is consumed as the energy efficiency of these products also continues to improve. The traditional household with a stationary home computer and entertainment system is slowly being replaced by mobile devices with Wi-Fi connections, which use relatively less electricity.

Energy efficiency is primarily achieved at household and business user ends, but 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. As certain parts of electricity generation are monopolistic (mainly in transmission and distribution), reform to regulate in these areas is necessary to complete an energy efficiency program.

Australia has a real opportunity to exploit the benefits of energy efficiency throughout the economy. While energy efficiency often requires capital investment, most opportunities deliver a financial return to householders and businesses who implement it[80]. The potential to implement energy efficiency policy measures will reduce electricity demand, and reduce emissions. The built environment alone has the potential to reduce projected emissions in half by 2050, and could meet over half of the national energy productivity target, and more than a quarter of the national emissions target[81].

Engineers Australia believes that Australia should more aggressively pursue energy efficiency policies in electricity generation as it 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.

79: Australian Energy Market Operator, 2016, National Electricity Forecasting Report June 2016, www.aemo.com.au/
80: ClimateWorks Australia, 2015, Australia's Energy Productivity Potential. www.climateworks.com.au
81: Australian Sustainable Built Environment Council, 2016, Low Carbon, High Performance

Information and data analytics

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 intermittent renewable energy sources. Modern electronics technology can be used to improve energy efficiency in a wide range of environments.

The use of control and communications technology in smart buildings reduces energy consumption by optimising functions such as passive heating and cooling. Energy wastage can be reduced by the use of sensing technologies by using room occupancy sensors to automatically control lighting and air conditioning systems.

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.

Transmission and distribution

Australia's transmission network was historically designed to transport large scale synchronous generation to load centres[82]. Similarly, the electricity distribution networks were traditionally designed for one-way power flow to customers. With the proliferation of new technologies within customer's premises, such as rooftop PV, distribution network operators are seeing reverse power flowing back into the grid. With this brings technical challenges that need to be managed such as quality of supply and voltage regulation.

But as emission reduction targets need to be met and more renewable energy sources are connected to the market, the networks designed for transporting energy from centralised coal generation centres will need to change to support generation in new areas where wind and solar resources are high. To ensure the security and reliability of the NEM, innovative solutions must be found to enable this integration and allow effective management of both the transmission and distribution systems.

The transmission network will also play a key role in ensuring that power system security can be retained in a system with lower levels of inertia[83].There are technical solutions which can help achieve inertia and frequency management outcomes including synchronous condensers, large scale batteries, flywheel technology and emulated inertial responses from wind farms[84]. Similarly, technical solutions at the distribution level will be required such as "smart" PV inverters. There will need to be a change in the traditional planning, control and operation strategies as well as development in forecasting and control techniques that provides the market operator with timely information.

Industry restructuring

The Australian government has signalled energy productivity as a major focus of Australia's energy policy through the release of the Australian National Energy Productivity Plan (NEPP). Through this plan the nation will manage and embrace changes in the energy industry, and aim to meet a significant portion of emission reduction targets. The NEPP sets a notional target of 40 per cent improvement in energy productivity between 2015 and 2030 and over half of the 40 per cent target could be achieved simply through continuation of current trends and within existing funding programs[85].

The proposed energy productivity savings are expected by just using a 'business as usual approach' without any further government intervention, much of which relies on current trends in industry restructuring. Engineers Australia views this passive approach as insufficient to meet Australia's future energy challenges and insufficient to make any significant contribution to Australia's emissions reduction ambitions.

Industry restructuring in a number of energy intensive industries has already been apparent in Australia, as production in them has slowed. Industries such as the mining and heavy manufacturing sectors which are traditionally energy intensive have been in decline. The Australian automotive manufacturing sector is a prime example, as it is expected to reduce energy use significantly by 2018-19 as the large scale production of automobiles previously made in Australia winds down[86]. Industry restructuring will continue to play a role in the reduction of energy consumption, but this is only part of the solution, as shutting down industries entirely is not desirable.

82: AEMO, 2016, National transmission network development plan for the national electricity market. www.aemo.com.au
83: Energy Networks Australia, CSIRO, 2016, Electricity Network Transformation Roadmap: Key concepts report 2017-27
84: Ibid.
85: COAG Energy Council, 2015, National Energy Productivity Plan
86: Australian Energy Market Operator 2016. National Electricity Forecasting Report June 2016. www.aemo.com.au/

The energy workforce

Engineers are vital to the construction, planning, design, maintenance and operation of Australia's electricity generation systems, with a large number of engineers working in the energy industry[82]. Many more engineers will be involved in the future research and development of new energy technologies as well as the implementation of many energy efficiency measures. A change in Australia's energy mix will ultimately influence those who currently work in the energy industry.

Large capacity power stations employ large numbers of people, and they are usually located in regional areas and on the fringes of major cities in small regional towns[83]. These communities become dependent on the economies of the power station and, if the power station were to close, the local town economy and community can be greatly affected. Widespread community dependence on a major power plant in a regional area can create pressure on decision makers to continue the status quo, and delay a transition.

Now is the time for governments to put forward transition plans for energy industry workers to upskill, or transition into new industries. Both Commonwealth and state governments must work together to ensure the best outcome for workers and their families, by investigating further options for structural adjustment packages and the stimulation of new industries.

Structural adjustment has long been discussed as a mechanism to handle significant changes in the economy. Because the closure of a major power station could greatly affect the local community, some compensation or training to affected workers through the method of structural adjustment can be used to assist in a transition.

The argument for structural adjustment assistance is that it has the aim of reducing short term economic disruption during a transition period, and it has the potential to minimise long-term unemployment[84].

In 2016, the announced closure of one of Australia's largest capacity power stations, Hazelwood power station and mine made headline news, leaving many regional jobs hanging in the balance. Governments have already pledged almost $100 million to help with the closure, but there are fears workers won't be able to find new jobs[85].

The aim of the adjustment should include plans for energy industry workers to upskill, or transition into new industries. Governments have the ability to put forward training packages and this can include training these workers to be skilled in the production and maintenance of emerging renewable technologies. Some structural adjustment methods point to compensation being delivered at a region-wide level, to provide for agreed purposes[86].

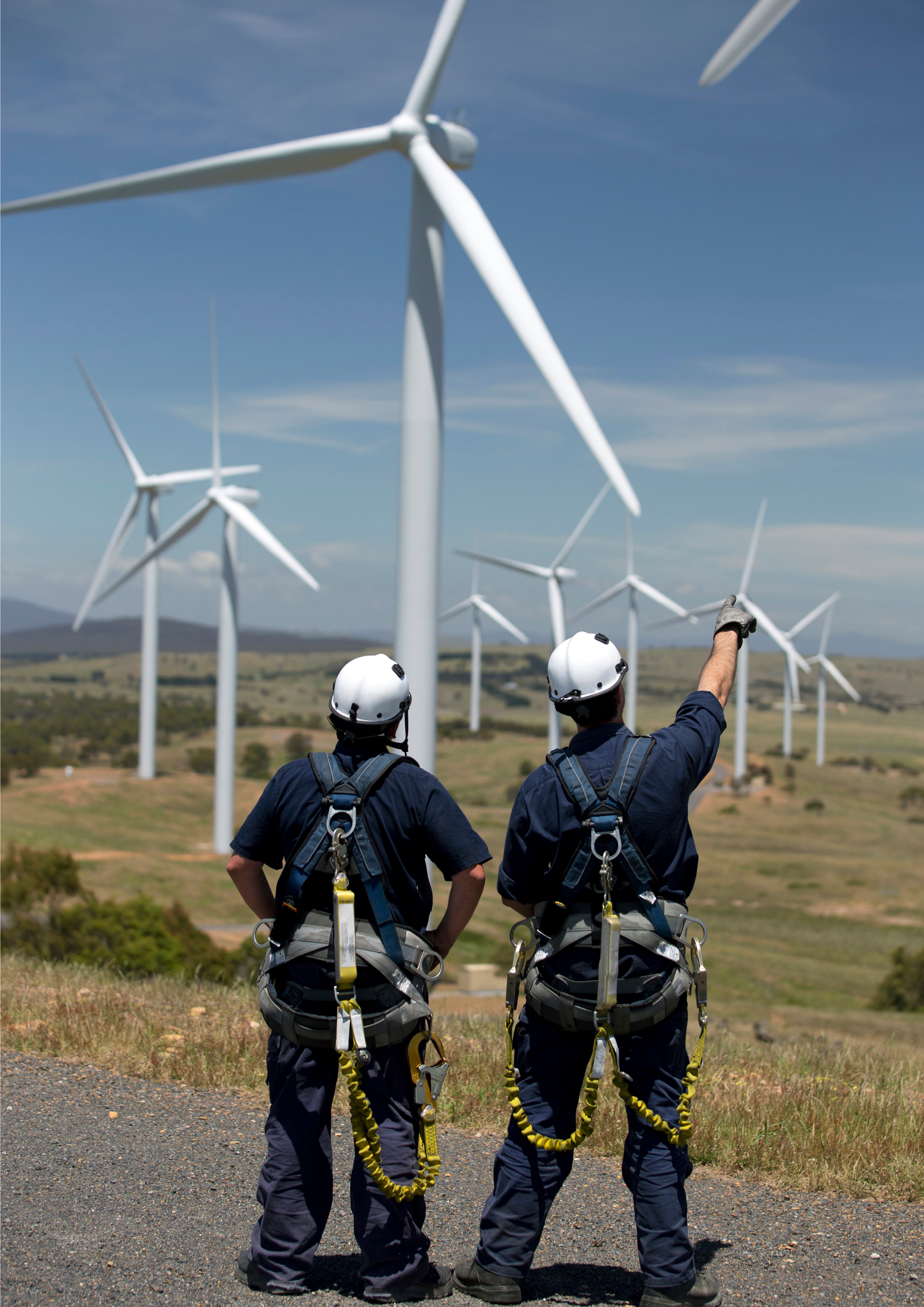
Additionally, if there are not clear rules set in place for structural adjustment, costs associated with the program can quickly escalate. Identification of the most affected workers needs to occur, so that benefits are not wasted[87]. Any compensation should look to facilitate adjustment rather than providing passive support, and any method of compensation should be transparent to ensure accountability.

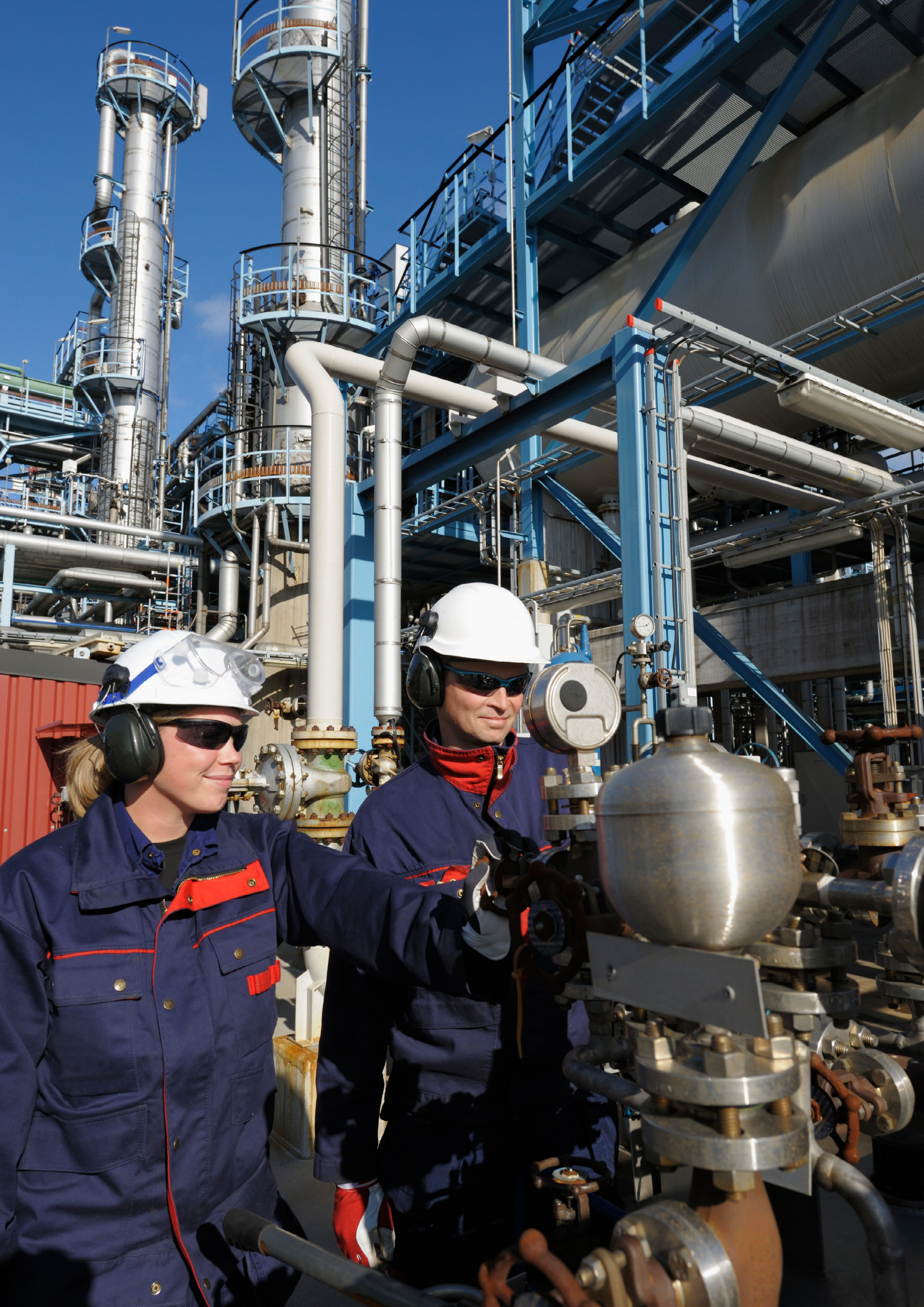
There is real potential to transition some of these regional workers into new energy technology workforces. Research conducted in the United States has found that growth in solar-related employment could help to absorb potential job losses in the coal industry[88].

A study which compared existing coal industry jobs to ones in the solar industry found that many of the skill sets were readily transferable. The study found that a relatively minor investment in retraining enables the vast majority of coal-fired power station workers to transition into solar related positions[89].

Relatively minor investment in retraining could allow the vast majority of coal workers to switch to solar related positions in the event of the shut-down of a coal-fired power station, providing a future for these workers, while also adding to the skills of Australia's renewable workforce. This is particularly the case with solar thermal technologies where the 'back end' involves steam-based or hot fluid boilers and turbines. As Australia moves towards a new energy mix, it is essential that Australia has the people with the right skills needed to implement and operate these new technologies.

82: Engineers Australia, 2015, The Engineering Profession: A Statistical Overview
83: Alcorn, D and Stanton, K, June 2016, What will fill the hole left by coal? https://www.theguardian.com/australia-news/2016/jun/29/what-will-fill-the-hole-left-by-coal?CMP=share_btn_link
84: Argy, F, 1999, Distributional effects of structural change: some policy implications. Australian Government Productivity Commission, Structural Adjustment – Exploring the Policy Issues. www.pc.gov.au
85: Drape, J and Meehan, M, November 3, 2016. The Australian, $85m support for sacked Hazelwood workers. www.theaustralian.com.au
86: Walsh, C, 1999, Structural adjustment: a mainly regional development perspective. Australian Government Productivity Commission, Structural Adjustment – Exploring the Policy Issues. www.pc.gov.au
87: Gray, M, 1999, Policy issues in structural adjustment. Australian Government Productivity Commission, Structural Adjustment – Exploring the Policy Issues. www.pc.gov.au
88: Louie, P and Pearce, J, 2016. Retraining investment for U.S. transition from coal to solar photovoltaic employment. Energy Economics, Volume 57, June 2016, Pages 295–302
89: Ibid.





Where is the Transition Plan?

Australia's fossil fuel power stations are aging, with the largest capacity stations accounting for a disproportionate share of greenhouse gas emissions which is incompatible with our Paris commitments. Yet there is no plan in place outlining a transition away from these power plants. Although there is currently no shortage of supply, there is already evidence that some of Australia's largest fossil fuelled power stations are beginning to explore market exit options.

The Australian government has stated that fossil fuels, particularly coal will continue to play a vital role in providing Australia's electricity supply[90]. However, traditional fossil fuel powered generators are much less flexible in the way they can operate in comparison to other technologies. With no real ability for reduced operation, there are limits to the involvement of older high capacity fossil fuel power stations in a transition plan.

Engineers Australia believes that it is time for a transition plan to be developed which looks at the best options for consumers, the economy and the environment. This transition must reduce uncertainty and send the right signals to potential investors[91]. Delaying a shift away from aging fossil fuel plants to low carbon options increases the likely risks and costs of a transition in the electricity sector, as it can take decades to plan, permit, finance and build new power infrastructure[92].

Given the long term nature of conventional electricity investments, investment decisions in baseload generating capacity are usually made on the basis of long-term fundamentals rather than short term behaviour[93]. If there is ambiguity in policies that will influence Australia's future electricity generation options, it can create uncertainty for investors.

There is widespread uncertainty that current direct action policies are believed to be inadequate to meet Australia's emission reduction target, and that the current policy would either need more funding, or need to develop into an emissions trading scheme for Australia to reach this target[94]. Further confusion is compounded as a number of jurisdictions are already putting forward their own climate change policies[95], which results in many states and territories working on different targets and approaches.

Climate change polices, 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 renewable technology generators are affected in respect to their ongoing profitability under the current policy scenarios.

Government policy intervention, clearly laid out through a national transition plan, has the ability to shape the future of Australian electricity generation. While government tone about the importance of a transition to help tackle climate change has recently become more positive[96], real action, and a real transition plan, are still missing from the national discourse. Doing nothing is not an option if Australia is going to follow through with the commitment to Paris targets.

90: Australian Government, Department of Industry and Science, 2015, Energy White Paper 2015, www.ewp.industry.gov.au
91: Clean Energy Council. Power Shift: A Blueprint for a 21st Century Energy System. www.cleanenergycouncil.org.au
92: Stock, A, 2014, The Climate Council, Australia's Electricity Sector: Ageing, Inefficient and Unprepared. www.climatecouncil.org.au
93: International Energy Agency, 2003, Power generation investment in electricity markets.
94: 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.
95: Appendix A
96: Middleton, K, 2016. Josh Frydenberg's approach to environment and energy. The Saturday Paper, 13 August 2016. www.thesaturdaypaper.com.au

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[97]. 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 found its way onto the market by a competitive basis.

Engineers Australia believes that some government intervention is warranted to kick start this transition in the light of the Paris COP21 agreement, and the subsequent emission reduction targets that were set. Australia will need to take advantage of 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.

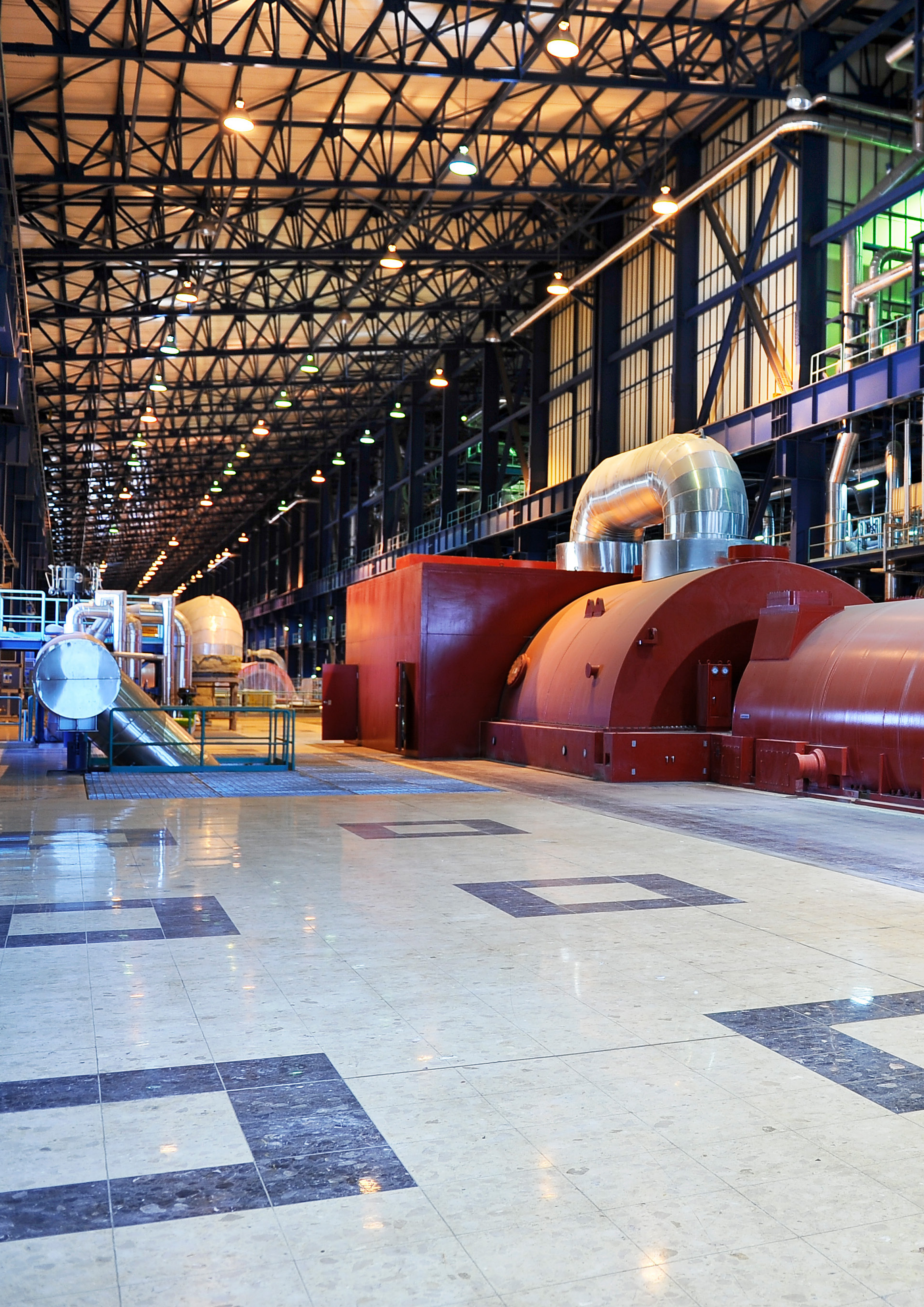
For emerging technologies, policies to create initial markets must run alongside research and development programmes, far ahead of widespread deployment of the technologies, and draw on competitive market forces where possible. Fostering the development and deployment of emerging technologies expands the number of low carbon technologies available at scale on a commercial basis, providing more flexibility and lowering overall cost[98]. Engineers Australia believes that to reduce emissions in the electricity generation sector, all options should be on the table.

Recommendations

Engineers Australia recommends that the Commonwealth Government develop a national transition plan for the electricity sector that:

- Reinforces the government's determination to achieve its emissions reduction target for 2030.
- Outlines the emissions reduction pathways available to achieve the target, recognising the age profile of coal fired generation plants.
- Establishes a consistent policy framework and associated technical rules to encourage the take-up of renewable and other low or zero emissions technologies, including adjustments to present arrangements to facilitate greater connectivity of renewable generation technologies to the grid and off-grid options.
- Sets an ambitious energy efficiency target for Australia to ensure that electricity users use no more electricity than necessary and outlines the role of energy efficiency in the transition to a low or zero emissions future.
- Determines arrangements to be applied in the event that economic circumstances lead to the premature shut down of an existing generation plant reducing electricity supply below requirements. These arrangements should also take into account impacts on effected economies and work forces.

97: Australian Government, Department of Industry and Science, 2015, Energy White Paper 2015, www.ewp.industry.gov.au
98: International Energy Agency. 2015. Energy and Climate Change, World Energy Outlook Special Report.



Conclusion

Recently, Australia's electricity market has experienced a fall in demand for electricity, and electricity market consumption is expected to remain relatively flat for the next 20 years. This is due to industry restructuring and greater public awareness of energy conservation, which has altered consumer behaviour. As a result, Australia's power stations are expected to continue to produce enough electricity to fuel peak demand, and no additional generation capacity is expected to be required for the next seven to 10 years unless existing generators close.

However, Australia's electricity supply is becoming characterised by aging power stations with as many as three quarters of Australia's major capacity power stations operating beyond their expected commercial lives. To compound this further, the majority of these high capacity power plants are fuelled by high emitting fossil fuels, and are major contributors to Australia's greenhouse gas emissions. This is incompatible with Australia's greenhouse gas emission reduction targets.

Policy makers must realise that a transitional approach is necessary, beginning with the recognition that these plants will need to be replaced with considerations to Australia's global commitments to emission reductions. Policy makers should seek the advice of experts, utilising resources available to formulate a transition plan that provides a more secure, reliable and sustainable energy system. Government policy intervention has the ability to reduce the current uncertainty faced by generators, and can send the right signals to potential investors.

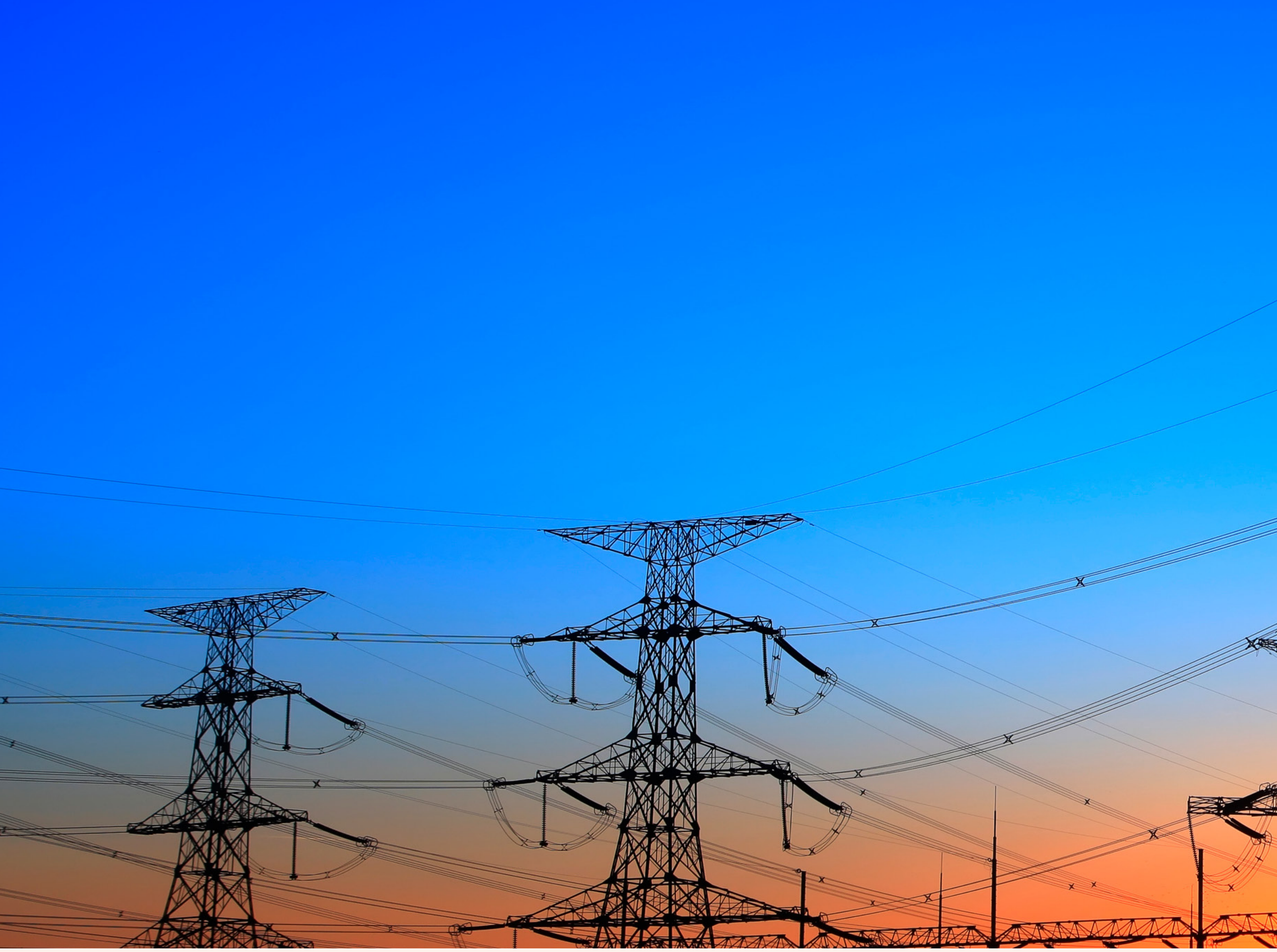
Engineers Australia believes all options which can help meet emission reduction targets should be considered. There is great value in strongly supporting Australia's renewable energy industry as there are promising developments in this sector and the cost competitiveness of new products has been shown to improve as the production of the technology becomes more efficient. Australia should more aggressively pursue energy efficiency policies in electricity generation as it has immediate potential to contribute to energy productivity and emission reduction targets.

If Australia is to reach its emission reduction targets, the future of energy generation will be spearheaded by new low carbon technologies, and new energy storage and distribution models coinciding with advancements in information and data analytics. An energy future such as this will require the expertise of Australia's engineering profession. Engineers have the critical skills to enable the nation to prosper in a future economy with reduced emissions.

Appendix A

State government Renewable energy targets

	State Government Targets
SA	50% by 2025
NSW	No Target
VIC	25% by 2020 40% by 2025
QLD	50% by 2030
WA	No Target
TAS	No Target
ACT	100% by 2020
NT	Proposed 50% by 2030
AUS	Coalition: 23.5% by 2020
	Labor: at least 50% by 2030



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