7

Energy

This chapter explores trends and issues in the stationary energy sector, including:

- Electricity generation, transmission and distribution networks, as well as forms of electricity storage, and retail issues that affect service provision
- Gas transmission and distribution infrastructure, covering the domestic market for energy
- Australia's oil and petroleum reserves.

For 22 million Australians – or 89% of the total population – electricity is provided by the National Electricity Market, covering the eastern half of the continent.[1] This market includes over 40,000 kilometres of transmission lines and cables, and supplies around 200 terawatt hours of electricity to users each year.[2] It is one of the longest interconnected electricity systems in the world, stretching from far north Queensland down to South Australia and across Bass Strait to Tasmania.

Beyond this grid, the Wholesale Electricity Market provides power in Western Australia, serving Perth and beyond. There are three smaller and separate networks in the Northern Territory, while many users in some areas, including Australia's external territories, have stand-alone electricity systems.

Australia's domestic gas market is split into three regions, in the east, west and north, based on the location of gas basins and pipelines that supply them. Wholesale gas is supplied to electricity generators and other large industrial users, as well as retail suppliers, who then sell it to businesses and households. Australia is connected to global markets via liquefied natural gas (LNG) export facilities, and is projected to be the world's largest exporter of LNG in 2019.[3]

Australia also holds reserves of oil, and there are four refineries in operation. We export most of the petroleum we produce, as most of Australia's oil is better suited to overseas refineries, and we import most of the oil and petroleum we consume.[4]

7.1 Introduction

The state of the energy sector

For many years, Australia has held a comparative advantage in energy costs, as well as an abundance of natural energy assets. This has propelled our economy, supporting improvements in the productivity of our businesses and helping us to compete in global markets. There are indications that this advantage is slipping, but Australia can overcome current challenges and spur a new wave of growth off the back of our energy resources and industry capability.

Much of Australia's energy infrastructure is fixed, costly and long-lived. Its markets are highly complex and sensitive to change. These characteristics are adding to the challenges of a sector that is undergoing a transformation, adapting to new generation sources and consumer preferences. This energy transformation is occurring against a backdrop of climate change and ongoing policy uncertainty, with inadequate coordination across Australia's governments on how best to manage changes. The result has meant a poor deal for many users, with bills rising rapidly over recent years and most users expressing dissatisfaction with the affordability of their energy services.[5]

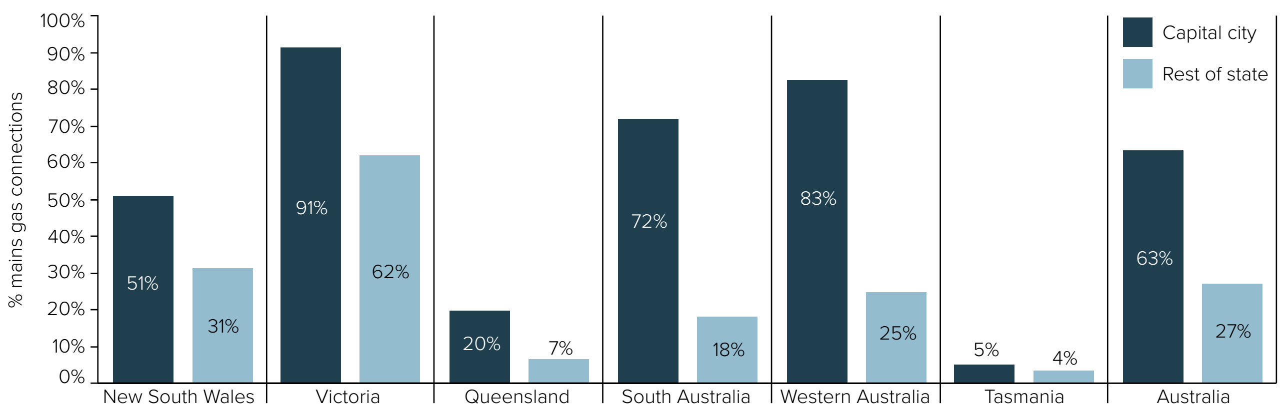
Our energy systems are well established

Over the last century, our energy systems have largely been one-way systems, connecting large and centralised sources of electricity generation and gas production outside our cities to household and business users. Transmission lines (for electricity) and pipelines (for gas) run to the outskirts of our cities and towns from centralised production sources. Smaller distribution networks branch out down our streets and highways to deliver energy to the houses and businesses that use it.

Two forms of energy are networked across Australia – electricity and gas. Neither is fully connected across the mainland. Small customers make up 98% of electricity connections and 99% of gas connections.[6] Gas connection rates vary widely by state and territory, and between cities and regions (Figure 1). Over 80% of Victorian households have a gas connection, compared to 5% in Tasmania. In capital cities, almost two-thirds of households have a gas connection, compared to just over a quarter of households elsewhere.[7]

Households only consume 25% of total grid electricity and 18% of our direct gas.[8] The manufacturing, mining and the services sectors consume the vast majority of grid electricity and gas, underscoring the importance of energy to our productive base.

Figure 1: While almost everyone has an electricity connection, gas connections are more varied



Note: Capital city and rest of state breakdowns are not available for Australian Capital Territory and Northern Territory.

Source: Australian Bureau of Statistics (2014)[9]

Australia's electricity is provided through a range of separate systems:

- The National Electricity Market (NEM) brought together historically developed state-based electricity systems as a spot market of five regions in 1998. There are over 300 participants in the market, including generators of electricity, transmission and distribution service providers, and retailers that sell to a customer base of over nine million households and businesses. Electricity generation in the NEM represents over 80% of total electricity consumed in Australia.[10]
- The Wholesale Electricity Market (WEM) in Western Australia commenced in 2006. The WEM serves over one million customers,[11] and operates under different market rules to the NEM. The WEM supplies the South-West Interconnected System (SWIS), which serves the main population centres of south-west Western Australia, including Perth.[12] The other major system in Western Australia is the North West Interconnected System (NWIS) in the Pilbara. The NWIS generates and transmits electricity to local communities, as well as into major resource operations.
- The Northern Territory system is composed of three unconnected regulated electricity systems: Darwin-Katherine (serving approximately 150,000 customers), Tennant Creek (7,000 customers) and Alice Springs (28,000 customers). Most of the electricity consumed in the Northern Territory is from locally-produced gas.[13]
- Numerous small regions across Australia are not connected to any of the above systems, including small remote inland and coastal communities, islands near the Australian mainland and Tasmania and external territories. These rely on a mix of locally-generated, via diesel or solar photovoltaics (solar PV), or imported energy.

As with electricity, Australia's gas network has an eastern market that stretches from Queensland down to Tasmania and across to South Australia, and separate Western Australian and Northern Territory systems. Australia has evolved from a relatively stable, closed domestic gas market to the world's largest exporter of LNG in less than a decade.[14] Overall, about 13% of the gas we produce is used to generate electricity domestically, and about 70% is now being exported.[15] In late 2018, the Northern Territory and eastern networks were connected by pipeline between Tennant Creek and Mt Isa.

Oil is the largest source of energy consumption in Australia, accounting for 37.7% of all energy consumed.[16] This is now mainly imported, and is chiefly an input into non-stationary energy via the transport sector, which consumes three-quarters of the total.[17]

The start and end points of our networks are changing

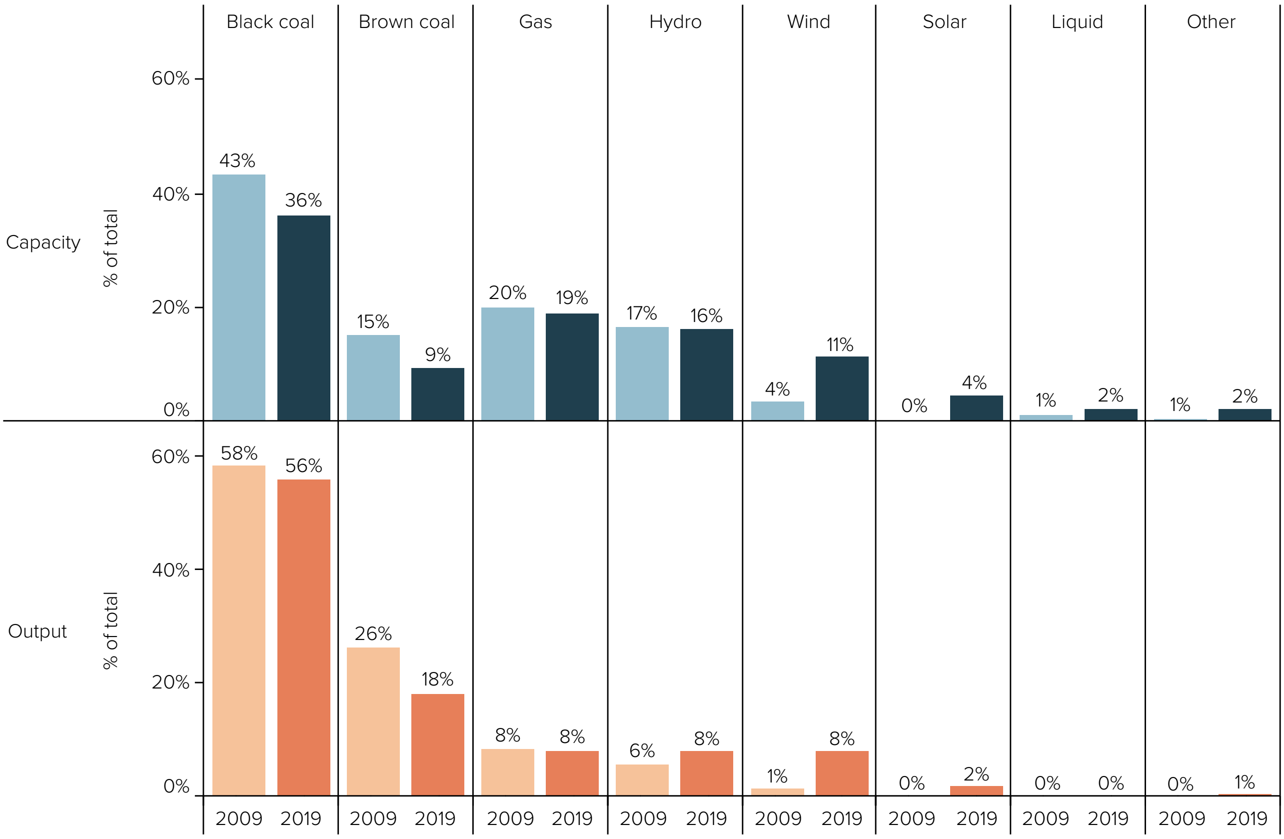
For generations, our cheap incumbent source of stationary energy has been black and brown coal, supported in small part by hydroelectricity and more recently, gas. The challenge of climate change, and concurrent technological change means that renewable energy sources are now effectively challenging traditional sources of energy on an economic basis.

We are already seeing both globally and nationally a major shift towards new generation capacity being renewable versus fossil fuelled. According to the International Energy Agency renewable generation capital expenditure in 2017 was US$298 billion compared with US$132 billion for fossil-fuelled generation. In the same year, US$17 billion was spent on nuclear generation – a 44% decrease from the previous year.[18]

The generation mix in the NEM is rapidly changing, as illustrated by Figure 2. Older coal-fired generators are retiring or approaching the end of their lives. At the same time, falling costs of rooftop solar PV and storage, combined with government subsidies, are changing the way our electricity is generated and used locally. In 2018, one in five households had rooftop solar, and 21% of electricity over the previous 12 months came from renewable sources.[19] This figure will continue to climb off the back of $20 billion worth of investment in large-scale renewable energy projects in 2018 – twice that of the year before.[20] According to Australian Energy Market Operator (AEMO), Australia could have one of the highest ratios of decentralised non-grid generation in the world.[21] By 2050, CSIRO and Energy Networks Australia estimate that between 30 to 45% of our annual electricity consumption could be supplied from consumer-owned generators.[22]

The changing generation mix increases the intermittency of supply, meaning a requirement to move electrons from end users back into the grid. These changes present major challenges for transmission networks. Encouraging investment in new fuels in efficiently developed new fuel precincts – called Renewable Energy Zones (REZ) – may help to optimise investment in networks to support this transformation.

Figure 2: The generation mix in the NEM is shifting to include more renewables



Note: Generation capacity at 1 July 2018. Rooftop solar output estimates derived from CER data on installed capacity and AEMO system output assumptions. Other dispatch includes biomass, waste gas and liquid fuels. Storage includes only battery storage.

Source: Australian Energy Regulator (2018)[23]

Energy affordability has become a major concern for users

The dominant issue in the energy sector since the last Audit has been the growth in energy prices. Over the past decade, the unit price of electricity has risen in real terms by 56%,[24] while retail gas for households has risen by 45% over the same period.[25] Many of the reasons for the spike in prices occurred prior to 2015 – including decisions to increase investments in electricity network assets, and to open the east coast gas market to global forces through the construction of new export facilities in Queensland.

However, in the years after 2015, wholesale electricity prices have risen steeply. This was caused by the closure of key coal-fired generation assets, issues with network reliability due to ageing assets, and rising costs for generation inputs such as coal and gas.[26]

The impact of this steep climb in users' electricity bills has been a negative shift in user perceptions of affordability – with electricity seen as the least affordable form of infrastructure by Australian consumers,[27] and least likely to improve over the next five years.[28] This is despite energy costs not forming a large component of the average household expenditure, ranking behind transport and telecommunications costs.[29]

Industry, including commercial activity, transport, construction, manufacturing, mining and agriculture, accounts for 89.2% of all Australia's total electricity and gas consumption.[30]

For sectors more reliant on energy as an input to their processes, recent price increases place extra pressure on their operations. Recent energy productivity gains by business are being reduced by energy cost increases.

A key challenge is balancing the vital, but countervailing forces, of reliability, environmental responsibility and affordability. Users, who ultimately pay the cost of greater reliability, are rarely engaged in decisions about reliability levels. Improvements in reliability beyond the current standard of 99.998% are likely to come at substantial costs to users, which they may not be willing to pay.

Uncoordinated government responses have fuelled a desire among many consumers to take control of their costs by seeking to move off-grid. Taxpayers are being impacted by government decisions to back programs or projects that affect the shape of the grid, and which tend to discourage market-based investment decisions by the private sector.

Uncertainty in energy policy remains an issue

Concerns about uncertainty expressed by Infrastructure Australia in the 2015 Audit persist into this Audit. The National Electricity Market, and the institutions which support its operation, have continued in the absence of decisive federal leadership. As a result, uncertainty on energy or emissions policy remain. Retail reform has taken a back seat to settling future arrangements in the NEM as it transforms its input energy mix.

However, there have been some gains in spite of ongoing uncertainty. While it may have affected some investment decisions, it is clear that investment in renewable generation has continued, notwithstanding uncertainty over long-term policy settings to deliver international emissions commitments at least cost. In spite of this uncertainty, many households and businesses have made changes to improve their energy efficiency and decrease emissions.

Gas has become an increasingly important energy policy issue since the 2015 Audit. Rising prices have put decisions to open Australia's east coast gas market to global forces under the spotlight. The opening of an interconnector between the eastern and northern markets will help to free up capacity for supply to domestic users in southern regions. The AEMO forecasts that the gas supply-demand balance is likely to remain tight into the next decade, with gas production in southern Australia continuing to decline, and supplies from Queensland limited by pipeline capacity.[31]

Australia could become a new energy superpower

Australia is endowed with tremendous energy potential. It should be a source of economic advantage for Australia, supporting our industrial base, jobs and national income. We have a great wealth of both traditional (generally non-renewable) energy and renewable energy.

As the world gradually transitions its energy fuel mix towards lower emitting technologies for domestic electricity production, Australia has an opportunity to take advantage of this transition as an even greater export opportunity, while concurrently returning Australia to its position as a low-cost energy producer.

As well as continued development of opportunities to benefit from our abundance of traditional energy sources, there are considerable opportunities for growth in renewable generation arising from our abundance of solar and wind energy. Australia could play an increasingly important role as a provider of renewable energy to our neighbours through direct electricity exports, or to global energy markets by exporting energy as hydrogen – a fledgling industry at present.

In this chapter

This chapter identifies challenges and opportunities facing energy infrastructure through users' eyes. It is framed around the four outcomes identified by Australia's Chief Scientist, Alan Finkel AO in 2017: increased security, future reliability, rewarding customers and lower emissions. The chapter also looks more broadly at Australia's changing energy mix, the balance between domestic consumption and export demand for our resources, the needs of users in remote areas, and how consumers are playing an increasingly important role in a traditionally 'top-down' infrastructure service sector.

7.2 Affordable and competitive energy looks at the first component of the Finkel Review – affordability. This includes how different groups of consumers and businesses view and are impacted by electricity and gas price rises that have outstripped inflation. We identify the infrastructure-related components of affordability, and discuss how better information can help consumers manage their grid energy costs.

7.3 Secure, reliable and sustainable energy looks at the remaining three components of the Finkel Review, with a focus on electricity reliability, different customers' willingness to pay, meeting climate policy commitments, and improving system resilience and security.

7.4 Transitioning to Australia's future energy fuel mix discusses Australia's short and longer term fuel market transition. The section also explores the challenges faced by each fuel and the effect of new forms of generation.

7.5 Planning our future energy networks considers the ability of existing governance structures to manage, and lead, through the ambiguity of the timing of the withdrawal of existing large generators and their replacement with new technology.

7.6 New opportunities for consumer choice considers the role of cheaper solar PV and storage in providing choice for consumers. The costs to the community of increased solar PV adoption and the challenges of integrating technology are also explored.

7.7 Delivering energy in remote communities discusses the costs and reliability of electricity provision in rural and remote areas. The section considers new technology and opportunities to better meet rural and remote users' energy needs.

7.8 Harnessing Australia's energy advantage considers some of the opportunities we can capitalise on to deliver Australia's potential as a new energy superpower.

Performance of the sector

Access

99%
of households have an electricity connection [32]

50%
of households have a gas connection [33]

Quality

95%
of supply interruptions originate in local distribution networks [34]

Access

2 million
Rooftop solar systems installed nationally, by June 2018 [35]

Access

64%
consumers are willing to **reduce energy use** on hot days [36]

Cost

Solar customers paid
$538
less on average for electricity each year [37]

Quality

1.1
Average local outages per customer in 2017 (except Western Australia) [38]

Cost

57%
Real rise in electricity unit costs for residences in the NEM between 2008 and 2018 [39]

Quality

34.2%
of greenhouse gas emissions contributed by **electricity sector** [40]

Cost

20%
Gas unit cost increase on the east coast between 2015 and 2017 [41]

Cost

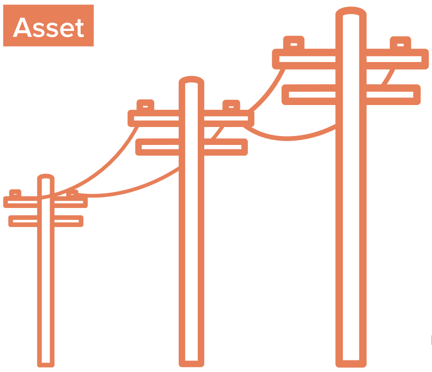
Less than 7 years
payback period for users of rooftop solar PV [42]

Cost

Australian **electricity prices** are now around
10%
above the European average [43]

Scale of the sector

Asset



40,000 kilometres of transmission lines and cables [44]

Customer

Australia has
27 days
of liquid petroleum reserves [45]

Industry

70% of local extracted gas is exported [46]

Industry

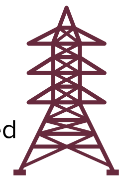
9 million NEM
1 million WEM
85,000 NT
households and businesses served [47]

Asset

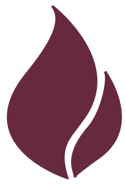
$9,100 per customer:
Value of investment and asset base for regulated NEM transmission and distribution [48]

Customer

25%
of **grid electricity** is consumed by household sector [51]



18%
of **direct gas** is consumed by household sector [53]



Industry

National Electricity Market accounts for
80%
of electricity generated [49]

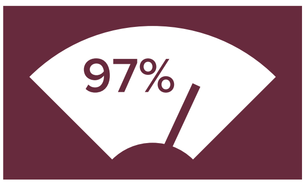
Asset

$0
investment in **coal baseload generation** has occurred since 2013 [50]

Customer

15% of Northern Territory dwellings have rooftop solar systems [52]

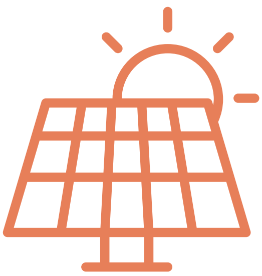
Customer



of consumers in Victoria have access to smart meters [54]

of consumers in rest of Australia has access to a smart meter

Asset



14%
of **Northern Territory** dwellings[55] and
33%
dwellings in **Queensland** have rooftop solar system [56]

Executive summary
Introduction
Future trends
Users
Industry
Transport
Social infrastructure
Energy
Telecommunications
Water
Next steps

7.2 Affordable and competitive energy

At a glance

Users are unhappy about their energy bills, with prices rising faster than inflation due to pressure on networks and generators. While most of this rise is linked to energy networks and generation, users are also paying for the move to new fuel sources.

Our cost of energy is rising faster than in many other countries, making us less competitive and undermining potential growth in productivity and investment.

Energy costs are front of mind for many

Many Australians are concerned about the affordability of energy.

In a survey undertaken for Infrastructure Australia, respondents rated electricity as the worst of all infrastructure sectors for affordability.[57] Over 60% of consumers see electricity as 'very costly' or 'costly', as shown in Figure 3. Figure 4 shows that gas also rates poorly for perceived affordability, with 38% of respondents seeing these services as 'costly' or 'very costly'. Consumers are also pessimistic about affordability in the future, with only one in 10 consumers expecting an improvement over the next five years.[58]

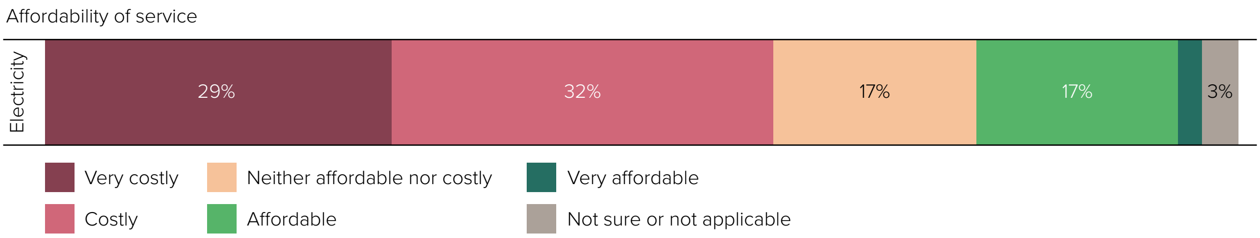
Despite Australians perceptions of energy affordability, average energy costs (about 3% of total household spending or $40 per week) are still relatively small when compared to transport costs (about 15% or $205 per week), and around the same level as telecommunications (about 3% or $45 per week).[59]

Bills have risen considerably over recent years

Much of this perceived lack of affordability is likely to be driven by recent price increases. While Australians used 8% less electricity per capita over the period 2003-04 to 2015-16, electricity bills rose by 30% in real terms, and gas bills rose by 37% over the same period.[60] Many households have seen their costs jump even more substantially over recent years, putting increasing strain on household budgets.[61]

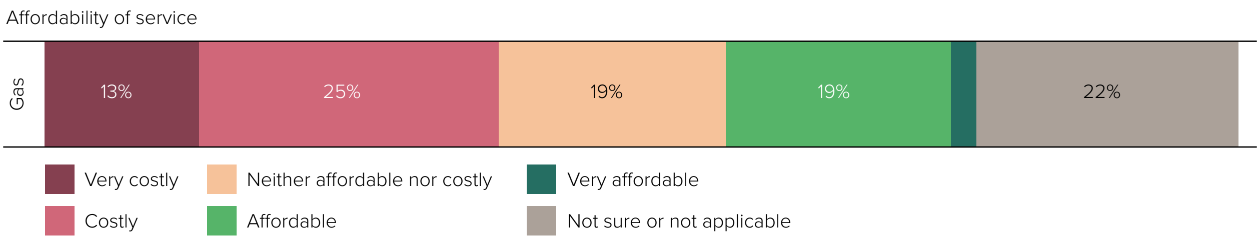
Household energy costs across Australia have grown faster than inflation in the past decade. However, as shown by Figure 5, this growth has not been equal, with cost increases faced by average customers in most of the NEM outpacing observed trends in Perth and Darwin. A significant part of the reason for this is due to price-setting and a taxpayer subsidy by the Western Australian,[62] and Northern Territory Governments.[63]

Figure 3: Electricity is perceived as the least affordable form of infrastructure, with over 60% of consumers rating it as 'costly' or 'very costly'



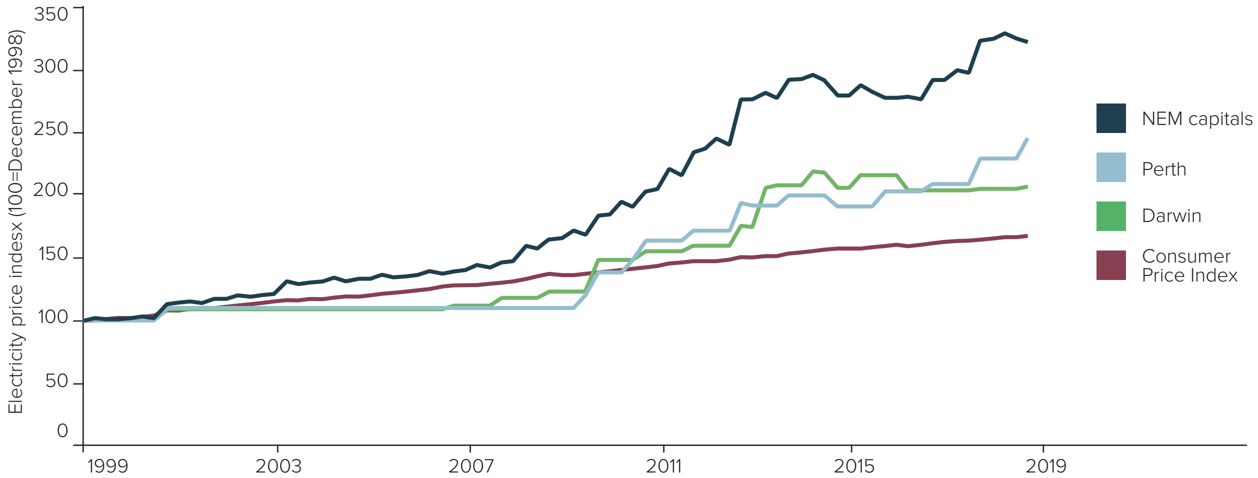
Source: JWS Research (2018)[64]

Figure 4: Affordability is also an issue with consumers of gas services



Source: JWS Research (2018)[65]

Figure 5: Electricity costs have risen much more than general inflation in the last decade, but costs in Perth and Darwin have risen less than in the NEM capitals



Note: NEM capital city index is unweighted.

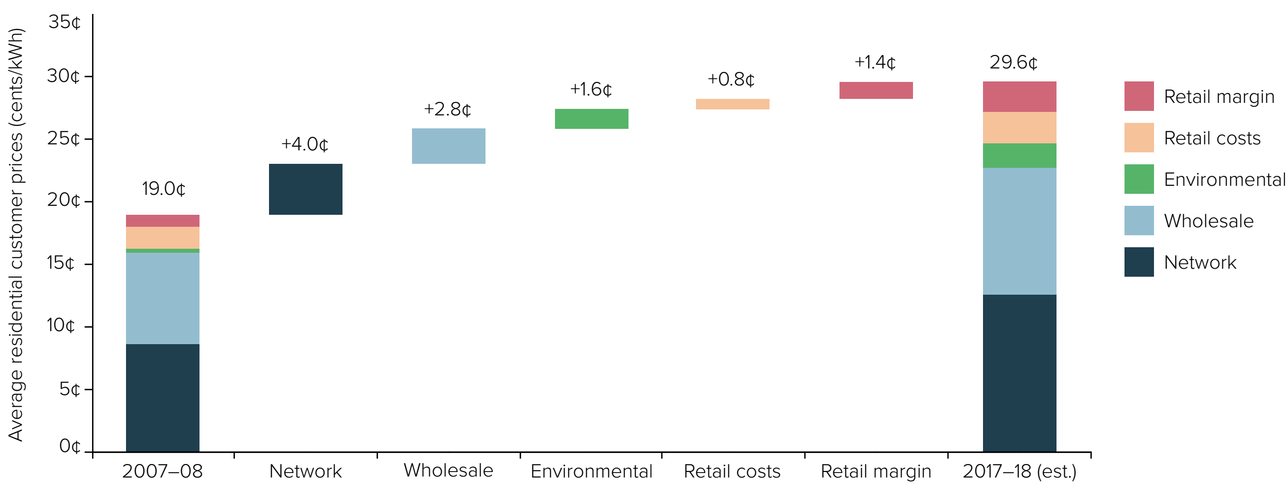
Source: Australian Bureau of Statistics (2019)[66]

Network and generation costs have driven electricity bill rises

For the National Electricity Market, the unit cost of electricity rose 56% in real terms, on average, over the past decade. However, consumers have also used less electricity over this period, meaning that the impact on household bills has been lower, but still substantial – 35% in real terms.[67] Much of the decline in demand was due to improvements in energy efficiency and more households with rooftop solar.[68] However, there is also evidence that people on low incomes have responded to price rises by rationing their energy consumption, to the detriment of their health and wellbeing.[69]

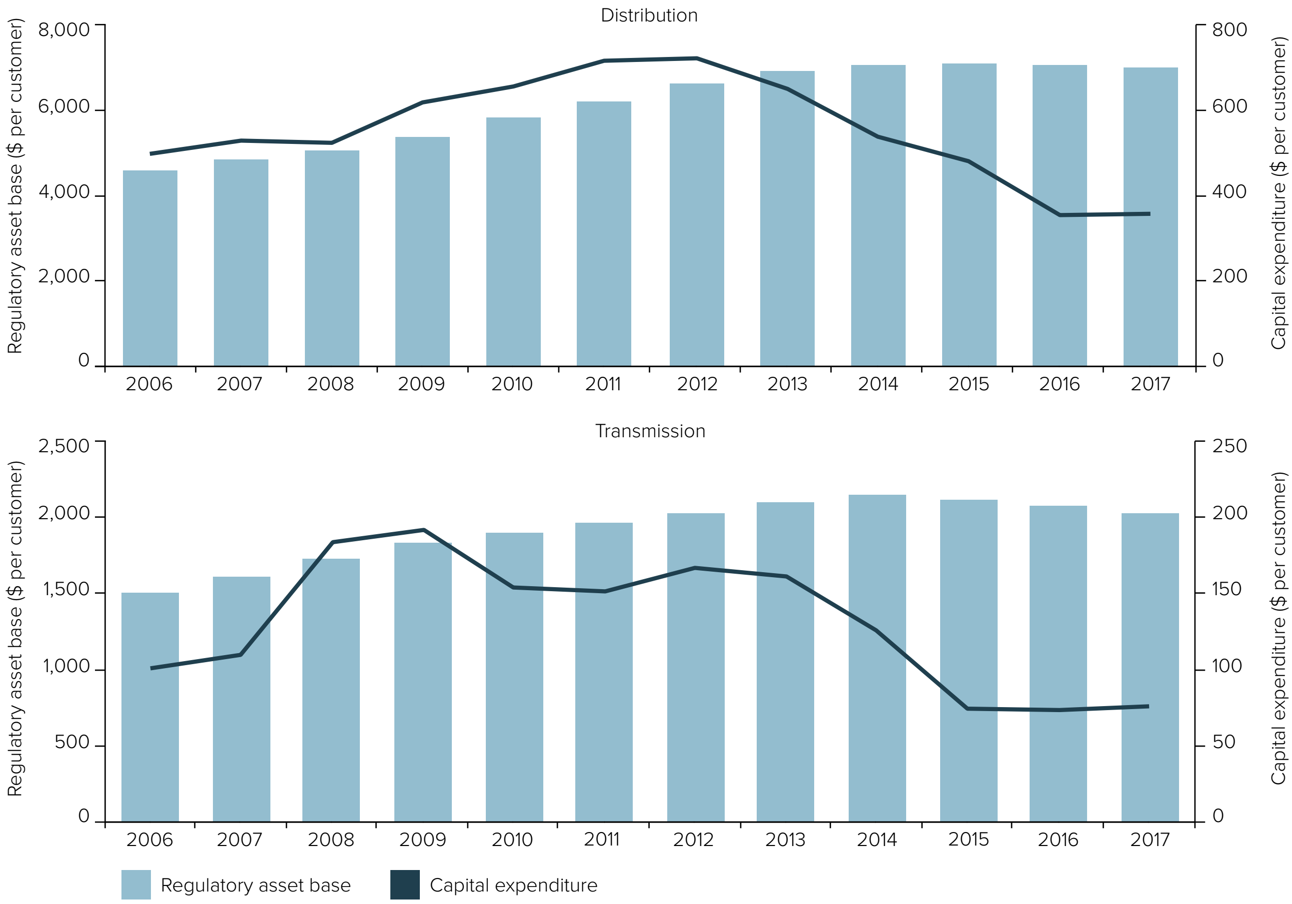
As shown by Figure 6, increases in network costs are responsible for the largest share of household price increases. Much of this stemmed from an increase in the NEM-wide regulated asset base from $50 billion in 2006 to $87 billion in 2017 (in 2017 dollars) – an increase of 75% in real terms.[70] Despite this increased expenditure, customers received decreasing value for money as the relative productivity of electricity networks decreased over the same period.[71] A report by the Grattan Institute estimates that up to $20 billion of investment in power networks was excessive, and that poor decisions by state governments in New South Wales, Queensland and Tasmania mean that consumers in those states pay between $100 and $400 more as a result.[72] The scale of growth in asset bases and capital costs per users is illustrated in Figure 7.

Figure 6: Network and wholesale costs are the two largest drivers of NEM price rises



Source: Australian Competition and Consumer Commission (2018)[73]

Figure 7: Per customer, the NEM regulatory asset base has increased while network investment has fluctuated



Source: Australian Energy Regulator (2018)[74]

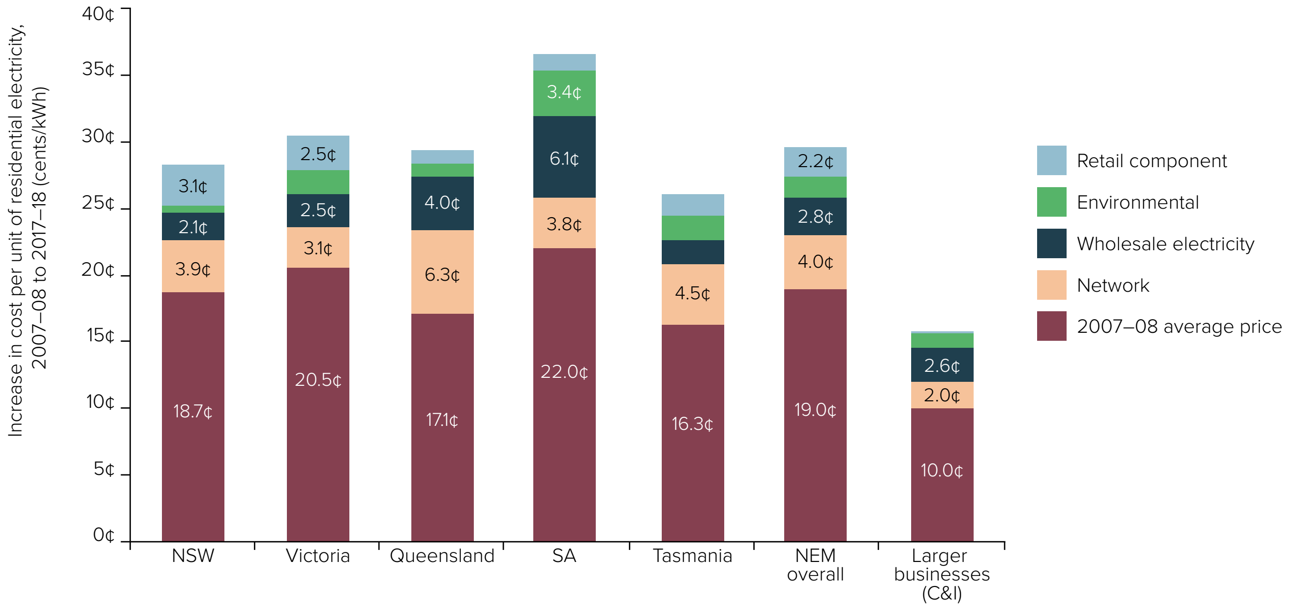
An increase in wholesale costs also caused a rise in bills for customers in the NEM, with costs rising sharply in the three years from 2014-15. Despite being offset by a decline in the cost of renewables, wholesale cost rises were due to a range of factors, including the retirement of major coal generators in South Australia and Victoria, a series of outages in ageing gas and coal generators, and interconnector constraints,[75] as well as higher gas and coal prices.[76] Generator rebidding – or 'gaming' of the market – was found to have added $243 million in wholesale price spikes in 2017.[77]

While environmental costs have also added to bills over the past decade, their direct contribution to cost increases is smaller than wholesale and network costs.[78] These are generally in the form of obligations placed on energy retailers to meet federal or jurisdictional policies.

Examples of these policies are the federal Renewable Energy Targets (RETs). These are the large- and small-scale schemes that require retailers to source a proportion of energy provided from renewable sources. The large scheme incentivises investment in large-scale renewable energy generation (initially wind but increasingly solar), and the smaller scheme subsidises household rooftop solar electricity and solar water heating systems. Several jurisdictions also have additional RETs.[79] There are also several dozen separate energy related incentives, rebates, grants and programs across states and territories, which include taxpayer support including for solar PV and battery installation, hot water systems, energy efficiency for households and businesses.[80]

Electricity price impacts have varied across different parts of the NEM and for different customers, as shown by Figure 8. These differences over the past decade reflect different population densities, fuels, and state policies that exist across the eastern market, and the ongoing constraints in electricity flow between these regions.

Figure 8: Across the NEM, reasons for price increases over the past decade vary by jurisdiction



Note: Values are inflation adjusted to 2016-17, excluding GST.

Source: Australian Competition and Consumer Commission (2018)[81]

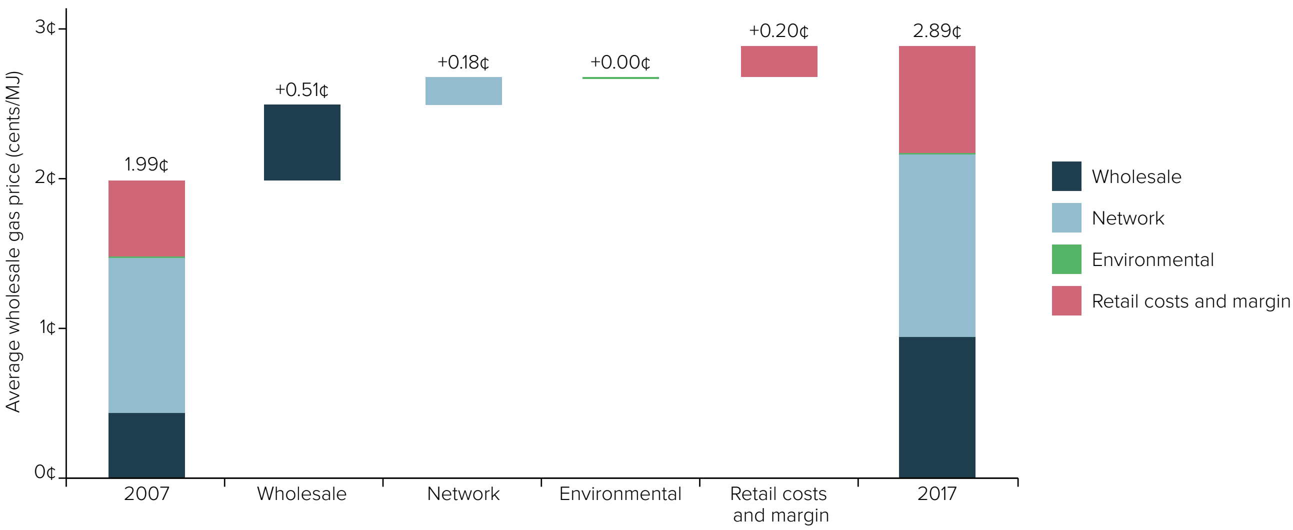
Rising gas prices have added to cost of living pressures

Household gas costs have also exceeded inflation over the last decade, driven by a 46% rise in the unit gas price over the decade to 2017.[82] This has largely been caused by a change in supply conditions for gas, following the ramp up of export volumes through the port of Gladstone. This has coincided with reducing Bass Strait volumes, and ongoing onshore gas supply constraints. Taken together, the wholesale price of domestic gas in east coast markets has substantially increased, as shown in Figure 9.[83]

In Western Australia, the opposite has occurred, with wholesale prices falling since a high in 2009. However, price reductions in recent years have been confined to large industrial users rather than households.[84]

However, household gas connection rates vary significantly across jurisdictions. For those with large gas distribution networks providing gas to residential customers, like Victoria, households are more significantly exposed to changes in the gas price, but relatively less affected by changes in the electricity price.

Figure 9: East Coast wholesale gas costs have been the main reason for gas price rises in the NEM



Source: Australian Energy Regulator (2018)[85]

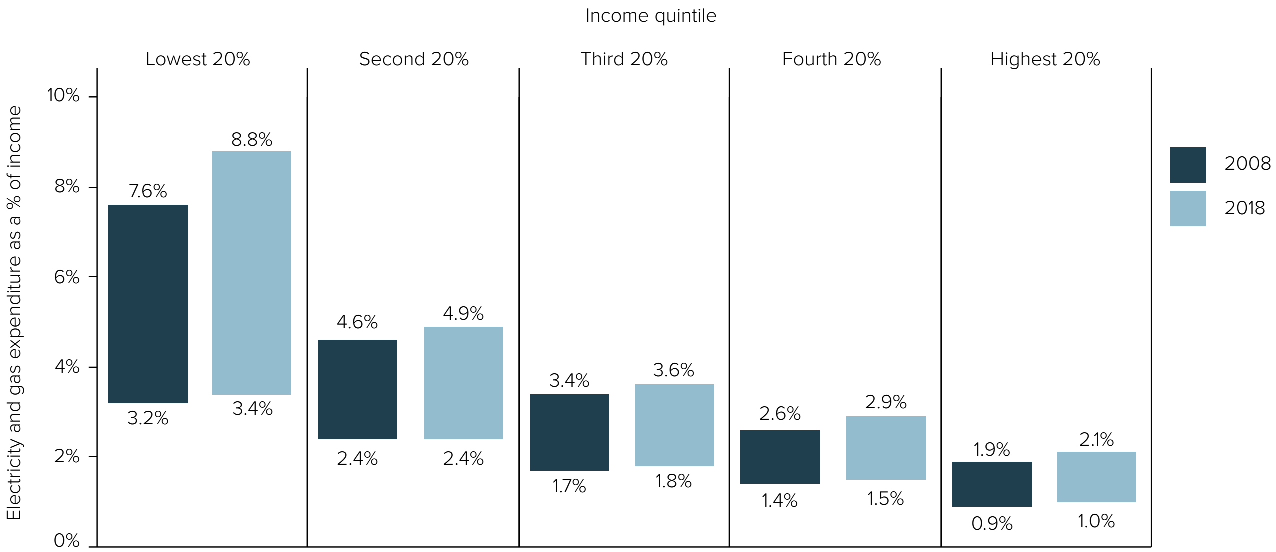
Energy costs are hard to avoid and are bigger parts of some household bills

Energy bill rises are hard to avoid for most users. Many households use a mix of gas and electricity for cooking and heating, while many businesses rely on gas for production, particularly as part of heavy industrial processes. Although electricity and gas are energy substitutes, most users have little capacity to switch between electricity and gas as their applications are fixed. Compounding this, a fall in the price of wholesale gas can increase demand for gas by centralised electricity generation, offsetting any potential savings for households and businesses that use gas.

For households, the cost of energy is hard to avoid or replace, and in many cases difficult to reduce with efficiency measures. Also, energy costs hit some of the most disadvantaged households hardest. Over the past 10 years, this impact has become even more regressive. Customers in the lowest income quintile have seen a greater increase in the proportion of their total income spent on energy than they spent 10 years ago, relative to all other energy users, as shown by Figure 10.

Notably, this was found to be the case after subsidies were taken into account, reflecting the regressive nature of essential services generally. Low income households are less likely to have efficient appliances, and those inefficient appliances are more likely to be used for heating or cooling a poorly insulated home.

Figure 10: Energy costs over the past ten years have become even more regressive



Note: Top value represents costs for households in 75th percentile, bottom value represents costs for households in 25th percentile.

Source: Australian Council of Social Service (2018)[86]

Market complexity adds to user costs and frustration

For the energy market to work well, users must be able to understand their current bill, find the retail offer most appropriate for them and switch retailers with confidence. However, energy retailers have added to poor outcomes for users through confusing pricing structures, opaque discounting and effective penalties for loyal customers.[87] A lack of transparency in bills has also added to frustration as many users are unclear whether rising costs are due to their usage or changing costs of supply.

This has left many customers paying more than they should. Despite consumers being more empowered in their energy choices and having more retail options than previously, 37% of customers have not searched for a better offer in the last 12 months, with even fewer actually taking one up.[88] Only 20 to 40% of customers that have been with a major retailer for more than three years are on offers equivalent in value to a new customer, though this may have improved following public awareness campaigns and subsequent commitments made by retailers in 2017.[89]

Some initiatives are underway to improve clarity of offers, including a consumer data right and a regulator-set standard default offer.[90] The Australian Government, through the Australian Energy Regulator, also launched the *Energy made easy* website to allow users to more easily compare energy offers in their area.[91]

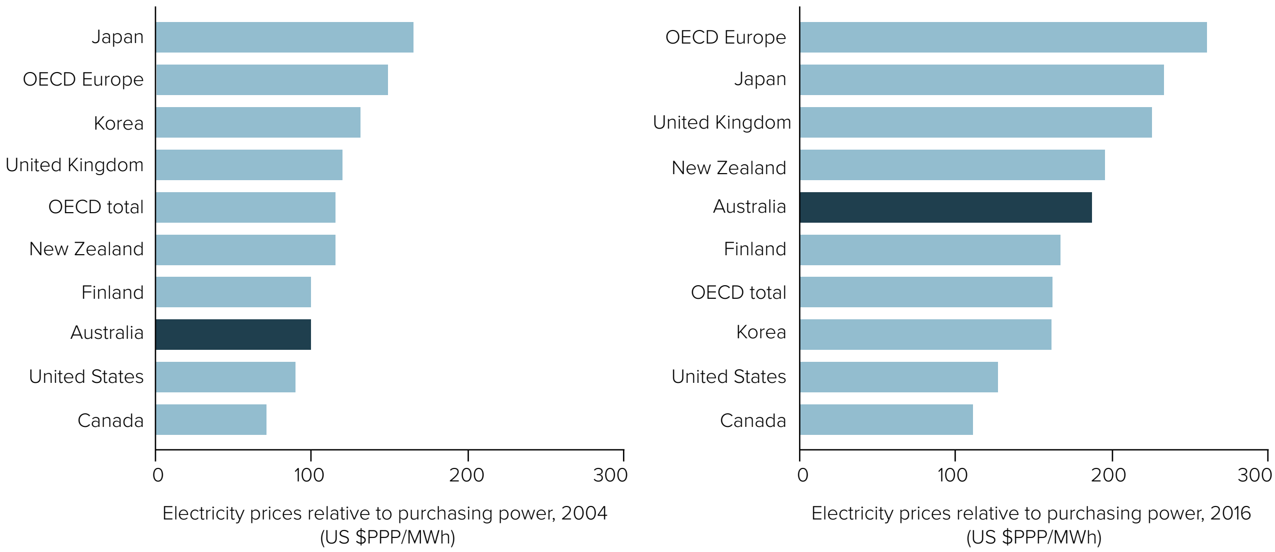
The economic consequences of higher energy costs are significant

The price of energy in Australia has risen compared to other nations. While Australia has held a strong advantage over many of its competitors through relatively low costs for energy, this advantage has eroded over recent decades, and we have slipped behind a number of other OECD nations, as shown in Figure 11. Given the wholesale cost increases experienced in the NEM since 2016, it is likely that Australia's position will have become less competitive than shown here.

Offsetting energy bill rises has been a 20% improvement in our energy productivity – that is, economic output per unit of energy – over the past decade.[92]

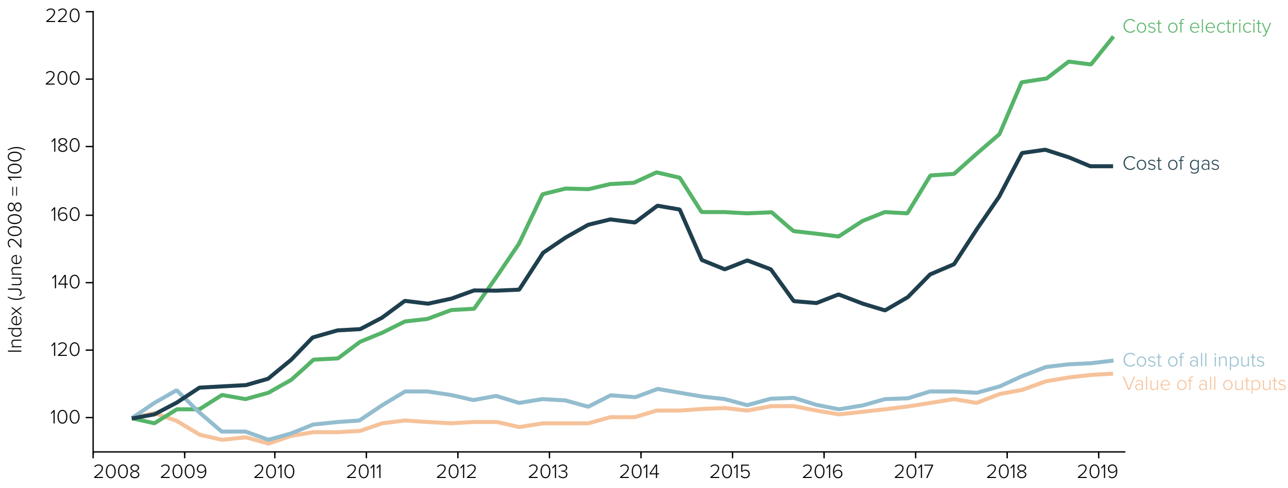
However, the recent jump in energy prices for industry are potentially outstripping energy productivity gains.[93] A permanent 10% rise in the wholesale cost of both electricity and gas could cost Australia over 13,000 jobs and reduce GDP by over $8 billion.[94] Some businesses have seen a 56% real increase in electricity costs over the decade (Figure 12)[95] and significant gas price rises, so there is potential for this trend, if sustained, to be a disruptive influence on business output.

Figure 11: Australia is losing its energy advantage against comparable nations



Source: Australian Competition and Consumer Commission (2017)[96]

Figure 12: Energy costs for key industries are rising, working against productivity gains



Source: Australian Bureau of Statistics (2018)[97]

133. Challenge

Transparent and affordable electricity prices are essential to reducing pressure on household budgets, particularly for lower income households. A continued rise in energy bills will place an added burden on many households and may reinforce inequality. Ongoing complexity of bills will add to user costs and frustrations.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

134. Challenge

Regaining energy price competitiveness is important for lower business costs and improving productivity of Australian firms. Australia risks becoming uncompetitive in some energy intensive industries due to rising energy costs.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

7.3 Secure, reliable and sustainable energy

At a glance

This section looks at how our reliability and security standards affect investment. Power outages can have severe consequences, but preventing them is costly. Suppliers pass that cost on to users.

We review the impact of climate change, and how uncertainty about long-term energy and emissions policy has further raised user costs. We also discuss cyber security and our obligations under the International Energy Program Treaty.

Consumers rate the quality of energy services highly

Most energy users receive reliable services. This was reflected in the results of a survey for Infrastructure Australia, in which the majority of users rated the quality of our electricity networks and services as good, with only 11% rating it as poor (Figure 13).[98] Perception of quality of gas networks and services was similar, although more users were unsure – an indication that they did not have a connection. This contrasts with users' negative perceptions of affordability.

There is a trade-off between electricity reliability and affordability

The consumer message is clear – people are generally content with their energy supply, but think the price – especially for electricity – is too high.

However, quality (which we link to supply interruptions) and affordability are linked. The Finkel Review into the future security of the NEM posited that Australia was facing a trade-off which included addressing affordability,[99] whilst also meeting reliability and security expectations and delivering on Australia's international climate change commitments.

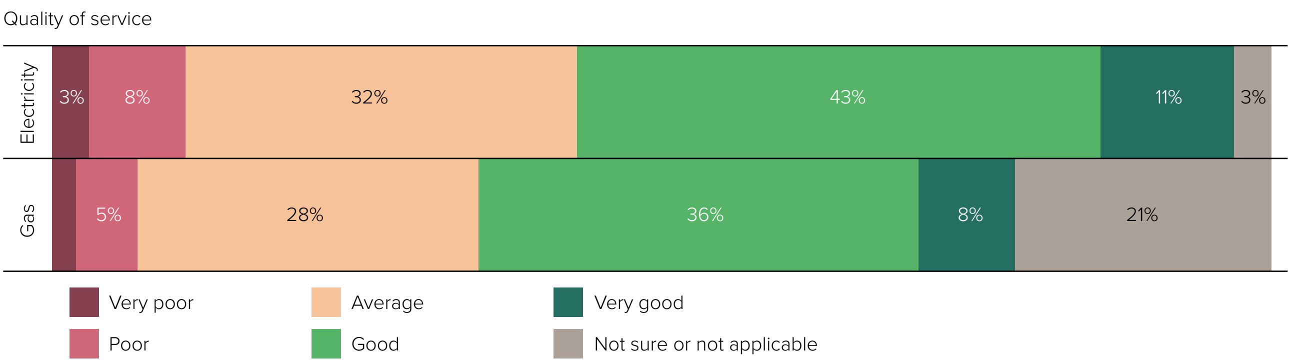
Maintaining a reliable and secure supply of energy, and doing so affordably, means understanding the risks and planning wisely to mitigate those risks. It also means understanding the value that customers place on reliability, and therefore the amount they are willing to pay for investment in infrastructure to mitigate risks to supply.

The reliability of Australia's electricity supply compares favourably with other countries.[100] Canada is perhaps the best comparison to Australia in terms of area, population density, settlement and fuels. Canadian customers experienced 18% more time per year with outages than Australians.[101]

Where reliability issues have occurred, these have been largely due to local factors, rather than a lack of generation capacity. Of the interruptions to power supply in the NEM over the past decade, 95% occurred in the local distribution system, and only 0.23% of interruptions were due to lack of generation capacity.[102] Across the NEM and the Northern Territory systems, the annual electricity outage duration per customer per year has been falling over the past decade.[103]

Importantly our electricity system is not expected to be 100% reliable 100% of the time. To demand this would increase energy costs dramatically, and exacerbate many of the affordability issues discussed earlier. Each advanced energy market establishes a reliability standard for its electricity system. In Australia this is measured as the number of instances of unserved energy (USE) with the standard being 0.002%.[104] AEMO predicts that the number of times the USE standard will be breached over the next 10 years will increase, as shown by Figure 14.[105]

Figure 13: The quality of electricity and gas services is seen by most users as good



Source: JWS Research (2018)[106]

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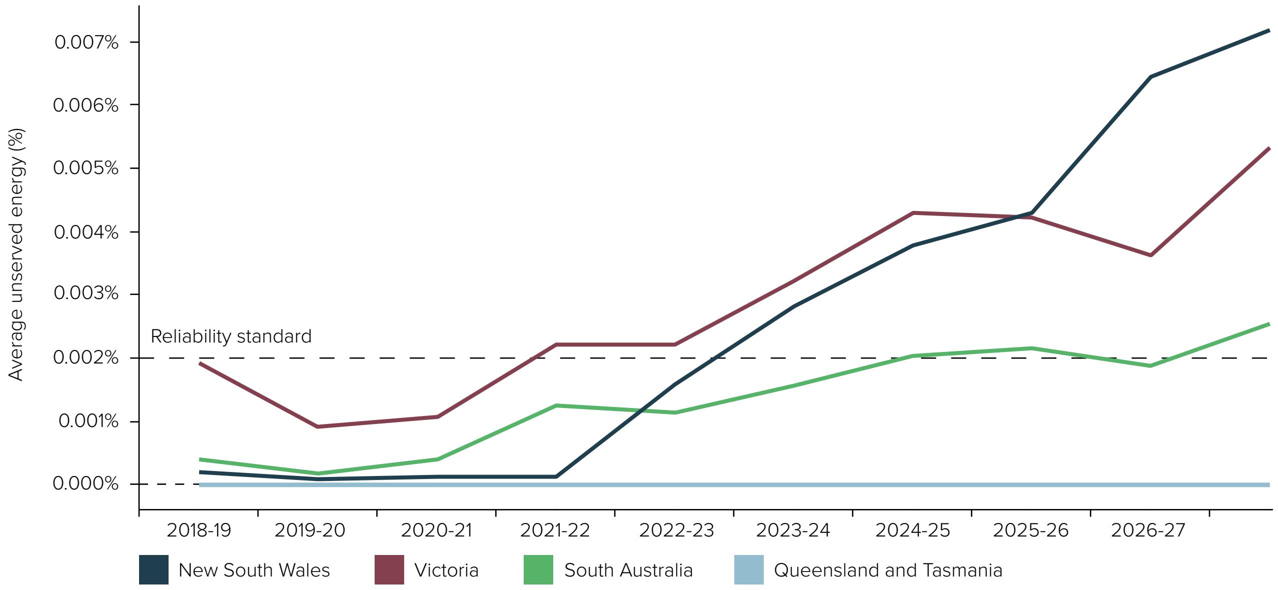
Figure 14: Forecast unserved energy in the NEM is projected to increase



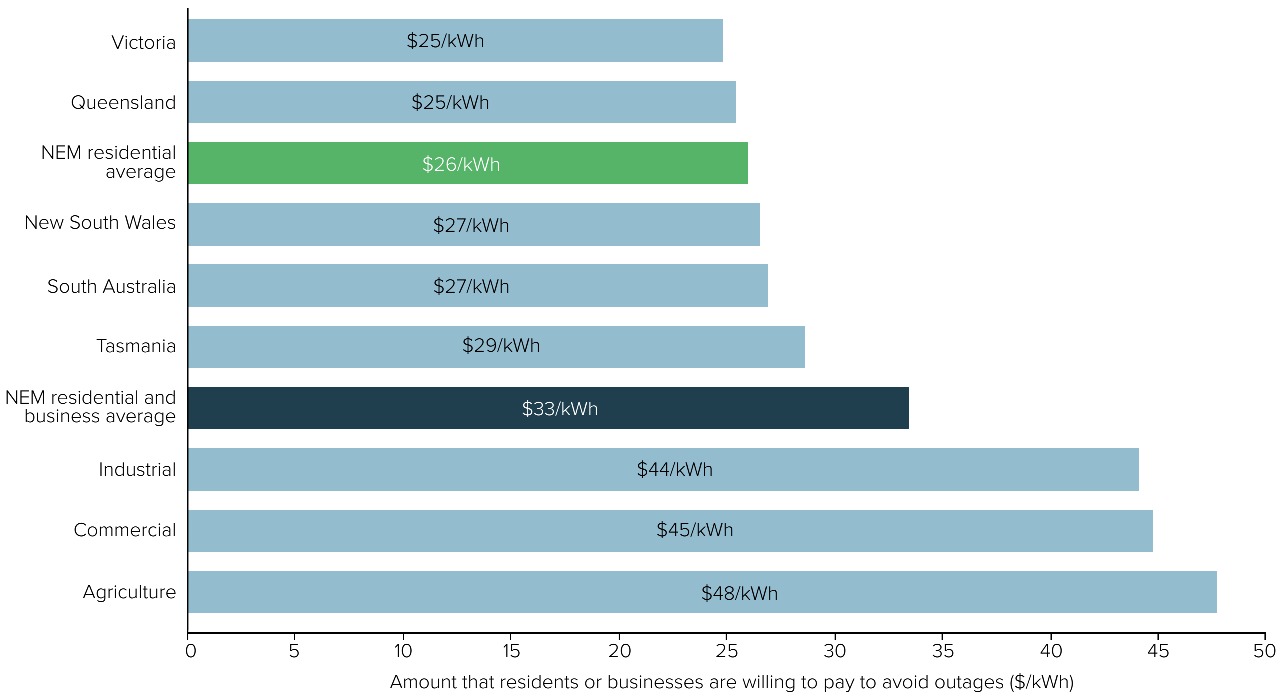
Source: Australian Energy Market Operator (2018)[107]

Customer willingness to pay for reliability varies

Users have different levels of risk, and different willingness to pay, so striking a community-wide balance between reducing and tolerating risk is a complex task. Work is underway to better integrate consumers' willingness to pay to reduce risk, as a means of better measuring the case for additional investment.[108] The Australian Energy Regulator (AER) has recently started a review of the value customers place on reliability, and how this varies across different regions and different customer types.[109] This review will update estimates AEMO developed for the NEM in 2014 (Figure 15).[110]

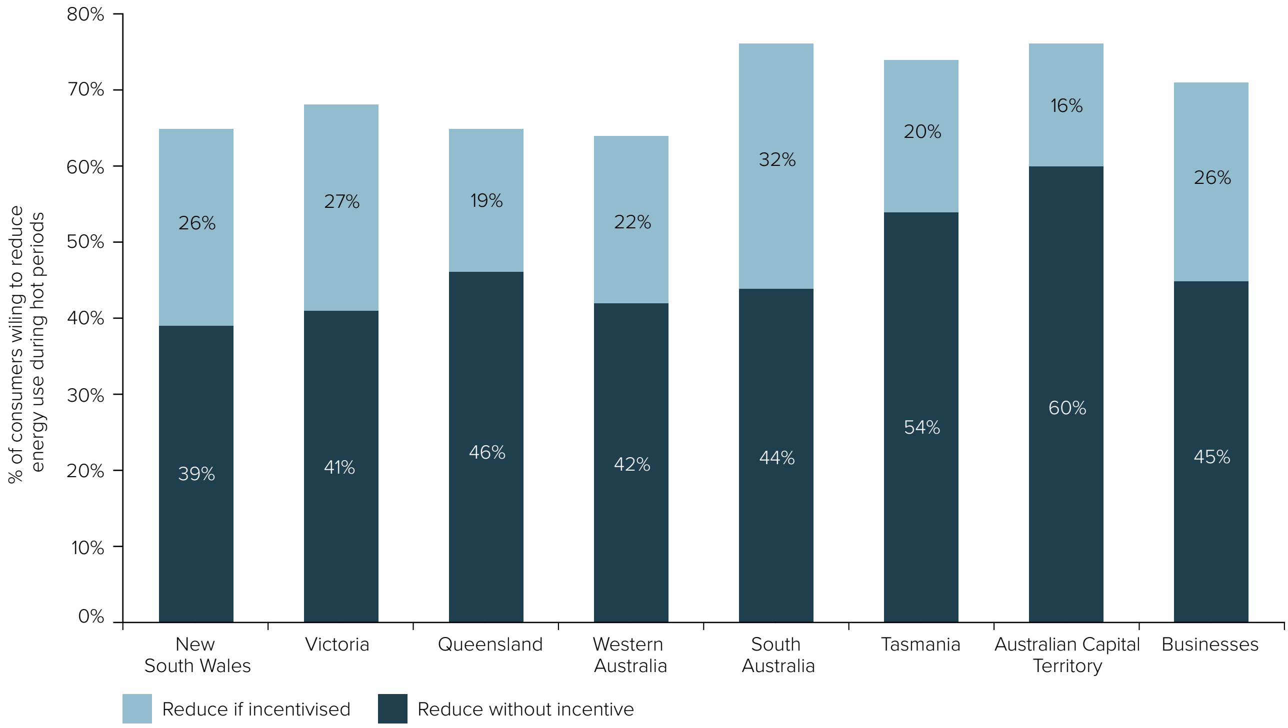
Across each state and territory, up to 64% of consumers surveyed by Energy Consumers Australia in 2018 said they were willing to reduce their energy usage at times of very hot weather (Figure 16). The responses varied across states and between household and business customers, providing insight into different consumer appetites for trading inconvenience for cost.[111]

Figure 15: Willingness to pay to avoid electricity outages varies between regions and customer type



Source: Australian Energy Market Operator (2014)[112]

Figure 16: Energy Consumers Australia's survey shows consumers' willingness to act to reduce peak demand



Source: Energy Consumers Australia (2018)[113]

135. Challenge

Balancing reliability and affordability in line with users' willingness to pay will be an ongoing challenge in energy systems with rapidly transforming wholesale and network characteristics. Failure to get the balance right will result in higher costs for users due to inefficient investments, or poorer reliability for users.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

Energy systems face emerging risks that could impact reliability

Energy systems face a range of risks, many of which have emerged over recent years or are continuing to evolve – including risks from climate change and cybersecurity.

In particular, climate change is expected to increase the frequency and severity of extreme weather events. This will impact on the reliability and security of the energy system, and increase costs over time. The CSIRO, Bureau of Meteorology and AEMO have identified key future climate-related risks, including:

- Increased demand during more frequent hot days and prolonged heat waves
- Increased bushfire risk to system assets
- Changing rainfall patterns affecting hydro generation, and availability of cooling water for thermal generation
- Changing wind speeds impacting wind generation and transmission infrastructure.[114]

Another consequence of our increasingly interconnected world is the cybersecurity risks to our critical infrastructure systems from foreign and domestic attacks. This issue was explored by the AEMO in 2018, in response to a recommendation of the Finkel Review. This identified opportunities to improve cybersecurity risk mitigation, including collaboration within the industry and consideration of potential regulatory models to strengthen AEMO's authority to manage cyber security risk.[115]

Australia faces some risks to fuel security

Beyond the electricity and gas systems, Australia requires reliable and secure reserves of oil. As a signatory to the International Energy Program Treaty, Australia is required to hold oil stocks equivalent to at least 90 days of the previous year's net imports.[116] Australian total petroleum reserves, measured as days of consumption cover, were estimated at 27 days at current consumption levels as at October 2018.[117]

Australia has been non-compliant since 2012 and is the only significantly non-compliant Treaty member.[118] However, Australia has not experienced a supply disruption in 40 years, and currently imports oil from 21 countries. A move to greater electrification of transport vehicles over coming years, as well as a declining reliance on diesel generation in the resources and manufacturing sectors, and by remote communities, will mitigate some risks through decreased reliance on oil. Nevertheless there is low-risk, high-consequence potential for geopolitical events to broadly impact physical movement of oil.

The Australian government is working with the International Energy Agency to return to treaty compliance by 2026 in a phased approach.[119] The cost of acquiring the oil stock shortfall has been estimated conservatively at over $7 billion.[120] If Australian stock increases, it will likely trigger the need for new storage and processing facilities, at additional cost. There would also be costs associated with maintaining and testing diesel, as it degrades when stored over six months.

136. Challenge

Governments, regulators, operators and service providers need to manage growing risks to Australia's energy systems and fuel sources, including risks from climate change, cyberattack or disruptions to fuel supply. Failure to effectively mitigate against risks to energy services could have substantial consequences for the economy.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

Lack of certainty on emissions policy is an ongoing challenge

Just as there is a trade-off between reliability and affordability, so too does sustainability require a balance of other energy objectives. In the absence of a settled policy to deliver on Australia's 2030 international commitments and the role of energy within it, uncertainty risks further driving up costs.

Electricity and gas are two of Australia's three largest emitting industry sectors,[121] and their decarbonisation will be central to Australia meeting its international commitment to reduce emissions to 26-28% below 2005 levels by 2030. The electricity sector is on a decarbonisation path, with new renewable capacity displacing higher emissions from generation. As our gas export industry grows, emissions from the direct combustion of gas for energy (including at LNG plants) are rising.[122]

Despite several iterations of a national emissions policy being proposed following the abolition of Australia's carbon pricing regime in 2014, the Australian Government did not settle on a policy for managing emissions until the release of the Climate Solutions Package in February 2019. The major energy regulators, led by the Energy Security Board,[123] the business sector, led by the Business Council of Australia,[124] and consumers, as represented by Energy Consumers Australia,[125] have all called for greater certainty on emissions and energy policy.

In the absence of a firm national policy, there is also an overlay of state policies to reduce emissions. Table 1 illustrates the range of Renewable Energy Targets committed to by each jurisdiction. These are generally state-based emissions targets, although New South Wales has a transmission infrastructure strategy focused on assisting the transition to low-emission generation sources.[126] Individual climate and territory targets and subsidies within the NEM risk suboptimal investment decisions. Most jurisdictions support a national policy, and acknowledge the benefits of a national approach.[127] It is important to note that states and territories are responsible for energy policy under the Australian Constitution. The last 20 years of the NEM and the relative consistency of rules and operations over that time have not been the norm since Federation.

Table 1: Renewable Energy Targets (RETs) by jurisdiction (% of energy sourced from renewable sources)

Jurisdiction	2020 RET	2022 RET	2025 RET	2030 RET
NSW				
Vic	25%		40%	
Qld				50%
WA				50%
SA				
Tas		100%		
ACT	100%			
NT				50%
National	23.5%			

Note: The actual Federal target is 33,000 GWh from renewable sources by 2020.

Source: Clean Energy Council (2019), ACT Government (2019), Northern Territory Government (2019), Climate Change Council (2017), Department of Energy and Water Supply (2018), Victoria State Government (2017).[128]

137. Challenge

Despite positive progress on the development of a national climate policy, ongoing politicisation of the issue and policy inconsistency between levels of government reduce market certainty. Uncertainty prevents timely investment in long-term infrastructure such as electricity generation and gas pipelines, increasing risks and costs to users.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

7.4 Transitioning to Australia's future energy fuel mix

At a glance

Australia draws on a complex and changing range of fuel sources. Coal's market share is falling as wind and solar energy become cheaper and markets move towards renewable sources. Gas is also in flux, as new technologies take over its role in smoothing our supply.

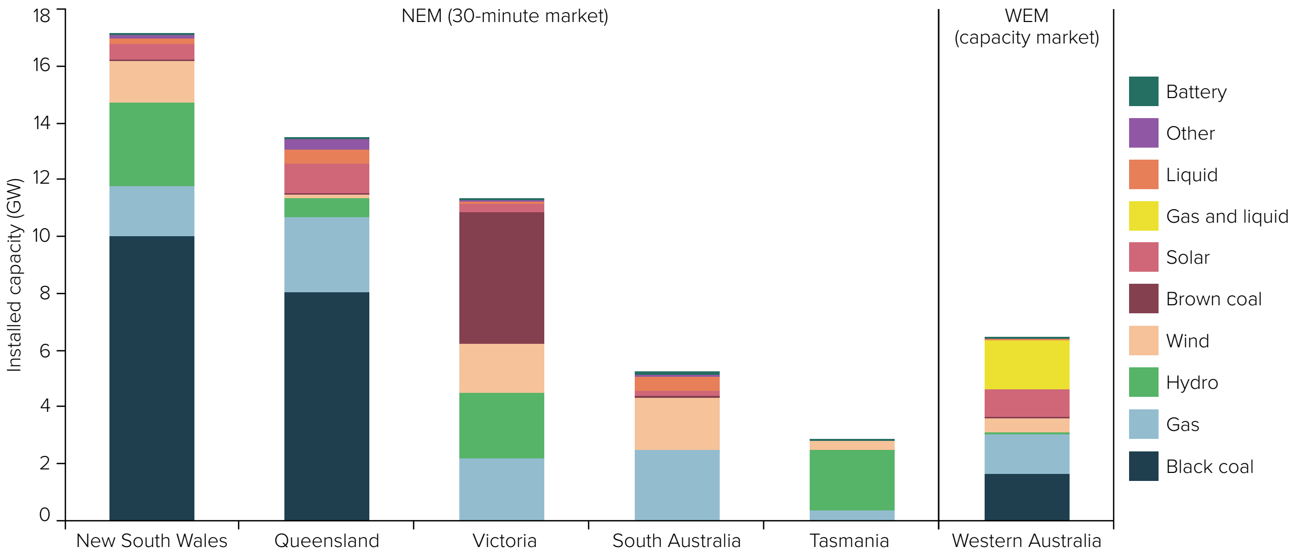
Australia is undergoing an energy transformation

Australia's energy markets are undergoing a complex transition. Failure to adequately plan for and manage this transition could result in poorer outcomes for users, with potential repercussions for grid stability, network efficiency and higher ongoing costs for consumers.

Australia's electricity sector draws on diverse forms of generation, many of which draw from an abundance of domestic sources of energy, as shown in Figure 17. Despite this abundance and diversity – or perhaps because of it – efficiently and reliably delivering electricity to users remains a key challenge for the sector.

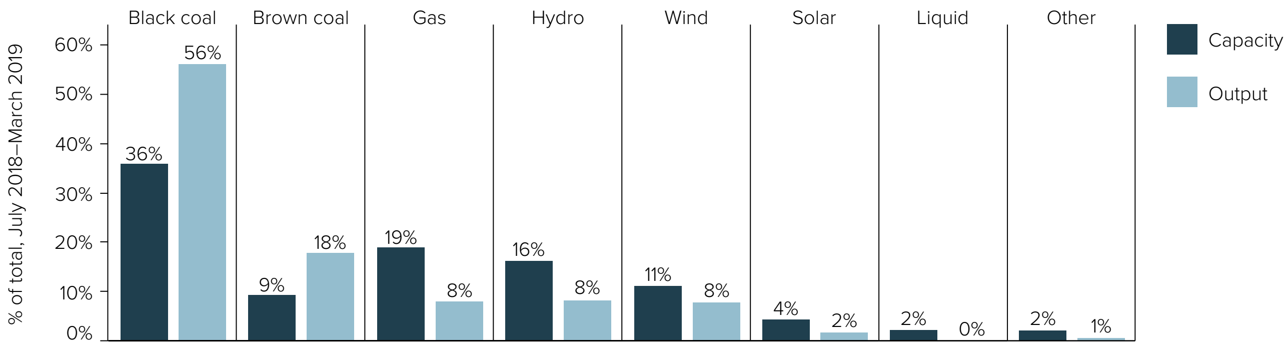
Each form of energy generation has different characteristics that determine how quickly and reliably they can be deployed. As electricity systems rely on supply always meeting or exceeding demand, it is essential to have versatile fuels that can cover unexpected events, and a level of confidence that bid volumes can be delivered at all times. Figure 18 shows installed infrastructure capacity by fuel source as a proportion of the NEM and compares each fuel against the proportion actually delivered, in the second half of 2018.

Figure 17: Fuel sources vary considerably by region in the current wholesale market



Source: Australian Energy Regulator (2019), Australian Energy Market Operator (2018)[129]

Figure 18: Different fuels have different strengths, which impacts capacity and generation output



Note: Figure represents capacity and output from NEM fuel sources for July-December 2018.

Source: Australian Energy Regulator (2019)[130]

Coal-fired generation is playing a diminishing role

For the last century, Australia's electricity system has relied heavily on coal-fired power as the main fuel source for electricity generation. Coal has also played a major role in regional growth. The LaTrobe Valley in Victoria, the Hunter Valley in New South Wales and Collie in Western Australia, among other regions, have for generations revolved around the local power stations and respective coal mines that fed them, with coal fired power contributing almost 80% of the nation's electricity at its peak.[131] The abundant and cheap mix of fossil fuels gifted Australia a comparative advantage in terms of electricity prices for several generations.

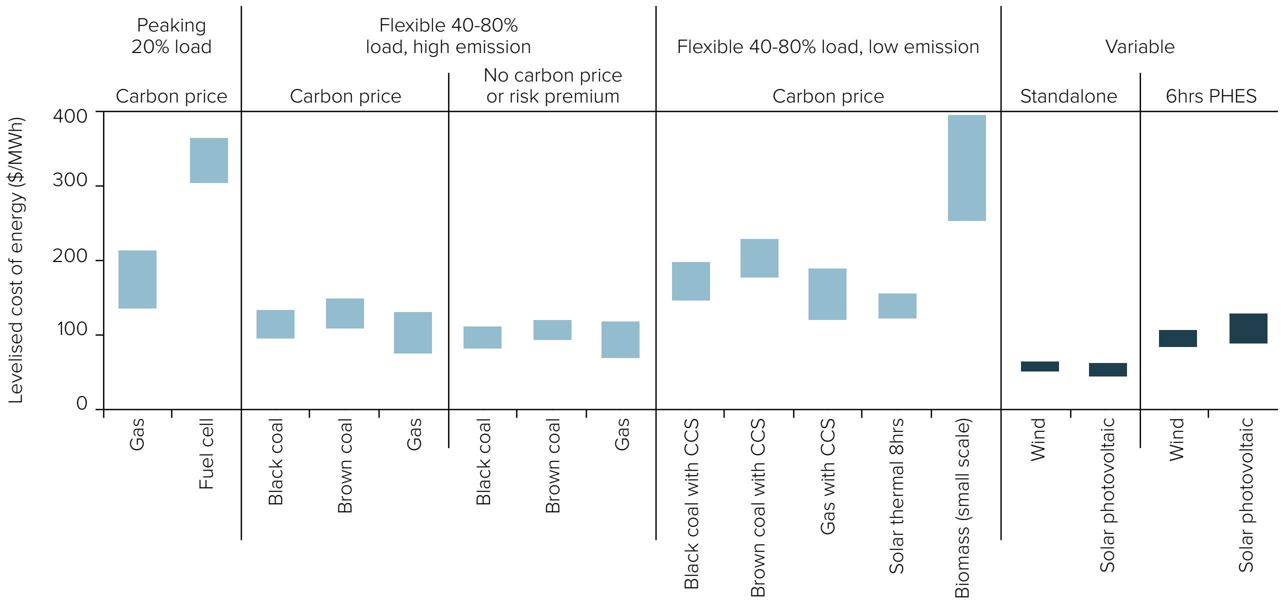
However the value of coal as an electricity input has now shifted significantly relative to other sources of supply, as illustrated by Figure 19. Over a relatively short space of time, variable wind and solar PV at large scale have come to challenge new coal plants as the cheapest sources of supply. The rapid cost reduction in renewables has coincided with factors that have magnified the severity of the change, including an increasingly peaky daily demand profile, and uncertainty as to the pricing of carbon emissions. This is due in part to a take-up by households of solar PV, which is less accommodative of relatively inflexible coal-based generation.

These developments place the NEM in the paradoxical position of being unable to commercially support new build coal-fired generation or to automatically accommodate the retirement of existing facilities. While existing market planning assumes that coal-fired generators will serve their full lives, there is a significant risk of earlier retirement occasioned by market factors. If this is not adequately coordinated, the market may not have sufficient dispatchable supply available and risks becoming increasingly reliant on expensive temporary measures, while becoming less reliable and affordable.

The NEM has already experienced several shocks triggered by one-off events, including the retirement of major coal generators. A failure to unpick the individual factors forcing the potential early withdrawal of capacity without enabling an effective replacement will leave the NEM at continued risk of supply side shocks. The Finkel Review recommendation,[132] now a NEM rule, requiring large generators to provide at least three years' notice of closure will help to support a more orderly transition from coal generation.

Like in the NEM, the WEM has seen retirements of coal-fired capacity, and take-up of renewables. In its smaller wholesale market, concentration is high, with one vertically integrated generation wholesaler-retailer, Synergy, dominating the wholesale market. While more deregulation of the retail market is planned, the regulator is urging action to boost wholesale competition before implementing further retail deregulation.[133]

Figure 19: Coal-fired generation is being overtaken by renewable forms of supply



Note: Levelised cost of energy by technology and category, calculated for 2020. Values are inflation adjusted to 2018–19.

Source: Commonwealth Scientific and Industrial Research Organisation (2018)[134]

138. Challenge

Many major coal generation assets are ageing and approaching retirement. The capacity they provide will need to be replaced. In the NEM, this capacity needs to be replaced or there may be impacts on reliability or competition. In the WEM, where there is overcapacity there may be scope to reduce surplus capacity. In both cases, there is a risk to the order of the market.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

Renewable generation has grown rapidly, and could grow much further

The costs of large-scale renewable energy generation have reduced substantially over the last decade. This has incentivised investment in renewable generation on an unprecedented scale. In 2018, one in five households had rooftop solar, and 21% of electricity over the previous 12 months came from renewable sources.[135] This figure will continue to climb off the back of $20 billion in large-scale renewable energy projects in 2018 – twice that of the year before.[136] According to AEMO, Australia could have one of the highest ratio of decentralised non-grid generation in the world.[137] From 2050 CSIRO and Energy Networks Australia estimate that between 30 to 45% of annual electricity consumption could be supplied from consumer owned generators.[138]

The ongoing cost reductions in variable renewable energy technology has made continued growth of its market share highly likely. This places Australia in an enviable position over the medium to long term given the abundant renewable resources that can be captured with relative ease. Optimally managed, Australia's renewable energy resources can form the basis of a comparative advantage similar to that provided by coal in previous decades.

Utility-scale solar generators and rooftop solar systems have near-zero operational costs. This has limited the capacity for coal and closed cycle gas generators to make revenue, creating pricing variability to which they are ill-equipped to respond.

The intermittency of renewable energy generators present a new set of challenges for electricity grids designed around large scale, stable generation facilities serving a reasonably consistent demand profile. The variable capacity of solar and wind has proved challenging for grid operators worldwide, with the need to balance load both for system frequency control and overall demand balance. A grid supplied predominantly by inflexible coal plants (that cannot be easily switched on and off) can quickly be thrown off balance by variable renewable energy with its low variable costs and intermittent (weather dependent) supply volumes. This issue has been identified in multiple reviews of the sector, with the recent Finkel Review proposing a Generator Reliability Obligation as a regulatory mechanism.[139]

Renewable energy projects face varied commercial challenges. For example, generators are not be paid for energy lost in transmission from generator to end user. The total electricity lost in transmission is called the marginal loss factor. Remote wind and solar projects are particularly susceptible to higher transmission losses because generation often exceeds transmission capacity. Losses also grow over large distances and many renewable generators are located a long way from the end user. For example, the Wattle Point Wind Farm in South Australia has a marginal loss factor of 0.82 for 2018–19.[140] This means that this project will only receive payment for approximately 82% of electricity generated. Uncertainty regarding the treatment of these issues can impact the commercial viability of current and future renewable energy projects due to potential reductions in payment.

139. Challenge

As the penetration of small- and large-scale renewables increases across the network, additional investment in networks and generation will be required to manage reliability and service levels. This will increase capital and operational costs in networks, but will be needed to be maintain balanced supply standards.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

The role of gas in Australia's energy mix is changing

A rise in gas prices has also shifted expectations for gas' role in the future generation mix.

Following the construction of LNG terminals in Queensland that opened the east coast market to global prices, the price of wholesale gas has risen from below $5 per gigajoule in 2009 to over $10 across most of the east coast (Figure 20).[141] This prompted the Australian Government to introduce a policy aimed at ensuring a sufficient supply of natural gas to meet the forecast need of energy users within Australia, by requiring the LNG projects to limit their gas exports or find new gas sources if there is a projected supply shortfall in the domestic market.[142]

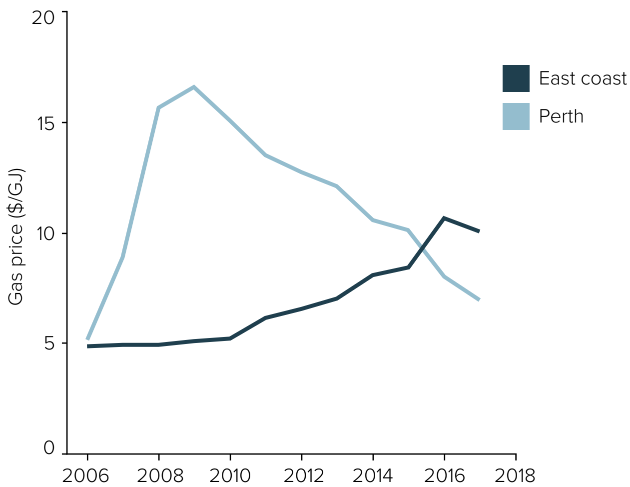
The experience is different in Western Australia, where prices have fallen over the past decade. Large exports from the west coast have been subject to a formal policy on gas reservation for domestic use for a little over a decade.[143]

In the past, short-term stabilisation of the grid (known as firming or balancing) has been provided by combined-cycle gas turbine plants. Consequently, the price of gas has been frequently been responsible for setting the electricity spot price in most NEM regions.[144]

However, the viability of combined cycle-gas turbine firming services is related to the gas price. A change in gas price will impact the competitiveness of variable renewable energy, relative to other technologies. Given the size and volume of proposed variable renewable energy generation, the grid will require a substantial expansion of complementary firming services in the coming years. In the NEM, the role of gas is likely to depend on the availability of lower cost domestic gas, possibly unlocked by opening new sources of supply.

In the Northern Territory, where gas is the main fuel source for electricity, the Utilities Commission anticipates reduced grid demand across its three regulated systems in the decade to 2026–27, driven by increased use of behind-the-meter solar PV. With the NT recently adopting a 50% renewables target, the regulator notes the technical challenges with the changing generation mix and maintaining system security.[145]

Figure 20: Gas prices on the east coast have nearly doubled since 2010



Source: Department of the Environment and Energy (2017)[146]

Pumped hydro and largescale batteries offer storage and firming

Wholesale generation market rules are adjusting to recognise the benefits of storage technology. In 2018, two new large scale lithium-ion battery facilities were connected to the NEM.[147] Large fixed batteries, such as the Hornsdale Power Reserve,[148] in South Australia are able to very effectively provide the rapid frequency control services that will be required to manage grid stability as the grid transforms.

The coming wave of variable renewable energy is also an opportunity for a growing role for one of Australia's older renewable energy technologies, hydroelectricity. Pumped hydro offers advantages over other storage methods, such as a longer technical life (50 years compared to current estimates of up to 15 for most batteries), and a relatively low unit price, particularly when built at scale.[149]

The Australian Renewable Energy Agency has identified approximately 22,000 potential pumped hydro energy storage sites around Australia with merit for investigation.[150] Together they have much more potential storage capacity than required across the NEM to support variable renewable energy. TasNetworks and ARENA are also proposing a second Bass Strait interconnector that would enable untapped renewable resources in Tasmania (including HydroTasmania's Battery of the Nation initiative focused on pumped hydro potential)[151] to be used to supply and firm renewable generation in the NEM.[152]

140. Opportunity

New forms of large-scale storage are increasingly available, including pumped hydroelectric and battery assets. Introduction of appropriate new firming capacity will complement variable renewable energy bids and aid the transition to the new electricity mix.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

7.5 Planning for our future energy networks

At a glance

As new fuels enter our markets, governments and regulators must plan for network growth. States have traditionally managed energy policy, but national bodies have taken over many functions. The recent Finkel Review found a rising need for whole-of-system planning and shared renewable energy zones as our interstate networks grow.

Renewable energy requires new stability services, and we must also manage our domestic gas through fragmented governance and market changes.

Networks need to keep pace with the energy transformation

Our transmission and distribution networks in the NEM, Western Australia and the Northern Territory are valuable national assets that will continue to form the core of our electricity system over the coming decades. However, significant factors are driving a reshaping of how our electricity networks will operate over the next decade.

The changing fuel mix in our electricity generation is redefining many existing start and end points of our regulated networks. To manage affordability, we need to make smart investment decisions as these networks are regulated natural monopolies whose costs are automatically added to user bills. We also need to recognise that modernisation of the grid is necessary to manage an increasingly complex energy system.

For network operators, integrating distributed energy resources at scale presents a number of technical challenges. These challenges rise considerably when variable renewable energy penetrates further into the overall market.[153]

As well as the basic need to augment transmission capacity in new areas, grid operators must also manage less predictable supply, with more smaller, distributed facilities, each of which are much more weather dependent than in the past. When combined with the overall intermittency of weather dependent energy sources, the grid will also require much greater use of frequency control services to ensure continued grid stability.

While the market for such services is not new, the demand for them will continue to increase as the penetration of variable renewable energy sources grows over time. Ultimately, where previously the grid was managed in a single direction, with stable supply and relatively consistent demand, the future electricity grid will likely require tighter management, as well as timely planning coupled with efficient investment to ensure that users' desired reliability of supply is maintained.

Operators are planning for future network needs

A key recommendation of the Finkel Review was for the development of what is now called the Integrated System Plan (ISP) for the NEM, which was released by AEMO in July 2018.[154] This plan seeks identify the most efficient means of meeting supply across the NEM as a whole, and forecasting the transmission investments needed to support it. The ISP identifies three distinct stages of transmission investment areas of focus:

1. Pre–2020: Transmission bottleneck upgrades
2. 2020–2030: Connecting strategic storage initiatives
3. 2030–2040: Increased interstate capacity and intrastate connection of Renewable Energy Zones

The first stage of the ISP is being expedited to increase connections between regions and strengthen parts of the southern regions. Importantly, notwithstanding reference their inclusion in the ISP, individual transmission investments projects are still expected to produce positive business investment cases under the Regulatory Investment Test before approval.

The 2019 Infrastructure Australia *Infrastructure Priority List* includes the AEMO ISP Stage 1 projects as a Priority Initiative over the next five years, and the latter two stages as a High Priority Initiative over the 5–15 year horizon.[155]

Steps to implement the ISP through coordination of generation and transmission investment (COGATI) decisions in the interests of consumers are also being taken, at the request of COAG Energy Ministers.[156] There are currently many competing generator (generally renewable energy) proposals to connect to networks. However, not all will proceed, and users have an interest in least cost transmission upgrades during the market transition.

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In the South-West Interconnected System in Western Australia, Western Power has taken steps to minimise the costs of network augmentation during the shift in generation mix towards renewables. This includes the option of market reform to open up access for new generation to existing networks via ending the existing unconstrained access of the large established generators. In turn, this will enable a lowest-price dispatch system for generation on the existing network, and encourage competition, similar to the NEM.[157]

Managing network planning for the NWIS in the Pilbara region is much harder, given the winding up and down of major energy-using projects, and their workforces, across the export commodity cycle. This makes long-term planning for regional power needs very difficult, and developing solutions is often part of the project approval process.

141. Challenge

Transmission networks need to respond to new generation in areas not currently served or without sufficient spare capacity. The outcome of these decisions will be paid for by users over many years. It is in the interests of users that the transition is efficient and guided by well-targeted investment.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

Renewable Energy Zones can help to direct efficient investment

A part of the ISP is to identify which parts of the NEM can best accommodate the coming wave of renewable energy investments that is forecast over the medium term. These are mainly large-scale wind and solar generation.

Retiring coal plants will need to be replaced, and the least cost means of doing so is likely to be a combination of renewable energy and firming services (via storage to address variability). Geographically however, these new fuel sources are unlikely to be located in the same place as the existing coal plants, and a reconfiguration of the transmission network will be required in order to accommodate the new renewables expected to be built by 2040.

Amid competing proposals, the ISP seeks to identify those locations where renewable resources overlap with existing parts of the transmission network with additional capacity and which have high quality renewable resources which provide diversity and can be integrated into the grid without causing material technical issues.

Renewable Energy Zones (REZs) are being prioritised for investment and to connect them to the grid. These zones will also require state planning approvals, and either economic assessment of regulatory funding by the AER, or coordination of commercial funding to support development. A feature of proposed REZs is the shared nature of transmission infrastructure, which means that coordinated connection of generators to the same transmission line can reduce the overall scale of new network investment and result in lower costs, compared with each generator connecting individually.

142. Opportunity

Coordinating investment in new generation and network assets in Renewable Energy Zones can promote investment in renewable generation, provide clarity for network investors, and increase scale and lower costs for new generation providers. Optimising investment in Renewable Energy Zones will lead to lower wholesale and network costs for users over time.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

Gas infrastructure is adapting to changes in the market

How domestic gas is transported to distribution networks and industrial users matters. Australia's gas transmission pipeline network is fragmented into three networks – eastern, northern and western, with the recent construction of the Northern Gas Pipeline connecting the Northern Territory's gas production to the east coast grid (Figure 21). The network is now privately run, though regulated to varying degrees.[158]

New or expanded sources of supply are likely to result in a need for new pipelines and processing facilities. Some potential sources are in remote on- and offshore locations, such as the Beetaloo Basin in the Northern Territory, and may require substantial investment to connect them to domestic markets and export facilities.

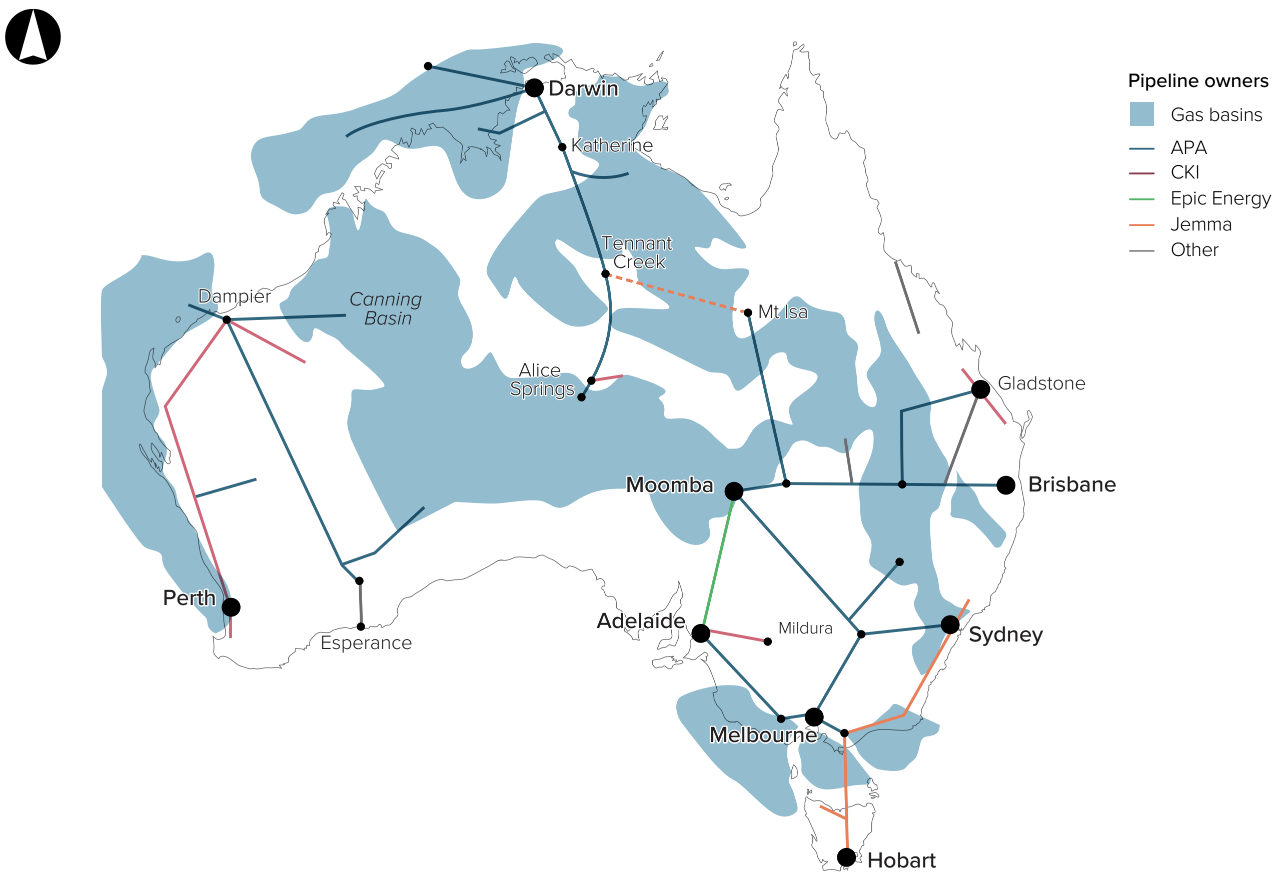
Recently legislated reforms as part of the *East Coast Wholesale Gas Market and Pipeline Frameworks Review* will see a number of steps taken to optimise the use of these pipelines to ensure that gas is delivered at the lowest cost wherever possible.[159] Reforms include mandatory trading of unused pipeline capacity (known as secondary trading), improved information provision for all stakeholders, and concentration of trading activity at two main gas hubs.

The Northern Gas Pipeline

The Northern Gas Pipeline was commissioned by the Northern Territory Government and received permitting and approval support from the Queensland and Australian Governments. The Northern Territory Government initiated a competitive bidding process in 2014 with the aim of increasing access to Northern Territory gas markets. The project was awarded to Jemena in November 2015 and was entirely privately funded to the value of around $800 million.

First gas flowed in December 2018. The project consists of 622 km of buried 12-inch gas pipeline and involved 10 Indigenous Land Use Agreements. The Northern Gas Pipeline connects the existing Amadeus and Carpentaria gas pipelines. Should further connections eastwards to the Galilee Basin in Queensland be built as is currently being planned, the Northern Gas Pipeline will enable gas from the centre of Australia for the first time to be delivered to Gladstone and increase supply to manufacturers in southern markets.

Figure 21: Australia's gas transmission has three main networks – eastern, northern and western



Source: Sydney Morning Herald (2018)[160]

7.6 New opportunities for consumer choice

At a glance

This section looks at how technology has allowed users to take control of their energy supply. Private energy production can improve our grids, but poor planning raises user costs. Small-scale solar is becoming increasingly affordable, however, different regional governance arrangements are affecting take-up.

We face challenges in integrating small private assets into our grids, making solar energy accessible to lower income households, and improving consumer control and visibility over their energy use.

But we have an opportunity to use electric vehicles for short-term electricity storage.

Many consumers and businesses are taking control of their energy

In 2008, Australian grid consumers owned almost no small scale energy assets. Over the last decade, two million premises (about 20% of the total) have installed rooftop solar systems. Rooftop installed capacity has grown to over 6,000 megawatts, and if larger systems are included, there are now over 10,000 megawatts installed nationally.[161]

New assets have transformed some traditional consumers into energy producers, otherwise known as prosumers.[162] From an historical perspective, if energy generation increases in close proximity to where it is consumed, this invites comparison with a century ago, before our centralised networks were formed, to when fire, oil and gas were used in the home for energy.

Many modern users want more affordable and environmentally responsible energy options. Private assets allow these consumers to reduce their bills, avoid some of the uncertainty of grid costs and acquire a sense of control over their energy use. A 2018 survey indicated that 60% of respondents installed solar PV systems because they want to reduce their reliance on grid electricity.[163]

Consumer assets also need to be integrated into grids. Neither legacy infrastructure nor electricity market regulatory frameworks were designed with rooftop generation in mind. Our electricity system was designed for electricity to flow in one direction: from large generators to consumers. A local distribution network can only host a proportion of bi-directional electricity flows before new expenditure is needed to stabilise the system and keep it within operational parameters.

The cost of solar panels and batteries is falling

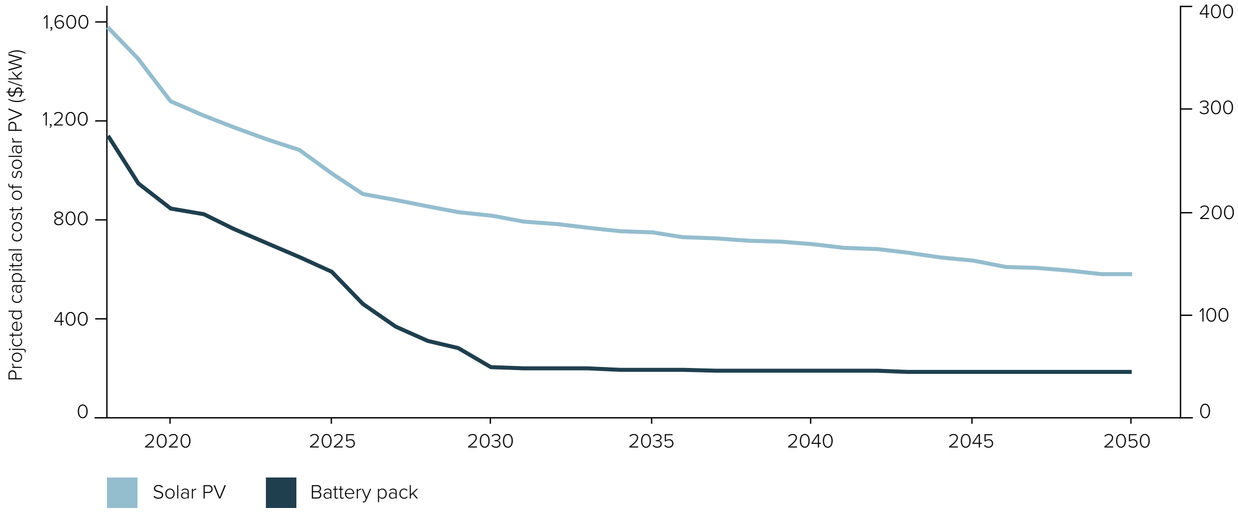
Australia now has one of the highest rates of adoption of household rooftop solar systems in the world. Batteries, smart appliances and electric vehicles, which sit behind the meter (outside the central grid), are mostly newer and have been adopted in smaller numbers. Uptake is likely to continue to grow, as CSIRO forecasts indicate continued falls in the cost of solar panels and battery storage technology.

Over the next 10 years, many more consumers will likely adopt home battery storage. Battery prices have fallen by 80% over 2010–17,[164] and are expected to continue to drop until 2030 (Figure 22). As with solar panels initially, the incentive to buy a battery will also be influenced by estimates of payback periods. Batteries could increase system paybacks because they could store cheap electricity during the day and use it at night when the grid price is higher. This type of tariff reform has often been mooted but is yet to be regulated in Australia.

Due to its current high price, battery storage presently only provides niche services to residential consumers. Only 2.6% of consumer solar systems installed currently partner with a battery system.[165] This is not due to a lack of interest in the technology. A 2018 survey found that between 24% and 39% of consumers across Australia's energy markets were considering purchasing a battery storage system.[166]

If high take-up occurs, AEMO predicts that Australia could have the most decentralised energy market in the world.[167] By 2050, CSIRO and Energy Networks Australia estimate that between 30 to 45% of annual electricity consumption could be supplied from consumer owned generators.[168] This has significant implications for all users, and for electricity infrastructure, as increasing decentralised resources lead to two-way flows on the networks and fundamentally changes the shape of demand for grid-based electricity.

Figure 22: The projected capital costs of solar PV and batteries are forecast to continue to decline



Source: Commonwealth Scientific and Industrial Research Organisation (2018)[169]

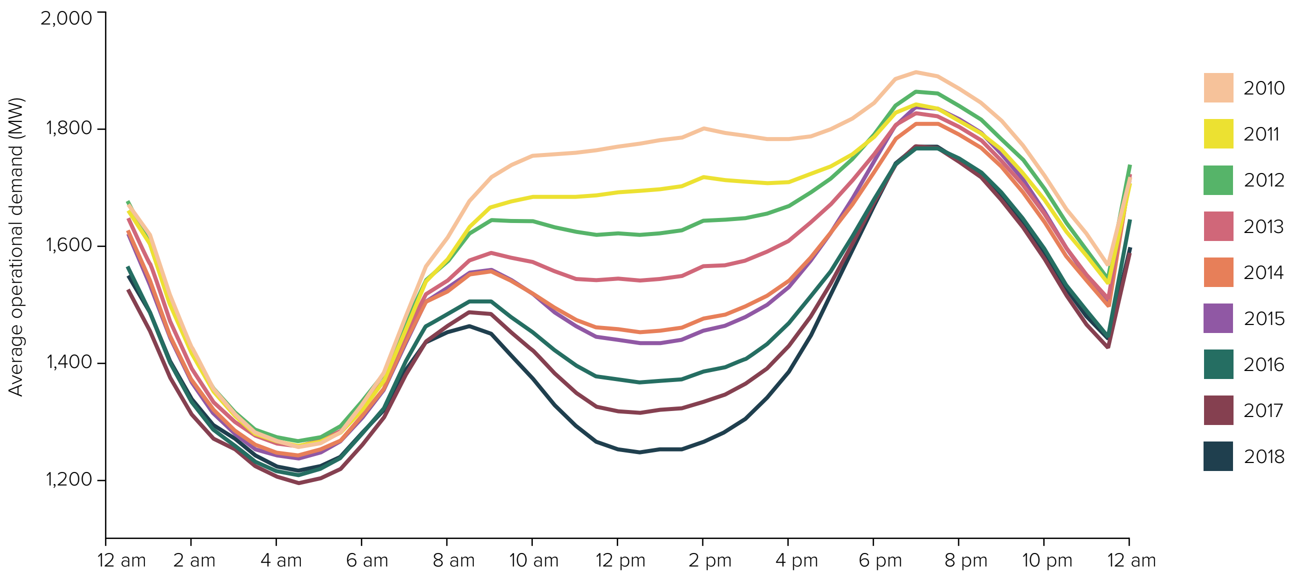
Small scale assets are changing patterns of demand for grid electricity

Small scale assets, and in particular solar PV, are significantly altering the profile of demand for grid supplied energy. Less grid power is being used when the sun is shining during the day, but a large amount of grid power is still required at peak times, when solar is not available. The effect of large scale solar PV adoption by consumers and industry on demand is shown in Figure 23.

Daily peak demand typically occurs between 5pm and 8pm. This increase in demand can be attributed to people returning from work and using energy intensive appliances such as air conditioners, cooking appliances, televisions and, in time, electric vehicles. Electricity must be generated and distributed to meet these needs.

New patterns of demand are likely to pose an operational challenge for market operators. Low periods of demand for grid electricity make it difficult to maintain minimum levels of generation to respond to large increases in demand. If incorrectly managed this can impact grid stability. New generation assets, such as pumped hydro or battery storage, can help smooth the effects of solar and wind intermittency, and increase grid reliability.[170] These assets can also provide capacity and ancillary services, which help manage new patterns of grid demand.

Figure 23: Solar PV adoption is having large impacts on grid demand in Western Australia



Source: Australian Energy Market Operator (2018)[171]

Adapting to and benefiting from energy storage assets

Battery storage has potential to delay or negate the need for network investment and help smooth the intermittent nature of renewable generation.[172] Large fixed batteries such as the Hornsdale Power Reserve in South Australia provide rapid frequency control services that improve grid stability and reduce energy bills.[173]

As the price of battery storage and energy storage declines, these assets could become more widespread across the grid and in users' homes. Large scale investment, helped by incentives, is already occurring. In September 2018, there were 55 large-scale energy storage projects that were existing, under construction, planned or proposed.[174]

Regulation will play a large role in how consumers adopt storage behind the meter, and investment in larger scale utility storage in the wholesale market.[175] It will be a challenge to ensure that regulatory frameworks are flexible and transparent enough to encourage private and consumer investment in energy storage.[176]

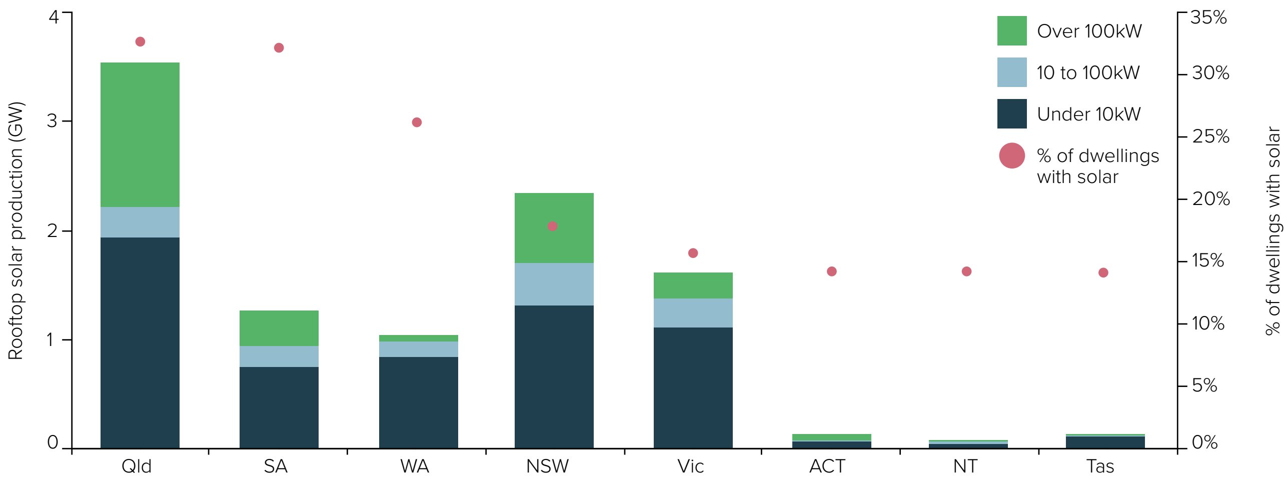
Rooftop and small-scale solar take-up varies across regions

Rooftop and small industrial installation data shows that different states and territories have different solar take-up rates (Figure 24).

This is in part because different regions have slightly different solar capacity factors (around 21% of nameplate capacity for fixed panels)[177] – meaning that some places are sunnier than others, and therefore able to generate more power per solar panel over a period of time. Capacity factors reflect a ratio between technical full capacity (that is energy generated if the sun shone 24 hours a day, and actual generation levels).

Generally capacity factors are higher in Australia's northern regions. This is in part why Queensland leads on both large and small rooftop capacity installed, and proportion of overall premises with solar installed. It is notable that the Northern Territory currently lags on proportion of premises with solar installed.[178]

Figure 24: Rooftop solar take-up varies across jurisdictions



Source: Australian Photovoltaic Institute (2018)[179]

User uptake is affected by uncoordinated government policy

Renewable energy targets, government subsidies and high feed-in tariff schemes have also incentivised take-up of rooftop solar systems. These include federal policies, such as the Small-scale Renewable Energy Scheme,[180] and other state and territory policies. These impact take-up and reshape grid infrastructure, but are largely unconnected, despite most of these jurisdictions being part of a competitive national market.

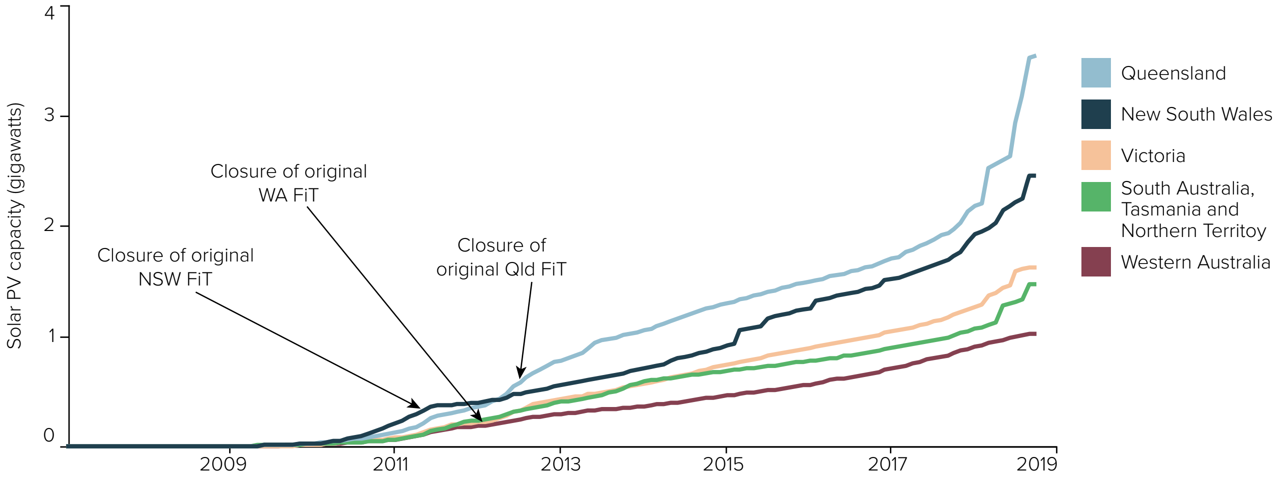
Figure 25 illustrates the rapid growth in small scale solar take-up for the four largest states, and also charts the smaller jurisdictions. It shows different rates of growth – for instance, New South Wales led take-up in the early part of the decade, and was then surpassed by the less populated Queensland, with their original, generous feed-in-tariff (FiT) schemes finishing at different times. The original Western Australian FiT scheme closed in August 2011.[181]

Solar FiT schemes in various jurisdictions provide varying levels of incentives for investment. Retailers offer to buy rooftop solar electricity at a certain price. To the extent that these tariffs are higher than the market price for generation, there is an incentive to invest. Initially, these schemes offered generous tariffs for all energy generated, but most have closed, been restructured or wound back towards the market price, or voluntary operation. However mandatory schemes with retailer obligations remain in the ACT, Victoria and South Australia.[182]

The kinks in the growth paths for each jurisdiction can be linked to policy changes at the state level (and some at the federal level with general application), which either increased or reduced incentives. In the background, capital costs were declining across the whole period. It underscores that user take-up is impacted by calculations of payback periods, after accounting for a range of factors, including capital cost, government subsidies, and FiT schemes.

While there are a range of drivers for these policies, and they differ across jurisdictions, achieving a reduction in grid prices would lengthen rooftop solar payback periods. This could in turn reduce demand for rooftop solar below what it would otherwise be. With several governments directly subsidising behind-the-meter solar, it appears that government energy policy levers are working against each other.

Figure 25: Government policy has influenced solar PV adoption over the past decade



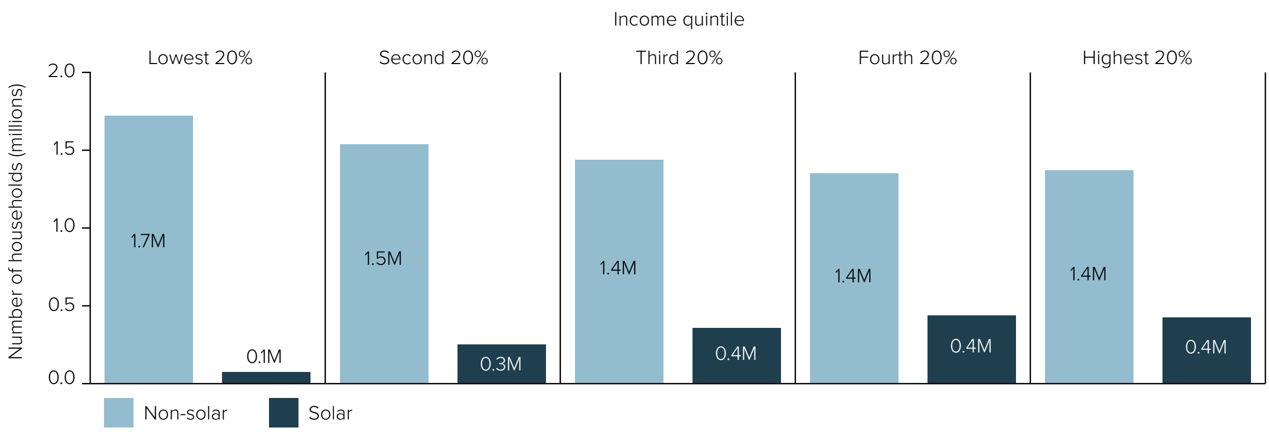
Source: Australian Photovoltaic Institute (2018)[183]

Take-up has tended to be in middle to higher income groups

As more solar and storage is adopted, households without access to private assets could pay more of overall grid costs. Network costs are typically recovered through units of grid energy sold under current tariff structures. Perversely, the most vulnerable people, who are generally less able to reduce their reliance on the grid, have the least flexibility and choice. However, network tariff reform is continuing across all jurisdictions, with many networks introducing demand charges to better capture the key drivers of network costs and provide signals for customers to change their demand in ways that reduce the need for future investment.

Research for the Australian Council of Social Service suggests that higher and middle-income households are more likely to install rooftop solar PV, as shown in Figure 26.[184] These households have both an incentive to reduce bills, and the means to afford the residual out-of-pocket capital cost. Low-income users, sole parents and public housing tenants are less able to afford solar PV installation, yet shoulder a higher electricity burden as a proportion of income.

Figure 26: More higher and middle income households have accessed rooftop solar PV than lower income households



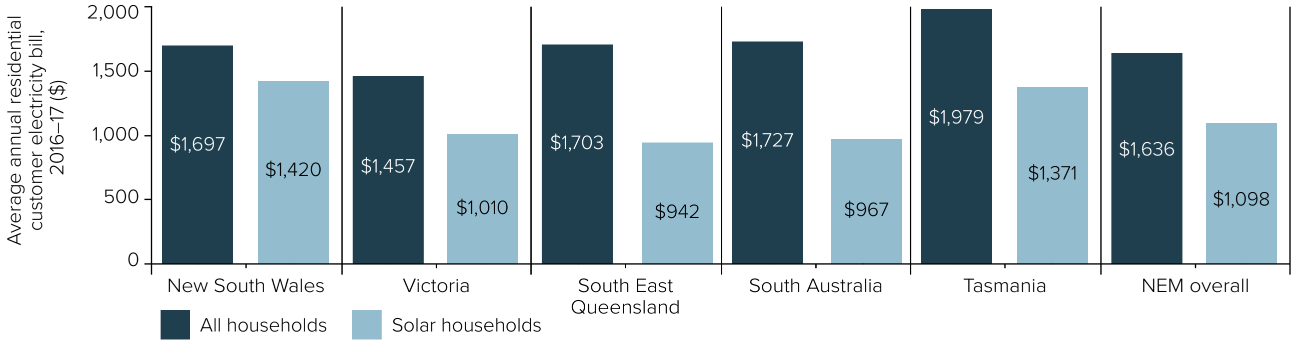
Source: Australian Council of Social Service (2018)[185]

Landlords and renters are in a split incentive position where the landlord's incentive to make an upfront capital investment is weak due to the benefit accruing to the tenant via lower bills. This is a significant issue as 31% of households are rented.[186] In Victoria, community housing providers can apply for solar panel rebates on behalf of their tenants.[187] There has been innovation around cost support for landlords' financing, with benefits shared through a small rent increase. Some councils in Melbourne and Adelaide have offered financing benefits to landlords via rates instalments.[188]

Figure 27 shows the average annual residential customer electricity bill for each NEM region, and the average annual bill for a solar customer in the same region. The gap at the top is the notional subsidy paid by retailers from revenues collected from all customers. In effect, these are paid for by non-solar customers via their bills (except in Queensland where it is now funded directly by taxpayers).[189] Note that electricity bill totals are impacted by differences in gas usage across jurisdictions.

The annual gap between lower average solar and higher average non-solar NEM customer bills in 2016-17 was calculated by the ACCC as 33%. That averages at $538 per customer.[190]

Figure 27: Solar customers on average pay far less than non-solar customers across the NEM



Source: Australian Competition and Consumer Commission (2018)[191]

143. Challenge

Home solar and storage can help users to save costs and control energy use, but government policies are uncoordinated. Developments in behind the meter energy systems risk leaving some users behind, while uncoordinated policies and subsidies add to costs over the long term.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

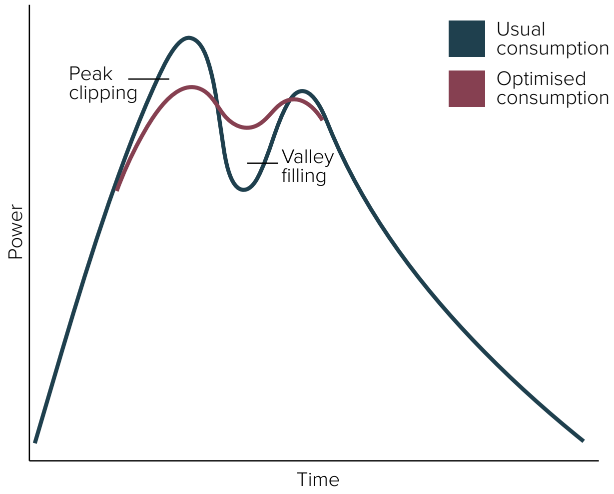
Shifting time of use can save expensive new peak capacity

Demand response occurs when consumers act to reduce or shift demand for electricity across the day at times of tight supply. It acts as an alternative to providing new capacity to meet rare and rising demand peaks. Figure 28 shows a simple example of demand peak shifting. Consumers are paid to reduce or defer their electricity use, lowering peak power demand in the system, and deferring new investment. Even the very occasional use of demand response can have a significant impact on lowering consumer bills.

In Australia, demand response management programs are beginning to take shape. Only around 235 MW of demand response is available to contract retailers, despite there being over 2,000MW of load that consumers would be willing to reduce for cost savings.[192] 64% of consumers say they are willing to reduce their energy usage at times of very hot weather, yet very few do.[193]

Retailers such as Mojo Power, Powershop, United Energy and Energex have trialled demand response programs during peak demand periods.[194] Ergon Energy's demand response program allows the retailer to remotely activate economy mode for participating consumers' air conditioners for short periods of times when the electricity network nears or reaches peak demand. Air conditioner use is only reduced for a few days of the year.

Figure 28: Consumers can shift their demand across the day to optimise consumption and save costs



Source: Northwest Power and Conservation Council (2019)[195]

In addition, we are starting to see the development of platforms that allow the aggregation of household energy resources that can then be offered to the grid as an alternative tool to manage peak demand on the network, as well as facilitating the sharing of resources between households ('peer-to-peer trading').

Despite the growing array of consumer energy assets, most Australians have limited control over their energy use. This is partly because only a small proportion of consumers have access to a smart meter. Consumers with smart meters can more effectively manage their bills.

Most Victorians, where a government led rollout has occurred, have smart meter access. However, outside of Victoria, only 5% of consumers have a smart meter.[196] Australia is lagging behind other nations. The European Union plans to install up to 80% smart meters by 2020, where it is cost effective to do so.[197] Delay in the Australian rollout has been caused by poor coordination between network businesses, retailers and metering coordinators, inadequate resourcing, a backlog of jobs and poor retailer systems.[198]

Even without smart meters, there remain options for consumers to gain greater control of their energy use through the adoption of smart appliances, and through tariff reform that provides stronger signals to consumers regarding the costs they impose on the network.

Managing pool pumps

The Australian Renewable Energy Agency (ARENA) has funded technology that optimises and automates energy use for swimming pool pumps. Typically 40% of swimming pool owners' household energy use is related to their pool.[199]

The trial aims to provide a low cost, low impact option to curb consumption during peak periods to prevent outages and reduce bills. While one or two pool pumps are insignificant, coordinating the over 1.2 million swimming pools in Australia could provide significant energy savings.

144. Opportunity

Demand response from users can defer or avoid expensive new electricity infrastructure investment, and better use existing infrastructure. This can save users the passed on costs of higher peaks.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

Plug-in electric vehicle batteries could store and export electricity

Electric vehicles (EVs) could allow users to have an additional layer of control and choice over their energy. Over a five to ten year timeframe, EV batteries could also play a secondary role as a short-term storage of electricity. This will, however, require addressing some cost and technical issues.

EVs, which on average sit idle for 95% of the time,[200] could take advantage of cheap, off-peak energy to charge up. Their mobility also allows them to act as a literal battery on wheels, sourcing power at one time and using or dispatching it at other times. When electricity is used locally and not transported large distances, there is less demand for expensive network infrastructure.

EV batteries could be an energy asset of national significance. By 2040, Bloomberg New Energy Finance predicts that 40% of Australia's vehicle fleet could be electric and act as a reservoir of storage. The potential is similar to the capacity of the proposed Snowy 2.0 scheme.[201]

Several regulatory and technical barriers exist before EV-to-grid can have application in Australia. To export electricity, consumers require a costly residential bi-directional charger and a smart inverter.

And, with existing technology, exporting electricity accelerates the degradation in capacity of EV batteries.

More fundamentally, Australian consumers have been slow to embrace EVs, amidst concerns about their cost, driving range and access to charging stations.

145. Opportunity

Electric vehicles could provide additional storage capacity to stationary electricity systems. There are regulatory and technical barriers to be overcome. This may provide a means of converging stationary and non-stationary energy at household level.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

7.7 Delivering energy in remote communities

At a glance

Remote and regional communities have reasonable access to electricity, but cost and reliability are major issues. Micro-grids have inconsistent regulation and often rely on costly imported diesel.

Renewable energy solutions could greatly improve this. Many local industries are already adopting these, but increasingly non-standard infrastructure poses challenges for regulators.

Rural and remote energy users and service providers face higher costs

The vast majority of Australian households and industry have access to energy in the form of electricity. Australia has a highly dispersed population spread across challenging geographic terrain. We also have a number of island regions and external territories. Electricity supply in these more remote areas is provided either via the main grid, or through stand-alone power systems. In both cases, electricity supply in these more remote areas is typically characterised by a higher cost of supply and lower levels of reliability. As shown in Figure 29, the key driver of cost is customer density.

Some Community Service Obligations (CSOs) have been funded directly from government budgets. In Queensland, for example, the government paid $465 million to Ergon Energy Retail in 2018–19 to ensure regional and remote customers paid similar electricity prices to other users.[202] As a consequence, many users in regional and remote areas are insulated from paying the true cost of supply.

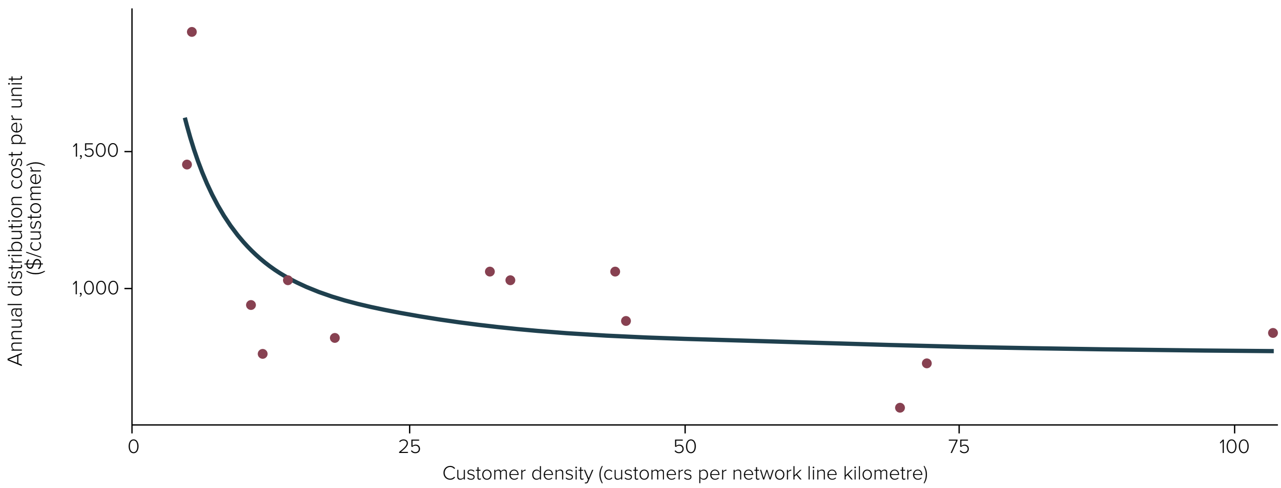
Remote users face distinct reliability challenges

The trade-off between cost and reliability is a particular issue in low population density areas. The AER's Service Target Performance Incentive Scheme operates by measuring average outcomes across major sections of the network. In a review of reliability standards, the Essential Services Commission of South Australia (ESCOSA) found that this can produce a decline in reliability in lower density areas.[203] The AER has acknowledged its scheme may distort outcomes by over-incentivising distribution network businesses to improve supply where it is not valued by consumers.[204]

ESCOSA has proposed changes to its reliability regime and Guaranteed Service Level scheme. Guaranteed Service Level payments will no longer be made to customers who typically have average or good reliability, but experience a one-off outage (of less than 20 hours). Queensland is also considering whether Guaranteed Service Level payments should be directed toward 'worst-served individual customers'.[205]

End-of-grid decision-making involves substantial choices about the costs and benefits of connecting (or remaining connected) to the centralised grid, as technology creates new options with separate costs and benefits. The Australian Energy Market Commission (AEMC) is seeking to determine a fit-for-purpose regulatory regime that would apply to communities or individuals wishing to leave the grid and establish a new micro-grid.[206]

Figure 29: Electricity distribution costs are higher for smaller communities



Source: Australian Energy Market Commission (2018)[207]

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Water
Next steps

Many remote systems rely on diesel and LPG

Electricity is supplied to regional and remote communities at the edge of grid using centralised power and embedded networks. In areas where electricity is provided off-grid via a stand-alone power system, services can be delivered through either a micro-grid, involving several customers and with a mix of generation and storage assets, or an individual power system. Information on stand-alone power system locations, generational sources, locations and costs is very limited.

Many areas rely heavily on diesel and LPG generators, with fuels typically delivered by trucks. The use of diesel-based electricity generation can have negative effects on remote communities. As it is required to be transported, it has potentially high supply costs and can require increased road maintenance.

Kaltukatjara in the Northern Territory, which is home to around 3,000 people, requires 60,000 litres of diesel fuel to be transported every eight weeks over a distance of more than 2,000 kilometres.[208] Washed out or flooded roads can delay delivery and compromise energy security. Remote communities and businesses operating diesel generators can also face uncertain petroleum prices.[209] Diesel generators can also have environmental impacts due to noise, emissions and spillage.

The growth and development of communities can be constrained by the capacity of their power generator. Where new capacity is needed, and a major capital expenditure decision is required, this can leave growth aspirations unmet.

Remote micro-grids are growing across Australia

Micro-grids can involve both generation and distribution infrastructure. They can range in size and ownership from the Mt Isa-Cloncurry micro-grid, which serves over 10,000 users, to the Mt Stirling micro-grid used to service a private ski resort in Victoria.

As shown by Figure 30, Ergon Energy owns and operates 33 remote micro-grids throughout Western Queensland, the Gulf of Carpentaria, Cape York, some of the Torres Strait Islands and Palm and Mornington Islands.

In South Australia, the Remote Areas Energy Supply scheme supplies electricity over an area of approximately 210,000 square kilometres, as shown by Figure 31. Services are provided to around 2,400 customers in 13 remote towns via micro-grids, and approximately 1,000 further customers through the Aboriginal Communities scheme.[210]

146. Challenge

The costs of serving remote and regional areas remain high, with customers in those areas also often receiving poor reliability outcomes. Poor energy reliability in remote areas undermines quality of life and opportunities for growth and investment.

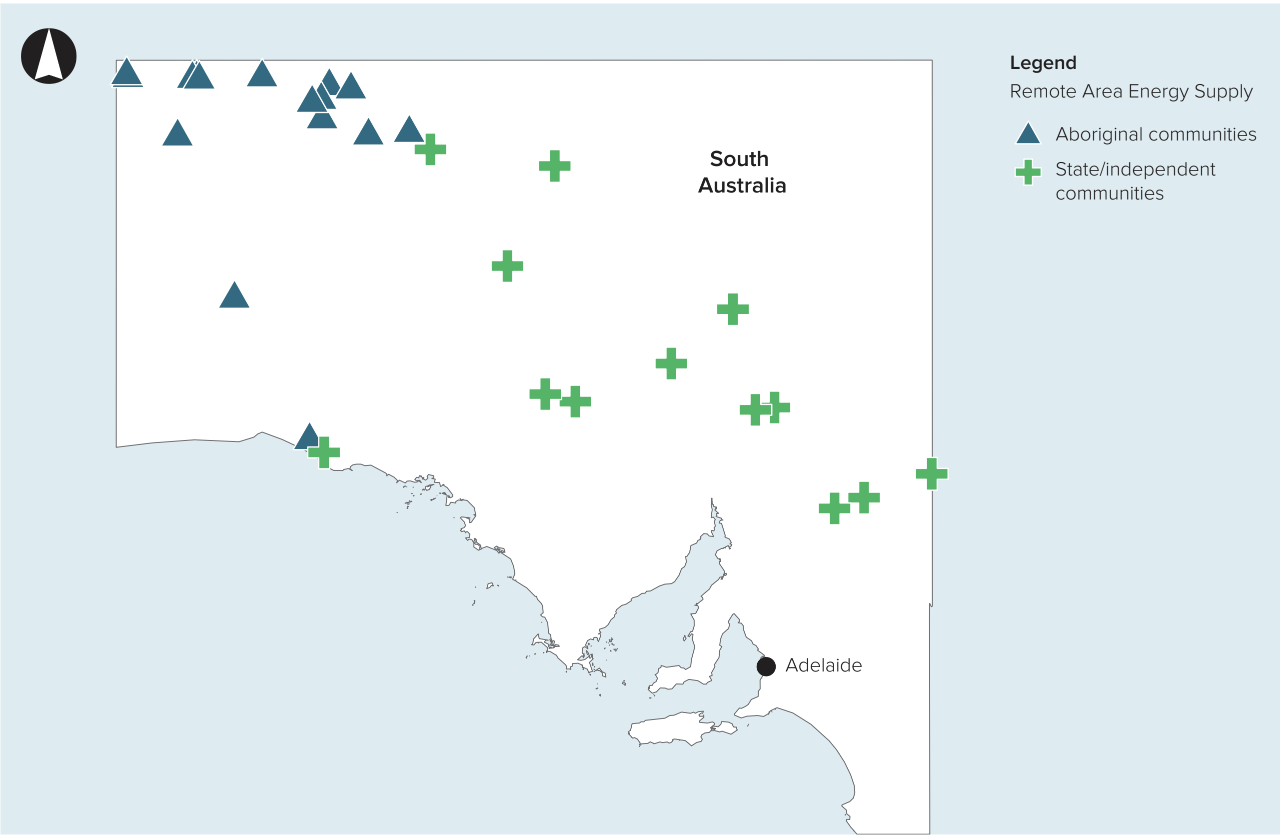
When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

Figure 30: Ergon Energy operates 33 micro grids in Queensland

Source: Ergon Energy (2019)[211]

Figure 31: Services are provided across South Australia through the Remote Areas Energy Scheme



Source: Department for Energy and Mining, Government of South Australia (2019)[212]

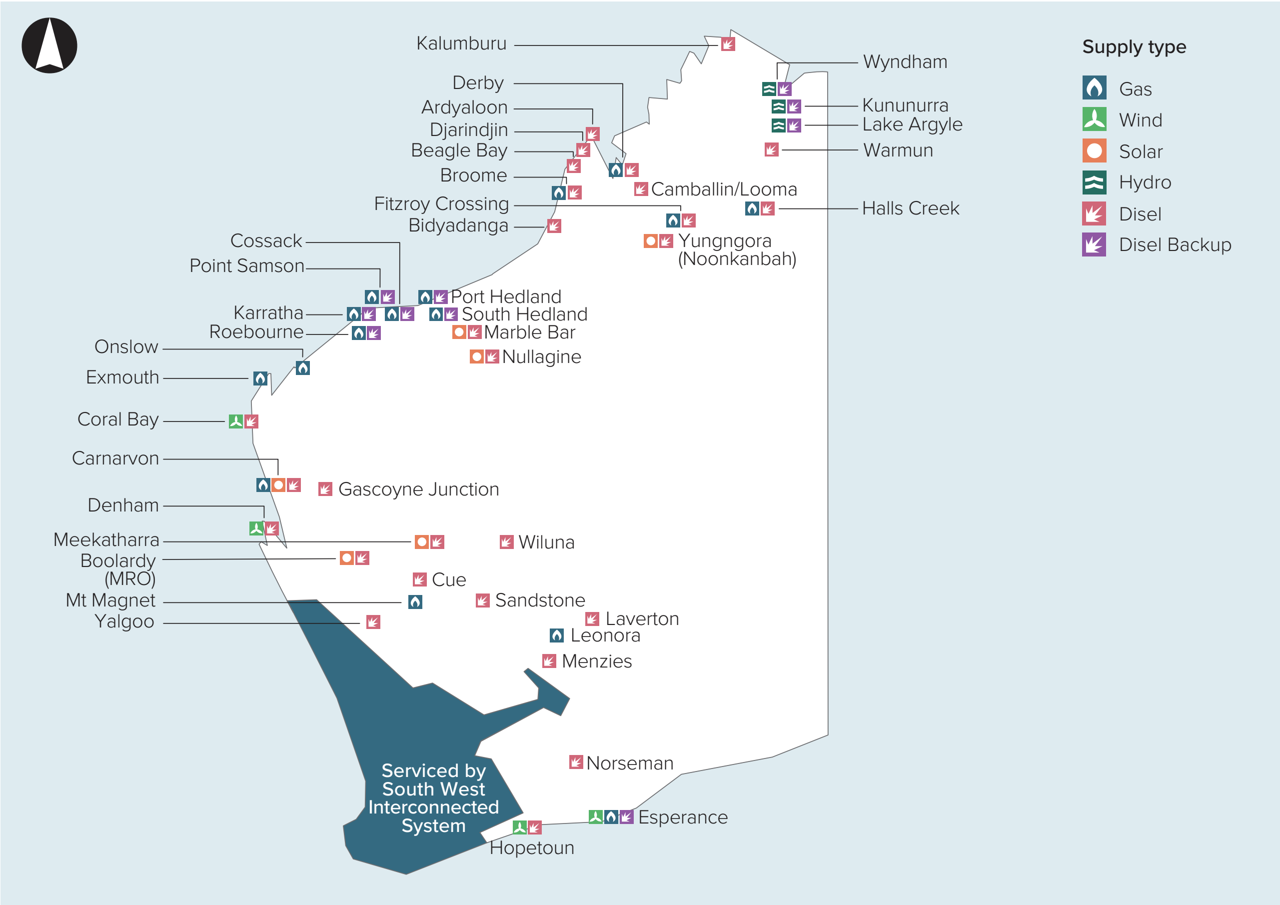
The Northern Territory Government, through Indigenous Essential Services – a subsidiary of Power Water Corporation – provides more electricity to 72 remote towns and communities, as shown in Figure 32. This network includes 52 diesel-fired and renewable power stations and nearly 1,400 kilometres of power distribution lines.[213] Reliance on diesel is expected to decline over the next five years as more renewable energy, storage and low emissions options become cost-effective.[214]

Figure 32: Remote communities serviced by Indigenous Essential Services

Source: Power and Water Corporation (2013)[215]

The Western Australian Government provides services through Horizon Power to more than 100,000 people and 10,000 businesses at 47,000 connections across 2.3 million square kilometres.[216] Horizon Power's network includes 37 micro-grids and eight micro power systems (Figure 33).[217] A further 91 Aboriginal remote communities are served by around 200 micro-grids, funded under the Remote Essential and Municipal Services program and run by the Western Australian Department of Communities.[218]

Figure 33: Horizon Power provides service throughout Western Australia



Source: Horizon Power (2018)[219]

New technologies can bring substantial benefits for remote users

Continued reductions in the price of solar and battery storage mean that smaller scale electricity generation, particularly solar PV, and small-scale battery storage are becoming increasingly cost-effective. This opens up the prospect of using self-contained renewable energy systems as a complement to, or substitute for, existing electricity supply arrangements.

The economic, social and environmental benefits of renewable energy systems can be considerable. The replacement of grid-connection with new stand-alone power systems based on solar photovoltaic panels, lithium-ion batteries, an inverter and backup diesel generator, can reduce the cost of supply, mitigate bushfire risk and improve reliability for consumers. Where communities are not connected to the grid, micro-grids, storage and demand response solutions can reduce the need for diesel generation, optimise energy generation and consumption, and improve reliability.

Development of renewable micro-grids can bring construction jobs, support for local business, reduced emissions and, depending on the location and relevant regulatory arrangements, reduced prices for electricity users or lower budgetary impacts of community service obligations. Renewable energy systems are also modular and scalable, allowing communities more choice and flexibility to adapt or expand based on their communities' changing energy needs.

Remote solar systems may also allow Aboriginal and Torres Strait Islander communities to use energy in a way that is more compatible with their cultural values. It can do so by reducing noise and pollution from diesel generators and the trucks required to bring fuels, while helping to combat climate change, and improving connection with earth and sky.[220] ARENA and the Northern Territory government have initiated the Northern Territory Solar Energy Transformation Program that aims to install 10 megawatts of solar PV across 26 communities.[221]

Renewable energy can bring benefits for the resources sector

Renewable generation and storage are being adopted in regional and remote Australia by the mining sector and local industry.

With electricity costs representing up to 40% of mine operations, many mining companies actively manage their energy requirements.[222] There is value in avoiding fluctuating wholesale electricity prices, given that spot prices for electricity can spike during tight supply periods. Australian miners, including members of the South Australian Chamber of Mines and Energy have committed to renewable energy deals in a bid to lower bills, increase sustainability and improve their profitability.[223]

Large scale renewable installations also reduce the need for imported fuels. Weipa bauxite mine in Queensland installed a solar plant that avoided the use of 600,000 litres of diesel each year.[224] Coober Pedy power station eliminated the need for one million litres of diesel over a six month period in 2017 by installing solar generation with battery storage.[225]

Some mining operations are acting to change their electricity demand patterns across the day, to match solar generation. SunMetals zinc refinery in Queensland, which operates a 124 MW PV plant, coordinates its energy intensive electrolysis process to coincide with peak solar generation.[226]

Bruny Island Battery Trial has saved taxpayers costs without sacrificing reliability

Bruny Island is connected to Tasmania's main grid via an undersea cable, which overloads at times of peak demand. Rather than incurring the sizeable costs of upgrading the cable – which is estimated to cost $1 million per kilometre – or installing diesel generators, residents have been provided with subsidies to install 40 battery and rooftop solar PV systems.

These batteries are used in a smart, automated way to reduce network costs, and deliver reliable and secure electricity. Battery owners maximise the value of their battery systems by exporting electricity when the need for energy is high. This shaves peak demand while keeping the network within voltage and capacity limits.[227] Since energy generation is more localised, there is less demand for distribution, reducing the cost of building, upgrading and maintaining poles and wires, thereby reducing costs to all electricity users.

Energy systems on Rottnest Island in Western Australia and King and Flinders Islands in Tasmania also have a high proportion of renewable energy assets, high system quality and reliability. Both projects have significantly reduced diesel consumption. Other remote communities and commercial operators with the appropriate characteristics, such as good solar and wind patterns, stand to benefit from integrating renewable generation and storage into their electricity system.[228]

147. Opportunity

There is an opportunity to leverage new local energy supply solutions that either replace or complement diesel generation in remote and regional areas. This can increase amenity, reliability and affordability for local communities and businesses.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

Regulation can affect the extent of the grid frontier

New technologies are particularly relevant at the edge of grid because the costs of providing a service are highest in these areas. However, in the absence of cost-reflective pricing for customers in remote areas, it likely that many users will opt stay on the grid.

Regulation of micro-grids is not applied consistently across all jurisdictions. In Queensland, remote users generally receive the same regulatory protections as NEM users.[229] In contrast, the micro-grid on Lord Howe Island (New South Wales) is overseen by an independent board.[230] Though not subject to NEM requirements, all tariffs, charges and retail conditions for the two micro-grids in the Bass Strait must be approved by the Tasmanian Economic Regulator.[231] In Western Australia, services provided to remote communities through around 200 micro-grids under the Remote Essential and Municipal Services program are unregulated.[232]

Other government policies can also impact regional and remote electricity users. Most jurisdictions operate a Guarantee Service Level scheme, which provides payments to customers in recognition of poor service, including reliability.[233] Though regional and remote customers receive such payments, funding for the schemes is shared with all users across the state or territory.

The regulatory framework currently constrains the ability for distribution businesses to transition edge-of-grid customers to stand-alone power systems. This could adversely affect decision-making about the best infrastructure solutions on the edge of the existing grids, and could impose extra costs for all users.

The AEMC is currently considering options to facilitate greater adoption of stand-alone power systems in circumstances where that would represent a more efficient solution to remaining grid-connected and where appropriate customer protections are in place. According to the AEMC, the numbers of customers that distributor network operators would seek to supply via stand-alone power system solutions might be relatively small in the context of markets as a whole – perhaps less than 10,000 over the next ten years.[234] However, these customers account for a disproportionately high share of these distributors' costs, and transition to off-grid supply could result in significant overall cost savings for all customers.

148. Challenge

The current regulatory regime does not optimise emerging opportunities for energy supply to regional and remote communities via stand-alone power systems. Without regulatory reform, rural and remote users may not take up lower cost and more reliable energy solutions, and overall costs may be increased for all users and taxpayers.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

7.8 Harnessing Australia's energy advantage

At a glance

This section explores ways we can harness our vast energy sources by expanding research, attracting energy-intensive industries, and better accessing our abundant natural gas to meet global demand. By managing royalties and taxes well, all Australians can enjoy the benefits of growth in this sector.

This section explores opportunities to use hydrogen domestically and as an export, and to lower peak power demands by shifting use times.

Australia has immense energy resources

Australia is blessed with an abundance of key energy assets, both renewable and non-renewable, meaning it has the potential to be a new energy superpower.

The scale of resources available relative to domestic consumption requirements has made Australia one of the world's major energy exporters. Coal and uranium dominated exports for decades, later joined by natural gas. At home, we simultaneously used this abundance to form a comparative advantage for Australia in domestic energy costs, attracting energy intensive industries to our shores.

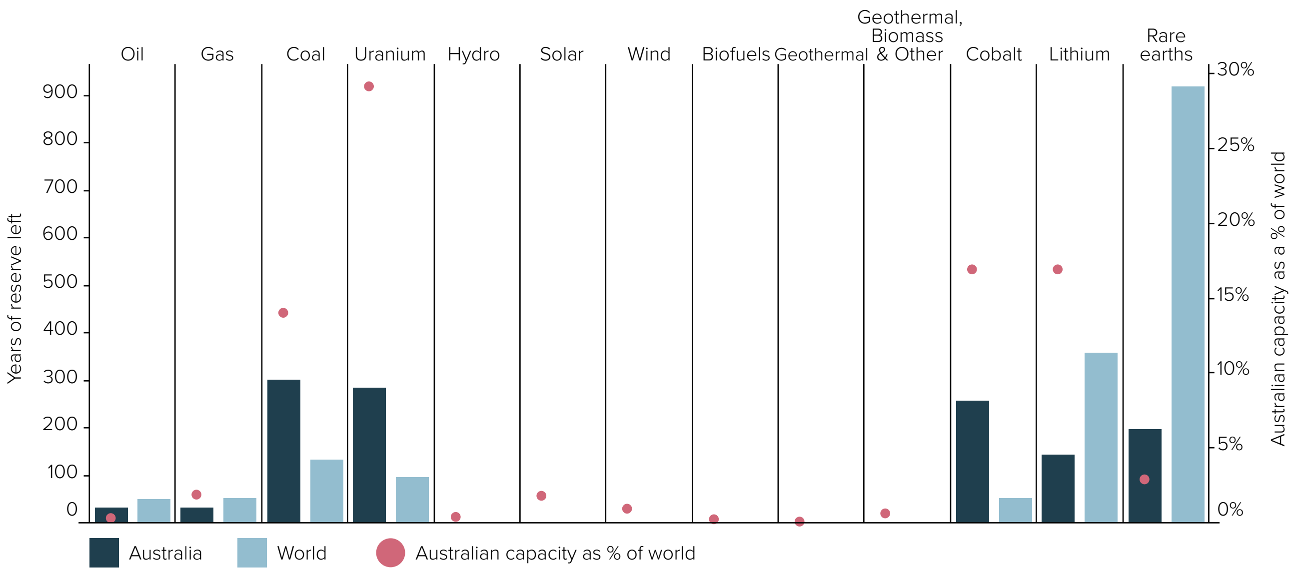
Few nations can lay a credible claim to having a massive energy surplus. Australia is one of them.

As the world gradually transitions its energy fuel mix towards lower emitting technologies for domestic electricity production, Australia has an opportunity to take advantage of this transition as an even greater export opportunity, while concurrently returning to its position as a low-cost energy producer.

As Figure 34 shows, Australia produces a relatively small proportion of the world's renewable energy despite our opportunity, and has a relative abundance of battery minerals such as cobalt and lithium, which will likely be critical to our future energy system. The opportunity available to Australia by developing new exports from renewables and storage is major. Decoupling renewables development from needing to access the local transmission network has potential to unlock significant income and jobs for Australia.

We also retain a sizeable share of traditional fuels such as thermal coal, uranium and gas.

Figure 34: Australia has high energy potential for certain fuel types, compared to the rest of the world



Note: Years of reserve left indicates the length of time remaining reserves would last if production were to continue at existing rates. It does not apply for renewable sources. Oil, gas, and coal are based on proven reserves. Uranium is based on known recoverable resources. Hydro and geothermal, biomass and other are based on generation. Solar, wind, and geothermal are based on installed capacity. Biofuels is based on production. Cobalt, lithium, and rare earth are based on reserves.

Source: British Petroleum (2018), World Nuclear Association (2019)[235]

149. Opportunity

Australia could develop new industries based on cheap and abundant new sources of energy, including large-scale solar and wind. This could attract energy intensive industries to Australia, or allow export of products with high levels of embedded cheap energy. This may require wider use of existing infrastructure, and new infrastructure investment.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

Australia leads on sun and wind, but captures little on a worldwide scale

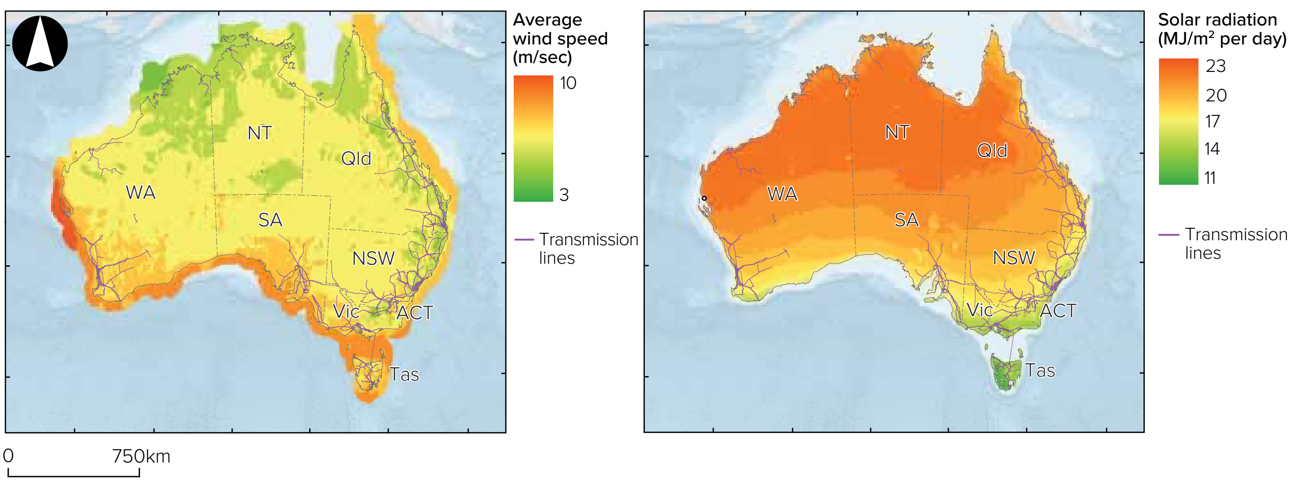
Geoscience Australia estimates that Australia receives solar radiation equivalent to approximately 10,000 times its total energy consumption.[236] At this level Australia has the highest solar radiation per square metre of any continent. The highest yielding areas are the desert regions in the northwest and centre of the continent.[237] Australia's best solar resources are towards the north and west of Australia, while wind performs better in the south and along the east coast, as shown in Figure 35.

Our wind resources are most prevalent in the south of Australia – in the coastal regions of western, south-western, southern and south-eastern Australia – where winds (for example the "Roaring Forties") are generally stronger, including around the Great Dividing Range on the east coast.

Harnessing these opportunities domestically is emerging as an opportunity to lower Australia's energy prices. With planning, the export opportunity from low marginal cost energy could be significant.

Figure 35: Australia has abundant wind and solar resources

Wind speed **Solar radiation**



Source: Geoscience Australia and Bureau of Resources and Energy Economics (2014)[238]

Research and development are important to unlock future opportunities

Unlike the fossil fuel resources which Australia has exported so successfully, directly exporting Australia's wealth in renewables is economically not yet feasible, though new opportunities are being explored.

There is an emerging opportunity to export our abundant energy by converting it to hydrogen. This has been studied by the CSIRO, which has developed some of the technologies required to facilitate this trade.[239] This would enable Australia to supply energy to trading partners such as Japan and South Korea, and assist with their path to decarbonisation.[240] The hydrogen supply chain would require new renewable energy infrastructure, pipelines, compression and port infrastructure.

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There may also be an opportunity to link the high-quality solar resources in Australia's North West to Indonesia using a High Voltage Direct Current (HVDC) undersea cable.[241] Indonesia's population is over ten times larger than Australia's, in a land area less than a quarter the size. Similar to the link connecting Tasmania to the mainland, it would add yet another lucrative export product to the existing iron ore and LNG industries operating out of that area.

Hydrogen also has the potential for domestic use. Trials have shown that existing gas pipelines can accommodate hydrogen for up to 10% of their transported gas with no physical changes,[242] providing a potentially lucrative alternative destination for renewable generation facilities. Energy Networks Australia has identified that hydrogen injection into Australia's LNG network could reduce carbon emissions from gas use. While conversion of electricity to hydrogen is not particularly efficient (output efficiency today is as low as 30 to 40%)[243] this is likely to improve over time.

Demand for gas is growing across global markets

Natural gas has been a source of relatively low-cost energy production in Australia over past decades. While for many years this was largely drawn from the Bass Strait and the Cooper Basin, development of Liquefied Natural Gas (LNG) technologies and hydraulic fracturing (fracking) have unlocked large quantities of natural gas in other parts of the country.

As shown in Figure 36, the span of proven gas reserves is broad. Projects such as Prelude, Gorgon, Wheatstone, and Darwin LNG among others are seeing tens of billions of dollars of investment directed towards regional and remote areas, particularly in northern Australia. In 2017, the ACCC estimated that well over 60% demand for LNG in the east coast gas market was export demand.[244] This has seen new infrastructure such as pipelines, ports and LNG facilities created in western, northern and north-eastern Australia in the past decade.

Combined, fracking and the many LNG terminals have made Australia the world's largest exporter of natural gas in recent years, exceeding Qatar.[245] The lower emitting nature of gas for energy production makes it particularly attractive as the world moves to limit carbon emissions, and Australia is optimally positioned to take advantage of this trend. The new LNG terminals enabled this export opportunity for Australia.

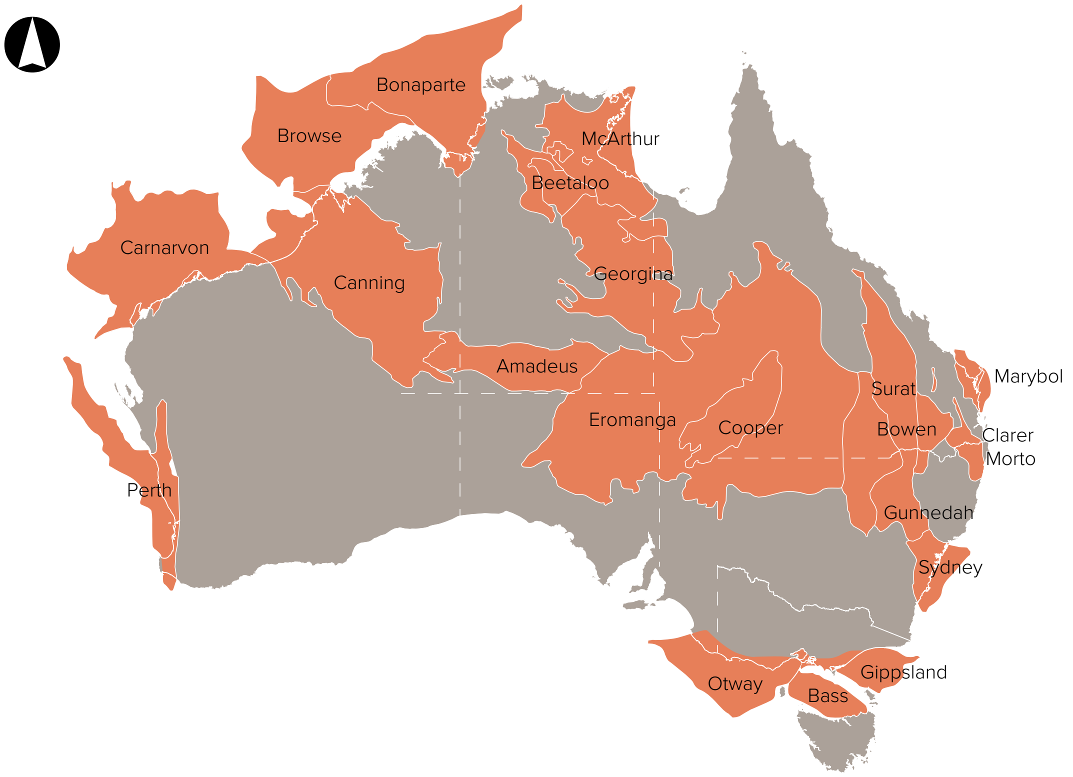
150. Opportunity

Australia could leverage its energy resources to provide global leadership and innovation on energy research and development through its high-quality research and education institutions. New discoveries and lower costs can provide Australia with an advantage on applied energy use, supporting new industries.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

Figure 36: Australia's Natural Gas Resources are spread across much of the country



Source: Icon Energy (2013)[246]

Under current settings, much of eastern Australia's proven reserves of natural gas cannot be exploited following a series of broad-based moratoriums and outright bans on exploration and mining using hydraulic fracturing. Some of the early exploration and extraction practices were reckless. However, recent studies have found that fracking, when done properly, can be both safe and cost-effective, and that Australia's regulatory structures are well-equipped to protect local environments and communities.[247]

151. Opportunity

Australia's regions have significant reserves of onshore gas. However, there are restrictions on accessing reserves across many regions. Unlocking these reserves could provide substantial export growth potential, as well as opportunities for lower prices for domestic users.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

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7.9 Challenges and opportunities

Affordable and competitive energy

133. Challenge

Transparent and affordable electricity prices are essential to reducing pressure on household budgets, particularly for lower income households. A continued rise in energy bills will place an added burden on many households and may reinforce inequality. Ongoing complexity of bills will add to user costs and frustrations.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

134. Challenge

Regaining energy price competitiveness is important for lower business costs and improving productivity of Australian firms. Australia risks becoming uncompetitive in some energy intensive industries due to rising energy costs.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

Secure, reliable and sustainable energy

135. Challenge

Balancing reliability and affordability in line with users' willingness to pay will be an ongoing challenge in energy systems with rapidly transforming wholesale and network characteristics. Failure to get the balance right will result in higher costs for users due to inefficient investments, or poorer reliability for users.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

136. Challenge

Governments, regulators, operators and service providers need to manage growing risks to Australia's energy systems and fuel sources, including risks from climate change, cyberattack or disruptions to fuel supply. Failure to effectively mitigate against risks to energy services could have substantial consequences for the economy.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

137. Challenge

Despite positive progress on the development of a national climate policy, ongoing politicisation of the issue and policy inconsistency between levels of government reduce market certainty. Uncertainty prevents timely investment in long-term infrastructure such as electricity generation and gas pipelines, increasing risks and costs to users.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

Transitioning to Australia's future energy fuel mix

138. Challenge

Many major coal generation assets are ageing and approaching retirement. The capacity they provide will need to be replaced. In the NEM, this capacity needs to be replaced or there may be impacts on reliability or competition. In the WEM, where there is overcapacity there may be scope to reduce surplus capacity. In both cases, there is a risk to the order of the market.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

139. Challenge

As the penetration of small- and large-scale renewables increases across the network, additional investment in networks and generation will be required to manage reliability and service levels. This will increase capital and operational costs in networks, but will be needed to be maintain balanced supply standards.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

140. Opportunity

New forms of large-scale storage are increasingly available, including pumped hydroelectric and battery assets. Introduction of appropriate new firming capacity will complement variable renewable energy bids and aid the transition to the new electricity mix.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

Planning for our future energy networks

141. Challenge

Transmission networks need to respond to new generation in areas not currently served or without sufficient spare capacity. The outcome of these decisions will be paid for by users over many years. It is in the interests of users that the transition is efficient and guided by well-targeted investment.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

142. Opportunity

Coordinating investment in new generation and network assets in Renewable Energy Zones can promote investment in renewable generation, provide clarity for network investors, and increase scale and lower costs for new generation providers. Optimising investment in Renewable Energy Zones will lead to lower wholesale and network costs for users over time.

When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

New opportunities for consumer choice

143. Challenge

Home solar and storage can help users to save costs and control energy use, but government policies are uncoordinated. Developments in behind the meter energy systems risk leaving some users behind, while uncoordinated policies and subsidies add to costs over the long term.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

144. Opportunity

Demand response from users can defer or avoid expensive new electricity infrastructure investment, and better use existing infrastructure. This can save users the passed on costs of higher peaks.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

145. Opportunity

Electric vehicles could provide additional storage capacity to stationary electricity systems. There are regulatory and technical barriers to be overcome. This may provide a means of converging stationary and non-stationary energy at household level.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

Delivering energy in remote communities

146. Challenge

The costs of serving remote and regional areas remain high, with customers in those areas also often receiving poor reliability outcomes. Poor energy reliability in remote areas undermines quality of life and opportunities for growth and investment.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

147. Opportunity

There is an opportunity to leverage new local energy supply solutions that either replace or complement diesel generation in remote and regional areas. This can increase amenity, reliability and affordability for local communities and businesses.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

148. Challenge

The current regulatory regime does not optimise emerging opportunities for energy supply to regional and remote communities via stand-alone power systems. Without regulatory reform, rural and remote users may not take up lower cost and more reliable energy solutions, and overall costs may be increased for all users and taxpayers.

When this will impact: 0-5 5-10 10-15 15+

Where this will impact:

Harnessing Australia's energy advantage

149. Opportunity

Australia could develop new industries based on cheap and abundant new sources of energy, including large-scale solar and wind. This could attract energy intensive industries to Australia, or allow export of products with high levels of embedded cheap energy. This may require wider use of existing infrastructure, and new infrastructure investment.

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Australia could leverage its energy resources to provide global leadership and innovation on energy research and development through its high-quality research and education institutions. New discoveries and lower costs can provide Australia with an advantage on applied energy use, supporting new industries.

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When this will impact: 0-5 | 5-10 | 10-15 | 15+

Where this will impact:

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