

END OF THE LINE: COAL IN AUSTRALIA



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Key Findings

1

Burning coal is the most polluting way to generate electricity.

- › Australia's coal dominated electricity sector produced a third of Australia's greenhouse gas pollution in 2017 (excluding land use).
- › Greenhouse gas pollution levels in the electricity sector have increased by 42% since 1990, largely from the burning of fossil fuels, especially coal.

2

There is no such thing as clean coal. No matter how "efficient" a coal-fired power station claims to be, it is always polluting.

- › A new "high-efficiency" coal power station using black coal would produce about 75% of the emissions of an existing power station of a similar size.
- › In some cases, coal power stations with carbon capture and storage (CCS) can actually result in more emissions than a standard coal power station.
- › Worldwide there are only two coal power stations with CCS currently operating.
- › Despite hundreds of millions of dollars of investment in "clean coal" technology in Australia over the past two decades, no commercially viable project has ever been developed.
- › The estimated cost of building a coal power station with CCS in Australia is over six times the equivalent cost of Australia's largest wind farm.

3

Australia's ageing coal power stations are unreliable and prone to breaking down in extreme weather events.

- › In the seven-month period to the end of June in 2018, there have been almost 100 breakdowns at fossil fuel power stations in the National Electricity Market.
- › Ten of Australia's coal power stations have already shut down over the last six years. At least eight more coal power stations are anticipated to close by 2040.
- › The Yallourn coal power station in Victoria is the most emissions intensive power station in Australia. It is also one of the oldest.

4

The burning of coal produces pollution that can cause a range of health problems including lung cancer, heart disease and premature death.

- › Hundreds of thousands of deaths occur each year in China and India from the burning of coal for power.
- › In the United States, 50,000 deaths annually are attributed to air pollution from coal-fired power stations, with coal contributing to four of the five leading causes of mortality.
- › In Australia, at least 11 people died from the effects of the 2014 Hazelwood mine fire in Victoria.
- › Coal miners in Queensland have experienced a re-emergence of black lung disease.

5

To protect Australians from accelerating climate change all of Australia's undeveloped coal reserves must stay in the ground and we must transition to clean, affordable and reliable renewables and storage.

- › If Australia is to do its fair share to tackle climate change effectively, no more coal-fired power stations should be built and no more coal deposits should be developed in Australia.
- › Wind and solar are the cheapest forms of new energy generation.
- › Renewables and storage beat coal on pollution, cost, reliability and health outcomes.
- › Renewables already generate 17% of Australia's electricity and there are no technical limitations to an electricity grid powered entirely by renewable energy and storage.
- › Over 30 major international companies have ruled out financing or stopped working for Adani on their Carmichael Mine project in Queensland. This includes Australia's 'Big Four' banks (ANZ, Commonwealth Bank, NAB and Westpac).

Introduction

Australia's coal power stations are not fit for purpose to power a 21st century economy. The majority of Australia's inefficient, ageing and polluting coal power stations are reaching the end of their operating lives, with at least eight expected to close over the next two decades (AEMO 2017c). These outdated power stations are increasingly unreliable, unsafe and struggle to operate in extreme weather conditions such as heatwaves (The Australia Institute 2018).

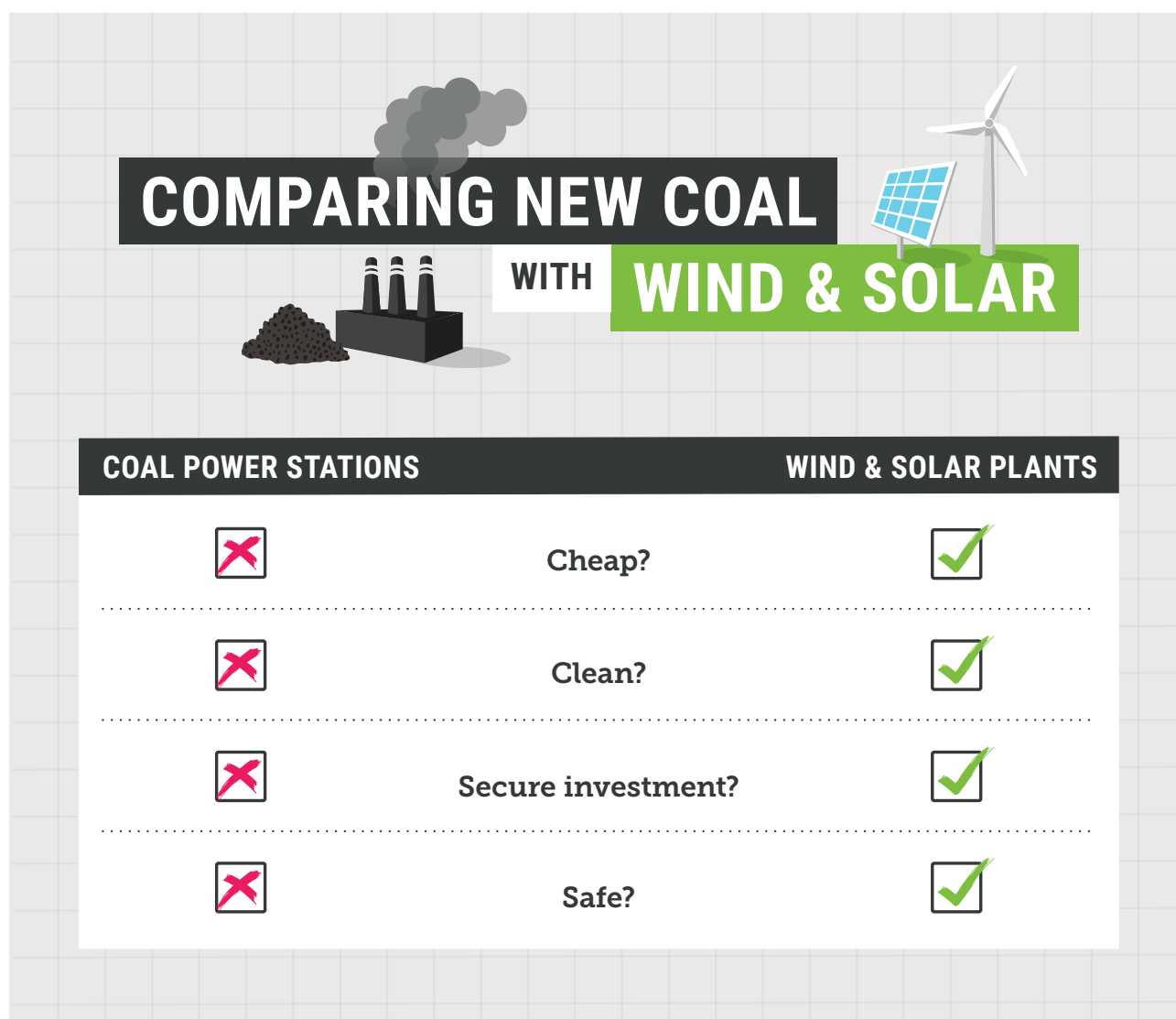
Building new coal power stations and extending the life of old coal power stations is extremely expensive. For example the cost of extending the life of the Liddell Power Station for an additional five years was estimated at \$920 million (Australian Financial Review 2018). Furthermore, new coal power is the most expensive form of new power generation (BNEF 2017).

There is no such thing as "clean coal". All coal power stations – old or new – cause greenhouse gas pollution. Coal power also emits toxic and carcinogenic air pollutants that are harmful to human health (Climate Council 2014). If Australia is to do its fair share to tackle climate change, no more coal-fired power stations should be built and no more coal deposits should be developed in Australia.

This report outlines why coal has no future in a modern 21st century electricity system in Australia. The nation is transitioning to renewable energy and storage technologies that provide a clean, affordable and reliable supply of electricity to meet the needs of Australians 24/7.

No more coal power stations can be built in Australia.

Figure 1: Renewables beat new coal on cost, pollution and safety while being a secure investment.



1. Coal is highly polluting

Burning coal is the most polluting way to generate electricity. Coal is responsible for the vast majority of Australia’s greenhouse gas emissions from the electricity sector. In order for Australia to meet its share of global commitments to limit the impacts of accelerating climate change and extreme weather events, all of Australia’s coal power stations must be retired, with no new coal power stations built.

Australia’s coal dominated electricity sector is the nation’s single largest source of greenhouse gas pollution. Australia’s electricity sector produced 33% of Australia’s emissions in 2017 (excluding land use emissions) (Department of the Environment and Energy 2018). Greenhouse gas pollution levels in the electricity sector have increased by 42% since 1990, largely because of the burning of fossil fuels, especially coal (Department of Environment and Energy 2018).

Australia produces a large amount of greenhouse gas pollution compared to the amount of electricity we generate. This means Australia’s electricity grid is very emissions intensive. Australia’s coal fired power stations use old technology and poor quality coal (Caldecott et al 2015). This is especially true in Victoria, where brown coal fuels the three dirtiest power stations in Australia. Ten of Australia’s coal power stations have already shut down over the last six years (refer to Table 1; APH 2017). At least eight more coal power stations are expected to close by 2040 (AEMO 2017).

Table 1: Ten of Australia’s coal power stations in the National Electricity Market have closed since 2012. Only three of these ten coal power stations reached 50 years of age.

Power station	State	Capacity (MW)	Age at time of closure
Morwell	VIC	189	56
Playford	SA	240	56
Hazelwood	VIC	1,760	53
Anglesea	VIC	160	46
Collinsville	QLD	180	44
Munmorah	NSW	600	43
Swanbank B	QLD	500	42
Wallerawang	NSW	1,000	38
Northern	SA	546	31
Redbank	NSW	144	13

Source: APH (2017).

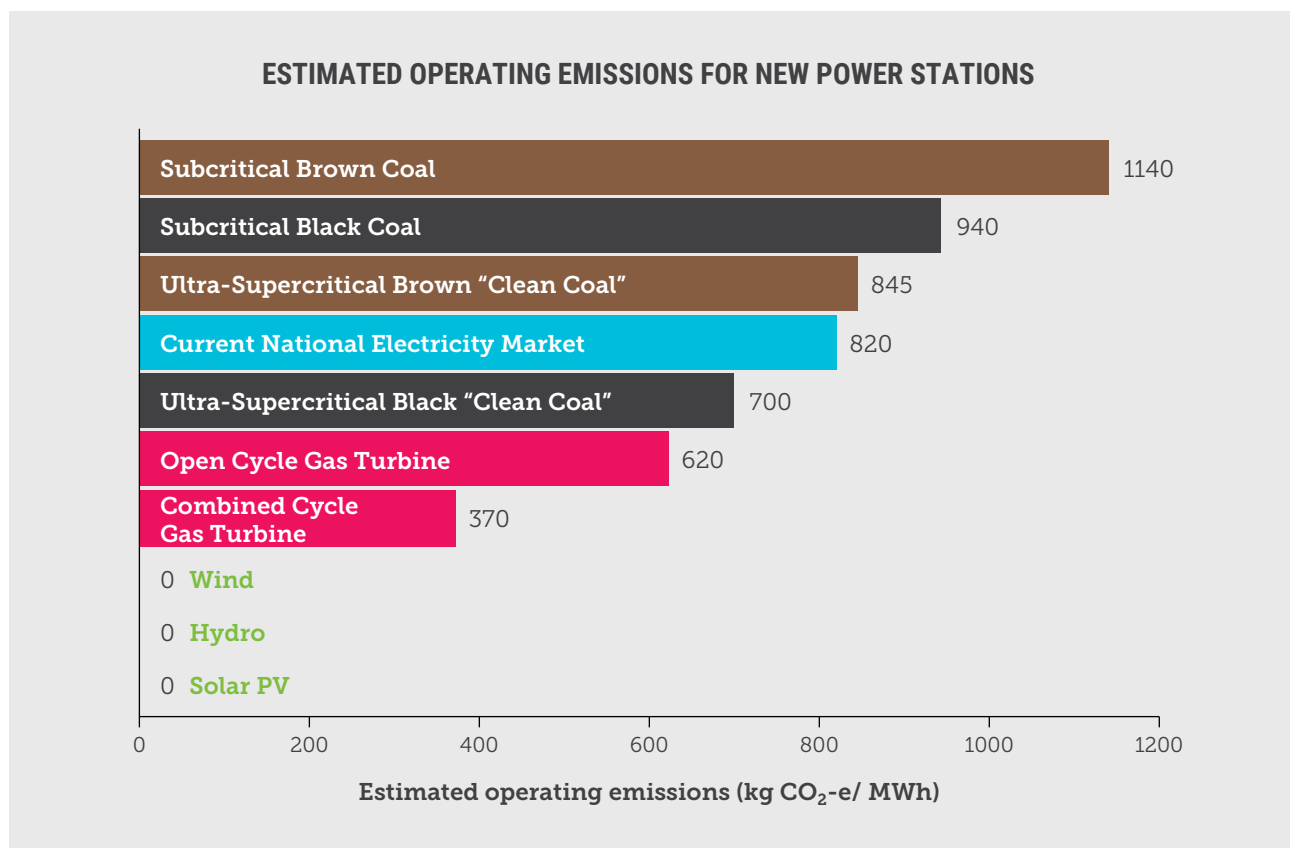
All coal power stations – new and old – burn coal and create greenhouse gas pollution. This is true of all coal power stations, whether they are labelled “ultra-supercritical” or “high efficiency low emissions (HELE)” or not. There is no such thing as “clean coal”.

Coal with carbon capture and storage (CCS) is also polluting. CCS is a technology used to capture, transport and store pollution from fossil fuel power stations and energy intensive industries (eg. cement, steel and chemical production). A new “high-efficiency” coal power station using black coal would still produce about 75% of the emissions of an existing power station of a similar size (refer to Figure 2). In contrast, renewables such as wind and solar produce zero emissions during their operation. In some cases, coal power stations with CCS can actually result in more emissions than a

standard coal power station (Rubin et al 2015). Worldwide there are only two coal power stations with CCS currently operating. Both of these power stations capture only a small proportion of their emissions and pump them underground in order to extract more oil. When this oil is burnt, this creates even more pollution (refer to Box 1).

No matter how “efficient” a coal-fired power station claims to be, it is always polluting. The term “clean coal” is an oxymoron. To meet our share of preventing more intense climate change, Australia must progressively retire and close all coal fired power stations, while replacing them with clean renewable energy and storage in a planned transition prior to their closure date. Put simply, in order to effectively tackle climate change, no new coal power stations should be built in Australia.

Figure 2: All coal fired power stations are polluting. There is no such thing as “clean coal”.



Source: Finkel (2016); The Climate Institute (2017).

BOX 1. WHY COAL POWER STATIONS WITH CARBON CAPTURE AND STORAGE END UP POLLUTING MORE

There are only two operational coal power stations with carbon capture and storage. Both these power stations capture only a small part of their greenhouse gas pollution and pump it underground as a means to extract oil. This process is called “enhanced oil recovery” (EOR) (Rubin et al 2015). The result is that once this extracted oil is burnt, these coal power stations with CCS and EOR cause more greenhouse gas pollution than a standard coal power station.

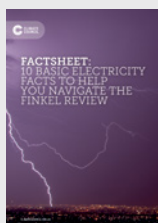
The CCS process for the Petra Nova power station in the United States results in 32% more carbon dioxide emissions overall due to the additional oil extracted.

Key facts include:

- › Coal burnt at Petra Nova power station produces around 21 million tonnes of CO₂ per year.
- › CCS only treats around 10% of the greenhouse gas pollution of this power station. Though 90% of these emissions are captured, a new 70MW gas power station was required to produce the energy to run the capture process. This adds emissions (Global CCS Institute 2017).
- › The captured CO₂ is then injected underground to enhance oil extraction, enabling the production of 14,500 barrels of extra oil a day (Upstream Online 2017).
- › When burnt (in cars, planes and heating) this additional oil produces 2.2 million tonnes CO₂ per year (EPA 2017).
- › The net result is that emissions not captured from the coal power station, the gas power station and additional oil extracted and burnt produce an extra 600,000 tonnes of CO₂ per year.

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For more details on “clean coal” and carbon capture and storage, please refer to the Climate Council’s Facsheet:



[‘Facsheet: 10 Basic Electricity Facts to Help You Navigate the Finkel Review’.](#)

2. The carbon budget: no more coal

Australia's burning of fossil fuels is driving climate change. In order to avoid dangerous climate change, 95% of Australia's coal reserves must stay in the ground.

Scientists have been warning for decades that rising global temperatures, driven by greenhouse gas pollution, will have very harmful, and perhaps catastrophic, consequences for humanity. In response, governments the world over have agreed to keep global temperature rise to no more than 2°C above pre-industrial levels.

If we are to have any chance of meeting this target, we need to rapidly reduce our greenhouse gas emissions and transition towards a decarbonised society. The carbon budget is an approach used to track progress against this goal. The carbon budget is a simple, scientifically-based method to determine how much carbon humanity can "spend". The higher the probability of meeting the warming limit, the more stringent the budget. That is, the less carbon we can spend.

A 2017 economic analysis of how much coal, oil and gas can be burned for the world to have a 50% probability of keeping global temperature rise below 2°C found that 95% of Australia's coal reserves and 51% of our gas reserves must be left in the ground (McGlade and Ekins 2015).

95% of Australia's coal reserves must stay in the ground in order to avoid dangerous climate change.

'Reserves' are defined as the fraction of fossil fuel resources that are economically profitable to exploit under current conditions. Resources on the other hand refer to all known deposits of fossil fuels, including those that are not profitable to extract under current conditions. Thus, reserves are a sub-set of resources.

In terms of resources, Australia's coal resources are so vast that exploiting them would consume two-thirds of the entire global carbon budget for a 75% chance of meeting the 2°C Paris target.

Furthermore, the carbon budget does not allow for any exploitation of unconventional oil or gas resources (McGlade and Ekins 2015). Only a very rapid phase-out of Australia's thermal

coal industry is compatible with staying within a 2°C carbon budget. Moreover, no new coal resources should be developed, including the huge resources in the Galilee Basin in Queensland.

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For more information on Australia's carbon budget, please refer to the Climate Council's report:



'Critical Decade 2017:
Accelerating Climate
Action'.

Figure 3: The Yallourn coal power station in Victoria is the dirtiest power station in Australia. It is also one of the oldest.



3. Coal is unreliable

Australia's ageing coal power stations are unreliable and prone to breaking down in extreme weather events. They are slow to respond to changes in supply and demand and struggle to quickly ramp up and down. Coal power stations cannot be depended upon to provide a reliable supply of electricity. Relying on them as they age and weather extremes intensify will increase electricity supply risks.

Australia's electricity generation is dominated by old, inflexible and polluting coal-fired power stations. Within a decade, half of Australia's coal-fired power stations in the National Electricity Market will be over 40 years old (Finkel 2017). These power

stations are technically already obsolete and increasingly unreliable. Faced with extreme weather events driven by climate change, these power stations already fail, on occasion leading to blackouts (AEMO 2017a).

Recent reports by the Australian Energy Market Operator (AEMO) (2017a) have highlighted the risk posed by ageing fossil fuel power stations to Australia's energy supply, particularly during extended heatwaves. One report states that "The overall responsiveness and resilience of the system is at risk from increased vulnerability to climatic events, such as extended periods of high temperatures, and the risk of loss of, or reduction in output of, major generation units" (AEMO 2017a, p. 1).

Table 2: The oldest coal power stations in Australia's National Electricity Market. Four of the six oldest coal power stations are in New South Wales.

Power station	State	MW	Age in 2018 ¹	Unit Trips between Dec 1 2017 and July 1 2018 ²
Liddell	NSW	2,000 ³	46	8
Yallourn	VIC	1,450	44	14
Gladstone	QLD	1,680	42	10
Vales Point	NSW	1,320	40	3
Eraring	NSW	2,880	36	-
Bayswater	NSW	2,640	36	1
Loy Yang A	VIC	2,180	34	15
Tarong	QLD	1,400	34	5
Callide B	QLD	700	29	3

Sources: APH (2017); The Australia Institute (2018).

¹ Where units at power stations were commissioned over several years, the age of the oldest unit has been listed.

² Only includes unit trips of greater than 100MW.

³ The Liddell power station has been de-rated to an effective capacity of 1680MW. This has significantly reduced the number of unit trips at the power station.

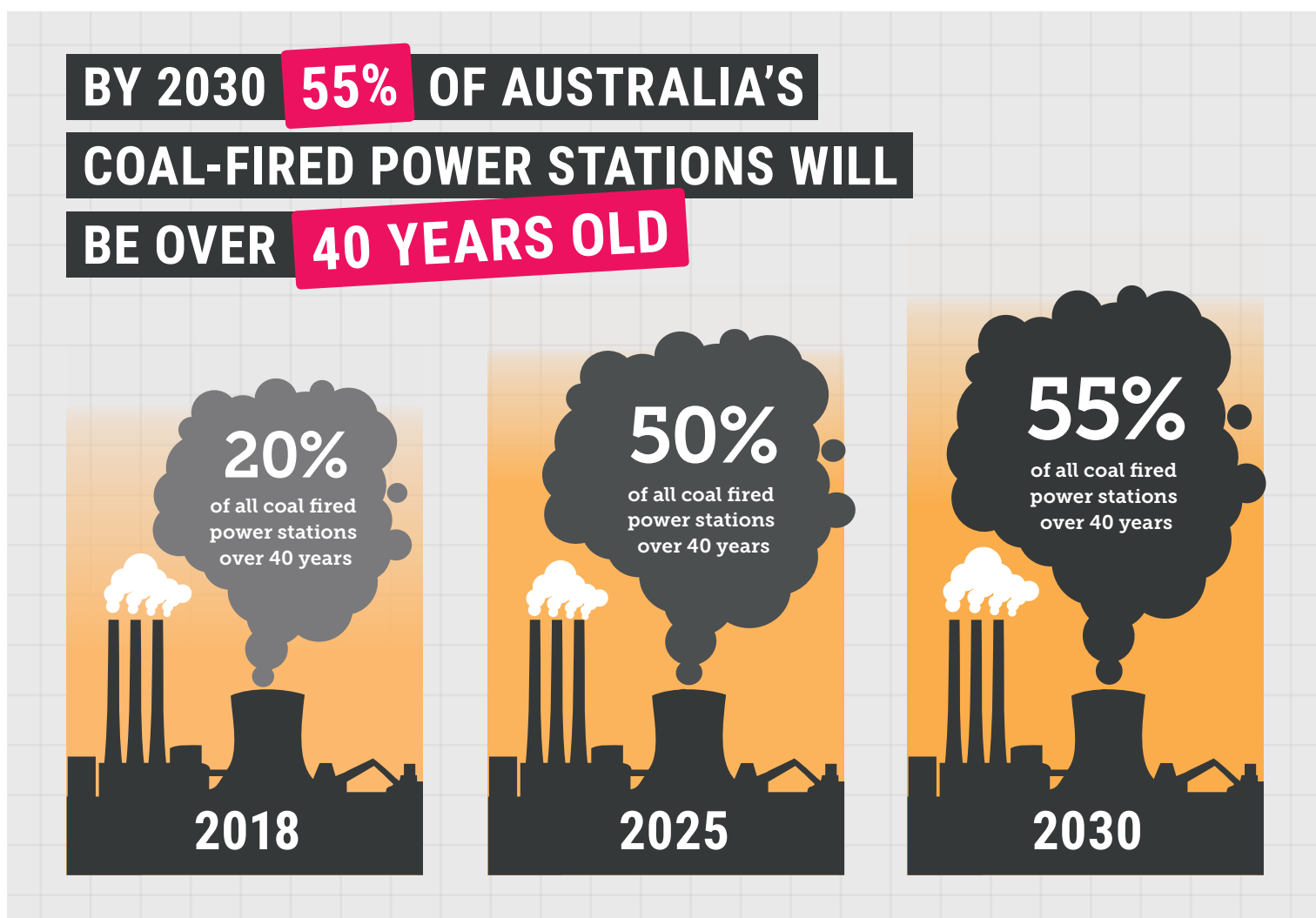
AEMO have also identified ageing coal power stations as a significant risk to a reliable electricity supply: "While no generation withdrawals have been announced in Victoria, there are risks of significant failure or outages in scheduled generation, due to the state's aging coal fleet... this risk exists for all coal generators across the NEM..." (AEMO 2017a, p. 38)

Many of these coal power stations are already failing when needed most, even though these power stations are aged in their 30s and 40s (AEMO 2017b). In the

seven-month period to the end of June in 2018, there have been almost 100 breakdowns at fossil fuel power stations in the National Electricity Market (refer to Table 2; The Australia Institute 2018). On average that is equivalent to a coal and gas power station breaking down every two to three days.

In a future where climate change driven extreme weather events like heatwaves, bushfires and storms are more frequent and more severe, coal power stations cannot be depended upon to provide a reliable supply of electricity.

Figure 4: Australia's coal fired power stations are ageing and becoming increasingly unreliable.



4. New coal is expensive

Building new coal power stations or extending the life of existing power stations is very expensive. It would cost billions of dollars.

By 2030, 55% of coal power stations in the National Electricity Market will be over 40 years old (Finkel 2017). Once power stations reach 40 years old, they become increasingly expensive to continue operating as maintenance costs increase. Extending the life of old, inefficient coal power stations beyond their technical life, even for a short period, is extremely expensive.

For example, the cost of extending the life of the Liddell Power Station in New South Wales for five years beyond its planned closure date (2022) is estimated to be \$920 million (AGL Energy 2017). Companies owning these power stations and investing money in refurbishments will inevitably pass costs on to consumers through increased power bills. Refurbishment investments are high risk as remaining operating years to recover the investment may be cut short by subsequent failures.

Building new coal power stations with CCS is the most expensive way to replace Australia's ageing coal fleet (BNEF 2017). There are only two operating coal power stations with CCS in the world: Boundary Dam in Canada (US\$1.5 billion for 110MW) and Petra Nova in the United States (US\$1 billion for 240MW). A further project, the Kemper Power Station, was intended to be the largest coal power station with CCS in the United States but the plan to use coal was scrapped in 2017 after costs doubled to reach US\$7.5 billion (ARS Technica 2017).

It would cost almost a billion dollars to extend the life of the Liddell Power Station for just five years.

These power stations required very large government subsidies to build and both only capture a small part of their greenhouse gas pollution. Solar and wind projects are substantially cheaper to build. The estimated cost of building a coal power station with CCS in Australia is upwards of \$352/MWh – over six times the equivalent cost of Australia’s largest wind farm (refer to Table 3). Unlike the price of renewable energy, which continues to fall, the cost of CCS is increasing substantially over time (Rubin et al 2015).

Despite hundreds of millions of dollars of taxpayer subsidies for so-called “clean coal” technology in Australia over the past two decades, no commercially viable project

has been developed (SMH 2018). Renewable energy and storage have won the affordability race. Wind and solar are the cheapest forms of new generation (BNEF 2017).

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For more information on the myths surrounding “clean coal”, please refer to the Climate Council’s briefing paper:



[‘Clean Coal: Briefing Paper’](#).

Table 3: The cost of building a new power station.

Power Technology	Levelised Cost of Energy (LCOE)\$ (AUD)/MWh
SA Solar Thermal Plant	\$78 ¹
Wind	\$60 - 118 ²
Solar	\$78 - 140
Gas Combined cycle	\$74 - 90 ³
Coal	\$134 - 203
Coal with CCS	\$352

Source: Climate Council 2017b.

¹ Government of South Australia 2017

² Note recent prices for wind are “well below” \$60/MWh.

³ Based on gas prices of \$8/GJ. Current gas prices are much higher than this, and at peak times can be up to 2-3 times higher.

5. Investing in coal is risky business

New coal power stations are risky for private investors. They risk becoming stranded assets and shutting well before the end of their technical life. Corporations also risk damage to their reputations by investing in coal. To avoid these risks banks, insurers, pensions funds and other financial institutions are choosing not to invest in, or moving investment away from coal mines and coal power stations.

Any new coal fired power station built in coming years will need to continue operating well beyond 2050 in order to achieve a return on investment. This is not consistent with tackling climate change as electricity emissions need to reach zero well before 2050. This means there are a range of financial risks attached to coal investments. These include carbon pricing risk, higher financing costs, the risk of shorter lifetime due to regulatory closure reducing the amount of time to recover capital and achieve any return, risk of the asset becoming stranded, corporate reputational risk, and potential for legal damages against directors and senior officers of the company (WRI 2015; Actuaries Institute 2016).

Australian companies in the financial and energy sectors are increasingly reacting to this risk. For example, over 30 major international companies have ruled out financing or stopped working for Adani on their Carmichael Mine project in Queensland (Market Forces 2018). This includes Australia's 'Big Four' banks (ANZ, NAB, Commonwealth Bank and Westpac) (Market Forces 2018).

Over 30 major international companies have ruled out financing or stopped working on Adani's proposed Carmichael Mine.

A range of global companies are also responding to this risk. The Norwegian Government Pension Fund Global, the largest pension fund in the world, has announced that it will reduce its exposure to fossil-fuel risk by divesting more of its coal-related holdings (The Guardian 2016a). This follows a number of high profile divestments including those by Stanford University and the Rockefeller Brothers Fund. One of the world's largest investment banks, HSBC, has also sounded the warning bell regarding stranded assets resulting from investment in fossil fuels (Clean Technica 2015). In July Swiss Re, the world's second largest reinsurer, announced it would no longer underwrite policies for companies with more than 30% exposure to thermal coal mining or generation (AFR 2018a).

The Australian Prudential Regulation Authority has recently warned insurers, banks and superannuation funds that climate change risks to their businesses should be reported. Climate change is now a risk management issue for business and they should take action to reduce this risk (AFR 2017). A number of large global banks including JP Morgan Chase, BNP Paribas, Crédit Agricole, HSBC, ING, Natixis, Société Générale have agreed to not directly finance new coalmines around the world (BankTrack 2016). Some of these banks have also ended direct financing of new coal power stations.

For more information on the business risk of investing in coal, refer to the Climate Council's report:



'Risky Business:
Health, Climate and
Economic Risks of the
Carmichael Coalmine'

6. Coal is not safe

The burning of coal produces pollution that can cause a range of health problems including lung cancer, heart disease and premature death.

When dug up and burned, coal pollutes the environment and damages our health. Burning coal for electricity emits toxic and carcinogenic substances into our air, water and land, severely impacting on the health of miners, workers and communities. Every part of coal's lifecycle drives adverse health impacts. This includes lung cancer, bronchitis, heart disease and other conditions of ill health, often leading to premature death (Epstein et al 2011). Hundreds of thousands of deaths occur each year in China and India from the burning of coal for power (Health Effects Institute 2016; 2018). In the United States, 50,000 deaths annually are attributed to air pollution from coal-fired power stations, with coal contributing to four of the five leading causes of mortality (Jones et al 2016).

In Australia, air pollution from coal mine fires increases the risk of cancers, respiratory diseases and heart diseases in nearby populations. At least 11 people died from the effects of the 2014 Hazelwood mine fire in Victoria (refer to Figure 5) and coal miners in Queensland have experienced a re-emergence of black lung disease (ABC News 2014; Queensland Government 2016). The impacts of coal on the health of Australians costs taxpayers about \$2.6 billion every year (The Australian Academy of Technological Sciences and Engineering 2009).

Coal is responsible for \$2.6 billion in health costs to Australian taxpayers every year.

As Australia's coal power stations age, they are increasingly unsafe for workers. The only safe use of coal is to leave it in the ground.

As coal power stations age, the steel used to build them suffers fatigue, and their equipment wears out, parts of the power stations require significant upgrades to ensure they are safe for workers. Numerous leaks of highly pressurised steam were reported in the final years of the Hazelwood coal power station, as well as other workplace accidents (ABC News 2016). The cost of making the power station safe was a major factor leading to the closure of the power station in 2017 (The Guardian 2016b). Australia's oldest coal power station, the Liddell power station in New South Wales, would also require significant upgrades to continue operating safely beyond 2022 (AFR 2018b).

For more information on the negative health effects of investing in coal, refer to the Climate Council's report:



['Joint Statement on the Health Effects of Coal in Australia'.](#)

Figure 5: Negative health effects from the 2014 Hazelwood mine fire are believed to have been responsible for the deaths of at least 11 people.



7. There is no future for coal

While coal served its purpose in the 20th century, coal has no future in a modern 21st century electricity system which Australian consumers demand to be clean, affordable and reliable. Any investment in new coal is expensive and risky, while old coal is increasingly unreliable and risky, and all coal is polluting. Burning coal creates pollution that has negative health impacts and ageing power stations are increasingly dangerous to work in. Australia must plan for the closure of all its coal fired power stations and no new coal power stations should ever be built.

Renewables and storage beat coal on pollution, cost, reliability and health. Renewables already generate 17% of Australia's electricity and there are no technical limitations to an electricity grid powered entirely by renewable energy and storage (Clean Energy Council 2018). Combined with demand response and energy efficiency, this is what a modern electricity grid looks like. Coal has no role to play.

Figure 6: Renewable energy like wind and solar, combined with storage (such as the Lakeland solar and storage project) can provide Australia with clean, reliable and affordable electricity.



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