Australia’s Energy Debate

Edited by Justin Healey

ISSUES IN SOCIETY
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Australia’s Energy Debate is Volume 454 in the ‘Issues in Society’ series of educational resource books. The aim of this series is to offer current, diverse information about important issues in our world, from an Australian perspective.

KEY ISSUES IN THIS TOPIC
Australia’s energy system is undergoing major transformation, driven by economic, environmental and engineering factors. Consumer preferences are also changing as we seek lower emissions and greater independence and control over our personal electricity supply and use.

Most of Australia’s baseload energy still heavily relies on its traditional, non-renewable resources of coal, oil and gas – yet Australia has plentiful clean renewable resources including solar, wind, hydro, bioenergy, geothermal and ocean power. We also have the world’s largest reserves of uranium to rely on, should we ever decide to choose nuclear as part of our energy mix. And then there is the long-held but unrealised promise of hydrogen to consider.

A secure supply of affordable, reliable and environmentally sustainable energy is essential to the nation’s future growth and prosperity. What are the pros and cons of Australia’s various energy options? Are we adapting quickly enough to renewables or clinging too long to fossil fuels, at a time when other advanced economies are leaving non-renewables behind to counter the impacts of greenhouse gas emissions on climate change? Australia’s energy policy debate is far from settled – how should we power into the future?

SOURCES OF INFORMATION
Titles in the ‘Issues in Society’ series are individual resource books which provide an overview on a specific subject comprised of facts and opinions.

The information in this resource book is not from any single author, publication or organisation. The unique value of the ‘Issues in Society’ series lies in its diversity of content and perspectives.

The content comes from a wide variety of sources and includes:
- Newspaper reports and opinion pieces
- Website fact sheets
- Magazine and journal articles
- Statistics and surveys
- Government reports
- Literature from special interest groups

CRITICAL EVALUATION
As the information reproduced in this book is from a number of different sources, readers should always be aware of the origin of the text and whether or not the source is likely to be expressing a particular bias or agenda.

It is hoped that, as you read about the many aspects of the issues explored in this book, you will critically evaluate the information presented. In some cases, it is important that you decide whether you are being presented with facts or opinions. Does the writer give a biased or an unbiased report? If an opinion is being expressed, do you agree with the writer?

EXPLORING ISSUES
The ‘Exploring issues’ section at the back of this book features a range of ready-to-use worksheets relating to the articles and issues raised in this book. The activities and exercises in these worksheets are suitable for use by students at middle secondary school level and beyond.

FURTHER RESEARCH
This title offers a useful starting point for those who need convenient access to information about the issues involved. However, it is only a starting point. The ‘Web links’ section at the back of this book contains a list of useful websites which you can access for more reading on the topic.
CHAPTER 1

Australia’s energy transition

ENERGY SUPPLY
OVERVIEW BY DEPARTMENT OF THE ENVIRONMENT AND ENERGY

Australia’s energy system is undergoing its greatest transformation since the 1950s. These changes are driven by economic, engineering and environmental factors. Consumer preferences are also changing, with an increasing desire for independence and control over electricity supply and use.

The government is leading a reform program of practical initiatives to improve energy security, reliability and affordability in Australia. Policy directions are being informed by the recommendations in a Blueprint for the Future.

WHERE DOES OUR ENERGY COME FROM?
Most of Australia’s energy relies on traditional sources – non-renewable fossil fuels. Coal and gas account for about 85% of electricity generation.

Non-renewable sources
Most of our electricity is produced from burning black and brown coal at large power stations.

Natural gas is the third highest energy source in Australia (after oil and coal). It’s used by power stations for electricity generation, factories for manufacturing, and homes for heating and cooking. It is a non-renewable source that emits around half the emissions of coal when used to generate electricity.

Gas used to come from large remote reservoirs, such as the Moomba and Bass Strait gas fields. More recently, coal seam gas comes from Queensland, with untapped reserves in New South Wales and Victoria.

Renewable sources
Renewable energy from sources like wind, solar and hydro provide about 15% of Australia’s electricity supply. This includes both large generators and small systems owned by Australian families and businesses.

As at 30 April 2019 there were more than 3.27 million small-scale renewable installations in Australia, including more than 1.17 million solar and heat pump water heaters, more than 2.1 million rooftop solar power systems, 423 wind systems and 18 hydro systems.

Today, Australian businesses and households have more options than ever to supply and manage energy. You might have an electric vehicle powered by the solar PV on your roof, or an in-home display linked to a smart meter that tells you when to reduce your power consumption in response to power prices that change during the day. Battery storage technology to store solar power for use at night is rapidly increasing in popularity.

Most of Australia’s energy relies on traditional sources – non-renewable fossil fuels. Coal and gas account for about 85% of electricity generation.

HOW DOES IT GET TO YOUR HOME OR BUSINESS?

Electricity
The National Electricity Market (NEM) interconnects the five eastern and southern states, and the Australian Capital Territory, and delivers around 80% of all electricity in Australia. Western Australia and the Northern Territory are not connected to the NEM – they have their own electricity systems and regulatory arrangements.

Large generators (power plants) produce the electricity from an energy source such as coal, wind, solar or hydro. High voltage transmission lines carry the electricity over long distances. Distribution networks then convert the high voltage back to low voltage currents for distribution via the local poles and wires to homes, offices and factories. Many homes have solar panels, and some of these have their own battery storage systems.

Gas
Gas is sourced from gas fields (oil and gas wells or coal seam wells) and processed to specification, including adding the ‘rotten egg’ odour for safety reasons, and compressing the gas for transport.

Some of the gas is used at this stage for gas-powered generation (GPG), or stored in large facilities for later use. The rest is sent long distances through large transmission pipes to what is known as a ‘city gate’. When the gas runs through the city gate, the pressure is reduced making it suitable for distribution through a smaller network of pipes to homes, offices and small industrial customers.


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Australia’s Energy Debate
ENERGY BASICS

AUSTRALIA HAS PLENTY OF FOSSIL AND RENEWABLE ENERGY RESOURCES, ACCORDING TO GEOSCIENCE AUSTRALIA

A secure supply of adequate, clean, reliable energy at an affordable price is vital for Australia’s economic growth and prosperity. Fortunately, Australia is well endowed with an abundance of both fossil and renewable fuels.

Our energy resources power our homes, cars and industry, and are a key contributor to Australia’s economic prosperity. The Australian energy sector directly accounts for 5 per cent of gross industry value-added; 20 per cent of total export value; supports a large range of manufacturing industries; and provides significant employment and infrastructure in every state and territory. The demand for energy is increasing as Australia’s economy and population grow.

To date Australia’s energy needs have been largely met by fossil fuels. Australia’s abundant and low-cost coal resources are used to generate three-quarters of domestic electricity and underpin some of the cheapest electricity in the world. Australia’s transport system is heavily dependent on oil, some of which is imported. At present renewable energy sources account for only modest proportions of Australia’s primary energy consumption (around 5%) and electricity generation (7%), although their use has been increasing strongly in recent years.

The Australian Energy Resource Assessment provides a comprehensive review of Australia’s energy resources, from fossil fuels and uranium to renewable energy, including a review of known and potential resources, technologies for extraction, and projected energy use and production in 2030.

AUSTRALIA’S ENERGY PRODUCTION, CONSUMPTION AND EXPORTS

- Australia has an estimated 46 per cent of uranium resources, 6 per cent of coal resources, and 2 per cent of natural gas resources in the world. In contrast, Australia has only about 0.3 per cent of world oil reserves.
- Australia produces about 2.4 per cent of total world energy and is a major supplier of energy to world markets, exporting more than three-quarters of its energy output, worth nearly A$80 billion.
- Australia is the world’s largest exporter of coal. Coal accounts for more than half of Australia’s energy exports. Australia is one of the world’s largest exporters of uranium, and is ranked sixth in terms of liquefied natural gas (LNG) exports. In contrast, more than half of Australia’s liquid fuel needs are imported.
- Australia is the world’s twentieth largest consumer of energy, and fifteenth in terms of per capita energy use.
- Australia’s primary energy consumption is dominated by coal (around 40 per cent), oil (34 per cent) and gas (22 per cent). Coal accounts for about 75 per cent of Australia’s electricity generation, followed by gas (16 per cent), hydro (5 per cent) and wind (around 2 per cent).

Data on Australia’s energy production and consumption are published annually in the Australian Energy Statistics produced by Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES). The database consists of detailed historical energy consumption and production statistics compiled from various sources.

RESOURCES

Australia’s abundant, high quality energy resources are widely distributed across the country. With the exception of oil, these resources are expected to last for many more decades, even as production increases. Australia has a significant proportion of the world’s uranium and coal resources and large resources of conventional and unconventional gas. Australia also has access to a range of high quality, abundant renewable energy sources, many of which are yet to be developed.

Australia’s non-renewable and renewable energy resources and their distribution are described in the Australian Energy Resource Assessment. Geoscience Australia provides annual assessments of Australia’s petroleum resources in Oil and Gas Resources of Australia and coal and uranium (and other minerals) in Australia’s Identified Mineral Resources.

Coal

Australia has substantial resources of coal, both black and brown. The most significant black coal resources are located in the Bowen-Surat (Queensland) and Sydney basin (New South Wales). Coal is Australia’s largest commodity export with annual thermal and metallurgical coal exports worth more than $40 billion, mainly to Japan, India, European Union, Republic of Korea and Taiwan. Economic demonstrated resources (EDR) of black coal are adequate for about 90 years at current rates of production.

Australia’s very large brown coal resources are located mostly in the Gippsland Basin in Victoria where it is used for electricity production. At current rates of production, there are nearly 500 years of brown coal resources remaining.

Gas

Australia also has significant resources of gas that include large conventional gas resources located mostly in the Carnarvon, Browse and Bonaparte basins off the northwest coast with smaller resources in the Gippsland Basin offshore Victoria and the onshore Cooper-Eromanga Basin in South Australia. EDR of conventional gas are adequate at current levels of production for around 60 years.

Substantial resources of coal seam gas (CSG) are associated with the major coal basins of Eastern Australia. CSG resources are being rapidly increased by exploration with significant economic demonstrated resources of CSG now identified in the Bowen, Surat and Sydney basins.
**Crude oil, condensate and liquified petroleum gas**

Australia’s crude oil resources, located mostly in the Carnarvon and Gippsland basins, are small by world standards but are boosted by substantial condensate and LPG resources associated with the major largely undeveloped gas fields in the Carnarvon, Browse and Bonaparte basins off the northwest coast of Western Australia. A number of sedimentary basins remain to be assessed. Australia also has significant oil shale resources, especially near Gladstone, Queensland that could provide additional liquid fuels if developed.

**Uranium**

Australia has more than one third of the world’s known economic uranium resources. Australia’s reasonably assured resources of uranium recoverable at less than US$80/kg (equivalent to EDR) are estimated to be around 1160kt, equivalent to more than 130 years at current production levels. Major uranium deposits are located in South Australia, the Northern Territory and Western Australia. All production is for export.

**RENEWABLE RESOURCES**

Australia’s large renewable resource base is also widely distributed across the country. With the exception of hydro energy resources which are largely developed and wind energy which is growing rapidly, large-scale utilisation of Australia’s renewable resources has been constrained by higher transformation costs relative to other energy sources (except for hydro), immature technologies, and long distances from markets and infrastructure.

**Geothermal energy**

Australia has large but as yet inadequately defined and quantified geothermal energy resources. These include hot-rock type geothermal resources associated with buried high heat-producing granites as well as hot sedimentary aquifer-type geothermal resources present in deep aquifers in a number of sedimentary basins.

**Hydro energy**

Australia’s hydro energy resources lie within areas of highest rainfall and elevation and are mostly in New South Wales and Tasmania. Hydro energy resources were developed early in Australia and are currently the largest source of renewable electricity. A dry climate coupled with high evaporation rates and highly variable rainfall over much of Australia limits substantial expansion of hydro power.

**Wind energy**

Australia has some of the best wind energy resources in the world, primarily located in western, southwestern, southern and south-eastern coastal regions but extending hundreds of kilometres inland and including highland areas in south-eastern Australia. Wind energy technology is relatively mature, and wind power is expanding rapidly, encouraged by government policies, notably the Renewable Energy Target. Wind energy is expected to become Australia’s largest source of renewable electricity in the near future.

**Solar energy**

High solar radiation levels over large areas provide Australia with some of the best solar resources in the world. The best solar resources are largely located in the northwest and centre of Australia, commonly in areas that do not have access to the electricity grid, and are distant from the major population centres and key energy markets. To date, relatively high capital costs have limited widespread use of solar energy resources but significant investment in research and development is aimed at increasing the efficiency and cost-effectiveness of solar power, including the development of solar thermal power stations.

**Ocean energy**

Australia has a world-class wave energy resource along its western and southern coastline, especially in Tasmania. The best tidal resources, on the other hand, are located along the northern margin, especially the northwest coast of Western Australia, and largely removed from the major demand centres. At present most ocean energy technologies are relatively new and still need to be proven in pilot and demonstration plants.

**Bioenergy**

Bioenergy is another significant potential energy resource in Australia. Biomass (organic matter) can be used to generate electricity generation and heat, as well as for the production of liquid fuels (biofuels) for transport. Currently Australia’s use of bioenergy for electricity generation is small and limited to bagasse (sugar cane residue), wood waste, and gas from landfill and sewage facilities. A small but increasing amount of biofuels is produced, mostly ethanol from sugar by-products and waste starch from grain.

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### Australian Energy Statistics

**SUMMARY FROM THE LATEST ANNUAL AUSTRALIAN ENERGY UPDATE**

#### Energy Consumption
- The Australian economy grew by 2.8 per cent in 2017-18 to reach $1.8 trillion. Population grew by 1.6 per cent to reach 25.0 million people.
- Australia’s energy consumption rose by 0.9 per cent in 2017-18 to reach 6,172 petajoules. This compares with average growth of 0.6 per cent a year over the past ten years. Growth in 2017-18 was 52 petajoules, the same amount of energy from filling a 55-litre tank of petrol 28 million times.
- Energy productivity (gross domestic product (GDP) divided by energy consumption) improved by 2.0 per cent in 2017-18, and by 20 per cent over the past ten years. Australia now creates $294 million in GDP for every petajoule of energy consumed, almost $50 million more than a decade ago.
- Most of the growth in energy use in 2017-18 occurred in the mining sector, which rose by 9 per cent, mostly increased natural gas and electricity consumption to support liquefied natural gas (LNG) exports. Energy use also increased in other parts of the mining sector.
- Transport remained the largest user of energy and grew by 2 per cent in 2017-18, underpinned by higher diesel use in road transport and increased use of jet fuel. Total refined product use rose by 3 per cent in 2017-18, and was nearly three times larger than total electricity consumption.
- Energy use for electricity generation fell by 4 per cent in 2017-18 despite a slight increase in electricity output, reflecting reduced brown coal use and an increase in renewable generation.
- Energy use in manufacturing was relatively flat in 2017-18. Consumption fell by 7 per cent in food, beverages and tobacco product manufacturing.
- Oil accounted for the largest share of Australia’s primary energy mix in 2017-18, at 39 per cent, followed by coal (30 per cent) and natural gas (25 per cent). Renewable energy sources accounted for 6 per cent.
- Coal use fell by 4 per cent in 2017-18, and was 21 per cent below its peak in 2008-09. The decline was all from a reduction in brown coal following power plant closures, with black coal consumption increasing.
- Natural gas consumption grew by 4 per cent in 2017-18. Gas use in LNG plants increased commensurate with higher output, as well as in electricity generation, but fell slightly in the manufacturing sector.
- Renewable energy consumption grew by 1 per cent in 2017-18. Strong growth in solar and wind energy was largely offset by a fall in hydro and biomass consumption.

#### Energy Production
- Energy production rose by 4 per cent in 2017-18 to 18,603 petajoules, primarily as a result of increased natural gas and black coal production. This outweighed a fall in oil and brown coal production.
- Natural gas production grew by 15 per cent in 2017-18, underpinned by increased production in Western Australia for LNG exports. Coal seam gas accounted for one-third of Australian gas production and over two-thirds of east coast gas production in 2017-18.
- Black coal production grew by 2 per cent in 2017-18, while brown coal output fell by 19 per cent, reflect-
ing the fall in brown coal-fired electricity.
• Crude oil and condensate production continued its longer term decline, falling by 4 per cent in 2017-18.

**ELECTRICITY GENERATION**
• Total electricity generation in Australia rose marginally in 2017-18 to 261 terawatt hours (940 petajoules). This figure includes industrial, rooftop solar PV and off-grid generation.
• About 13 per cent of Australia’s electricity was generated outside the electricity sector by industry and households in 2017-18.
• Brown coal-fired generation fell by 17 per cent in 2017-18, while black coal rose by 3 per cent, with the combined share of coal at 60 per cent of total generation. The share of coal was also 60 per cent in calendar year 2018.
• Australia is now less reliant on coal than at the beginning of the century, when coal’s share was more than 80 per cent of electricity generation.
• Natural gas-fired generation grew 7 per cent in 2017-18, remaining at about 21 per cent of total electricity generation. Its share fell in calendar year 2018, to 19 per cent of total generation.
• Renewable generation increased 10 per cent in 2017-18, contributing 17 per cent of all generation. The majority of renewable electricity growth was in wind, but growth also occurred in solar. Generation from municipal and industrial waste and biogas was 3 per cent of renewable generation.
• Renewable generation grew in calendar year 2018, to 19 per cent of total generation. Hydro accounted for 7 per cent of total generation in 2018, while wind accounted for 6 per cent.
• Solar accounted for 5 per cent of total generation in 2018, with the majority of this small-scale PV. Large-scale solar was the fastest growing source of generation in 2018.

**ENERGY TRADE**
• Most of Australia’s energy production is exported. Net exports (exports minus imports) were equal to two-thirds of production in 2017-18.
• Energy exports grew by 4 per cent in 2017-18 to 14,739 petajoules. LNG exports grew by 18 per cent to 3,376 petajoules, as new capacity in Western Australia came online. Exports of black coal and crude oil grew by 1 per cent and 2 per cent respectively.
• Australia is also a significant exporter of uranium oxide, for use in nuclear power plants overseas. Uranium exports grew by 15 per cent in 2017-18 to 8,118 tonnes.
• Energy imports increased by 6 per cent to 2,454 petajoules in 2017-18. Most imports are of refined petroleum products and crude oil. Domestic refineries imported over three-quarters of their feedstock, while nearly 60 per cent of refined product consumption in Australia was met by imports.

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A major transition is underway in the electricity sector due to:

- The inevitable retirement of Australia’s ageing, unreliable and inefficient coal-fired power stations.
- Dramatically falling costs for solar, wind and battery storage.
- Rapidly changing consumer preferences in response to high electricity prices and emerging technologies, with many seeking greater control over their power bills.
- Rising domestic gas prices due to expanded Liquefied Natural Gas exports linking Australian gas markets with international markets.
- Action on climate change requiring an orderly transition from fossil-fuelled power stations to zero emission renewable power sources (Finkel 2016).

Energy and climate policy uncertainty in Australia has reduced investor confidence, and continues to hold the country back from making a smooth and orderly energy transition. In the absence of credible federal climate and energy policy, states, cities, businesses and households are increasingly leading this transition.

Ageing infrastructure

By 2040, 70% of the coal fleet in the National Electricity Market will be 50 years or older, this means the transition to renewables and storage is more important than ever. Because of their age, almost all of Australia’s coal power stations use obsolete and highly polluting technology.

Age, obsolete technology and the high proportion of power generated from coal explain why Australia’s electricity is one of the most polluting in the OECD.

Costs

Australia needs a plan to replace ageing, coal-fired power stations and to reduce pollution from the electricity sector; this will require investment in new low or zero pollution power plants, such as wind and solar.

Wind and solar power are now the lowest cost sources of new power generation (Reputex and Carbon 2017).

Modern technologies

Solar, wind and energy storage costs continue to fall rapidly. These technologies now dominate new global power capacity. At the same time, new consumer products are providing households and businesses with more control over how they generate and use power.

Together these developments are rapidly changing the make-up and operation of electricity systems, with a move away from long electricity grids relying on single-sources of power (like coal and gas stations) to a more geographically distributed grid powered by a wide range of energy sources, and a diverse range of power plant sizes from household-scale to large-scale.

Climate change

In response to climate change, countries around the world, including Australia have agreed (under the Paris Agreement) to limit global temperature rise to 1.5-2 degrees Celsius. This requires transitioning away from coal and gas to zero pollution power sources well before 2050.

In Australia, tackling climate change requires at least 50-70% renewable electricity by 2030, and a transition to zero net emissions in the electricity sector well before 2050 (ClimateWorks 2017).

Reliability

A reliable power system is one in which there is sufficient generation and transmission capacity to meet all grid demand (Finkel 2016). High levels of renewable energy from variable sources like solar and wind can, and have already been achieved in countries such as Denmark, Ireland, Spain and Germany without compromising the reliability of electricity supply (IEA 2017).

Variability per se, is not the issue but rather, how electricity demand and supply are matched. The electricity grid has always been designed to cope with variability. This is an essential feature of all electricity grids as electricity demand and supply must always be in balance.

A mix of technologies including variable renewables (like wind and solar photovoltaics), on-demand renewables (such as solar thermal, biomass or established hydro), storage (such as pumped hydro or batteries) and ‘demand response’ (paying consumers to reduce their energy usage) may be used to ensure reliable supply.
Energy transition: climate of the nation
A chapter extract from the latest report based on the annual Climate of the Nation survey by The Australia Institute

The electricity sector remains the largest source of greenhouse gas emissions in Australia (33.2% of national emissions). Australia’s electricity generation is dominated by coal power plants, most of which are old and often fail in hot weather when they are needed most. Wind and solar are the cheapest forms of new generation, while renewables with storage are now competitive with other forms of generation. The energy transition is already underway.

Over the last decade, electricity emissions in Australia declined by more than 15% as 12 coal-fired power stations closed down and gas power generation also declined. Renewables now account for more than 20% of generation in the National Electricity Market (NEM). The increase in renewables generation over the last decade is equivalent to all Australian energy generation in the 1950s.

However, without clear policy to manage this transition, uncertainty has delayed investment – increasing unreliability, emissions and costs for all users.

SOLAR REMAINS THE PREFERRED ENERGY SOURCE
Asked to rank a list of energy sources from most to least preferred, Australians continue to strongly support renewable energy sources over fossil fuels.

Solar power topped the list for the fourth year running, with over three quarters of Australians (76%) ranking solar among their top three most preferred energy sources.

In fact, solar power was the most favoured energy source across all gender, age, state and voting groups; and even among those who don’t believe in or hold any concern about climate change.

A majority of Australians (58%) ranked wind power among their top 3 most preferred power sources. Hydro energy is among the top 3 preferences of 39% of Australians, demonstrating Australians’ solid preference for renewable energy over fossil fuels.

| TABLE 7.1: PREFERRED ENERGY SOURCES WHICH RANKED IN RESPONDENTS’ TOP 3 PREFERENCES* |
|---------------------------------|---|
| Solar                           | 76% |
| Wind                            | 58% |
| Hydro                           | 39% |
| Power storage                   | 29% |
| Nuclear                         | 22% |
| Tidal/wave                      | 21% |
| Gas                             | 20% |
| Coal                            | 18% |
| Geothermal                      | 17% |

* Excludes 8% who did not answer.

NUCLEAR POWER IS DIVISIVE
Three times as many Australians rank nuclear power their least preferred power source of all power sources (34%) as rank it their most preferred energy source (11%).

The electricity sector remains the largest source of greenhouse gas emissions in Australia (33.2% of national emissions). Australia’s electricity generation is dominated by coal power plants, most of which are old and often fail in hot weather when they are needed most.

While nuclear energy is increasingly touted as a climate change solution, preference for nuclear energy is strongest amongst those not at all concerned about climate change (30% select as top preference). Among those very concerned about climate change, only 5% select nuclear energy as their top preference (Fig 7.1).

One in five (22%) ranked nuclear energy in their top three, behind solar, wind, hydro and power storage (batteries). More than twice as many Australians ranked nuclear in their bottom three (59%) as their top three.

GAS AND COAL REMAIN UNPOPULAR
Australia is the world’s biggest coal exporter and LNG exporter, yet coal and gas are unpopular energy sources for Australia. Only 5% of respondents rank gas as their number one energy source, and only 7% rank coal as their number one. Two thirds (64%) of Australians rank coal in their bottom three energy sources (18% top three).

In Western Australia, the biggest producer of gas in Australia, preference for gas as an energy source is particularly low. Only 3% of West Australian respondents select gas as their most preferred energy source.

In Queensland, solar beats coal almost four-to-one as the preferred energy source. Almost half (45%) of Queenslanders choose solar as their most preferred energy source, while just over one in ten (12%) of respondents choose coal.

WHO IS TO BLAME FOR ELECTRICITY PRICE INCREASES?
Controversy about high electricity prices, as well as who or what is to blame, has become a fixture of Australian...
Most Australians blame increasing electricity prices on either the excessive profit margins of electricity companies (57%, up from 55%) or the privatisation of electricity infrastructure (55%, up from 52%).

Without clear policy to manage this transition, uncertainty has delayed investment — increasing unreliability, emissions and costs for all users.

43% of Australians also blame Federal Government policy uncertainty or poor policy making. The absence of a federal climate and energy strategy, despite a federal minister responsible for both energy and emissions reduction portfolios, is a growing source of consternation – especially in South Australia (where 52% blame Federal Government policy uncertainty or poor policy making).

In addition, increasing numbers of Australians blame excessive gas exports for really expensive domestic gas, up from 34% in 2018 to 38% in 2019. Liberal Party and One Nation voters were most likely to blame excessive gas exports (43% and 42% respectively).

Australia’s massive increase in LNG exports has linked Australia to international markets, meaning increased gas production has been putting upwards pressure on domestic gas prices.

The least blamed factor was over-investment in poles and wires (18%). This is significant as numerous government authorities have confirmed that costs from poles and wire upgrades are the single biggest reason for cost increases over the decade, indicating a large gap between evidence and public perceptions.

**DEMAND RESPONSE AS AN ENERGY SOLUTION**

The Australia Institute has been advocating for a rule change to allow electricity companies to pay users to use less electricity during times of high demand, known as demand response. For the first time, *Climate of the Nation* asked whether respondents would consider participating in a ‘demand response’ scheme and almost three quarters (72%) said yes.

There is across the board support for demand response, with a majority of Australians, from all political party preferences, states, age groups and incomes,
backing a demand response scheme which would help the electricity market cope with the increasing number of extreme heat and peak demand days.

**THE TRANSITION SHOULD BE PLANNED**

Australia currently has no national plan to manage the changing nature of the electricity system, particularly as our ageing coal-fired power stations reach – or in some cases continue beyond – their designed lives. The Australian Government is currently considering underwriting new coal investments and extending the life of existing generators.

70% of Australians support a government plan to ensure the orderly closure of old coal plants and replacement with clean energy. 68% support a government plan for an orderly phase-out of coal so that workers and communities can prepare.

Compared with last year there is less faith in letting the market and energy companies decide when old coal plants are closed. 40% disagree with letting the market decide, up from 36% in 2018.

In total, four in five (78%) want a plan to phase out coal power. Of those, 52% want a “gradual” plan to manage costs over time while 26% want a “rapid” shift even if the costs are bigger. Only 9% of Australians said we do not need to phase out coal and 13% want to keep old generators running and deal with costs later.

In Queensland, almost three quarters (73%) of respondents think that coal-fired power stations should be phased out either as soon as possible (24%) or gradually (49%). 13% think that coal does not need to be replaced by other power sources.

Greens voters were most likely to select a rapid transition (53%) while Liberal voters were most likely to say it should be managed gradually (57%). However, a clear majority of voters for all parties supported a phase out (78%) (Fig 7.3).

**HOW QUICKLY DO AUSTRALIANS THINK THE PHASE OUT SHOULD HAPPEN?**

Two in three (66%) respondents think coal-fired power should be phased out in the next twenty years, including two in five (39%) who think it should happen within the next ten years. 17% think coal should never be completely phased out (Table 7.2).

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<th>WHEN SHOULD AUSTRALIA COMPLETELY END COAL-FIRED POWER GENERATION?</th>
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<td>Subtotal (within next 20 years)</td>
<td>66%</td>
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<td>Within the next ten years</td>
<td>39%</td>
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<td>In the next 10-20 years</td>
<td>27%</td>
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<td>In the next 20-30 years</td>
<td>12%</td>
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<td>In the next 30-50 years</td>
<td>5%</td>
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<tr>
<td>Coal-fired power should never be completely phased out</td>
<td>17%</td>
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YOUR GUIDE TO RELIABLE ELECTRICITY

The public debate about the reliability of Australia’s electricity system continues and some of it is misinformed. The Climate Council has put together this conversation guide for you. Here are their top talking points on reliable electricity.

Four facts on reliable electricity:

• **Fact 1:** Australia’s power supply is reliable.
• **Fact 2:** The vast majority of interruptions to power supply (97%) are caused by events affecting power lines (distribution or transmission lines).
• **Fact 3:** Australia’s ageing and inefficient fossil-fuelled power stations are struggling to cope in extreme heat.
• **Fact 4:** A modern grid powered by diverse renewable energy and storage can provide secure, reliable, clean and affordable power for Australians.

Australia’s power system is reliable

A reliable power system is one which supplies electricity, as required, to meet the needs of customers (industry, households and businesses). Australia’s electricity system is reliable by world standards.

The reliability of our power system has actually improved

In general, over the past ten years, the reliability of Australia’s electricity system has improved. A recent Parliamentary Inquiry found:

“Excluding impacts following floods and cyclones, customers who previously experienced an average of two interruptions a year now experience one interruption a year.”

Power lines are the main source of outages

The vast majority of interruptions to power supply (97%) are caused by events affecting power lines (distribution or transmission lines). Electricity networks are vulnerable in the heat – with distribution-related power outages three times more likely to occur on days over 35°C.

Events affecting power lines can include:

• Weather events like extreme heat, strong winds, heavy rain, flooding, lightning and bushfires.
• Technical issues such as equipment failure, tripped circuit breakers and planned works.
• Car accidents, tree branches, animals and vandalism.

For example, in New South Wales on 31 January 2019, 45,000 households lost power due to overgrown weeds at a substation on the electricity network.

Not having enough supply from power stations contributes to a tiny percentage of interruptions to supply – less than 1 per cent. Despite power stations being a negligible source of power interruptions, this issue continues to receive disproportionate attention from politicians and the media.

Electricity supply issues generally occur in hot weather, due to ageing coal and gas power stations

On the rare occasions when outages occur as a result of not having enough electricity supply from power stations, these events are often caused by ageing, inefficient coal and gas power stations. Australia’s coal and gas power stations struggle to operate in extreme weather conditions, especially heatwaves.

For example, in Victoria on 25 January 2019, more than 200,000 homes experienced power outages due to a combination of factors – high temperatures, high electricity demand and outages at Victoria’s ageing coal power stations.

Ageing coal and gas power stations are unreliable

The recent track record of Australia’s ageing, inefficient coal and gas power stations is poor. These power stations have failed more than 150 times since December 2017.

What do we need to do to ensure reliable power?

The Australian Energy Market Operator already has measures in place to ensure there is sufficient electricity supply to meet demand, and more measures are on the way such as the Retailer Reliability Obligation.

Future power system reliability requires planning to improve the resilience of the power system to extreme weather events, as well as to replace ageing and unreliable coal and gas power stations with new renewable energy and storage.

A decentralised and highly distributed grid, powered by renewable energy and storage, together with some transmission and distribution upgrades will deliver a much more resilient electricity network overall, less vulnerable to disruption from extreme weather events.

Coal has no future in a modern twenty-first century electricity system

Within a decade, half of the coal power stations in the National Electricity Market will be over 40 years old. These power stations are technically already obsolete and increasingly unreliable.

Climate change, driven primarily by the burning of fossil fuels like coal and gas, is exacerbating extreme weather events around the globe and in Australia. Worsening extreme weather is a key risk to reliable electricity supply.

A modern grid powered by diverse renewable energy and storage can provide secure, reliable, clean and affordable power for Australians.

Building new coal, or extending the life of existing coal power stations is not only expensive, it risks locking in greenhouse gas pollution for decades to come.

In response to climate change, countries around the world, including Australia, have agreed (under the Paris Agreement) to limit global temperature rise to 1.5-2°C. This requires transitioning away from polluting fossil fuels like coal, oil and gas to solutions such as renewable energy well before 2050. Every country in the world has signed up to the Paris Agreement, although the United States have announced their intention to withdraw.

Australia's Renewable Energy Target (RET) is federal legislation designed to achieve 33,000GWh (or “at least” 20% of Australia’s electricity) from renewable sources by 2020. In 2015, the RET was reduced from 41,000GWh. The Australian Government has announced that they will not extend the RET beyond 2020, nor have they adopted a Clean Energy Target as recommended by the 2017 Finkel Review.

A number of state and territory governments have set renewable energy targets and are leading the transition to renewable energy in the absence of credible climate and energy policy from the Federal Government.

South Australia is on track to achieve its previous target of 50% renewable energy by 2025. While New South Wales and Western Australia do not have state-based renewable energy targets, New South Wales has announced a longer term goal to reach net zero emissions by 2050.

Australian local governments are working towards a renewable energy future, including several aiming for 100% renewable electricity.

Climate change: government and international initiatives

Australia is meeting its climate change targets, improving the environment and supporting an effective international response, according to the Department of the Environment and Energy.

The Paris Agreement is a powerful symbol of countries’ commitment to a low-carbon, climate resilient future. On 10 November 2016, Australia ratified the Paris Agreement and the Doha Amendment to the Kyoto Protocol, reinforcing our commitment to action on climate change. In 2017, the Government reviewed its climate policies to ensure they remain effective in achieving Australia’s 2030 target and Paris Agreement commitments. The 2017 review of climate change policies report was released on 19 December 2017.

Australia has a comprehensive suite of policies to reduce domestic emissions, support effective international efforts without compromising economic growth and driving up energy prices.

The Government’s climate change plan includes:

- Reducing emissions by 5 per cent below 2000 levels by 2020.
- Reducing emissions by 26 to 28 per cent below 2005 levels by 2030.
- Doubling Australia’s renewable energy capacity to be achieved in 2020 which is driving innovation, creating jobs and providing a cleaner future.
- Encouraging the uptake of renewables through the Renewable Energy Target to deliver over 23 per cent of Australia’s electricity supply in 2020.
- Helping improve energy productivity by 40 per cent, by 2030.
- Ensuring big business and Australia’s largest emitters do their part and continue to reduce emissions.
- Helping expand and protect our green spaces and iconic places such as the Great Barrier Reef.
- Spurring businesses, communities, households and individuals into ongoing action to reduce emissions.
- Investing in innovation and clean technology to help capture the opportunities of a cleaner future.
- Managing climate risks by building resilience in the community, economy and environment.
Australia has met its renewable energy target. But don’t pop the champagne

Wind energy has played a major role in Australia’s fulfilment of the renewable energy target, reports Dylan McConnell

A wind farm project in Tasmania this week helped Australia reach something of a milestone, nudging it over the line to reach its renewable energy target. The Clean Energy Regulator announced it had approved capacity from the 148.5 megawatt Cattle Hill wind farm project, meaning the nation’s Large-scale Renewable Energy Target will be fulfilled.

Federal energy and emissions reduction minister Angus Taylor seized on the development, suggesting it showed the government’s record investment in renewable energy was world-leading.

Taylor has previously declared his government will not extend the target – the primary national mechanism supporting renewable energy. But this week he insisted “investment is not slowing down”. This bold claim flies in the face of the evidence. Investment in new renewable energy capacity is slowing down.

The latest data from Bloomberg New Energy Finance clearly shows a 21% drop in investment from the 2018 to 2019 financial years. As Australia’s emissions reduction task becomes ever more urgent, the investment downturn begs the question: what happens next?

IN FACT, AUSTRALIA CRUISED OVER THE LINE

It is ironic that the Morrison government rushed to claim a win on the renewable energy target when many in the Coalition had claimed it would be difficult to meet, or wanted it scrapped altogether. The policy involved tradeable certificates which created a financial incentive for new or expanded renewable energy power stations, such as wind and solar farms.

Under the target just met, 33 terawatt-hours (TWh) of Australia’s electricity would be produced by new renewables by 2020, bringing the total share of renewable energy to about 23.5%. The target was established by the Rudd Labor government and overhauled by the Abbott Coalition government after it came to power. It commissioned a contentious review of the target, then in 2015 reduced it to 33TWh after protracted negotiations with Labor.

As it transpired, that target was easily met. But the then industry minister Ian Macfarlane described the task as an “enormous challenge”, and industry figures suggested the required wind energy was “almost impossible”. Even Taylor initially said the target was “too high”.

The cut itself was bad enough for the renewable energy industry. But the uncertainty created during the review devastated investment.

Investment did boom following bipartisan support for the new, lower target. But we can only speculate what may have been possible without the uncertainty created by the review.

IT’S NOT LOOKING ROSY FOR RENEWABLES

The drop-off in investment is a worrying trend for the renewable energy industry, and for climate action more broadly. We can expect a drop-off in new additions in capacity in line with the drop in investment.

The table above shows the current committed projects for next 12-18 months. While more projects are likely to be committed over the next 12 months...
18 months, it’s hard to see the peak of 2018 repeated soon, particularly with investment dropping away.

The achievement of the renewable energy target leaves a federal policy void. Renewable energy may now be the lowest-cost source of new electricity supply. But it is competing against assets such as coal-fired power stations with sunk costs – meaning that new renewables projects are essentially competing only with a coal plant’s fuel costs. Absent a price on carbon or similar policy, coal assets are allowed to pollute the atmosphere for free.

WHAT NEXT?
There are lessons to be learned from Germany to ensure a less bumpy transition to a decarbonised electricity sector. “Deployment corridors” help make the development of renewable energy sources more predictable, improve integration into the power system, and keep additional costs to consumers manageable.

But unless emissions-intensive generation closes or renewable energy expansion in Australia is unlikely to proceed at the pace required to meet the Paris targets. Keeping the global average temperature rise well below 2°C requires “rapid and profound near-term decarbonisation of energy supply” and strong upscaling of renewables.

The states are attempting to fill the federal policy gap. Several have their own renewable energy support schemes and all states in the east coast’s National Electricity Market have committed to net zero emissions by 2050.

Continued renewables growth also requires transmission infrastructure and storage technologies to ensure the distributed energy can be delivered where it is needed, and that reliability is maintained. Several states have also recently committed resources to transmission investment.

The state-led action calls into question the effectiveness of the Council of Australian Governments’ (COAG) energy council. The group comprises the nation’s energy ministers and claims to maintain national “policy leadership” on energy.

However it hasn’t met in almost nine months and its overarching agreement is more than 15 years old, and doesn’t refer to environmental outcomes or emissions cuts.

A new direction for the council is probably wishful thinking in the current political environment. But as emissions continue to rise in Australia, the need for significant reform only intensifies.

DISCLOSURE STATEMENT
Dylan McConnell has received funding from the AEMC’s Consumer Advocacy Panel and Energy Consumers Australia.

Dylan McConnell is a Researcher at the Australian German Climate and Energy College, University of Melbourne.

**Figure 2: Entry and exit of generation capacity**

Source: AEMC analysis.
Australian energy Market Commission data showing committed renewable energy projects for the next 12-18 months.
WHY NO ENERGY POLICY?

The Energy Policy Institute of Australia is Australia’s only independent and apolitical energy policy body. EPIA focusses on high-level policy, governance and regulatory issues affecting the national interest, the economy as a whole, the environment and the community.

The Institute advocates that Australia must maintain a secure investment climate and be internationally competitive, whilst moving towards and contributing as much as it can to global efforts to build a low-carbon society. The views expressed in this paper by John McDonnell do not necessarily represent the official position of the Institute or any of its members.

Key points

- Populist policy interventions have destroyed political consensus and given rise to unsustainable energy policy in Australia.
- At the present time, neither of the major Australian political parties has an energy policy that can last past one electoral cycle.
- Politicians have to make difficult choices between the destruction of sectors of the Australian economy and minimising the risk from climate change. They need reliable evidence about costs to enable them to make these choices without causing unnecessary harm. They need to know the least-cost way of achieving the agreed level of emission reduction while producing reliable and stable energy flows.

INTRODUCTION

Since the late 1990s, when climate change emerged as a significant issue on the political horizon, Australia has not had a politically sustainable energy policy. Energy policy has been driven instead by the vagaries of political posturing, giving rise to investor uncertainty and a consequently fragile energy market.

There is one clear reason for this: successive governments have failed to procure the necessary economic and engineering analysis to underpin solid evidence-based policy and win political consensus.

Energy policy is not a component of the science of climate change. As former Prime Minister Malcolm Turnbull astutely observed at one point, energy policy is a function of engineering and economics. Unfortunately his government, along with all others since the advent of the Howard government, failed to undertake the analysis that would determine the best engineering solutions that could be implemented at the least cost.

There was an ostensible reason for this: supporters of market-based energy policies mistakenly believed that, given the right parameters, the market would deliver least-cost, best-practice outcomes. A major flaw in this logic was that the cost of populist policy interventions had never been explicitly identified and there was, and still is, no bulwark against such interventions.

To appreciate how we arrived at the 2019 energy policy position, it is necessary to look at the various economic policy paradigms that have been adopted over the last twenty years.

THE PURE COMPETITION MODEL

In 2000, the energy market was largely privatised and highly competitive. Australia had among the lowest electricity prices in the world. This had boosted productivity and investment in energy-intensive industry and lowered the cost structure of the Australian economy generally. There was an assumption that Australia would transition to gas-fired electricity generation because gas was ubiquitous and cheap. As Margaret Beardow and Harry Schaap of Benchmark Economics, consultants to the Electricity Supply Association of Australia, pointed out at a Productivity Commission Workshop on Micro-Economic Reform held in 2000:

“The gas-based scenarios will see a decline in electricity-related emissions intensity of around 871 tonnes per gigawatt hour in 2000, to 719-755 tonnes per gigawatt hour in 2010 and 645-674 tonnes per gigawatt hour in 2020. This shift to gas would lead to carbon intensities approaching current high-cost electricity countries such as the Netherlands, Portugal and the United Kingdom and would lead to a fundamental change to the Australian economy.”

At the same workshop Clive Hamilton and Richard Denniss of the Australia Institute disputed the competitive market approach on the basis that externalities such as the cost of greenhouse gas emissions were not included in the cost of production of energy:

“The erroneous assumption that competition always leads to more efficiency has been especially dominant in the process that resulted in the National Electricity Market. As this paper will show, competition policy in the electricity market has been associated with a loss of efficiency because it has imposed large additional costs on the community in the form of increased greenhouse pollution. Unfortunately, this simple point, powerful as it is, appears to have failed so far to dent the faith of reformers in the benefits of competition.”

By 2007, the Productivity Commission had come to the conclusion that the absence of a price on carbon emissions represented a partial market failure.

THE CARBON PRICE APPROACH

In December 2006, the Howard government established the Shergold Task Force on Emissions Trading. In a submission to the task force, the Productivity Commission argued for a carbon price to be established, based on an emissions reduction mechanism, without derogations or exemptions. It said that this approach would be optimal if it was adopted on a multilateral basis. If that was not possible, then it argued that governments should adopt a modest approach to greenhouse gas reduction. Above all it recommended that:

“There is a need for an informed, transparent assessment of the costs and benefits to Australia of independent, group and
global action, as well as of the particular regulatory alternatives available. Considerable attention should be directed at the development and design of a suite of consistent measures to target the best mix of abatement and adaptation, within a framework that is flexible enough to respond to changes in the state of knowledge and international developments.”

The Commission also argued strongly for a national approach as opposed to interventions by different jurisdictions. The Howard government did not, however, ask the Productivity Commission to undertake a cost-benefit analysis of greenhouse gas abatement, nor did the Rudd government (although the Hawke government had commissioned a similar review in 1991).

It is also worth remembering that the Howard government intervened in the previously open electricity market by establishing the mandatory renewable energy target in 2001. It did not commission any analysis of the economic impact of this policy.

THE GARNAUT RECOMMENDATIONS

Professor Ross Garnaut produced reports on climate change policy for the Rudd government in 2008 and the Gillard government in 2011. Both reviews by and large adopted the approach outlined in the Productivity Commission submission of 2007. Garnaut argued strongly for a market-based approach, as opposed to an interventionist approach which, he said, would be far more expensive. In the 2011 report he said:

“The threat that the 21st century return of the anti-productive Australian political culture will be long lasting is much greater if regulatory approaches are taken to reaching emissions reduction targets. The opportunities for vested interests to influence the policy process are much greater because the government must negotiate individual solutions to mitigation challenges as they arise. The difficulties of establishing a basis for international trade in entitlements are greater. The technical difficulties of assessing assistance levels through objective and independent processes are greater. And the danger that vested interests in other countries will persuade their governments to punish Australia for not doing its fair share in mitigation is greater. The largest cost of mitigation through regulation is the damage that it will do to productivity-raising reform. Expansion of regulatory intervention will entrench the pressure of vested interests on the political process and the anti-productive political culture of the early 21st century. Strong productivity and flexible markets are the cushions upon which the eventual bust will fall.”

Garnaut acknowledged the need for intervention in the energy market. He estimated that his proposal for an initial fixed carbon price would raise $12 billion a year but emphasised that this should be distributed to mitigate the impact of the carbon price and to assist research into new technologies. However he was emphatic that any distribution should be undertaken by an independent authority based on clear principles and rigorous cost-benefit analysis.

The weakness of policymaking following the Garnaut reviews was that neither the Rudd nor the Gillard governments commissioned analysis that would provide hard evidence to support his contention that a market-based approach would produce the least-cost, most-efficient energy market, taking into account the need for emission reductions. This left the way open for the interventionist approach that Garnaut warned about, based on imperfect knowledge and the influence of vested interests.

THE INTERVENTIONIST APPROACH

The interventionist approach currently characterises Australia’s energy policy. It consists of regulation, subsidies and government purchase of carbon abatement. The real cost and benefits of each of these measures to the Australian economy has never been determined.

The first intervention in the energy market was the introduction of the mandatory renewable energy target by the Howard government in 2001. This specified that retailers should source 10% of their electricity from renewable sources by 2010. In September 2009, the Rudd government increased the target to 20% by 2020. The Rudd government also introduced subsidies for household roof-top solar.

In January 2011, the Gillard government split the renewable energy target into two parts: the large-scale renewable energy target at power station level and a small scale renewable scheme, mainly for solar installations at the household level.

In June 2011, the Productivity Commission released a report that highlighted the problems associated with determining the cost of abatement in Australia in relation to electricity generation because of the paucity of data. The Commission continued to maintain that a market-based approach was the most cost-effective way to reduce carbon emissions.

In June 2012, the Gillard government established the Clean Energy Finance Corporation and provided it with $10 billion to invest in ‘clean energy’. At roughly the same time it created an unlimited number of carbon units that could be purchased at $23 a unit, the so-called carbon tax.

In July 2014, the Abbott government abolished the carbon tax. At the same time, it established the emission reduction fund that appropriated $2.25 billion to purchase carbon abatement using a competitive bidding process. It also increased the renewable energy target to 23.5% of generation by 2020.

During the course of the Coalition government’s term in office, many of the states have adopted renewable energy targets. None of these has been subjected to proper enquiry and report.

THE FINKEL REVIEW

Shortly after the re-election of the Turnbull government in 2016, the Council of Australian Governments (COAG) Energy Ministers commissioned a review of the national electricity market. The objective of the review was to develop a plan for the market that would ensure reliable and affordable electricity while, at the same time,
meeting whatever emissions targets were imposed by the government of the day. The review was deluged by interested stakeholders with data about the electricity market but lacked the capacity to analyse the data it received. It also commissioned modelling but this was limited to modelling its own proposals for reform of the electricity market within a limited context. Such modelling was of questionable value.

The key recommendation of the review was the Clean Energy Target. This was a mandatory target that compelled energy retailers to provide a certain amount of their electricity from “low-emissions” generators – sources that produce emissions below a threshold level of carbon dioxide per megawatt. Crucially, Dr Finkel did not make a recommendation as to the precise threshold or the amount of ‘clean’ electricity that had to be sourced, which made meaningful modelling pointless. The Turnbull government declined to accept the recommendation for a Clean Energy Target and instead opted for a policy called the National Energy Guarantee which incorporated many of the suggestions of the Finkel review but substituted the Paris Agreement emission reduction targets for the Clean Energy Target. The absence of analysis of the costs and benefits of the National Energy Guarantee proved fatal for its policy future. Had it been the subject of proper enquiry and report, it may have been shown that its objectives could be achieved without significant disruption to the Australian economy. Instead, it died on a political whim.

**THE PRESENT SITUATION**

The state of the national energy market was described in the most recent five-yearly productivity review of the Australian economy released by the Productivity Commission in August 2017:

“The Australian energy sector, especially in the east coast, is in a fragile state. While the past reforms that injected competition into the sector and radically altered its structure have served Australia well, the sector has undergone significant change in the last decade. – Technological change is radically altering the economics and structure of the sector, particularly in the electricity industry. – The construction of five LNG trains in Queensland have linked the east coast gas market to the international market. – Government policies, particularly those mandating the uptake of renewable sources, have significantly altered the mix of technologies being used.

“In electricity, a lack of stability and uncertainty in climate change policy has created an uncertain environment for investment. – This has resulted in insufficient investment in new generating capacity that complements renewable generation. Sharp rises in the cost of gas prices and supply concerns are limiting the ability of gas-fired generation to complement the uptake of renewables and constraining the sector’s ability to reduce carbon emissions by replacing coal-fired generation. No one jurisdiction can fix the issues currently confronting Australian energy markets. – Australian governments need to work cooperatively to resolve the issues. – Fixing these issues will require sustained commitment from governments, including to an emission reduction strategy.”

**WHY ARE WE IN THIS SITUATION?**

In its 2017 review, the Productivity Commission made a series of recommendations for reform of energy policy:

- “Australian governments should set a clear and considered long-term strategic vision for energy markets. – This should include a clear transition path from current arrangements. – Energy consumers should be central to this vision. – A balance will have to be struck between reliable, affordable and sustainable energy. Governments need to be clear about the trade-offs that they are willing to make. – Governments should avoid ad-hoc policy fixes.
- “A market-driven national emission reduction policy should replace the myriad of existing Australian and state and territory government policies. – Governments and opposition parties should commit to an agreed emission policy for a specified period of time to provide much needed investment certainty. – This will enable emissions reduction targets to be met at the least overall economic cost.
- “The uptake of renewables is having unintended implications for network security and reliability. – The renewable generators should bear the costs of ancillary services that the characteristics of their supply impose on the network.
- “More effective stakeholder engagement processes should be adopted to allow the moratoria on gas supply to be overturned.
- “The cost of not fixing the current mess will be significant, as indicated by the problems that beset South Australia in September 2016.”

The problem with this rational policy advice is that it has no hope of being accepted in the current populist political environment. The public is reluctant to accept prognostications from experts unless they are backed by hard evidence. In its report, the Commission acknowledged how difficult it was to demonstrate the efficacy of its policy conclusions. It pointed out that there
had been a multiplicity of studies of the energy sector but that these were not comprehensive enough for the development of a sustainable energy policy:

“These industries are in transition. In the case of electricity, governments have legislated significant uptake of renewable energy, and rapid technological change is materially altering the economics of the entire industry. In the case of gas, the development of export facilities in Queensland now link the eastern Australia grid to world markets. These changes have prompted a significant number of official reviews into the electricity and gas industries. The recent review into the future security of the National Electricity Market (the Finkel Review) identified 23 separate studies or reviews that were then currently underway or that had been completed in the last five years. Further reviews have been commissioned in the wake of recent electricity and gas market difficulties. These studies deal with complex technical and economic issues, are frequently lengthy and often deal with aspects of markets.” ...

“Evidence-based policy requires access to comprehensive, coherent, reliable and timely data for the entire energy sector. Data collected according to a consistent framework can support analysis of the sector at different levels and for different jurisdictions. Time-series data can support the identification of longer term trends. Australian energy data is of mixed quality. There is a lot of very detailed and useful data collected for parts of the sector and some useful aggregate data as well. Much of the data is granular and becoming increasingly fragmented over time. The official data sources used in this supporting paper do not make it possible to provide a consistent overview of the energy industry in Australia at a single point in time (such as for 2015-16 or 2016-17). Furthermore, the most recent year for which data are available varies between sources, ranging from a dated 2013-14 to 2017. This makes it difficult to gauge recent industry developments, particularly in a broader historical context. This is particularly an issue for electricity.”

Once again, the Productivity Commission asked the government to task it with undertaking a comprehensive analysis of the Australian energy sector as well requesting the establishment of a comprehensive and consistent database for the sector.

**HOW CAN WE GET A POLITICALLY SUSTAINABLE ENERGY POLICY?**

At the present time, neither major political party has an energy policy that can last past one electoral cycle. The Coalition’s policy is vulnerable to the charge that it does not do enough to reduce emissions. Labor’s policy is vulnerable to the charge that it has no plan for the structural adjustment it will impose on the economy through its high emission reduction target and no plan for the transition of the electricity market from fossil fuels to low-carbon generation.

The public has unreal expectations that Australian governments can reduce the impact of climate change solely through national measures and that greater renewable generation will lead to lower electricity prices. These unrealistic expectations are likely to continue until evidence to the contrary is produced or materialises in the form of a crisis. In these circumstances, the only way to achieve sensible energy policy is for the political leadership to be convinced by analysis that will show the maximum amount of emission abatement that can be achieved at an acceptable level of economic cost. This should be accompanied by analysis that reveals the least-cost way of achieving the agreed level of emission reduction while producing reliable and stable energy flows.

In its report to the COAG Energy Council in December 2018, the Energy Security Board emphasised the need for the Commonwealth and the states to adopt the ‘Strategic Energy Plan’. This would be a good first step in locking in the political leadership to agreed parameters for energy policy reform. Once the plan has been adopted then a new round of analysis could be mandated to establish the costs and benefits of the range of policy options for emission abatement and the least-cost approach to achieving the outcomes which the Finkel Review, the Energy Security Board and the Strategic Energy Plan have stipulated for a national energy policy.

In the view of this author, there are two steps that should be carried out as essential elements of any analysis: the first would be the establishment of an eminent persons group, with extensive experience in industry, to analyse all the material developed in the Finkel Review and subsequent reports of the various authorities involved in energy policy in order to develop a reference to the Productivity Commission for the analysis required. The second would be a full enquiry and report by the Commission into a national energy policy which would model a range of policy outcomes and the impact on consumers including the long-term competitiveness of industry sectors.

In the end, politicians will have to make difficult choices between the destruction of sectors of the Australian economy and minimising the risk from climate change. If they have reliable evidence that enables them to make these choices without causing unnecessary harm, it will be easier for them to agree on those choices, free from the impact of vested interests.

**John McDonnell** has over forty years’ experience as a policy adviser. He was an adviser to Prime Ministers Fraser and Hawke as well as the governments of Papua New Guinea, Pakistan, Mongolia, Kazakhstan, Sri Lanka and the Republic of Korea. He has worked as an economic and legal consultant for the World Bank and the Asian Development Bank. From 1986 to 1989 he advised the Government of the Peoples Republic of China on the entry of China into the WTO.

For the last fifteen years he has been working with various state governments on aspects of micro-economic reform. He is also widely published as a journalist commenting on economic policy matters.

CHAPTER 2
Future energy options

Guide to Australia’s future energy options

Despite recent cuts to the renewable energy target in Australia, leaders elsewhere are looking to a future without coal. So what are our other options? Carl Smith from ABC Radio National guides us through Australia’s alternative energy sources – exploring how they work, their potential and why they aren’t used already.

WIND

How does it work?
Windmills have been used for hundreds of years, and wind turbines expand on the simplicity of that design – using a rotor, gearbox and generator to create power. The wind spins the blades, and the tower transfers that energy to the generator. A typical 80-metre tower has blades that are around 44 metres tall. They’re huge structures, and wind turbines have gotten bigger over the years, with some now taller than 100 metres. The bid to build higher turbines is driven by the fact that there’s more wind at higher altitudes.

How much have we got?
Australia’s potential wind resource is vast. Geoscience Australia estimates the nation’s wind resources are among the best in the world. It’s hard to gauge just how much of that potential can be converted into energy, however. There are some limitations on where the turbines can be placed – which are both social and technological. Many don’t want wind turbines near their properties, and, because of how they are designed, turbines can only sit in areas of suitable wind availability.

What are the major advantages?
Wind turbines are a proven technology, and turbines have started to be mass-produced – driving their costs down. The government-commissioned Australian Energy Technology Assessment predicts by 2020 wind will be one of the three cheapest energy generation methods in the country.

Are there any downsides?
When the wind stops blowing, or blows too much, wind turbines shut down. So wind power isn’t baseload – and we’re reliant on what the weather throws at us. Then there is social acceptance. An outspoken minority believe that infrasound emanating from turbines causes health problems, although there is no evidence for such complaints. Others, like the prime minister, say they’re ugly.

SOLAR

How does it work?
To convert the sun’s power into electricity we use layers of silicon placed in solar panels. When a photon from the sun wacks into these panels, it dislodges an electron from the silicon atoms and forces it to cross a junction. Ultimately, allowing those free electrons to flow by hooking the panel up to a circuit gives us power.

How much have we got?
The solar energy hitting Australia each year could power the country for 10,000 years. Even if you only factor in flat land within 25 kilometres of existing transmission lines, there’s still enough radiation to power Australia 500 times over.

What are its major advantages?
Incredible advances in solar power technology have dramatically improved efficiencies over the past few decades. According to Professor Andrew Blakers from the Australian National University, energy conversion rates in standard panels are close to 20 per cent. Meanwhile, the cost of building solar panels has plunged.

Are there any downsides?
Initially, there were concerns over how many resources were being poured into developing solar technology. But that investment has paid off, says Laszlo Csanyi, from FRV Services Australia, the company which developed Royalla Solar Farm near Canberra. “We have an industry which actually produces more energy than was actually used to create it,” he says.

Why aren’t we using it now?
Well, we are, and it’s predicted to be one of the fastest growing energy sources over the coming decades. By the end of 2013 there were 68 wind farms operating across Australia, and between 2012 and 2013, the amount of wind energy in our electricity mix jumped from about 2.5 per cent up to 4 per cent.
HYDROGEN

How does it work?
Hydrogen gas is used to fuel spacecraft. Down here on Earth it could power transport or electricity. Hydrogen gas doesn’t occur naturally, but can be generated by splitting water into oxygen and hydrogen using an electric current. It’s powerful stuff. It’s what was inside the Hindenburg.

How much have we got?
Australia has a lot of it. As long as there’s water, we can split it into oxygen and hydrogen.

What are its major advantages?
It is a practically limitless resource.

Are there any downsides?
While plants can split water to free up hydrogen efficiently, we can’t. Many scientists, including the ANU’s Emeritus Professor Ron Pace, are on the case, however. They’re looking to plants for inspiration to make the process more efficient. Another issue is storage. Hydrogen gas has a low density, which means that to store it we must use high pressure or we have to liquefy it at very low temperatures. Both of these solutions pose practical and safety issues, as hydrogen gas is fairly explosive – particularly when exposed to oxygen.

Why aren’t we using it now?
Hydrogen cars do exist, but generating their fuel efficiently remains a challenge.

NUCLEAR

How does it work?
Like many sources of energy, nuclear power is all about spinning turbines using steam. In a nuclear power plant, that steam is made by heating water through a process called fission. For fission to occur, enriched uranium (normally U-235) stored in rods is pelted with subatomic particles called neutrons. The tiny particles hit the uranium with such force that it splits them, and when this happens, they release heat as well as their own neutrons. This can create a spiralling chain reaction in the nuclear core, where newly released neutrons split more enriched uranium atoms, releasing more heat. This heat can then be transferred into water to make steam directly.

How much have we got?
While estimates vary, it’s believed that Australia has about one third of the world’s uranium, and an even higher percentage of its recoverable uranium. Much of the recoverable uranium is stored under the central deserts, and Australia currently has three operating uranium mines: Olympic Dam and Four Mile in South Australia and Ranger in the Northern Territory.

What are its major advantages?
As with fossil fuels, electricity from nuclear sources can generate power whenever we like – allowing us to use it for baseload generation. Plus, like the renewables, it doesn’t release carbon dioxide.

Are there any downsides?
Dealing with nuclear waste – the spent metal rods – is a big problem, but many analysts have pointed to Australia as one of the best places in the world to store it. The country’s geological and political stability, for example, make it prime real estate for nuclear waste.

Then, of course, there are the safety concerns borne out of disasters at Chernobyl, Three Mile Island and Fukushima. Professor Ken Baldwin from the Australian National University, however, offers a counterpoint. “The nuclear industry by and large has been extremely safe over many, many years,” he says. “If you look at industries like coal mining where, for example, hundreds of people die around the world each year, nuclear is looking very safe as an alternative.” Baldwin adds that the technology used to generate nuclear power has become increasingly sophisticated. Due to concerns around safety, further checks and balances have been introduced into newer reactors. Consequently, if Australia were to embrace nuclear power, reactors being built would be generation III or even IV, with significantly improved safety measures when compared to the 1960s-style reactors that led to the Fukushima, Chernobyl and Three Mile Island meltdowns.

Why aren’t we using it now?
Aside from safety and waste management concerns from the community, there are technological impediments to setting up a nuclear industry. Developing such an industry, and the professionals needed to run it, would take decades, says Baldwin.

GEOTHERMAL

How does it work?
Geothermal energy taps into the heat stored below the surface of the Earth. Just a couple of meters under our feet, the grounds remains at a fairly constant temperature. If you go down further, however, things can get really hot – radioactively decaying rocks generate temperatures above water’s boiling point, while lava seeping around Earth’s belly can push the mercury even higher.

There are a couple of different ways we can use that heat for energy. We can inject fluid deep into hot rocks so it will convert into steam, rise to the surface and spin turbines. Or we can run pipes infused with gas or liquid just below Earth’s surface to heat them to a constant temperature. This heat can then be run into buildings to warm them up. Think of it as using the ground as a giant heat sink.

How much have we got?
There’s a lot of geothermal energy buried under us. Geoscience Australia estimates that one per cent of the geothermal energy shallower than five kilometres and hotter than 150°C could supply Australia’s total energy requirements for 26,000 years. That’s pretty incredible.
What are its major advantages?
If we can tap that reserve of heat, it would be an amazing resource for Australia. What’s more, unlike many other renewables, geothermal is baseload – meaning geothermal plants could run continuously and wouldn’t be disrupted by days without wind or direct sun.

Are there any downsides?
While Australia has a lot of heat, it’s position is scattered and variable. There are also less super-hot spots close to the surface compared to countries like Iceland, which are already exploiting geothermal power. That means accessing potential heat can be a very costly exercise. Currently, even finding the right sites to tap isn’t cheap. “It’s very expensive up-front for geothermal,” says Dr Bridget Ailing from Geoscience Australia.

Why aren’t we using it now?
Small geothermal heating systems are used in buildings around the country. This technology is simple, has been used for decades, and helps large buildings reduce their heating and cooling costs. However, in terms of generating electricity from geothermal, companies haven’t cracked how to do this cost effectively yet.

According to Ailing, more research and development is needed to reduce drilling costs. Research continues, though, and Ailing says some companies have achieved promising first steps. A pilot station in Birdsville, southwest Queensland, is using 100°C water from the Great Artesian Basin and is “generating approximately 80 kilowatts at the moment,” she says.

OCEAN

How does it work?
Wave energy harnesses the bobbing, or oscillatory, motion of waves. This can be done using giant submerged steel buoys, which pump water through a closed system to generate power.

Tidal energy taps energy from the water moving in and out, or up and down. There are a few other niche ocean energy generation methods, including exploiting ocean currents, temperature gradients in bodies of water and even salinity gradients. But wave energy appears to have the most potential.

How much have we got?
A lot. Dr Peter Osman, an ocean energy specialist from the CSIRO, says there is enough wave power on the south coast of Australia to supply five times our electricity needs.

What are its major advantages?
There’s plenty of wave power out there. But, harnessing it is tricky.

Are there any downsides?
It’s expensive. The Australian Energy Technology Assessment pegs wave and tidal energy as among the most expensive ways to generate power in the country, even looking decades into the future. This is partly because the technology is still in its infancy. “We are really just at the start of the journey still,” says Dr Mike Ottaviano from Carnegie Wave Energy.

It’s likely to be a trying journey, given the harsh environmental conditions required for wave power. “It’s energetic, it’s wet, which makes it difficult to install and to maintain,” says Ottaviano. “And it’s salty.” There are also concerns over how these devices may interact with marine environments, surf breaks and ocean amenities. It could also be difficult to hook up a finished product to the electricity grid, says Dr Mark Hemer from CSIRO.

Why aren’t we using it now?
The technology is still being developed, and many are concerned about reliability and costs even if the devices can be optimised.

BIOENERGY

How does it work?
Bioenergy converts organic matter – be it sugar cane pulp, wood, algae or human waste – into energy. The most common way of doing this is by burning it as fuel. First generation biofuels were based on fermentation and distillation of ethanol from sugar to make biodiesel. Larissa Brown from Wilmar Sugar says her company now produces more energy from sugar cane pulp than the sugar mill uses in a year, and the excess is given to the grid, powering 60,000 homes each year.

Second generation biofuels squeeze energy sources from so-called ‘lignocellulosic material’, like the woody parts of plants or woodchips, as well as algae. Sewerage and landfill sites can also be turned into energy by harnessing the gases that are released when organic material decomposes.

How much have we got?
“Australia’s potential bioenergy resources are large.” So says Geoscience Australia. According to them, we are under-utilising the energy found in the crop, plantation and waste stream by-products.

What are its major advantages?
Bioenergy can piggyback off established industries, squishing clean energy from livestock manure, used cooking oil or landfill gas.

Are there any downsides?
Burning stuff isn’t particularly efficient. You lose a lot of energy through heat. For example, in most coal-fired power stations, about 70 per cent of the energy in coal is lost. The same rules apply for bioenergy.

Why aren’t we using it now?
We are! Bioenergy actually made up a whopping 68 per cent of Australia’s renewable energy use in 2011-12. However, due to inefficiencies it’s unlikely to emerge as a standalone industry.

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COAL V RENEWABLES. HERE’S WHAT YOU NEED TO KNOW
A REPORT FROM TRIPLE J’S HACK PROGRAM

Coal is good for humanity,” former prime minister Tony Abbott once said, while wearing high-vis and opening a new mine. So what’s the case for coal? The last few months has seen the argument between the opposing coal and renewables camps growing even more intense.

• There were the South Australian blackouts, which Prime Minister Malcolm Turnbull blamed on renewables;
• There have been electricity price rises, which the PM blamed on renewables;
• There was the announced closure of the Hazelwood power station in Victoria (Australia’s dirtiest coal-fired plant), which the Coalition blamed on Labor;
• The Treasurer of Australia Scott Morrison went into question time with a lump of coal supplied by a lobby group, saying, “This is coal. Don’t be scared”;
• There was the news today that Australia’s largest operator of coal-fired power stations is pushing for Government to back renewables.

Let’s look at the arguments.

Argument one: Coal is cheaper than renewables
The most comprehensive recent study of Australian electricity generation costs was done in 2015 by CO2CRC. The company has an interest in coal power – it’s developing technology designed to capture and store emissions – but it made sure the study included an electricity industry reference group of about 40 organisations, so it wouldn’t be seen as biased.

Here’s what it reported:
Of the renewables, wind power has lowest LCOE zero. Fossil fuels would be more expensive if the price included the cost of carbon pollution.

Where are these prices going? The CO2CRC report estimated that by 2030, the cost of solar panels would reduce by 35-50 per cent, and solar thermal (using mirrors to concentrate the heat of the sun and drive a turbine) costs would halve. It also predicted the cost of coal and gas would go up due to government putting a price on carbon – i.e. the Emissions Trading Scheme the Coalition opposes.

The price of renewables varies. AGL’s most recent wind project at Silverton on the NSW and South Australian border is generating power at $65 per megawatt hour. Origin Energy’s solar project in Queensland is estimated to be $80 a megawatt hour.
This is more expensive than the old coal-fired power plants currently operating, but cheaper than the estimated cost of building new, more efficient coal-fired plants.

A carbon price of about $20 a tonne of carbon (a conservative estimate) would add about $16 per megawatt hour to the cost of clean coal power, according to the Australian Industry Group – a key representative of the energy-hungry manufacturing sector.

**Argument two: Coal is more reliable**
The wind doesn’t blow all the time and the sun doesn’t shine all the time – wind and solar are therefore intermittent power sources. The state that relies the most on renewable energy is South Australia, which has 50 per cent solar and wind. It’s seen as a bit of a guinea pig for the uptake of renewables. The Prime Minister has called it a “canary in the coalmine” (pun not intended?)

When the state had blackouts last year, the Turnbull Government partly blamed wind power, which it said had failed to keep working in the conditions.

“I regret to say that a number of the state Labor governments have over the years, set priorities and renewable targets that are extremely aggressive, extremely unrealistic, and have paid little or no attention to energy security,” the PM said on national TV.

Subsequent reports found wind power was not to blame, and that the blackout had been caused by the massive loss of power lines.

Recent Australian National University computer modelling suggests solar and wind could reliably supply 90 per cent of the national electricity market. The modelling matched historical data for wind and sun with every hour of power demand for the years 2006-10. It found that by spacing solar and wind generation far apart, the network could supply shortfalls in areas where the weather was overcast and still – i.e. bad for solar and wind generation.

But building power lines for this vast national grid would be expensive. A separate study found a national grid of 100 per cent renewables would need to be two-and-a-half times larger than our current grid, including linking WA and the NT with the eastern network.

A separate issue is whether coal is the best backup option for renewables. According to the Ai Group, the peak body for industry, they’re not. That’s because conventional coal power plants are slow to fire up, and they’re also expensive to have sitting around not being used.

“The electricity market is clearly becoming very unfriendly for such inflexible generators,” Ai Group’s principal national advisor Tennant Reed has written in his blog.

“Much of the time there is an abundance of power from solar or wind, with rooftop solar taking a lot of demand out of the market entirely.”

The best option, he said, would be a few small gas generators that could be fired up quickly to guarantee supply during peak demand.

**Argument three: ‘Clean coal’ is the future**
‘Clean coal’ refers to burning coal more efficiently to generate less emissions, and also to capturing these emissions and storing them in the ground.

Investment in Carbon Capture and Storage (CSS) technology has gained momentum over the past few years. Around the world there are 38 large-scale projects either in production, under construction or being planned, according to a report released by the Global CSS Institute in 2016. None of these projects are in Australia, and many doubt the technology is viable.

The other kind of ‘clean coal’ is low-emission power stations. But even the best of the high-efficiency, low-emission plants emit far more carbon into the atmosphere than gas-fired power stations. Some energy analysts also estimate the next generation of ‘ultra supercritical’ reactors aren’t that much cleaner than the current generation of supercritical reactors.

Last year, AGL Energy, one of Australia’s largest utilities, promised to shut down all its existing coal plants over the next 35 years. Ai Group has argued against a new-for-old replacement of coal power plants. Today, Energy Australia, another large operator of coal-fired plants, called for a non-partisan push for renewables – importantly, it did not mention ‘clean coal’.

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COAL IS PART OF THE SOLUTION IN TRANSITION TO NEW ENERGY SOURCES

We are all so dependent on coal to produce our electricity, that you simply can’t abolish it, argues Graham Young

The cowardice of Australia’s largest coal miner Glencore in bowing to activist pressure and capping its coal production torches the reputation of coal by implying coal mining is unethical.

This is grossly unfair to the industry and those who work in it, or use its products, which is all of us. The ethical case against coal is weak.

Yes, coal produces CO₂, which is a greenhouse gas, but modern living is so dependent on electricity, and electricity so dependent on coal, that you just can’t abolish it.

Yes, coal produces CO₂, which is a greenhouse gas, but modern living is so dependent on electricity, and electricity so dependent on coal, that you just can’t abolish it.

Multiple projections based on the Paris Accord predict that by 2040 we will still be burning about as much coal as we are now. Coal is part of the solution to a transition to new energy sources.

IN FAVOUR OF COAL: KEY POINTS

Key points from a submission to the Inquiry into the Retirement of Coal-Fired Power Stations by the Minerals Council of Australia

• The demand for coal is set to continue for decades – Australia continues to benefit from growing demand for affordable energy in India, China and SE Asia and their collective need for Australian high-quality coals.
• Low-cost electricity, built on coal-fired power generation, was an essential element of Australia’s comparative advantage during the 20th century and modern coal technology can deliver the same benefit this century.
• This economic edge has been lost over the last decade due to costly policy interventions – including the carbon tax, the expensive Renewable Energy Target, a lack of a national energy plan and deep uncertainty about future electricity prices, reliability and security.
• Australia does not have to choose between coal and a low emissions future. New coal generation technologies are reducing CO₂ emissions by up to 40 to 50 per cent and carbon capture and geological storage offers the prospect of reducing emissions by up to 90 per cent. There are 725 HELE units in place in Asia alone, with another 1150 planned or under construction.
• An informed debate is crucial – there is limited understanding of the nature of electricity, where it comes from, and the complementary roles that renewables and fossil fuels can and do play.
• The announcement of the closure of the Hazelwood power station, and the recovery issues in South Australia after its blackout are a reminder that Australia must work to maintain its long-held competitive advantage in low-cost electricity.
• Under a technology-neutral approach to Australia’s energy needs, the Latrobe Valley – and other areas where there is a geographic concentration of coal-fired power generation or heavy industry, and skilled employees – still have a big future.

As part of a medium term plan to keep domestic energy costs down and CO₂ emissions levels lower, Australia should seek to capitalise fully on its rich natural endowment in all baseload energy sources.

What activists have decided is that they know better and they will try to take energy decisions away from the sovereign governments of the world. This is a subversion of international norms, and the rule of law.

Activists are anti-democratic and in telling developing countries how to run their economies, neo-colonial. Their actions will also cause more harm than the status quo, because they will actually increase emissions.

There is plenty of coal in the world, but ours causes the lowest emissions. Coal importers will simply shift to higher emissions sources, increasing greenhouse gases. If coal were abolished tomorrow that would also increase poverty and misery.

Coal makes up $67 billion of Australian export income and, in Queensland, contributes about $3.8 billion in royalties to state revenue. That’s a lot of jobs, and a heap of hospitals, schools and police stations. Abandoning coal will devastate regional areas and state budgets, and again, for no tangible gain.

But coal is more deeply embedded in modern life than that. Electricity is the key to modern civilisation, and coal contributes about 40 per cent of its generation at the moment.

Even allowing for rapid growth in renewables, projections put coal at about 30 per cent of generation in 20 years’ time, and at a similar volume to now.

If activists put a clamp on coal worldwide then the outlook for poorer economies is catastrophic. Power provides water and sanitation. Lack of clean water and sewerage are the greatest causes of mortality in the world.

Electricity also allows people to cook safely inside. If they don’t have electric power, they burn wood, or dung, which emit particulates, causing pollution and ultimately deaths from lung cancer and other respiratory diseases.

There will be spin-off impacts for children, women and the environment. As countries get richer, women’s status tends to improve, children are spared from work and gain education and the environment improves. Richer societies have the resources to be able to afford to care.

CO₂ also brings direct environmental benefits. Additional warmth allows more land to be cultivated and additional CO₂ increases plant growth. This is a good thing with the world’s population currently 7.4 billion, and heading towards something like 11 billion by 2100. People need to be fed.

Multiple projections based on the Paris Accord predict that by 2040 we will still be burning about as much coal as we are now. Coal is part of the solution to a transition to new energy sources.

Indeed, the net cost of limiting additional CO₂ in the atmosphere is open to debate with recent calculations by newly minted Nobel Laureate, William Nordhaus, suggesting the cost is impossibly high.

Then there is the damage that activists potentially do by forcing wind and solar on us. These are ancillary technologies that can’t produce baseload at a reasonable cost. Apart from fossil fuels, the only fuel we know of that can is nuclear. But that has been ruled out.

Climate change is what economists call a “wicked” problem. Solutions are not simple, and unintended consequences are numerous. It won’t be solved by chanting slogans, and it certainly won’t be solved by stopping Adani.

Those who think it will are ethical impostors.

This article was first published by the Courier Mail.

Graham Young is the chief editor and publisher of On Line Opinion. He is executive director of the Australian Institute for Progress, an Australian think tank based in Brisbane, and the publisher of On Line Opinion.

How to transition from coal: 4 lessons for Australia from around the world

With a dozen coal power stations in Australia closed since 2013, a full transition out of coal is coming, according to Chris Briggs, Elsa Dominish and Franziska Mey

Around the world, governments and stakeholders are considering how to implement a “just transition” from coal to clean energy – a transition that’s fair for local workers and communities in coal regions.

Some coal-producing nations, such as Germany and Spain, are delivering major just transition packages. Other nations are less successfully trying to navigate social conflicts around the transition, such as Poland and South Africa. But so far in Australia, there is little planning for the transition.

What can Australia learn from other international experiences to plan our own just transition? Through our ongoing research we found four important lessons.

LESSON 1: BUILD A SOCIAL COMPACT
Climate science demands the energy transition be as rapid as possible. But faster transitions threaten the capacity of local labour markets to replace jobs lost in coal.

Unions have begun shifting from defensive support for coal towards a just transition perspective, but this support can unravel once job losses start to hit. In South Africa, for instance, trade unions helped pioneer a just transition. But they brought legal action to stop renewable energy auctions amid coal closures without adjustment support for workers.

Germany, on the other hand, has managed industrial transitions in the western coal regions since the late 1960s through effective negotiations. In 2018, Germany’s government-appointed “coal commission” developed a pathway for the full closure and transition of the coal industry by 2038. It involved a process with representatives from unions, industry associations, coal regions, scientists, local communities and environmental NGOs.

A social compact between the key parties is needed to manage the conflicts that can emerge over a transition out of coal. Just transition commissions have been established in Canada, Scotland – and now South Africa.

So Australia should be considering two things to build a social compact for coal transition:
• A taskforce including all the key stakeholders to negotiate an overarching framework for a transition out of coal
• An ongoing process for including stakeholders at national and regional level, because it will be a long-term process requiring negotiated trade-offs.

LESSON 2: PLAN EARLY FOR CLOSURES
If transition planning is delayed until mass redundancies are on the horizon, labour markets will not cope with the volume of displaced workers.

Planning for closures is starting to emerge at an industry and company-level in some nations (such as Italy, Germany and Australia) – which includes retraining, support for early retirements and the redeployment of workers.

Victoria is a global leader on regional level adjustment. The La Trobe Worker Transfer Scheme is redeploying retrenched Hazelwood power station workers to other sites.

Site remediation is also an important way we can restore the local environment quality and create semi- and low-skilled jobs at the most critical time of the transition. Mandatory requirements need to be established for funds allocated to the coal industry.

LESSON 3: DIVERSIFY THE REGIONAL ECONOMY
The Institute for Sustainable Futures has modelled the global employment impacts in the energy sector if we meet the Paris Climate Agreement.

National climate and energy policy is a fiasco in Australia. The federal government has no energy transition plan ... On a positive note, there have been some innovative regional responses.
The modelling found jobs will grow across almost all occupational categories. There will be big job losses among machine operators and assemblers as coal closures occur, but this group also experiences the strongest job growth within the renewables sector, especially solar.

But market restructuring alone will not deliver a just transition. In each of the coal regions we examined, there is little prospect for large-scale renewable energy because the best solar and wind resources are located elsewhere.

This means workers will rarely transfer seamlessly to new jobs without having to move away from home. And as many of the new jobs are in the construction phase, ongoing jobs will be replaced by a higher volume of temporary jobs.

Local solar and energy efficiency can be a source of new jobs but ultimately diversifying the regional economy is the solution for creating new jobs beyond coal. Each region has different mixes of sectors and capabilities, so economic diversification strategies need to be tailored.

These are some features of successful plans to diversify regional economies:

- Develop links with related industries and establish new industries
- Extend the capabilities of existing industries and workers
- Fund labour-intensive projects, such as site remediation and plant decommissioning
- Target infrastructure upgrades and skill development for coal regions.

**LESSON 4: ESTABLISH FUNDS AND AUTHORITY FOR A JUST TRANSITION**

Specialist funds are being established to oversee, develop and implement coal transition programs. The European Commission’s coal and carbon-intensive regions in transition initiative is investing funds in 13 coal regions.

In Germany, the coal commission has recommended a funding package of €40 billion to support the coal regions, with legislation due May 2019. The Spanish government has established a €250 million fund, which includes support for workers, economic diversification and environmental restoration.

**HOW IS AUSTRALIA PLACED?**

National climate and energy policy is a fiasco in Australia. The federal government has no energy transition plan and refused to sign a Just Transition declaration at the Poland climate conference in December 2018.

On a positive note, there have been some innovative regional responses. The Victorian Government has established the La Trobe Valley Authority, which is funding economic diversification initiatives. The ALP will establish a Just Transition Authority if it wins the federal election, which will develop regional transition plans and oversee redundancy schemes. Unions, industry and local communities will have direct input.

But without a coordinated exit schedule like the German coal commission, coal closures will still likely be abrupt, driven by technical breakdowns or renewables growth squeezing out less profitable generators.

The ALP scheme also only covers power generators – not coal mining – which will be more challenging because there are more low-skilled workers (around half are drivers and machine operators).

Social and political support can unravel very quickly once regional communities start to transition. In Queensland, mining unions are opposing any candidates that will not support the Adani mine after their national body led the shift to a just transition policy by the ACTU.

Australia would be wise to invest heavily in just transition planning and investment alongside technology development.

**DISCLOSURE STATEMENT**

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Chris Briggs is Research Principal, Institute for Sustainable Futures, University of Technology Sydney. Elsa Dominish is Senior Research Consultant, Institute for Sustainable Futures, University of Technology Sydney. Franziska Mey is Senior Research Consultant, Institute for Sustainable Futures, University of Technology Sydney.

THE ADVANTAGES AND DISADVANTAGES OF SOLAR POWER

BY JON CAPISTRANO FOR THE SOLAR TRUST CENTRE, AN AUSTRALIAN SOURCE FOR SOLAR ENERGY NEWS, TOOLS AND RESOURCES

There are several factors driving solar’s increasing adoption, from improved technologies and decreasing installation costs to a generous federal tax credit that the government provides according to Investopedia. As a result, how residential power works is more than just the conversion of sunlight into electricity. To truly understand it you have to follow the light from the solar panel to your own budgetary needs.

Just a bit of history, humans have used the sun to heat water and preserve food for thousands of years, but solar electric power or photovoltaic (PV) started in the 1950s. Since then, there have been many technological advances which makes solar power a very attractive alternative today.

The solar panels are made up of solar cells, like the ones that you see on solar watches and calculators, a racking system that is used to attach the panels to the rooftop. The solar installers will orient the rack to make sure that the modules get the most direct sunlight as much as possible. If the roof is not suited for the planned solar panels, the modules can be placed in a yard using a ground-mounted system.

The solar installers will orient the rack to make sure that the modules get the most direct sunlight as much as possible. If the roof is not suited for the planned solar panels, the modules can be placed in a yard using a ground-mounted system.

And as installers have gained more experience, they have become more efficient at installing panels. Installations that used to take days can now be done within hours. Plus, the cost of solar has gone down in recent years.

To help you further in deciding if you want to go for solar panels, below are some of the advantages and disadvantages of solar power systems.

SOLAR POWER ADVANTAGES

It’s renewable and an infinite source of energy
As long as the sun shines, there will be solar energy. And if you’re watching Discovery Channel or fond of reading anything science-related, the sun’s life span is about 10 billion years. According to scientific calculations, the sun’s present age is about 4.6 billion years old. So we still have 5.4 billion years of sunlight before the fuel runs out. So we’re all be long dead before the sun dies out. Traditional energy sources like coal and oil will have its limits.

Abundant energy
The potential of solar energy is beyond our imagination. The Earth’s surface receives 120,000 terawatts of solar...
radiation. That’s twenty thousand times more power than what is needed to supply the entire world. There is no combustion involved nor does it require water when generating electricity.

**No greenhouse gases**
The solar power system does not emit any greenhouse gases. Solar energy is made by conducting the sun’s radiation into electricity through solar panels.

**It’s sustainable**
A renewable and abundant energy source is also sustainable. Sustainable energy sources meet the needs of modern-day consumers without compromising the ability of future generations in meeting their needs.

And if you think of it, there is no way people can over-consume solar energy. It doesn’t need any raw materials and has lower operational labour as compared to conventional power production.

**It’s environment-friendly**
Harnessing the sun’s energy does not produce any harmful by-products that can pollute the environment. However, there are emissions linked with the creation, transport and installation of solar power systems but overall, solar energy is clearly a decrease on traditional fossil fuels in term of environmental impacts.

**Solar energy is available anywhere**
Solar energy is available around the world. As long as there is sunlight in your country or area, solar power can be used.

For example, in Europe which is known for snow and rain, Germany has by far the highest capacity for solar power in the world. As long as you know how to take advantage of solar power, you can have electricity.

**Decreases the cost of electricity**
With the introduction of feed-in tariffs and net metering schemes, households can now sell any excess electricity or receive bill credits every time they produce more electricity than what they actually consume. This also means that any homeowner with solar installed can reduce their overall electricity bills by switching to solar.

**Multiple applications**
Solar energy can be used for different applications and purposes. It can be used to power up places that lack grid connection. It’s also referred to as ‘the people’s power’, meaning that some solar power setups can be easily deployed at the consumer’s level. With the introduction of thin-film and flexible solar cells, solar power can even be integrated into materials used for building construction.

**Zero noise**
A solar power system has no moving parts thus, there is no noise associated with photovoltaics. There will be no vibration or hissing issues when you have solar power.

**Low maintenance**
Most present-day solar power systems do not require extensive maintenance. Most residential solar panels
usually need cleaning probably every quarter or 6 months, depending on your location. Most solar companies also ship 10-25 year warranties with their solar panels.

**Technology is always improving**
Just like computers, technological advancements are constantly being made in the solar power industry. Innovation in quantum physics and nanotechnology has the potential to have three times the electrical output of solar panels.

**SOLAR POWER DISADVANTAGES**

**Expensive**
If you pay an upfront cost, it will be expensive but there are available payment schemes that the solar power provider, the state or the government can provide. The cost will also depend on the components offered. It will depend on the different types of solar panels, the brands of solar panels and inverters. Also, be aware that the solar provider conducts site visits to quote and customise the system depending on your circumstances or your solar requirements.

**Inefficiency of solar**
One of the most common criticisms of solar power is its inefficiency. Currently, solar efficiency is at around 22% this means that a large amount of surface area is needed to produce adequate electricity. However, solar panel efficiency has developed dramatically in the last 5 years and will also continue to rise steadily over the next 5 years.

**Intermittent**
Solar energy is an intermittent energy source and in some cases, access to sunlight is limited at certain times. Predicting the weather, specifically overcast days, can be difficult but with the advances, these issues have been solved. Take for example Germany, as mentioned earlier, which has by far the highest capacity for solar power in the world. They are not a sunny or tropical country but they have excess power.

**Solar battery storage is expensive**
Solar battery storage will help smoothen the load and demand in your house, making solar more stable, but it is expensive. Tesla, Origin, and Samsung are the primary battery distributors in Australia. These manufacturers are trying to make batteries more affordable in the future, but for now, if you want to have back-up power, you will spend more.

**Associated with exotic materials and pollution**
Although solar power is less polluting compared to traditional fossil fuels, there are issues that surround it. Some of the manufacturing process is linked with greenhouse emissions. Nitrogen trifluoride and sulphur hexafluoride have been traced to solar panel production. These two are some of the most potent greenhouse gases and have a big impact on global warming as compared to carbon dioxide.

There are also some solar cells that require materials that are rare or expensive. This is true for thin-film solar cells that are either made from copper indium gallium selenide or cadmium telluride.

**It needs space**
Watt per square meter or power density is important when looking at how much power can be juiced out from a certain area of your property or real estate of an energy source. The worldwide mean power density for solar radiation is 170 watts per square meter. It’s more than any other renewable energy source but is not comparable to fossil fuel or nuclear power.

Solar energy spurs debates, discussions and reassessment of the importance of interaction between investment, the environment and economics. Although not everybody is in favour of solar power, the fact that there are talks about the validity of the status quo is a good development. State authorities and some branches of the government are encouraging solar use by way of incentives like tariffs, subsidies and rebates.

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ABOUT COAL SEAM GAS

Coal seam gas (CSG) has been extracted and used in Australia for nearly 30 years. It is only in recent times that the practice has come under public scrutiny, according to this report from ABC News.

Environmental concerns have been raised about the impact of CSG on ecosystems and the potential for the escape of toxic chemicals into the environment.

Likewise, some agricultural landholders believe CSG will adversely affect prime farming land by drawing down deep aquifers and potentially polluting valuable ground water reserves. Farmers also say the placement of gas-well infrastructure on their farms will mean a loss of land in food production.

The industry argues CSG will produce significantly lower greenhouse gas emissions than coal, provide vast amounts of irrigation water and provide clean energy for the rising economies of China, India and South East Asia.

The scientific community also appears divided. The release of research supporting CSG, its methodology and effectiveness is invariably followed by a second report that appears to refute many of the claims.

Meanwhile state and federal governments are debating policy that protects land resources while also encouraging the development of industry.

Australia is on the cusp of major expansion of natural gas production, of which CSG will play an increasing role. In Queensland alone it is estimated there will be 40,000 new wells extracting coal seam gas in 40 years.

WHAT IS COAL SEAM GAS?

Many people are familiar with the concept of natural gas (NG) being extracted from deep below the sea bed and piped onto land to be either liquefied (LNG) or used as is. This type of gas, usually found in deep sandstone reservoirs, is known as ‘conventional gas’.

Coal seam gas (CSG), which as its name implies is extracted from seams of coal underground, is known as ‘unconventional gas’. Other unconventional gas sources are shale beds and so-called ‘tight gas’ fields where gas is bound up in rocks which need to be shaken up or ‘fractured’ so the gas can be extracted.

CSG is predominantly methane that collects in underground coal seams by bonding to the coal particles. These coal seams are full of water and the pressure of that water keeps the gas on the surface of the coal in a thin film.

HOW IS CSG EXTRACTED?

Like all natural gas, coal seam gas is the by-product of prehistoric plant matter that has been buried for millennia. The plant matter itself is what coal is made of.

To produce the CSG, the first step is to sink wells to extract the water that is associated with it. This reduces the pressure and releases the gas from the coal seam. The water and gas are pumped back up the well, separated at the well head, and then the gas is sent to a processing plant and the water to a water treatment plant.

If the methane gas is too tightly bounded up in the coal the well may be subjected to a process called fracturing or ‘fracking’ (also spelt as ‘fraccing’). Fracking involves pumping large amounts of water, sand and chemicals into the hole to break up the surrounding rock and allow the gas to escape.
rocks and release the methane gas. The wells can go as deep as 1,000 metres each and a single deposit of CSG may require hundreds of them spread over a large area.

**WHAT ARE THE ENVIRONMENTAL ISSUES ASSOCIATED WITH CSG?**

The potential for detrimental environmental outcomes from coal seam gas mining drives much of the opposition to its ongoing development.

In the spotlight is the potential for contamination from the gas extraction process and the long-term effects on ground water aquifers.

While the industry argues that gas is a far cleaner way to produce electricity, when compared with coal, opponents claim that methane release into the atmosphere from faulty and leaking gas wells is exacerbating the greenhouse problem.

**COAL SEAM GAS EXTRACTION, FRACCING AND GROUNDWATER**

The process of extracting gas from the coal seam has come under considerable scrutiny in recent times.

The industry says hydraulic fracturing, or fraccing, is well established, tightly regulated and has been used internationally for more than 60 years and for 15 years in Australia.

Opponents argue the process of extracting coal seam gas will always involve contaminated water. They suggest highly toxic water is drawn to the surface along with gas.

There is also concern that fracturing the gas deposit to create a pathway for the release of the gas may create unintended pathways for the fracturing fluid and gas to enter groundwater systems.

Opponents claim the fracturing fluid is a dangerous cocktail of volatile organic compounds including benzene, toluene, ethyl benzene and xylene, known as BTEX. They also point to the use of butoxyethanol and methanol in the fracturing process in Australia.

Countering those claims, CSG producers suggest there is unfounded concern about the chemicals used in the fraccing process and have released a list of the compounds used in Australia.

They say that Queensland and NSW have banned the use of BTEX and that many of the chemicals in use are common in Australia.

The process of extracting gas from the coal seam has come under considerable scrutiny in recent times.

The industry also says that CSG wells are cased with cement and steel to prevent gas or other substances leaking into water aquifers, but it’s also argued, by opponents, that the integrity of the bore casings can’t be guaranteed into the future.

Opponents suggest that steel casings corrode in saline water and that cement seals can deteriorate over time, particularly when they are under pressure.

Both sides point to the international CSG experience to make their case. While the industry says investigations in the UK and US show the process to be safe, opponents claim that grave concerns have been raised about the process and the chemicals used, particularly in the US.

**A CLEANER ENERGY OPTION?**

Concerns have been raised about the level of carbon dioxide produced during the process extracting CSG, transporting and converting it to liquefied natural gas (LNG).

Is there a benefit to the environment and a reduction in greenhouse gases added to the atmosphere with the growth of the coal seam gas industry?

Industry body, The Australian Petroleum Producers and Exploration Association (APPEA) commissioned a report from Australian engineering firm Worley Parsons.
The report is available on the APPEA website and has been peer reviewed by Curtin University in Western Australia. The report concluded that for every tonne of carbon dioxide emitted during the CSG-LNG production process, up to 4.3 tonnes of emissions are avoided when gas is used instead of coal for power generation.

Opponents of CSG argue that up to 35 per cent of a gas well's output is lost into the atmosphere as a result of leaks. They also argue that methane has a significantly higher 'warming potency' when compared to coal.

CSIRO RESEARCH INTO COAL SEAM GAS
The CSIRO does acknowledge coal seam gas as one of several ‘unconventional gas’ resources that will achieve a lower carbon economy in Australia. Other ‘unconventional gas’ resources include shale gas, tight gas and basin centred gas.

The CSIRO work into these gas resources is focused on growing their production for use domestically and overseas. Research projects are looking into improving evaluation of coal seam gas resources and enhancing gas drainage from the seam, including with the use of carbon dioxide from power station.

The CSIRO also highlights research into addressing the environmental impacts of coal seam gas production, particularly the management of water.

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Solar photovoltaics (PV) and wind energy are growing fast enough to eliminate global coal, oil and gas consumption before 2050, resulting in global greenhouse gas emission reductions of 85 per cent – with the time frame depending mostly on politics.

The exponential rise and rise of PV and wind offers the only realistic chance of avoiding dangerous climate change (for more information, see The Conversation’s Explainer: What is photovoltaic solar energy).

Indeed, it is difficult to see any timely solution to climate change that does not involve PV and wind doing most of the heavy lifting. No other solution comes even close.

Solar PV meets all these criteria, while wind energy meets many. Together, PV, wind and other renewables can eliminate coal, oil and gas use and thereby reduce greenhouse gas emissions by 85 per cent. Renewables already dominate capacity markets (Figure 2) since both wind and solar overtook coal and gas in 2015.

PV and wind depend only on energy from the sun, which will be available for billions of years. Complete replacement of all fossil fuels requires solar and wind collectors covering much less than 1 per cent of the world’s land surface area. A large proportion of collectors are installed on rooftops and in remote and arid regions, minimising competition with food production and ecosystems.

The solar resource is ubiquitous – we are unlikely ever to go to war over access to sunlight or wind. Most of the world’s population lives at low latitudes (less than 35 degrees), which has good solar availability that varies little with the seasons (unlike at high latitudes). Complementing this, wind energy is also widely available – particularly at higher latitudes. Very wide distribution of PV and wind collectors over most regions of the world means that everyone has local energy generation, and this helps to minimise disruptions from natural disasters, war and terrorism.

In addition, PV and wind have minimal environmental impact and water requirement. PV uses raw materials that are effectively in unlimited supply – silicon, oxygen, hydrogen, carbon, aluminium, glass and steel – plus small amounts of other materials.

Wind energy is an important complement to PV because it often produces at different times and places, allowing a smoother combined energy output.

In terms of annual electricity production, wind remains ahead of PV, but PV is growing much more

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rapidly. As the wind energy resource is much smaller than the solar resource, PV will dominate in the end.

Other low-emissions energy technologies can realistically play only minor supporting roles. The solar thermal industry is hundreds of times smaller than the fast-growing PV industry (due to higher cost), meaning an extravagant growth rate sustained over many decades would be required to catch up.

The resource base for hydro, geothermal, wave and tidal is significant only in some regions. Energy from biomass suffers from very low efficiency of sunlight capture, and unresolved conflict with food and ecosystems for land, water, fertilisers and pesticides. Nuclear is too expensive, and planning and construction rates are far too slow, to catch up with PV and wind.

Stabilising an electricity grid with high levels of variable PV and wind is straightforward (as explained in the ScienceDirect article, 100% renewable electricity in Australia) and comprises storage and strong interconnection with high voltage cables over large areas to smooth out the effect of local weather.

By far the leading storage technologies are pumped hydro and batteries, with a combined market share of 97 per cent, according to the DOE Global Energy Storage Database’s global project installations over time. For more information see The Conversation’s Want energy storage? Here are 22,000 sites for pumped hydro across Australia and Explainer: What can Tesla’s giant South Australian battery achieve?

The cost of PV and wind have been declining rapidly for many decades and is now in the range $55-$70 per megawatt-hour in Australia. This is below the cost of electricity from new-build coal and gas units.

There are many reports of PV electricity being produced from large-scale plants for $30-$50 per megawatt-hour (for example, the RenewEconomy article, Energy market tipping point is coming, and fast).

PV and wind have been growing exponentially for decades. In 2017, PV and wind comprised 60 per cent of net electricity generation capacity additions world-wide, with coal, gas, nuclear, hydro and other renewable capacity comprising the rest (Figure 2).

Importantly, the combined global installed generation capacity of PV and wind has now reached half that of coal and will pass coal in the mid-2020s on current growth trends. It seems likely that global coal generation capacity will peak in 2019 and decline thereafter.

In Australia, PV and wind comprise effectively all new generation capacity. About 10-11 gigawatts of PV and wind is expected by the Federal Government’s Clean Energy Authority to be installed in 2018 and 2019, compared with peak demand of 36 gigawatts in the national electricity market.

This installation rate is sufficient for Australia to reach 50 per cent renewable electricity by 2024 and 100 per cent in the early 2030s – meeting Australia’s Paris emissions target entirely by emission reductions within the electricity system (as explored further in the paper, Australia’s renewable energy industry is delivering rapid and deep emission cuts).

The amount of electricity required to completely displace fossil fuels is about three times current electricity consumption.

The cost of meeting Australia’s Paris target is zero because of the low and declining cost of PV and wind (for more information, see The Conversation’s What’s the net cost of using renewables to hit Australia’s climate target? Nothing).

Globally, the share of annual generation by PV and wind is no longer invisible – together they are producing about 8 per cent of the world’s electricity and they are growing much faster than competitors. The worldwide growth rate of new PV and wind capacity over the past five years is 28 per cent and 13 per cent
WIND POWER: PROS AND CONS

PROS OF WIND ENERGY

- Wind energy is clean, causing no pollution or waste.
- Wind creates a lot of energy, if well located.
- Wind is renewable, which means that it can never be used up, and is always available.
- It is a well-established, predictable, safe form of renewable energy.
- Wind is a good energy source for people living far away from conventional sources of power requiring power lines.
- Wind farms can coexist with agricultural operations as an income supplement for struggling farmers.
- Once the farms are established, wind power is a very cheap form of energy to produce.
- It is much easier and faster to build wind farms than coal-fired or hydro-powered plants in order to generate the same amount of electricity.
- Energy security is guaranteed as wind is a free, local renewable resource, not controlled by global markets.

CONS OF WIND ENERGY

- Wind turbines can be noisy and impact on the mental health of people living nearby.
- Wind turbines can be visually unappealing as they need to be located in open and exposed places.
- Although the costs are decreasing, wind energy is still more expensive than coal and gas-generated power.
- Relies on the wind, which is variable and unpredictable.
- Direct supply of electricity from turbines is unreliable due to wind not blowing steadily.
- Requires many resources as well as fossil fuels to create the wind farms, e.g. trucks/construction materials.
- In isolated areas people using wind power have to store electricity in batteries or rely on other energy sources to compensate for changing supply.
- Large areas of cleared land is required for the turbines.
- Turbine blades can harm birdlife who fly into them.

These trends are already well established and would yield a 56 per cent reduction in current greenhouse gas emissions (Figure 1) at zero net cost.

The best available prices for PV already match the current wholesale price of gas in Australia ($10-15 per gigajoule after losses, according to the Department of the Environment and Energy’s Gas Price Trends Report 2017).

The outlook for the oil and gas industries is poor as PV prices continue to fall. High temperature heat, industrial processes, aviation and shipping fuel, and fugitive emissions can be displaced by renewable electricity and electrically produced synthetic fuels, plastics and other hydrocarbons. There may be a modest additional cost depending on the future price trajectory of PV and wind.

Taken together, the amount of electricity required to completely displace fossil fuels is about three times current electricity consumption. In other words, worldwide electricity production must triple.

Remarkably, current annual global growth rates of PV (with support from other renewables) are enough to eliminate coal, oil and gas use in the 2040s (Figure 3 shows the first 14 years). Continued rapid growth of PV and wind (with support from other renewables) will minimise dangerous climate change with minimal economic disruption. Many policy instruments are available to hasten their deployment.

Government policy should recognise PV and wind as the by far the cheapest route to deliver the necessary solution to global warming in a short time frame.

This essay was written for the ANU College of Asia & the Pacific’s Paradigm Shift: Securing our Energy publication, which can be downloaded at http://asiapacific.anu.edu.au/energysecurity

WILL PUMPED HYDRO UNLOCK THE TRANSITION TO RENEWABLES?

Could Australia’s oldest renewable source of energy be the key to a renewable energy future? ARENA explains how pumped hydro could play a key role in the transition to renewables

With Snowy 2.0 officially signed off by its board this week, Tasmania’s ‘Battery of the Nation’ making progress and the NSW Government announcing its pumped hydro roadmap, all signs point towards the technology underpinning Australia’s renewable energy transition.

The resurgence of interest in hydroelectricity marks a return to the future moment for Australia’s energy generation. Since Tasmania’s Waddamana hydropower plant supplied Australia’s first transmitted electricity in 1916, other states took a different path. In 1921, the first sod was turned at the site of Gippsland’s Loy Yang A brown coal power station, which was sending 75 MW of electricity towards Melbourne. Other mainland states also took advantage of plentiful supplies of coal.

Now, in the search for more low emissions sources of electricity generation, hydroelectricity is making a comeback in a big way. Unlike hydro plants of the past, the new generation are embracing pumped hydro technology. Using excess renewable energy at periods of low demand, water is pumped uphill to be stored in a reservoir that functions like a ‘natural battery’. When energy demand and prices rise, the water is released to power a turbine to create electricity.

Compared with other storage options available today – like grid scale batteries that are most cost-effective for short periods – pumped hydro can produce large amounts of electricity over a long duration. While there are only a few pumped hydro systems operating in Australia today, almost all of energy storage capacity in the USA is supplied by pumped hydro.

And plans are in place to dramatically increase Australia’s pumped hydro capacity as more renewables come online and the need for storage grows. This week, the board of Snowy Hydro approved the “Snowy 2.0” plan to add 2,000 MW of new renewable pumped hydro capacity to the iconic Snowy Hydro Scheme. Located between Sydney and Melbourne in the Snowy Mountains, the proposed expansion will bolster the National Electricity Market (NEM) with 175 operating hours of storage.

In a statement released after the meeting, Snowy’s board said that "After almost two years of rigorous due diligence on every aspect of the Project, including detailed financial analysis and ongoing geotechnical drilling, the Board is confident Snowy 2.0 is a strong
Snowy 2.0 will now need to be approved by the Federal Government, as the sole shareholder of Snowy Hydro after the Commonwealth bought out NSW and Victoria. Federal Minister for Energy Angus Taylor has said the government will now consider Snowy 2.0 on their merits.

For Tasmania, hydroelectricity has never gone away. The technology first revolutionised industry in the 1920s before growing to today supply more than 90 per cent of the state’s electricity requirements. Now work is underway to scope whether the island state could become the ‘battery of the nation’, supplying storage for the NEM as renewables take over from aging coal plants.

ARENA funding is supporting the studies, including the scoping of potential new pumped hydro locations. As part of the project, Hydro Tasmania has found 14 locations for new pumped hydro storage, with a total generation capacity of 4,800 MW. The shortlisted locations are being refined further to meet the target of 2500 MW set out in the Battery of the Nation plan.

This week, the Tasmanian Government – with Minister Taylor – put out a white paper with analysis from Hydro Tasmania that outlined how the proposed second interconnector across the Bass Strait would unlock new renewable energy generation. At present, Tasmania export electricity to the mainland at Basslink’s capacity.

Hydro Tasmania’s analysis also indicated that 400 MW of “latent dispatchable capacity” in the system could be unlocked with no new investment required, with more interconnection and the right market signals. More capacity could also be found by upgrading existing hydro assets at Gordon and Tarraleah.

New South Wales is now looking to build on Tasmania’s success, releasing a plan to “supercharge nature’s battery” with 24 potential pumped hydro sites shortlisted for development. With 7,000 MW of capacity, the NSW Energy Minister Don Harwin said the projects could supply 50 per cent of the state’s peak demand on the hottest summer days.

The Minister said the “roadmap will drive investment to ensure our energy system in NSW is robust and reliable into the future, better for our environment and importantly – cheaper for households and businesses.”

In late October, ARENA announced funding for Origin Energy to scope the feasibility of almost doubl-

### HYDRO POWER EXPLAINED

- Hydroelectric power is produced by passing water, usually from a reservoir or dam, through an electricity generator known as a turbine. As the water passes through the turbine blades, it drives the generator to convert the motion into electrical energy.
- Hydropower includes a number of generation and storage technologies, for the most part hydroelectricity and pumped hydro energy storage (PHES).
- PHES uses water reservoirs as a way of storing energy. Excess energy, either from the grid or a renewable energy source such as a wind or solar farm, can be used during low demand periods to pump water from a lower dam to a higher one, essentially converting the upper reservoir into a giant battery.
- The stored energy can then be released by returning the water through a hydroelectric turbine into the lower reservoir. Hydroelectricity can be generated almost immediately and at any time, making it possible for the power to be fed into the grid when it is needed, to help reduce surges, avoid blackouts, or meet spikes in electricity demand.
- Hydroelectricity has been providing around 5-7% of Australia’s total electricity supply for several decades and is currently the largest source of renewable energy in Australia, accounting for around 40% of the nation’s renewable energy.
- There are over 100 operating hydroelectric power stations in Australia, both large and small, mostly located in south eastern Australia, including the well-known Snowy Mountains Hydro-Electric Scheme. There are also three major PHES systems connected to the national electricity grid.

Compiled by The Spinney Press.
ing the capacity of its existing Shoalhaven pumped hydro power station in the NSW Southern Highlands which was built back in 1977. If the project proceeds, Origin’s Shoalhaven plant could provide power to 80,000 homes.

Based on the events of the week, it is a safe bet that pumped hydro will play an important role in Australia’s transition to renewables.

**Australian Renewable Energy Agency (ARENA) (14 December 2018).**

*Will pumped hydro unlock the transition to renewables?*


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**Hydroelectric power: pros and cons**

### PROS OF HYDRO ENERGY

- Hydro is renewable and clean, unlike greenhouse gas-emitting resources such as coal, oil and gas.
- Does not require the transportation or use of fuel, saving money and the environment.
- Energy storage (pumped hydro) is possible with most hydro power plants, making them ideal storage for wind and solar power which are intermittent in nature.
- Low operating costs and little maintenance. Most hydro plants are automated, requiring minimal staff and overheads.
- Relatively cheap to produce as it depends on water, a renewable resource, and not the price of uranium, gas or oil, enabling suppliers to keep prices low for consumers.
- Hydroelectric plants have a much longer life span than those used for other power sources, lasting 50-100 years, making them very profitable.
- Hydro power is much more reliable than wind and solar, though less reliable than coal and nuclear as a baseload source of power. Hydroelectricity is mostly predictable, although it can decrease in summer months when the water is low in catchment areas.
- Small and versatile—small and micro hydroelectric power plants don’t require large-scale set-up and can draw on lesser bodies of water than large dams, such as small rivers to channel water through a turbine. Hydroelectricity can be produced at almost any size, making it very versatile.

### CONS OF HYDRO ENERGY

- Hydroelectric energy does in fact create pollution in the form of carbon dioxide and methane emissions during the initial establishment stage; greenhouse gases are emitted when huge levels of carbon are released from trees and plant life from the initial flooding of the reservoir.
- Wildlife and fish are affected by the creation of dams, as the normal flow of the river is completely changed to essentially form a lake, destroying native habitats.
- Large dam construction has been linked to increased incidence of earthquakes in China and India.
- When water flows it transports particles downstream, having a negative effect on dams and subsequently their power stations, particularly those on rivers or within catchment areas with high siltation.
- Hydro cannot be built anywhere, but rather only in specific places with compatible geography and water supply.
- Constructing a large hydro power project can take between 5-10 years to complete, which can lead to time and cost overruns.

Compiled by The Spinney Press.
Renewable ocean energy harnesses the power of the oceans to produce electricity. This can be done in several ways, but the resources that have the most immediate potential in terms of energy production for Australia and globally are:

- Waves: using wave energy converters (WEC) to generate electricity
- Tides: using tidal barrages, fences and turbines to generate electricity.

Several wave energy converters, tidal turbines and tidal stream devices are at various stages of development in Australia. While there are many more devices in Australia, those mentioned below reflect the diversity of the technologies.

Ocean Energy in Australia

Carnegie is a private company that has developed wave energy technology. It has one wave unit deployed off the coast of Garden Island in Western Australia, supplying power to the Royal Australian Navy base located on the island. There are plans to deploy further devices.

This unit is a “point absorber”, which means it can accept wave energy from any direction. It is out of sight under the waves and works by pumping water to the surface and through a hydro turbine to generate electricity. This high pressure ocean water can also be used in a desalination plant to produce fresh water.

Oceanlinx has several designs under development. They are oscillating water columns, which operate like a blowhole; waves flow into and out of a tunnel, displacing air and forcing it through a turbine. These devices are a “line absorber”. This means that they need to be oriented toward the wave front to generate energy.

Ocean Power Technologies Australasia plan to construct a 19 MW point absorber wave farm off the coast of Victoria. The rise and fall of the waves causes a floating buoy to move up and down. The oscillating action is converted to electricity via a mechanical generator.

BioPower Systems have both wave and tidal energy devices. A pilot plant is being developed at Port Fairy in Victoria using the BioWave wave energy converter. The BioWave is an inverted pendulum design and it mimics the motion of kelp in the ocean by swinging back and forth with wave motion. This swinging motion is turned into electrical energy.

Tenax have plans to deploy tidal turbines which can be used to harness both tidal and ocean current flows. They want to deploy the technology off the coast of Darwin to take advantage of the larger tides in that region.

International Testing

Each of these technologies has key advantages and disadvantages over alternative renewable technologies.

On the positive side, ocean energy is more forecastable and consistent than wind and solar photovoltaics. But the ocean is a tough environment in which to operate continuously over long periods of time.

Internationally, there are a number of marine energy test centres in countries such as the United Kingdom, USA, Ireland and Netherlands for testing the capabilities of devices in the oceans over a longer period of time.

Several wave energy converters, tidal turbines and tidal stream devices are at various stages of development in Australia.

A wave farm was constructed in Portugal using the Pelamis device, but due to financial uncertainty in the region it was abandoned. The Pelamis device is like a long snake that sits on the surface and individual parts move and drive a hydraulic fluid through a motor.

A wave test facility has been operating at Lysekil in Sweden since 2001 using an array of Seabased AB point absorber wave energy devices. This site is now being turned into a full-size wave farm using the same technology. The first generator was installed in March 2013.

As the UK and Ireland have large tidal resources, a tidal turbine has been deployed off the coast of Northern Ireland, supplying electricity to the grid.

An Alternative to Other Renewables?

There is still much to be understood about the tech-
By combining Australian wave energy resource data and the performance curve of one type of wave energy converter, we can determine the annual amount of electricity (MWh) that could be generated from farms of such devices. The best places for wave power in Australia are along the south coast of Western Australia, South Australia, Victoria and Tasmania.

There is still much to be understood about the technologies and the ocean renewable resource itself.

Tidal power is currently only cost-competitive in areas with large tidal resources. However, there may be niche opportunities in remote areas which rely on more expensive generation options, such as in northern Australia and regions of the Bass Strait.

The potential for wave energy in Australia in particular is large. CSIRO modelling has shown that by 2050, wave energy has the resource and the economic potential to supply up to 10% of Australia’s future projected electricity demand. Wave energy could also have an impact globally with significant potential in Europe, Canada, USA and South Africa.

DISCLOSURE STATEMENT

Jenny Hayward was involved in the technology cost projections of the Australian Energy Technology Assessment undertaken by BREE as referenced in this article. Chris Knight does not work for, consult, own shares in or receive funding from any company or organisation that would benefit from this article, and has disclosed no relevant affiliations beyond his academic appointment.

Jenny Hayward is Research Scientist, Energy Economist, CSIRO.

Chris Knight is Senior Research Engineer, CSIRO.

OCEAN ENERGY: PROS AND CONS

PROS OF OCEAN ENERGY

- Clean – wave energy and tidal energy do not produce greenhouse gases or other pollution while operating, and reduce reliance on fossil fuels. There are also no waste products created by ocean power generation.
- Renewable – wave energy and tidal energy both use the natural dynamics of the abundant ocean, and do not use any non-renewable fuels to generate electricity.
- Abundant – wave and tidal power generators are built along coastlines, offering huge potential to countries with long coastlines.
- Lower running costs than other forms of power generation such as oil, coal and nuclear plants.
- Visibly non-intrusive – most ocean power technologies are either underwater or have a low profile above water, making them less aesthetically disruptive than wind, solar and other land-based energy technologies.

CONS OF OCEAN ENERGY

- Marine life may be affected, particularly through being struck by turbine blades; studies are still determining how often this happens in reality. Tidal barrages could also change the salinity of water in enclosed bays and rivers, having detrimental effects on marine plants and animals.
- Weather effects – extreme weather events like storms and hurricanes can damage ocean power technology, particularly those anchored to the sea floor, increasing maintenance and repair costs.
- Locations are highly limited.
- Could change coastal structure and cause erosion of dunes.
- Expensive to research and build; investors may become reluctant to fund these projects as many don’t make a return for years.

Compiled by The Spinney Press.
GEOTHERMAL ENERGY: PROS AND CONS

Geothermal energy is heat derived from the Earth. Generally, temperature increases with depth in the Earth – this is the geothermal gradient. The temperature at the centre of the Earth is estimated to be more than 6000°C. Heat flows from hot to cold: the flow of heat from the centre of the Earth to the surface and into space is called ‘heat flow’.

- Geothermal energy is abundant, one of the cleanest and most reliable sources of energy, with minimal wastes or pollutants, and virtually 100 per cent sustainable. Unlike most renewable resources, geothermal energy is not variable and does not require energy storage to provide a constant supply of electricity or heat.
- Australian geothermal installations include many ground source heat pumps, numerous direct-use installations (e.g. heating large swimming pools), spas and one operating electricity generation plant at Birdsville. Most direct-use installations are in the Perth, Otway, Gippsland and Great Artesian basins. Most ground source heat pumps are installed in the colder parts of Australia.
- The geothermal sector in Australia is still in the early stages of development. There has been no noticeable recent growth in electricity generation for Australia from this energy source.


![PROS OF GEOTHERMAL ENERGY](https://via.placeholder.com/150)

- Renewable and almost inexhaustible – while the heat of a hot rock reservoir tapped for its energy can be depleted, it will eventually be replaced. If managed carefully, geothermal resources can be used sustainably.
- Baseload – unlike other renewable energy sources like solar and wind, it does not rely on favourable weather conditions, or storage systems, to generate power and could be available all the time.
- Domestically available – Australia has a range of potential geothermal resources, which if tapped will reduce the need to bring in energy from abroad.
- Non-polluting – modern closed-loop geothermal power plants emit little to no greenhouse gases, lifecycle greenhouse emissions are lower than for solar/natural gas; and geothermal power plants use less water than other conventional power generation technologies.
- Small footprint – geothermal power plants are compact and require less land than coal, wind, hydro or solar operations.

![CONS OF GEOTHERMAL ENERGY](https://via.placeholder.com/150)

- Technical challenges – the techniques for tapping hot rock resources are still being developed.
- Start-up costs – initial costs of establishing hot rock geothermal operations are very high due to the lack of existing technologies and the costs of drilling.
- Infrastructure – the position of geothermal sources in Australia is scattered and variable; site distance from population centres can be a problem.
- Contamination – in some systems, the hot geothermal fluids contain dissolved minerals and gases which might risk groundwater contamination and the release of greenhouse gases into the atmosphere.
- Seismic effects – hydrofracturing process employed in the creation of hot rock reservoirs can induce low-level seismic activity or mini earthquakes.

Compiled by The Spinney Press.
BIOENERGY

BIOENERGY AUSTRALIA EXPLAINS HOW RENEWABLE SOURCES CAN PROVIDE US WITH FUEL, GAS, HEAT AND POWER

ABOUT BIOENERGY

Imagine energy made from renewable sources that could fuel your car, warm your home, or transport a plane. This energy source is not a fossil fuel, unlike petroleum, it is sustainable and increases the security of our energy supplies. It is sourced affordably and locally, and its industry stimulates regional development and employment in Australia.

This is the future: bioenergy

Bioenergy is energy derived from plants, animals, and their by-products and residues. Agriculture, farming, human habitation and forestry generate crop wastes and remains, manures and sludges, rendered animal fats, used oils, and timber residues. These products are known collectively as “biomass”. Biomass converted to bioenergy can provide the power for our cities and industries, the liquid fuel for our planes and automobiles; it can heat our showers, and warm and cool our homes.

For example:
• We can create liquid fuel from sugarcane crop residues and used cooking oil.
• We can create gas for heating and power from poultry farms and animal manures.
• We can create heat from waste nut shells.
• We can create power from timber industry waste materials.

Bioenergy is the world’s primary source of renewable energy, providing approximately a tenth of the world’s total primary energy. It has a long track record of cost-effectively reducing carbon emissions, improving energy productivity, generating reliable baseload renewable energy, and growing regional jobs around the world. But these technologies are not widely deployed in Australia, contributing only 0.9 per cent of Australia’s electricity output, well below the OECD average of 2.4 per cent.

Estimates indicate that bioenergy could sustainably contribute between 25% and 33% to the future global primary energy supply (up to 250 EJ) in 2050. It is the only renewable source that can replace fossil fuels in all energy markets – in the production of heat, electricity, and fuels for transport. Bioenergy has a vital role to play as part of Australia’s clean energy future.

FUEL

Bioenergy derived from biomass can create liquid biofuels for transport, replacing petrol for cars and diesel in trucks. Biodiesel, bioethanol and biocrude are all biofuels that can be used as renewable alternatives to fossil-based fuels.

Estimates indicate that bioenergy could sustainably contribute between 25% and 33% to the future global primary energy supply in 2050.

Biofuels can be used to reduce emissions and improve Australia’s energy security. Australian biodiesel has the potential to reduce emissions by over 85 per cent in comparison to diesel, and Australian bioethanol can reduce emissions by approximately 50 per cent. Liquid biofuels are the only viable low-carbon technology for heavy transport, freight, aviation, defence and shipping applications.

Aviation fuels from biomass offer a huge opportunity for airlines who have committed to adopting sustain-

BIOENERGY: PROS AND CONS

PROS OF BIOENERGY
• Bioenergy emits little to zero net greenhouse gas emissions.
• Bioenergy is also a useful way of disposing of waste debris.
• It is a well-established technology, able to deliver reliable energy.
• Storage involves minimal energy loss.
• In plentiful supply where there are forestry and agricultural crops.
• Bioenergy assists in reducing erosion, stabilising and improving soils.
• Cogeneration power plants are able to generate both heat and electricity.

CONS OF BIOENERGY
• Bioenergy is more expensive than fossil fuels, because it requires more fuel to produce the same amount of energy.
• Can also be expensive to produce when factoring in the total cost of harvesting, extracting, transporting and handling biomass.
• Uses a lot of wood from natural forests, contributing to deforestation.
• Sooty particles can be released causing widespread pollution if wood is not fully burnt.
• Land and water resources used for biomass crops would be better dedicated to food production.
• Accounts for only 1.5% of Australia’s energy mix and lacks the capacity to provide consistent baseload power.

Compiled by The Spinney Press.
able aviation fuels as part of their plans to reduce greenhouse gases. Qantas, Virgin, Jetstar and Air New Zealand are just a few of the airlines already running commercial biofuel flights, and Virgin Australia is planning to regularly use biofuels on flights out of Brisbane.

Global biofuels production in 2014 was 126 billion litres and has grown at an annual rate of 15 per cent since 2000. Australia has successful bioethanol and biodiesel plants, and several pilot projects are underway to increase the production of the next generation of biofuels.

GAS
Biogas is a methane-rich gas which is produced when organic matter is broken down by bacteria. It is made from organic materials such as agricultural and food processing waste, sewage, plant materials, green waste or food waste. Biogas can even come from landfills where wet organic wastes are decomposing anaerobically in municipal waste sites and dumps.

Biogas is a very flexible bioenergy source. It can be cleaned to meet natural gas standards and used similarly to other gases: compressed as a transport fuel in cars, buses and trucks; for heating, cooling and cooking; and in specially designed gas engines which turn the gas into energy for powering transmission systems.

The nutrient-rich sludge that remains after anaerobic digestion, called digestate, is also a valuable biofertiliser. It can support food production and further reduce greenhouse gases by decreasing our reliance on energy-intensive manufactured fertilisers.

HEAT
In some countries around the world, more energy is required for heating purposes than for electrical power. Renewable heat can be derived from bioenergy feedstocks, such as forestry residues and other biomass products, and turned into energy for heating living and working spaces, and water.

In the United States, for example, one-quarter of the total delivered energy consumption provides heating and cooling for buildings, domestic water, and a variety of industrial processes. In Scandinavian countries such as Sweden, Denmark, and Finland, renewable heat is the leading bioenergy source and makes a substantial contribution to the energy consumption of those populations.

Wood pellets from forestry wastes and other forms of biomass can be used as a direct replacement for generators and power plants that have previously used coal, oil or diesel. Renewable thermal technologies offer clean, efficient, safe and cost-competitive alternatives to fossil fuels in replacing these conventional energy sources. They reduce emissions and air pollutants without sacrificing living comforts. Bio-heat is considered to be the ‘sleeping giant’ of the bioenergy world.

POWER
Bioenergy derived from biomass can create sustainable and reliable electricity. Unlike many other renewable energy sources, bioenergy can be stored and deployed to meet demand as they vary, making bioenergy a potentially valuable component of a reliable renewable energy integrated grid.

It is the only renewable source that can replace fossil fuels in all energy markets – in the production of heat, electricity, and fuels for transport.

Biomass and organic waste streams – whether in liquid, solid or gaseous forms – can produce power-using technologies which are readily available internationally and in Australia.

But producing electricity from bioenergy is still in its infancy in Australia. According to the Clean Energy Council’s Clean Energy Report 2016, 1.5% of total Australian electricity generated in 2016 was from bioenergy. Most generation comes though the Australian sugar industry (480 MW of installed capacity) from post processing sugarcane residue.

According to the Clean Energy Finance Corporation, most electricity generation from bioenergy facilities in Australia is small plants with capacity less than 10MW [source: The Australian bioenergy and energy from waste market, Nov 2015]. The long-term potential for electricity from biomass in 2050 could be as much as 72,629GWh/year – approximately 40 times the current level.

To build a sustainable, dependable electricity network there is a growing need for renewable electricity that is dispatchable, reliable and independent of wind and solar energy. Bioenergy can provide that electricity, and play an important role across the country as we move sensibly towards a carbon-neutral future.

Removing the prohibition on nuclear power

Minerals Council of Australia presents the case for removing the nuclear ban

It's time to rethink Australia's ban on nuclear power. Nuclear energy was banned less than two decades ago in Australia, a decision that has cost the nation significant global investment and scientific collaboration on new nuclear technologies.

Nuclear power was prohibited in Australia in 1998, horsetraded for the passage of legislation centralising radiation regulation. Public debate at the time, flamed by the anti-nuclear movement, centred on the replacement of the Lucas Heights reactor. The political fix was to draw a line through the industry. After all, the need for nuclear was low – energy was affordable, abundant and with a country full of coal, there was no reason to believe that would change.

The good news is the nuclear ban can be reversed with a single amendment to the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth). The removal of four words – ‘a nuclear power plant’ – in Section 140A(1)(b) would allow nuclear industries to be considered for development in Australia. Any nuclear projects would still have to meet Australia’s stringent environmental and safety requirements.

Nuclear energy is a readily deployable, zero emissions, baseload energy and it shouldn’t be excluded from Australia’s energy mix. It has met energy challenges around the world, powers more than 30 economies and been deployed at substantial scale within a decade in countries such as the UAE.

Nuclear power is also behind the new generation of innovative nuclear start-ups, such as Bill Gates’ TerraPower and Transatomic out of MIT. Australia, with its educated workforce, established uranium, nuclear research and university sectors and strong non-proliferation credentials, would be a partner of choice for private venture capital-funded new nuclear.

Global investment and scientific collaboration on nuclear technologies and fuel development are just four small words away from becoming a job-creating reality in Australia.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969</td>
<td>Proposal to build Australia’s first nuclear power plant in Burrup, Western Australia, was voted down by Parliament, despite its political promise for the nation’s energy future.</td>
</tr>
<tr>
<td>1980s-90s</td>
<td>Anti-nuclear movement gains momentum, driven by public concern over nuclear waste management and leaks in the Lucas Heights reactor.</td>
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<tr>
<td>1998</td>
<td>The Australian Nuclear Safety and Regulator Agency Act 1999 (ANSSRA) passes through Senate and is enacted into law. The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) are merged and renamed the Australian Nuclear Science and Technology Organisation (ANSTO).</td>
</tr>
<tr>
<td>1999</td>
<td>Nuclear plants are required to have cooling towers and underground storage facilities for nuclear waste.</td>
</tr>
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</table>

THE CASE FOR REMOVING THE NUCLEAR BAN

1. Reliability

Nuclear power is reliable. In the United States, nuclear power provides around 20 per cent of the country’s electricity needs. America’s almost 100 reactors have been operating on average at over 90 per cent of their rated capacity. In early 2014, US nuclear power plants were instrumental in supplying power during an extreme polar vortex when gas electricity generation was disrupted due to frozen pipelines.

2. Zero carbon emissions

Nuclear power has close to zero carbon emissions. The National Renewable Energy Laboratory in the US concluded emissions from nuclear (12g CO2-e/kWh) were less than solar PV (18-50g CO2-e/kWh) and equivalent to wind (12g CO2-e/kWh). Nuclear is also a high-density energy – one drum of uranium oxide could power almost 2,000 average Australian homes for a year.

3. Proven technology

Nuclear power is a proven technology. Thirty countries operate nuclear power plants today. Nuclear power generates around 11 per cent of global electricity consumption and underpins electricity supply in many of them. More than 220 new plants are under construction or planned. France produces over three-quarters of its electricity via nuclear power and as a consequence has amongst the lowest emissions per kWh in the industrialised world.

Australia is the only high electricity consuming country without nuclear – or plans to include nuclear – in its energy mix.

Top 20 highest electricity consumption countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Nuclear power consumer</th>
<th>Nuclear power planned</th>
<th>Nuclear power prohibited</th>
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<tbody>
<tr>
<td>China</td>
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<td>US</td>
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<td>South Korea</td>
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<td>United Kingdom</td>
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<td>Saudi Arabia</td>
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<td>Taiwan</td>
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<tr>
<td>Australia</td>
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<tr>
<td>South Africa</td>
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* More than 80 per cent of electricity imported by Italy comes from nuclear-powered countries. Source: BP Statistical Review of World Energy June 2017.
4. Affordable
Nuclear power is affordable. All baseload power projects are capital intensive, but countries that invest in nuclear plants – and there are 58 reactors under construction today – will have assets that generate large amounts of power for 60 years at a stable cost. Small modular reactors (SMRs) are close to commercialisation in the US. A Nu-scale 50MWe SMR, for example, is projected to cost around US$250 million.10 Three of these would cost and produce around the same amount of power as the largest wind farm in the southern hemisphere – and it would be reliable, synchronous, on-demand power.

Comparable in size and cost – but only nuclear provides 24/7 reliability

Nuclear power has a much smaller footprint than wind and solar

5. Safe
Nuclear power is safe. Studies repeatedly show that nuclear power is safe. A study commissioned by Friends of the Earth in the UK concluded that: “Overall the safety risks associated with nuclear power appear to be more in line with lifecycle impacts from renewable energy technologies”.21 Of the three well-publicised accidents in almost four decades, two resulted in no radiation-related fatalities.

6. Low waste
Nuclear power produces low waste. Nuclear waste is low in volume, completely contained and can be managed safely. The South Australian Nuclear Fuel Cycle Royal Commission “found that there are now advanced programs in a number of countries that have developed systems and technologies to isolate and contain used nuclear fuel in a geological disposal facility.”22

7. Global innovation
Nuclear innovation is surging. New generation nuclear is being driven by private sector-funded development of innovative nuclear technologies, such as Bill Gates’ Terrapower, MIT’s Transatomic and Oklo Inc, and the Gateway for Accelerated Innovation in Nuclear (GAIN). Removing Australia’s ban on nuclear power would see international nuclear innovators engage Australian scientists, engineers and universities in technology and fuel development leading to jobs, high-tech R&D and potentially the development of a global SMR manufacturing hub.13

HOW TO REMOVE THE NUCLEAR BAN IN AUSTRALIA

While the prohibition on nuclear power exists in two Acts of Parliament, only one needs immediate reform to allow the development of a nuclear industry to be considered – the Environment Protection and Biodiversity Conservation Act 1999. A similar prohibition appears in the Australian Radiation Protection and Nuclear Safety Act 1998, but this applies only to Commonwealth entities and is therefore not an immediate barrier for the consideration of nuclear power by either a state government entity or a private sector developer.

Environmental contribution of nuclear industries: Australia vs Canada

<table>
<thead>
<tr>
<th></th>
<th>Australia</th>
<th>Canada</th>
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<tbody>
<tr>
<td>Jobs</td>
<td>60,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Value</td>
<td>A$600m</td>
<td>C$5b</td>
</tr>
</tbody>
</table>

The EPBC Act Section 140A(1)(b) that requires deletion.
NEXT STEPS TOWARDS A FUTURE NUCLEAR INDUSTRY

Repealing s140A(1)(b) of the EPBC Act is the critical first step. This will allow global entrepreneurs and innovators to develop and commercialise their designs and technology in Australia, with the prospect of possible deployment in the vast array of Australia’s energy applications.

The repeal of s140A(1)(b) does not mean a nuclear power plant will be built in Australia. A nuclear power plant would firstly need to be economic and secondly, would trigger an environmental approval requirement by the federal government. Nevertheless, the removal of the prohibition in the EPBC Act would incentivise private activity with the prospect that a development which is economic, safe and environmentally sustainable could be implemented in the future.

Other reforms that should be pursued concurrently include:

- The establishment of a Commonwealth government working group, perhaps under the auspices of the COAG Energy Council, to investigate and advise state and federal ministers on a regulatory pathway for environmental approval of specific nuclear power generation proposals. This could be done with assistance from the International Atomic Energy Agency.
- Removing uranium mining, milling, decommissioning and rehabilitation from the definition of a ‘nuclear action’ in the EPBC Act. These activities are not nuclear actions. They are mining activities. Uranium projects should not automatically trigger a duplicative federal/environmental approval process, and the costs and delays that come with that, for no environmental benefit.

ENDNOTES

2. World Nuclear Association, World nuclear power reactors & uranium requirements, August 2017.
11. Tyndall Centre, A review of research relevant to new build nuclear power plants in the UK, January 2013.
20. Prof S Davidson and Dr A de Silva, Realising Australia’s uranium potential, Minerals Council of Australia, October 2015.

Nuclear power stations are not appropriate for Australia – and probably never will be

Periodically, as with the changing of the seasons, various individuals appear in the media extolling the virtues of nuclear energy, promising a panacea of clean and reliable electricity to solve Australia’s energy crisis. But the truth is far less rosy, according to these arguments from the Climate Council

WHAT IS A NUCLEAR POWER STATION?

Nuclear power stations run on uranium. When the nucleus of a uranium molecule is split inside a reactor, heat is produced. This process is called nuclear fission. The heat produced from this process is used to create steam from water. The steam drives a turbine that powers a generator. The generator creates electricity.

Unlike coal and gas, no greenhouse gas pollution is created in the operation of the nuclear reactor. However, all other steps involved in producing nuclear power (from mining, to construction, decommissioning and waste management) result in greenhouse gas pollution. But nuclear energy is not “renewable”. Uranium is a finite resource just like coal or gas.

NUCLEAR ENERGY DOESN’T MAKE SENSE IN AUSTRALIA

Australia exports very large amounts of uranium to other countries – we are the third largest uranium producer in the world.

However, there are a number of reasons why nuclear power is not appropriate for Australia:

1. Nuclear power stations are highly controversial, can’t be built under existing law in any Australian state or territory, and are a more expensive source of power than renewable energy, and present significant challenges in terms of the storage and transport of nuclear waste, and use of water.

2. Nuclear power stations also present significant community, health, environmental, and cost risks associated with potential impacts from extreme weather events and natural disasters, such as occurred in Fukushima, Japan in 2011. Nuclear power stations leave a long-term and prohibitively expensive legacy of site remediation, fuel reprocessing and radioactive waste storage.

3. Australia is one of the sunniest and windiest countries in the world, with enough renewable energy resources to power our country 500 times over. When compared with low-risk, clean, reliable and affordable renewable energy and storage technology in Australia, nuclear power makes no sense.

NUCLEAR POWER STATIONS ARE EXPENSIVE

Nuclear power stations are extremely expensive to build. For example, the Hinkley nuclear power station under construction in the UK will cost 20 billion pounds (AU$36 billion).

Nuclear cannot compete on a cost basis with wind and solar, which are the cheapest forms of new generation. The cost of energy from the Hinkley Power station is significantly higher than large-scale solar, wind and offshore wind energy in the UK.

ON AVERAGE, NUCLEAR POWER STATIONS TAKE A DECADE TO BUILD

The Hinkley power station will take nine years to build. The global average is 9.4 years. This would be even longer in Australia given there is currently no nuclear industry here. It is not unusual for nuclear power stations to take over a decade between the start of approvals and coming online. For comparison, wind and solar farms take just one to three years.

Australia cannot wait this long to replace our ageing fleet of coal power stations, which are already struggling to cope with extreme heat.

NUCLEAR POWER STATIONS ARE INFLEXIBLE AND ILL-SUITED TO A MODERN GRID

Nuclear power stations are inflexible – that is, they cannot quickly increase or decrease the amount of electricity they produce.

Nuclear power generation is not well suited to modern, fast and flexible electricity grids with large amounts of wind and solar generation. Unlike inflexible nuclear, fast response technologies such as batteries, pumped hydro and solar thermal can be turned on and off, or ramped up and down to balance electricity supply and demand.

In California, where wind and solar provides more than 30% of the state’s power needs, the last nuclear power plant will shut by 2026.

NUCLEAR POWER STATIONS NEED A LOT OF WATER

Nuclear power stations require massive quantities of water to operate. In a dry continent like Australia, prone to hot summers and drought conditions which are only likely to get more severe as climate change worsens, it would be reckless to rely on a water-hungry power source like nuclear.

The bottom line is this: it makes no sense to build nuclear power stations in Australia.
HYDROGEN: HELP OR HYPE?

Australia’s government is currently developing a strategy for including hydrogen in a future low-carbon energy system. Andrew Reddaway at Renew magazine looks at where it has potential, and where it doesn’t.

Much is being made of the announcement that at the Tokyo Olympic Games next year, hydrogen will burn in the Olympic torch and even power the athletes’ village. By some accounts, in the not-too-distant future we’ll all be using this high-energy, ‘clean’ fuel to run our cars, heat our homes, cook our food and power our electric appliances. But as we transition to a low-carbon energy system, how much of this posited ‘hydrogen economy’ is realistic, and how much is hype?

Australian federal and state governments are working on a hydrogen strategy document to be completed by the end of this year. Renew’s energy projects team has been involved in the roundtable discussions for the strategy, and has developed a discussion paper exploring the areas in which hydrogen for energy has potential, and where it is better avoided in favour of more efficient alternatives. In this article, we take a brief look at some of the team’s findings.

What is hydrogen?

Hydrogen is a gas which burns very cleanly, leaving behind only water vapour. It can be used to generate heat or electricity, including for use in transport, with no greenhouse gas emissions. It can act as energy storage and can also be transported, opening the door for energy export. However, thus far its use for energy purposes has been very limited. Currently, it is produced from fossil fuels and used in industries such as metalworking, glass and electronics.

The main barrier to more widespread use has been obtaining the hydrogen – unlike fossil fuels there are no geological deposits; instead renewable hydrogen must be created by splitting water, a process that requires energy. (In fact, more energy must be expended to create it than the hydrogen contains.) Thus, hydrogen is only a carrier of energy rather than an energy source.

When produced using renewably generated energy such as solar and wind, hydrogen is a renewable, emission-free fuel. Its main downside is inefficiency, because the required conversions waste a lot of the original energy in losses.

Renewable energy for transport: hydrogen vs batteries

A heavily promoted use of hydrogen is for transport. In a fuel cell electric vehicle (FCEV), hydrogen from the car’s fuel tank is fed into a fuel cell which generates electricity. This is then stored temporarily in a small battery and used to power the car’s electric motor.

Because of the significant energy losses in the process of creating and supplying hydrogen, an FCEV is much less efficient than a battery electric vehicle (BEV) in which renewable electricity is used more directly via the car’s larger battery.

Although these numbers include many uncertainties, when comparing the range of results in these four scenarios it’s clear that renewable hydrogen is an inefficient option to propel a vehicle, compared to using renewable electricity via a battery. Figure 2 presents this in a different way, showing how many more solar panels would be required for a daily 10km commute using hydrogen and an FCEV than using a BEV.

FCEVs also face a chicken-and-egg problem; manufacturers won’t export them to Australia until there’s a refuelling network, but investors won’t build the fuelling stations until they’re confident of business.

The CSIRO is relatively optimistic about the economics of hydrogen for road transport (bit.ly/csro-nhr), but its study considered only vehicles powered by fossil fuel rather than batteries, which are the real competitor...
for hydrogen vehicles. In a few years a BEV’s running cost will be much lower than a petrol car’s. Because of this and the relative inefficiencies of PCEVs, we conclude that Australia should not devote resources to a network of hydrogen refuelling stations. Such efforts should instead be devoted to chargers for BEVs.

Hydrogen in homes and businesses
Natural gas is widely used in Australian homes and businesses for space heating, hot water and cooking. It has traditionally been considered a cheaper and ‘greener’ option than the electric alternative, but this is no longer the case as gas tariffs have risen and efficient electric appliances have been developed. As gas becomes increasingly sourced from coal seams and grid electricity from wind and solar, natural gas will become a liability in the context of reducing emissions.

It’s possible to pipe renewable hydrogen to gas appliances instead, but this has many downsides. Existing gas appliances must all be replaced, as well as valves, meters and so on. Appliances could not be replaced gradually – rather installation must coincide with the gas change-over. We don’t believe this is a realistic prospect; in addition, CSIRO projections indicate that compared to natural gas, consumer bills would increase with hydrogen.

We contend that for powering homes and businesses, efficient electric appliances are a much better option than both fossil natural gas and hydrogen. (Although we note that renewable hydrogen gas may make sense for some large businesses with industrial processes in which electricity is no substitute.)

Hydrogen as exportable energy
One area where a hydrogen industry has significant potential is as exportable energy. For example, Japan is energy-poor and currently relies almost entirely on imports of fossil fuel and uranium, much of it from Australia. It has little suitable land available to host solar farms or wind farms. Japan’s response is a strategy to move toward hydrogen for energy, which states that by 2030 the country will develop supply chains to import 300,000 tons of hydrogen annually. The clear intent is to import multi-use hydrogen generated from renewable energy rather than from fossil fuels, to meet Japan’s commitment to the Paris Agreement. Korea and China may adopt similar strategies.

In contrast to Japan, the Pilbara region of Western Australia has an enormous, high-quality renewable energy resource but no significant market, as the remote area has no transmission line to Perth, let alone the eastern states. A massive project, the Asia Renewable Energy Hub, is in early-stage development. It aims to generate electricity from wind and solar and use it to produce renewable hydrogen for export. Allowing for cost reductions over the next several years, the developer claims that it will produce “the cheapest power in Asia”.

Australia has a great opportunity to develop an industry to export renewable hydrogen (possibly in the form of ammonia, see box) and meet global demand. We are the world’s largest exporter of fossil natural gas; in a future where the world stops burning fossil fuels, our hydrogen exports could displace those of coal and gas.

Producing renewable steel
Coal is important in traditional steel refining processes not only for its heat but also for its carbon, some of which ends up in the steel. Unfortunately, emissions are high: iron and steel manufacture is responsible for 7% to 9% of all direct emissions from fossil fuels. One way to produce emission-free steel is using hydrogen: a pilot plant is currently under construction in Sweden to test the technology.

Since Australia is currently a major exporter of both iron ore and energy, in a future low-carbon world it would seem logical to develop a local industry processing iron ore into steel, using renewable hydrogen. This adds value to the raw commodity, saves energy and cost by transporting a more compact product and reduces energy consumption by our customers, making it easier for them to achieve their own fully renewable energy supply.

Inter-seasonal energy storage
As we progress to a future high-renewable grid, energy will need to be stored in large quantities ready for supply during periods of low generation due to cloudy, calm...
weather. The Snowy Hydro 2.0 pumped hydro facility will meet some of this requirement, since it can supply as much power as a large coal-fired power station for a whole week. However, this asset alone will be insufficient.

One option to boost energy storage is to create renewable hydrogen whenever there’s an oversupply of wind and solar generation. It could be stored for long periods (in salt caverns, or potentially in facilities such as the Iona Underground Storage Facility, a depleted gas field near Port Campbell, Vic, currently used for storing fossil natural gas) and used to generate electricity when required.

Supporting renewable microgrids
On a smaller scale, hydrogen could displace diesel as a backup for off-grid communities supplied by solar and wind.

A prime example is the Daintree region in far north Queensland; the federal government has granted nearly $1m to design and plan a solution for a local electricity grid including a solar farm and hydrogen storage. Such projects have great potential to reduce diesel consumption, and hydrogen’s inefficiency is not so important in situations where excess renewable energy is otherwise wasted.

Ammonia: hydrogen in disguise
Shipping hydrogen is very challenging – it must be either pressurised or liquefied, and both options involve heavy energy losses and other practical difficulties. An alternative is to create and transport ammonia. This gas can be produced from renewable hydrogen, shipped more easily in a standard type of ship much more efficiently than hydrogen, and then converted back or used as a fuel itself. It emits no carbon dioxide when burnt.

Figure 3 illustrates two options to supply enough renewable, stored energy to power one million Japanese homes: an 11.5km square local solar farm plus a pumped hydro facility, and a 14.7km square solar farm in the Pilbara providing energy to create hydrogen-rich ammonia that is shipped to Japan and burned in a turbine to generate electricity.

Although efficiency losses mean a larger scale solar farm is required for the Pilbara option, land there is cheap and abundant compared to Japan, and this option is attractive.

Conclusion
So, is hydrogen a help or just hype? As with most things, the answer lies somewhere in between, and there are various pitfalls and issues requiring consideration.

For a fast transition to a low-carbon energy system, we must make maximum use of renewable energy such as wind and solar. The most efficient use of renewable electricity is to employ it directly via transmission lines or via energy storage.

If it’s converted into hydrogen, much of its energy is lost in the process; thus, hydrogen should be used only where more direct methods are not practical. For example, for road transport we believe resources should be devoted to battery electric vehicle chargers rather than to a network of hydrogen refuelling stations for FCEVs.

Proposals exist to supply hydrogen produced from fossil fuels. Such proposals have been termed ‘brown hydrogen’ and should be viewed critically for their impact on climate change. Most make little sense, as oil, gas and black coal are easier to handle and transport than hydrogen. A variant is ‘blue hydrogen’, which still uses fossil fuels but adds the unrealistic suggestion of carbon capture and storage (CCS) to clean up its emissions.

Water consumption is significant: it takes nine litres of water to produce a kilogram of renewable hydrogen. The impact on our water supplies can be managed by using recycled water and desalination, but this will increase hydrogen’s cost over currently published estimates. Also, safety issues must be managed when transporting hydrogen or ammonia.

However, renewably generated hydrogen is potentially useful in several niche applications as summarised in Table 1.

For export to energy-poor countries, hydrogen’s inefficiency is countered by Australia’s high-quality renewable resources and abundance of land. In a low-carbon future, hydrogen could replace our present fossil fuel exports. To ease shipping challenges, hydrogen may be converted into ammonia.

Within Australia, hydrogen may be very useful for inter-seasonal storage as we approach a fully renewable electricity grid, and perhaps to supplement solar and wind power for off-grid communities.

For deeper analysis and references, please refer to the discussion paper on our website: renew.org.au/research/hydrogen-help-or-hype

Andrew Reddaway is an Energy Analyst in Renew’s Energy Projects team.

EXPLORING ISSUES

WORKSHEETS AND ACTIVITIES

The Exploring Issues section comprises a range of ready-to-use worksheets featuring activities which relate to facts and views raised in this book.

The exercises presented in these worksheets are suitable for use by students at middle secondary school level and beyond. Some of the activities may be explored either individually or as a group.

As the information in this book is compiled from a number of different sources, readers are prompted to consider the origin of the text and to critically evaluate the questions presented.

Is the information cited from a primary or secondary source? Are you being presented with facts or opinions?

Is there any evidence of a particular bias or agenda? What are your own views after having explored the issues?

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MULTIPLE CHOICE 55
Brainstorm, individually or as a group, to find out what you know about Australia’s energy debate.

1. What is non-renewable energy? Provide at least three (3) examples of non-renewable energy sources, and include a brief description of each one.

2. What is renewable energy? Provide at least three (3) examples of renewable energy sources, and include a brief description of each one.

3. What are the major reasons why Australia needs to transition to new energy sources?

4. What are the major reasons behind why Australia is having difficulty in establishing a politically – and environmentally – sustainable energy policy?
Complete the following activity on a separate sheet of paper if more space is required.

*Most of Australia’s energy relies on traditional sources – non-renewable fossil fuels.*  
*Coal and gas account for about 85% of electricity generation.*  


Investigate which non-renewable energy sources make up the majority of Australia’s *current* energy production. Based on the latest data – is it in fact still 85%? Write a few paragraphs identifying what proportion of energy each non-renewable source currently produces, and explain the projected outlook for each of these sources in our energy future. What are the preferred forms of non-renewable energy, and why?


Investigate which renewable energy sources make up the remaining proportion of Australia’s *current* energy production. Write a few paragraphs identifying what proportion of energy each renewable source currently produces, and explain the projected outlook for each of these sources in our energy future. What are the preferred forms of renewable energy, and why?
Energy and climate policy uncertainty in Australia has reduced investor confidence, and continues to hold the country back from making a smooth and orderly energy transition. In the absence of credible federal climate and energy policy, states, cities, businesses and households are increasingly leading this transition.

The Climate Council, Key energy issues.

Form into groups of two or more people and identify the ways in which states, cities, businesses and households are committing to Australia’s energy transition. In your discussion, consider how Australia’s energy future might include a mix of renewables, battery storage, electric vehicles and hydrogen. Choose one specific energy source or initiative and assess how effective it would be in terms of future energy production, infrastructure, efficiency and cost. Discuss your ideas with other groups in the class.

Multiple projections based on the Paris Accord predict that by 2040 we will still be burning about as much coal as we are now. Coal is part of the solution to a transition to new energy sources.

Graham Young, Coal is part of the solution in transition to new energy sources.

Form into groups of two or more people and discuss the role of the coal sector in Australia’s future energy mix. In your discussion, consider coal’s availability, infrastructure and its impacts on the environment, economy and employment. Is coal still an important part of Australia’s energy future? Discuss your ideas with other groups in the class.
Complete the following multiple choice questionnaire by circling or matching your preferred responses. The answers are at the end of this page.

1. According to the Department of the Environment and Energy (2019), coal and gas account for about what percentage of Australia’s current electricity generation?
   a. 25%
   b. 35%
   c. 50%
   d. 65%
   e. 70%
   f. 85%

2. Net exports of Australia’s energy (exports minus imports) are currently equal to what amount?
   a. one-tenth of production
   b. one-quarter of production
   c. one-third of production
   d. one-half of production
   e. two-thirds of production
   f. three-quarters of production

3. Australia’s 2020 Renewable Energy Target (reached in 2019), was based on what percentage of the nation’s energy supply being sourced from renewable energy?
   a. 10%
   b. 20%
   c. 23.5%
   d. 33.5%
   e. 44.5%
   f. 50%

4. In response to climate change, countries around the world including Australia have agreed under the Paris Agreement to limit global temperature rise to how many degrees Celsius?
   a. 1ºC
   b. 1-1.5ºC
   c. 1.5-2ºC
   d. 2-2.5ºC
   e. 3-4ºC
   f. 4-5ºC

5. Which of the following are considered to be disadvantages of solar power? Circle all that apply.
   a. Renewable
   b. Abundant
   c. Expensive to install
   d. Environmentally-friendly
   e. Air polluting
   f. Intermittent
6. Match the following terms to their correct corresponding descriptions.
   a. Bioenergy  1. Refers to all forms of renewable energy derived from the sea.
   b. Geothermal  2. Process in which flowing water is used to spin a turbine connected to an electricity generator.
   c. Hydroelectricity  3. Heat energy from underground used to power steam turbines and generate electricity.
   e. Ocean energy  5. Conversion which generates electric power directly from the light of the sun in a PV cell.
   g. Wind power  7. Produced from hydrogen, the most common chemical in the universe.

7. Respond to the following statements by circling either ‘True’ or ‘False’:
   a. Australia is the world’s largest exporter of coal.  True / False
   b. Australia is the world’s twentieth largest consumer of energy, and fifteenth in terms of per capita energy use.  True / False
   c. Coal is Australia’s top export.  True / False
   d. Australia is now less reliant on coal than at the beginning of the century, when coal’s share was more than 80% of electricity generation.  True / False
   e. Most of Australia’s energy supply is imported.  True / False
   f. 13% of Australia’s electricity was generated outside the electricity sector by industry and households (2018 figures).  True / False
Australia’s energy system is undergoing its greatest transformation since the 1950s. These changes are driven by economic, engineering and environmental factors. Consumer preferences are also changing, with an increasing desire for independence and control over electricity supply and use (Department of the Environment and Energy, *Energy supply*). (p.1)

Most of Australia’s energy relies on traditional sources – non-renewable fossil fuels. Coal and gas account for about 85% of electricity generation (*ibid*). (p.1)

Renewable energy from sources like wind, solar and hydro provide about 15% of Australia’s electricity supply. This includes both large generators and small systems owned by Australian families and businesses (*ibid*). (p.1)

Australia has an estimated 46% of uranium resources, 6% of coal resources, and 2% of natural gas resources in the world. In contrast, Australia has only about 0.3% of world oil reserves (Geoscience Australia, *Energy basics*). (p.2)

Australia produces about 2.4% of total world energy and is a major supplier of energy to world markets, exporting more than three-quarters of its energy output, worth nearly A$80 billion (*ibid*). (p.2)

Australia is the world’s largest exporter of coal. Coal accounts for more than half of Australia’s energy exports. Australia is one of the world’s largest exporters of uranium, and is ranked sixth in terms of liquefied natural gas (LNG) exports. In contrast, more than half of Australia’s liquid fuel needs are imported (*ibid*). (p.2)

Australia is the world’s twentieth largest consumer of energy, and fifteenth in terms of per capita energy use (*ibid*). (p.2)

Australia’s primary energy consumption is dominated by coal (around 40%), oil (34%) and gas (22%). Coal accounts for about 75% of Australia’s electricity generation, followed by gas (16%), hydro (5%) and wind (around 2%) (*ibid*). (p.2)

With the exception of hydro energy resources which are largely developed and wind energy which is growing rapidly, large-scale utilisation of Australia’s renewable resources has been constrained by higher transformation costs relative to other energy sources (except for hydro), immature technologies, and long distances from markets and infrastructure (*ibid*). (p.3)

A major transition is underway in the electricity sector due to: the inevitable retirement of Australia’s ageing, unreliable and inefficient coal-fired power stations; dramatically falling costs for solar, wind and battery storage; rapidly changing consumer preferences in response to high electricity prices and emerging technologies, with many seeking greater control over their power bills; rising domestic gas prices due to expanded liquefied natural gas exports linking Australian gas markets with international markets; and action on climate change requiring an orderly transition from fossil-fuelled power stations to zero emission renewable power sources (The Climate Council, *Key energy issues*). (p.6)

The electricity sector remains the largest source of greenhouse gas emissions in Australia (33.2% of national emissions). Australia’s electricity generation is dominated by coal power plants, most of which are old and often fail in hot weather when they are needed most. Wind and solar are the cheapest forms of new generation, while renewables with storage are now competitive with other forms of generation. The energy transition is already underway (The Australia Institute, *Energy transition: climate of the nation*). (p.7)

Over the last decade, electricity emissions in Australia declined by more than 15% as 12 coal-fired power stations closed down and gas power generation also declined. Renewables now account for more than 20% of generation in the National Energy Market (NEM). The increase in renewables generation over the last decade is equivalent to all Australian energy generation in the 1950s (*ibid*). (p.7)

In response to climate change, countries around the world, including Australia have agreed (under the Paris Agreement) to limit global temperature rise to 1.5-2°C. This requires transitioning away from polluting fossil fuels like coal, oil and gas to solutions such as renewable energy well before 2050. Every country in the world has signed up to the Paris Agreement, although the United States have announced their intention to withdraw (The Climate Council, *Energy policy*). (p.11)

The achievement of the renewable energy target leaves a federal policy void. Renewable energy may now be the lowest-cost source of new electricity supply. But it is competing against assets such as coal-fired power stations with sunk costs – meaning that new renewables projects are essentially competing only with a coal plant’s fuel costs. Absent a price on carbon or similar policy, coal assets are allowed to pollute the atmosphere for free (Dylan McConnell, *The Conversation, Australia has met its renewable energy target*). (p.13)

In the end, politicians will have to make difficult choices between the destruction of sectors of the Australian economy and minimising the risk from climate change. If they have reliable evidence that enables them to make these choices without causing unnecessary harm, it will be easier for them to agree on those choices, free from the impact of vested interests (John McDonnell, *Why no energy policy?*). (p.17)

Multiple projections based on the Paris Accord predict that by 2040 we will still be burning about as much coal as we are now. Coal is part of the solution to a transition to new energy sources (Graham Young, *Coal is part of the solution in transition to new energy sources*). (p.23)

The demand for coal is set to continue for decades – Australia continues to benefit from growing demand for affordable energy in India, China and SE Asia and their collective need for Australian high quality coals (Minerals Council of Australia, *In favour of coal: key points*). (p.23)
**Baseload**
The minimum level of demand (load) on an electricity supply system that exists 24 hours a day.

**Bioenergy**
Decaying plant or animal matter producing gases that can be used to power turbines for electricity generation. Biomass includes wood waste, manure, landfill wastes; crop by-products like sugarcane; and forest by-products. Biomass is a carbon-neutral energy source.

**Carbon**
Chemical element found in all plants and animals on Earth. All molecules that contain carbon are known as organic molecules. When fossil fuels are burned the carbon is released into the air and can join with oxygen to make carbon dioxide.

**Climate change**
Change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

**Coal**
Fossil fuel formed over millions of years from decomposing plants. Coal is burned in power stations to make electricity and as a heat source for industry. Most of the electricity generated in Australia is derived from burning coal. When burned, coal produces large amounts of carbon dioxide, one of the gases responsible for the greenhouse effect.

**Coal seam gas**
CSG is natural gas (methane) sourced from underground coal formations, sometimes known as coal bed methane.

**Electricity**
The flow of electrical power or charge. It is a secondary energy source, meaning it is derived from the conversion of primary sources of energy e.g. coal, natural gas and oil.

**Energy**
The capacity to do work, or many forms of conversion, using various fuels.

**Fossil fuels**
A hydrocarbon deposit in geological formations that may be used as fuel such as crude oil, coal or natural gas. Fossil fuels are non-renewable resources because they take millions of years to form, and reserves are being depleted much faster than new ones are being formed.

**Gas**
Natural gas is formed when layers of decomposing plant and animal matter are exposed to intense heat and pressure under the surface of the Earth over millions of years. The energy that the plants originally obtained from the sun is stored in the form of chemical bonds in the gas.

**Geothermal energy**
Heat energy from underground used to power steam turbines and generate electricity.

**Global warming**
The gradual increase, observed or projected, in global surface temperatures.

**Greenhouse gases**
These are gases in the atmosphere, such as water vapour, carbon dioxide, methane, ozone, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrous oxide that create a greenhouse effect, trapping heat near the Earth's surface.

**Hydroelectricity**
Process in which flowing water is used to spin a turbine connected to an electricity generator; includes pumped hydroelectricity.

**Hydrogen energy**
Produced from hydrogen, the most common chemical in the universe. It can be produced as a gas or liquid, or made part of other materials, and has many uses such as fuel for transport or heating, a way to store electricity, or a raw material in industrial processes.

**Non-renewable energy**
Energy derived from sources which cannot be replaced once used. Non-renewable energy sources include diesel, petrol, LPG, aviation fuel, fuel oil, and fossil fuels such as coal, natural gas and crude oil.

**Nuclear power**
The energy produced by splitting atoms (such as uranium) in a nuclear reactor.

**Ocean energy**
Refers to all forms of renewable energy derived from the sea. There are three main types of ocean technology: wave, tidal and ocean thermal. All forms of energy from the ocean are still at an early stage of commercialisation.

**Renewable energy**
Defined as those energy resources that are naturally replenishing. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include: biomass, hydro, geothermal, solar, wind, ocean thermal, wave action and tidal action.

**Resources**
A concentration of naturally occurring solid, liquid or gaseous materials in or on the Earth's crust in such form and amount that its economic exploitation is currently or potentially feasible.

**Solar power**
Photovoltaic conversion which generates electric power directly from the light of the sun in a photovoltaic (solar) cell.

**Wind power**
The conversion of wind energy into electricity using wind turbines.
Websites with further information on the topic

Australian Energy Regulator  www.aer.gov.au
Australian Energy Resources Assessment (AERA)  https://aera.ga.gov.au
Australian Nuclear Association  www.nuclearaustralia.org.au
Australian Renewable Energy Agency (ARENA)  www.arena.gov.au
Bioenergy Australia  www.bioenergyaustralia.org.au
Clean Energy Council  www.cleanenergycouncil.org.au
Clean Energy Regulator  www.cleanenergypolicyregulator.gov.au
Climate Change Authority  www.climatechangeauthority.gov.au
Climate Council  www.climatecouncil.org.au
Department of the Environment and Energy  www.energy.gov.au
Energy Efficiency Council  www.eec.org.au
Energy Facts Australia (Climate Council)  www.energyfactsaustralia.org.au
Energy Made Easy  www.energymadeeasy.gov.au
Geoscience Australia  www.ga.gov.au/scientific-topics/energy
Grattan Institute  www.grattan.edu.au/home/energy
Minerals Council of Australia  www.minerals.org.au
Renew (Alternative Technology Association)  www.renew.org.au
RenewEconomy  www.reneweconomy.com.au

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