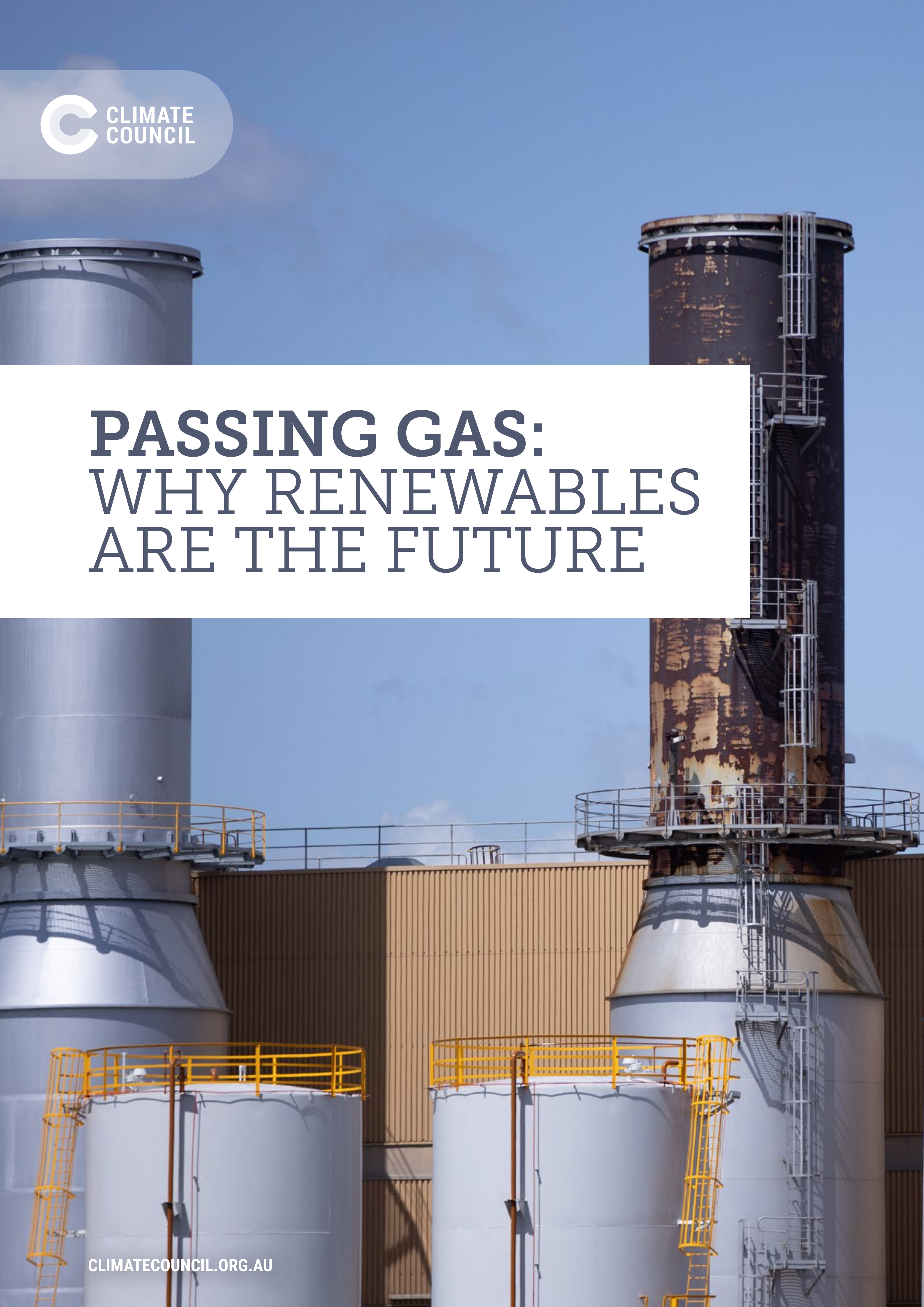
CLIMATE COUNCIL

PASSING GAS: WHY RENEWABLES ARE THE FUTURE



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Key findings

1

Australia's in the grip of a climate crisis. Extracting and burning more gas escalates risk and puts more Australians in harm's way.

- The past year of climate extremes—an unprecedented drought across vast swaths of Australia, the Black Summer bushfires, and a third mass bleaching of the Great Barrier Reef in five years—was driven by the 1.1°C of warming that's already occurred as a result of climate change.
- Climate change is driven by the consumption of fossil fuels: coal, oil and gas. Although a limited and discrete use of existing gas may be necessary as we fully transition to renewables and storage, if we are to avoid slipping from a climate crisis to a full-blown catastrophe there cannot be any expansion of fossil fuel production of any kind.
- There is still a chance to hold global temperatures to well below 2°C above pre-industrial levels, but any new fossil fuel infrastructure puts this target at risk. That includes any new gas production, or new gas projects.

2

Gas causes climate harm and its emissions are under-reported in Australia.

- Even before it is burned, gas causes climate harm. The main component of gas, methane, is a greenhouse gas nearly 100 times more potent than carbon dioxide in the short term. Along the entire gas supply chain large quantities of methane are emitted.
- Australia is not counting the true contribution of gas towards climate change. Upstream emissions of gas, as well as other leaks, are under reported, using out-of-date measures based on decades-old analyses conducted in other countries. Once corrected, the supposed climate benefit of gas often disappears.

3

The international gas market is in crisis, and Australia is dangerously exposed to job losses and power price volatility.

- A drastic increase in our gas exports has exposed Australia to international boom-and-bust market cycles. The wholesale price of gas reached record highs for most Australians between 2016 and 2019, before plummeting as a result of a global supply glut in late 2019.
- Most of Australia's gas is expensive to produce compared to international competitors. The centrepiece of the Federal Government's gas-led recovery, a stretch goal of $4 per gigajoule for gas, was described as a 'myth' by the extraction industry's own lobbyists.
- The combined impact of COVID 19 and a price war between Russia and Saudi Arabia saw the Australian oil and gas industry lose more jobs than any other sector of the economy in the first round of job losses this year; shedding 40% of its employees between March and April 2020.

4

The second biggest user of gas in Australia is the gas industry itself, and that is costing all Australians.

- In 2019, Australia became the world's largest liquefied gas exporter, with nearly three times as much gas exported than is used in Australia each year.
- Rising emissions from the gas industry are cancelling out all the gains we have made in building a record amount of solar and wind.
- More than one quarter of all gas consumed in Australia is burned by the gas industry to liquefy and chill gas for export overseas.

5

We do not need new gas when renewables are cheaper and cleaner.

- Seismic shifts in the economics of renewables over the past decade mean new gas infrastructure is not needed. The cost of the core components of lithium ion batteries, used for battery storage, have fallen by nearly 90% in the past decade, from $1,100 per kilowatt hour in 2010 to a mere $156/kWh in 2019.
- It will be more expensive for Australia to transition from coal to gas. Wind and solar powered generation, even after being backed by storage, is the cheapest form of new electricity generating infrastructure.
- The Australian Energy Market Operator sees a steadily shrinking role for gas over the next 20 years. In most scenarios, more than two thirds of gas power stations will retire, without being replaced with new ones.
- Incentivising gas-powered generation means disincentivising cheaper and smarter options. As the sunniest and windiest inhabited continent on the planet, and with careful planning of infrastructure, Australia can transition to 100% renewable electricity supply firmed by a mix of storage, and demand side solutions.

1. Introduction: Gas has no place in Australia's economic recovery, or climate safe future

For too long, gas has flown under the radar. Along with coal and oil, it is a major driver behind rising global temperatures, hotter conditions in Australia and worsening extreme weather events. It has played an oversized role in driving up power prices – putting the manufacturing sector at risk. Today, it is being positioned as the "new" saviour of the economy – based on overblown claims that gas is cleaner than coal and an overestimation of the industry's workforce.

Right now, Australia is facing twin crises – COVID-19 and climate change – and gas is not the answer to either. The necessary public health response to COVID-19 has had a huge impact on the economy: both in Australia and around the world (Climate Council 2020a). Economic recovery is top of mind for most Australians, and governments have a crucial role to play in making targeted investments and implementing policies that put Australians back to work. In doing so, Australian governments can choose to invest in initiatives that set us up for the future, creating win/win solutions that create jobs and tackle long-term problems at the same time (AlphaBeta & Climate Council 2020).

Growing the gas industry will hinder, not help, this recovery with expensive energy. The Australian gas industry has been behind rising energy bills for years. The price of gas for most Australians has reached historic highs (Australian Energy Regulator 2020a) and, in turn, this has driven up the price of electricity (McConnell & Sandiford 2020). Promises of cheap gas have been described as a 'myth' by the industry's own lobby groups (Australian Petroleum Production and Exploration Association 2020).

In addition, growing the gas industry can't provide the jobs that Australians desperately need. Neither producers nor consumers of this fossil fuel can provide stable employment given the current international price volatility. Both producers and consumers of gas have been subject to significant job losses in recent times. Chasing a dream of economic recovery through growth of gas will be more expensive and less worthwhile on a jobs front compared to the alternative of a renewables-led recovery (AlphaBeta & Climate Council 2020; Australia Institute 2020a).

Luckily, we don't need to follow this path. In many industries – including electricity, which is the principal focus of this report – zero emissions replacements for gas are cheaper and more reliable. This is most obvious in the electricity sector, where a rapid decline in Australian gas-powered generation over the coming decades looks increasingly likely as technologies like batteries and pumped hydro storage become even cheaper (Australian Energy Market Operator 2020a).

Even before COVID-19 hit, Australia was struggling through a series of destructive climate impacts. Over the past two years, Australians have lived through record-breaking drought, the Black Summer bushfires, intense heatwaves and yet another mass bleaching of the Great Barrier Reef; the third in five years (Climate Council 2020b).

As both a fossil fuel and a greenhouse gas in its own right, gas is part of the problem. In contrast, the climate benefits of moving to wind and solar are undeniable. While there is a discrete, and short-lived and short-lived role for some existing gas to firm up renewables, new gas infrastructure won't fix the problem – it will only delay the solution.

The only stable recovery for Australia is one that is based on building the infrastructure of the future, not the past. A future where we rapidly reduce greenhouse gas emissions, build competitive industries and create sustainable jobs that last for generations. This would address the immediate problem of economic recovery from COVID-19 at the same time that we tackle the long-term threat of climate change.

Growing the gas industry can't provide the jobs that Australians desperately need.

2. Australia's climate challenge

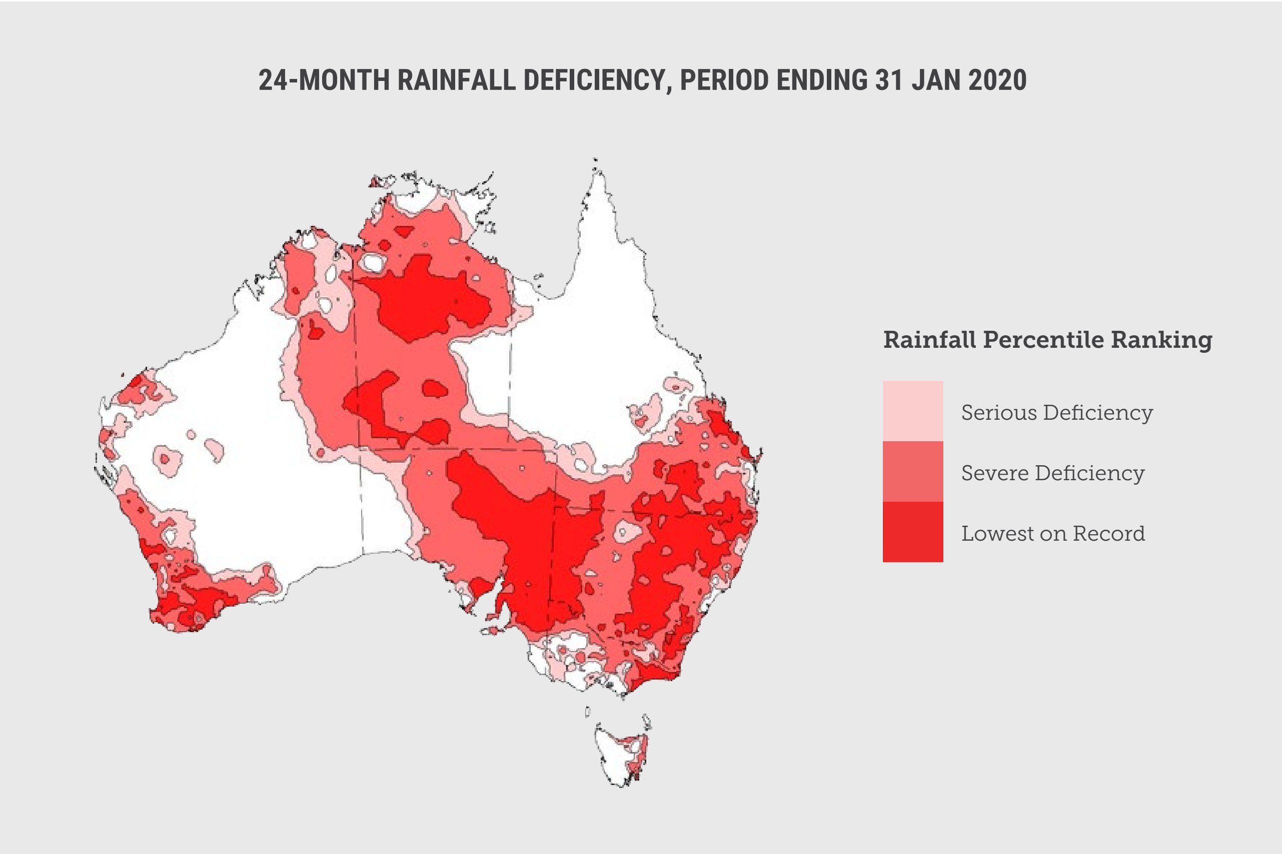
Producing and burning fossil fuels, like gas, coal and oil, produces greenhouse gases that drive climate change. This section explains why we must reduce greenhouse gas emissions as deeply and rapidly as possible to avoid dangerous climate change. This means that there can be no expansion of fossil fuel production of any kind. This includes new gas production and new gas projects.

Australia is already in the grip of a climate crisis having lived through one of the most extreme and dangerous years ever recorded. This was driven by climate change. Global average temperatures have increased 1.1°C since the second half of the nineteenth century (World Meteorological Organization 2020). The planet has almost certainly not experienced such a rapid increase in temperature at any time in the past several million years (Hansen et al. 2013).

The impacts of climate change are already being felt in Australia. In the past few years, the continent experienced unprecedented drought across vast tracts of the country's most productive land. Every mainland state was severely affected (see Figure 1).

The consumption of fossil fuels is a cause of the recent extreme weather events in Australia.

Figure 1: 24-month rainfall deficiency, period ending 31 Jan 2020. **Source:** Bureau of Meteorology (2020a).



Australia experienced its hottest and driest year on record in 2019 (Bureau of Meteorology 2020b). Australia's climate has warmed by more than 1.4 °C since 1910 (CSIRO & Bureau of Meteorology 2020). Every year since 2013 has been among the 10 hottest years on record for Australia and the earliest year in that top ten is 1998 (Bureau of Meteorology 2020b).

These changes are being felt acutely in regions all over Australia. The Murray-Darling Basin, for example, set an all-time heat record last year; experiencing temperatures that were more than 2.5°C above the long-term average. This eclipsed the previous record – 2.3°C above average set in 2018 – and the previous second hottest – 2.1°C above average set in 2017.

2019 set a record for lack of rainfall in the Basin as well, with average rainfall across the region less than half of the long-term average. The three-year period ending in 2019 was the driest in the Murray-Darling Basin by a considerable margin (Bureau of Meteorology 2020b). These trends, both warming and drying, are directly linked to climate change (CSIRO & Bureau of Meteorology 2020; Abram et al. 2020). These are trends are expected to worsen in future (Grose et al. 2020; Ukkola et al. 2020).

These hot, dry conditions led to unprecedented fire risk, and ultimately to the most horrific fire season ever recorded on the continent: the Black Summer fires (Filkov et al. 2020). Nearly 80 percent of Australians were affected by these bushfires either directly or

Australia is acutely vulnerable to climate change and is already experiencing its effects.

indirectly (Biddle et al. 2020). Thirty-three people lost their lives in the fires (Bushfire Royal Commission 2020), and a further 429 are estimated to have died due to bushfire smoke (Johnson et al. 2020). More than 3000 homes were lost across the country (Bushfire Royal Commission 2020), and around 3 billion vertebrates were either killed or displaced (WWF Australia 2020). Dozens of threatened and non-threatened species are likely to have their conservation status revisited, with some expected to have been driven to extinction (Ward et al. 2020; Wintle, Legge & Woinarski 2020) and across the entire country, at least 24.3 million hectares burned (Bushfire Royal Commission 2020). In eastern Australia alone, an area roughly the size of England – just under 13 million hectares – burned (Wintle, Legge & Woinarski 2020). Australia also recorded its largest ever fire, the Gospers Mountain mega-fire, which burned through half a million hectares on its own (NSW Government 2020).

The Great Barrier Reef bleached again in March 2020 (ARC Centre of Excellence for Coral Reef Studies 2020) - the third such event in five years after massive bleaching episodes in 2016 and 2017 (Hughes et al. 2018). This type of bleaching event has been shown previously to be driven by climate change (King et al. 2016) and the links have again been made (ARC Centre of Excellence for Coral Reef Studies 2020). As global emissions continue to rise, many tropical coral reefs will struggle to survive in coming decades as a result of ocean heating (Hoegh-Guldberg et al. 2018). The reef is far from being the only Australian natural wonder that is under threat from climate change with many other species and ecosystems across the country facing an uncertain future (Climate Council 2019a).

Australia is one of the most vulnerable developed countries in the world to the impacts of climate change (Reisinger & Kitching 2014; Grose et al. 2020). If it were possible to halt global temperature increases to the 1.1°C of warming that has occurred so far then, as this past year has shown, life would be perceptibly worse as a result of climate change. For Australians and the county's natural environments, the future will certainly be far more difficult than it is today as a result of burning coal, oil and gas (Hoegh-Guldberg et al. 2018).

The 2015 *Paris Agreement* establishes a shared global goal of limiting global mean temperature rise to well below 2°C above the world's average temperature at the time that industrial scale burning of coal, oil and gas began, and pursuing efforts to limit average warming to 1.5°C above the same baseline (UNFCCC 2015 article 2.1). Notwithstanding the United States' temporary withdrawal, this goal has been agreed to by all 197 members of the United Nations, and formally ratified by all but eight countries, making it the global benchmark for domestic climate policy (United Nations Treaty Collection 2020). Australia is a signatory to this agreement and ratified it in 2016.

Figure 2: Emissions from the fossil fuel sector, including the gas sector, are driving the climate impacts being seen today across Australia.

In 2018, the Intergovernmental Panel on Climate Change (IPCC) released its special report, Global Warming of 1.5°C (Masson-Delmotte et al. 2018). This report made clear why warming must be limited as much as possible (Hoegh-Guldberg et al. 2018). Put simply, the closer global average temperatures are to the conditions where human society evolved, the easier it will be to secure productive and successful lives and livelihoods. That report also outlines what must be done to meet the goals of the *Paris Agreement*: immediate, deep and enduring cuts to greenhouse gas emissions across the world (Rogelj et al. 2018).

The burning of coal oil and gas is driving climate change. It is not possible to tackle climate change unless we rapidly phase out all fossil fuels, including gas. Expanding or developing new fossil fuel infrastructure of any kind means that we put more Australian lives and livelihoods in danger.

Existing coal, oil and gas infrastructure is more than enough to push the world past 1.5°C of warming (Tong et al. 2019). Existing and planned fossil fuel infrastructure is sufficient to push the world past 2°C of warming (Stockholm Environment Institute et al. 2019). There is clear benefit to holding global temperatures to the lowest level possible, with 1.5°C, 2°C or higher global average temperatures representing step changes along a path to catastrophically dangerous levels of warming (Hoegh-Guldberg et al. 2018).

3. Gas makes a major contribution to the climate crisis

There are many false narratives about gas, both in Australia, and across the world. The reality is that gas is a fossil fuel and there can be no new gas or gas expansion if we are to tackle the climate crisis. While there is a discrete and short-lived role for existing gas, we do not require any new gas infrastructure, pipelines or drilling.

This section steps through several key facts about gas.

First it steps through the sectors of the Australian economy that use Australian gas. More gas is burned in Australia to generate electricity than in any other sector. However, nearly as much gas is consumed in Australia by the gas industry itself just to process Australian gas for export and nearly three times as much Australian gas is sent overseas each year than is used here.

Next, this section steps through four core realities about the climate impact of gas. The core component of the gas burned in Australian homes and industries is methane, which is itself an extremely powerful greenhouse gas and produces carbon dioxide when burned. As scientific knowledge has progressed on the climate impact of methane over the past several decades, at each re-assessment, methane is shown to be a more powerful greenhouse gas than previously thought.

This section then deals with the various extraction methods for gas, with a particular focus on clarifying the various forms of unconventional gas extraction (described below). While unconventional gas extraction does not produce harms that can be detected at the surface in every instance, there are worrying trends in the scientific literature about the health impacts of these forms of extraction.

Then this section discusses so-called fugitive emissions. Despite the name given to these emissions in official reports from the Australian Government, the 'fugitive emissions' recorded in official statistics are almost entirely intentional releases of carbon dioxide and methane from the industry for operational reasons across the full supply chain. The total quantity of greenhouse gas pollution released in the gas supply chain in Australia rivals several developed nations even before considering that this gas will eventually be burned and so release still more climate pollution. To make matters worse, the methods used to estimate the greenhouse gas emissions of the Australian gas industry have significant integrity issues. The true climate impact of the Australian gas industry may be far worse than is currently reported.

Finally, this section steps through the various gas-powered electricity generation technologies. The oft-repeated claim that gas-powered generation is 'half' the emissions of coal does not stand up to scrutiny. The reality is that while one gas-powered generation technology – combined-cycle gas turbine – can meet this standard in certain instances, this is not the form of gas-powered generation that is most well-suited to a future grid.

Overall, gas is a large source of greenhouse gas emissions and these emissions are not being correctly reported or accounted for. This means Australian gas may be significantly worse for the climate than is conventionally understood.

Figure 3: Emissions from gas infrastructure begin at the wellhead and extend along the length of the supply chain.

3.1 The use of gas in Australia

In Australia, gas is used for several different purposes. More than half of the gas consumed here is used in generating electricity or in the manufacturing sector – mostly to provide heat for various industrial purposes (Department of Industry, Science, Energy and Resources 2020a). Another one fifth of the gas burned in Australia goes to various smaller purposes such as residential and commercial heating. The breakdown of Australian gas use by sector is shown in Figure 5, opposite.

Figure 4: As the largest liquefied gas exporter in the would significant quantities of Australian gas are sent overseas in tankers like this one, outside Darwin.

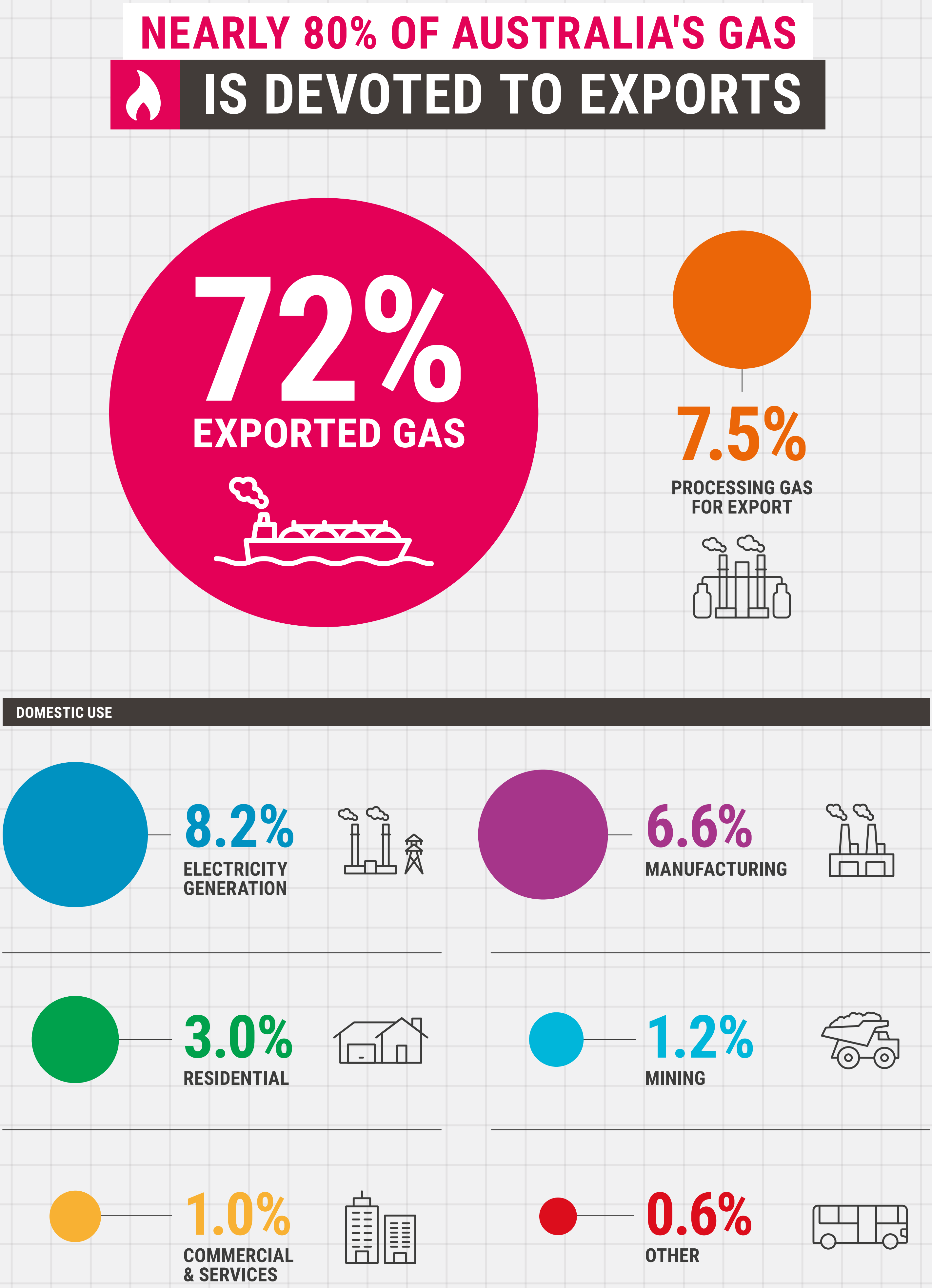


Figure 5: Proportion of gas consumed in Australia by sector (2018-19 financial year). **Data source:** Department of Industry, Science, Energy and Resources (2020a).

In 2019, Australia became the world's largest liquefied gas exporter (Office of the Chief Economist 2020). Processing gas for export, particularly liquefaction so it can be transported overseas on ships, requires immense quantities of energy; most of which is provided by burning gas on site. Nearly three times as much Australian gas was sent overseas in 2019 as was used here. The quantity of gas burned by the Australian gas industry was enough to make it the second biggest consumer of gas in Australia is the gas industry itself (Department of Industry, Science, Energy and Resources 2020a). As a result of this, more than one quarter of all gas consumed in Australia – 425 petajoules – was burned by the gas industry to provide the energy required to process and compress its own product for sale overseas.

The total impact of gas extraction, processing and transport on Australia's emissions is immense (Department of Industry, Science, Energy and Resources 2020b). Since 2005, annual greenhouse gas emissions from electricity have declined by 15 million tonnes.[1] This reduction was thanks to record deployments of wind and solar, which have dramatically reduced the emissions intensity of the major electricity grids (Clean Energy Council 2020).

Unfortunately, growing greenhouse gas emissions from the gas sector have cancelled out this progress. Broadly, the climate impact of the gas industry can be split up by upstream emissions (see section 3.4) and emissions from burning the gas for energy at the final destination (see section 3.5). Over the same period as the decrease in electricity emissions, annual greenhouse gas emissions from just the upstream emissions of the Australian gas industry have increased by 25 million tonnes (Department of Industry, Science, Energy and Resources 2020b).

Australia's gas export industry consumes more gas processing its product for export than the entire Australian manufacturing sector.

1 On a carbon dioxide equivalent (CO_2-e) basis using the global warming potential values in Working Group I's contribution to the fourth assessment report to the IPCC (Forster et al. 2007). These assessments are explained in the following section.

3.2 Gas is mostly made of methane, a potent greenhouse gas

While gas is a fossil fuel, its main component is methane, a potent greenhouse gas in its own right. This means that the use of gas directly contributes to climate change in addition to producing carbon dioxide when it is burned. Over decades of research the trend has been one where, with each reassessment of the climate impact of methane, the scientific community is learning that methane is significantly worse for the global climate than had previously been understood.

This section demonstrates the critical importance of accounting for the impact of methane accurately. Recent shifts in accounting practices for Australia's emissions will add significantly to Australia's climate bottom line. Australia's total emissions will increase by 3 per cent, but completely considering the impact of methane would cause a much more significant revision than this.

The extraction of all fossil fuels results in significant methane emissions even before the fuels are burned, but the Australian gas industry emits significantly more of this greenhouse gas per unit of energy than the Australian coal sector.

All greenhouse gases trap energy that would otherwise have escaped to space and, as a result, heat the atmosphere, land surface and oceans. However, different greenhouse gases affect the climate in different ways. These differences relate to their relative ability to trap heat, their lifetime in the atmosphere, the impact they have on the concentration of other gases and the lifecycle impact that emitting the gas has on the climate system overall. On top of these inherent qualities, another difference is the rate at which the gas is being added to the atmosphere.

Gas is no climate cure, it is both a fossil fuel and a potent greenhouse gas.

BOX 1: CARBON DIOXIDE IS STILL THE MOST IMPORTANT GREENHOUSE GAS

The increase of carbon dioxide in the atmosphere has been the most important contributor to climate change. Human activity – principally the burning of coal, oil, and gas – has added immense quantities of carbon dioxide to the global atmosphere since the industrial revolution began in the 18th Century (Hawkins et al. 2017; Gütschow et al. 2019). However, per tonne of gas, the warming effect of carbon dioxide is relatively weak compared to most other greenhouse gases, including methane, nitrous oxides and the diverse range of synthetic gases (Myhre et al. 2013). Once carbon dioxide reaches the global atmosphere, it is stable and does not break down readily. It can only be removed from the atmosphere if it is drawn down by human activity – something that is not currently feasible at scale – or natural processes such as vegetation growth or dissolution in ocean waters.

The cumulative impact of carbon dioxide, and its long life in the atmosphere, means that cutting fossil fuel consumption of all kinds is by far the most important step in avoiding ever-worsening climate impacts. This includes gas, which is the fastest growing fossil fuel and the fastest growing source of greenhouse gas emissions (International Energy Agency 2020a; Stockholm Environment Institute et al. 2019).

Given that greenhouse gases differ in their effects on the global climate in many ways, scientists have developed simple metrics that enable comparisons between different gases (Myhre et al. 2013). These metrics are necessary but principled simplifications. The most commonly-used metric – 'global warming potential' or GWP – assesses the degree to which different gases shift the energy balance of the planet over time. From this perspective, emitting methane is always worse than emitting the same mass of carbon dioxide, but the difference between the gases narrows over time (Gillett & Matthews 2010; Myhre et al. 2013).

Until recently, virtually all Australian climate assessments that considered the impact of methane on global heating – from project approvals to the country's national greenhouse accounts – assumed methane to be 25 times worse than carbon dioxide in accordance with the GWPs provided in the IPCC's fourth assessment report (Forster et al. 2007). While this was allowable under old international reporting guidelines, the choice to use this assessment, which is now more than a decade old, ignores substantial shifts in the scientific understanding of methane since that time.

This year, Australia's reporting guidelines were finally updated to bring them into line with the IPCC's Fifth Assessment Report, released in 2013 (IPCC 2013). However, as is shown below, this update does not entirely reflect the information contained in the work of the IPCC. Along with this, improved assessments of methane's climate impact since that time mean that the next IPCC Assessment Report – due in 2021 – will likely include further, significant upward revisions

Figure 6: While invisible, upstream emissions from the gas sector nonetheless contribute significantly to climate change and accounting for them accurately is essential to determining the industry's impact.

to the calculated GWP of methane. As shown in Table 1, a complete assessment of methane's climate impact in line with the latest available science would increase the GWP of methane by 60% compared to the value currently used by the federal government in reporting greenhouse gas emissions.

First, the IPCC report makes clear that there is a significant difference in the climate impact of methane emission sources. From a whole-of-system perspective, methane emitted from active biological processes – such as from livestock or landfills – has a different effect on the heating of the planet to methane emitted from ancient sources such as fossil methane, or gas. For the purposes of this report, these can be described as 'biotic methane' and 'fossil methane'.

- **Biotic methane** is created by methane-producing bacteria that break down organic matter. As well as being central to the climate impact of the waste sector, and the land use sector more broadly, these bacteria live in the stomachs of most cattle and other livestock. This is a major contributor to the agricultural sector's climate impact.

- **Fossil methane** is also very often the product of living processes but rather than being part of the active carbon cycle, this is the result of ancient life. Fossil methane is made up of carbon that has been stored underground for millions of years far from the surface and the global atmosphere. Virtually all gas burned for energy today is fossil methane.

Recent assessments of methane's climate impact indicate that it is significantly more powerful than previously thought.

The release of fossil methane has a greater overall impact on the climate than biotic methane (Boucher et al. 2009). In basic terms, this is because the emission of methane from recent biotic sources is inextricably linked to the cycling of carbon through the biosphere. The creation of each biotic molecule of methane relies on the withdrawal of at least one carbon dioxide molecule from the atmosphere.

The extraction of fossil fuels and release of fossil methane, on the other hand, re-introduces to the atmosphere a greenhouse gas that had previously been locked away for millions of years. As a result, from a whole-of-system perspective, fossil methane contributes more to the destabilisation of the global climate than biotic methane (Myhre et al. 2013).

But methane's total impact goes well beyond the effect of the original release. Because methane is such a powerful greenhouse gas, its release significantly contributes to carbon cycle feedbacks in the natural environment (Gillett & Matthews 2010; Sterner & Johansson 2017). When greenhouse gases are emitted by human activity, and the planet heats, this triggers the release of further greenhouse gases from destabilised natural processes. All greenhouse gases play a role in causing these additional emissions, but because of the way the metric works, accounting for these feedbacks has a more meaningful impact on the calculated GWP of more potent greenhouse gases like methane. Most of the processes causing this are subtle, and the scientific community still has much to learn about their overall impact (Steffen et al. 2018), but there are also dramatic, easier-to-understand examples (Department of Industry, Science, Energy and Resources 2020c).

Around 800 million tonnes of carbon dioxide were released into the atmosphere by the 2019-20 Australian bushfires (Department of Industry, Science, Energy and Resources 2020c). Historically, fire is a somewhat cyclical process and a feature of the Australian landscape. However, many aspects of this past season were unique, and driven by climate change (Filkov et al. 2020; Bushfire Royal Commission 2020). Undoubtedly, as forests and grasslands burned in the 2019-20 fire season regrow, some of the carbon dioxide released by the fires will be drawn back out of the atmosphere. However, the increasing frequency of fire means that it is certain that significant permanent change will occur (Enright et al. 2015; Fairman et al. 2017; Schmidt 2020).

These shifts in local- and global-scale natural cycles, where heating of the global atmosphere drives new greenhouse gas emissions which in turn drive further heating of the atmosphere, can be accounted for in GWP calculations. Doing so significantly affects the outcome for powerful but relatively short-lived gases like methane (Myhre et al. 2013). This is because, weight-for-weight, potent gases like methane are driving significantly more heating of the atmosphere. Factoring these in, even in a basic way, sees an upward revision to the calculated impact of methane of around 20% (Gillett & Matthews 2010; Sterner & Johansson 2017).

Finally, since the publication of the IPCC's Fifth Assessment Report in 2013 scientific knowledge has progressed on the cumulative climate forcing impacts of emitting methane. While some outstanding uncertainty remains (Smith et al. 2018), more recent re-assessments have found that the total impact of methane is substantially higher than was once thought, increasing previous estimates by 14% (Etminan et al. 2016). These well-regarded assessments will inform the position taken by the IPCC in its Sixth Assessment Report.

The full impact of methane varies considerably by source.

Australia is vastly understating the true impact of its methane emissions, and consequently, the emissions of the gas industry.

Taking all of this into account means the Federal Government is vastly under-reporting the impacts of methane, and so Australia's overall emissions. Rather than being only 28 times worse than carbon dioxide – as is now claimed by the Federal Government – a more complete and up-to-date analysis would show that methane is up to 40 times more potent over a 100-year period. Over 20 years, methane is nearly 100 times more potent.

Australia emits approximately 5 million tonnes of methane per year (Department of Industry, Science, Energy and Resources 2020b). Recently announced adjustments – that take the GWP of methane from a value of 25 to a value of 28 – will add 3% to Australia's total reported emissions. This will effectively add another Papua New Guinea worth of emissions to Australia's bottom line (Gütschow et al. 2019). However, if the adjustments had been made using the latest science, and in a way that accurately accounts for the different sources of methane, Australia's total reported emissions would increase by a further 10% – adding another Sweden to the planet as well, even when using the government's preferred 100-year time horizon.

The accounting method used by Australia is allowable under international reporting guidelines. However, by ignoring the difference between sources of methane, subsequent scientific developments and flow-on effects of introducing methane into the atmosphere, Australia's official reports vastly understate the true impact of its methane emissions. This includes those emissions from the gas industry.

As it is such a powerful greenhouse gas, small emissions of methane along the gas supply chain have a considerable impact on the total assessed impact of the gas industry. The emissions of unburned methane along the gas supply chain are substantial, with the Federal Government officially estimating that

Table 1: Global warming potential of methane relative to carbon dioxide. This table shows the relative shift in the energy balance of the atmosphere from the emission of one tonne of methane relative to one tonne of carbon dioxide. **Sources:** Myhre et al (2013) and Etminan et al (2016).

	Time horizon	Default value (IPCC AR5)	Carbon cycle feedback	After Etminan et al. (2016) revision
Fossil methane	20 years	85	87	99
	100 years	30	36	40
Biogenic methane	20 years	84	86	98
	100 years	28*	34	38

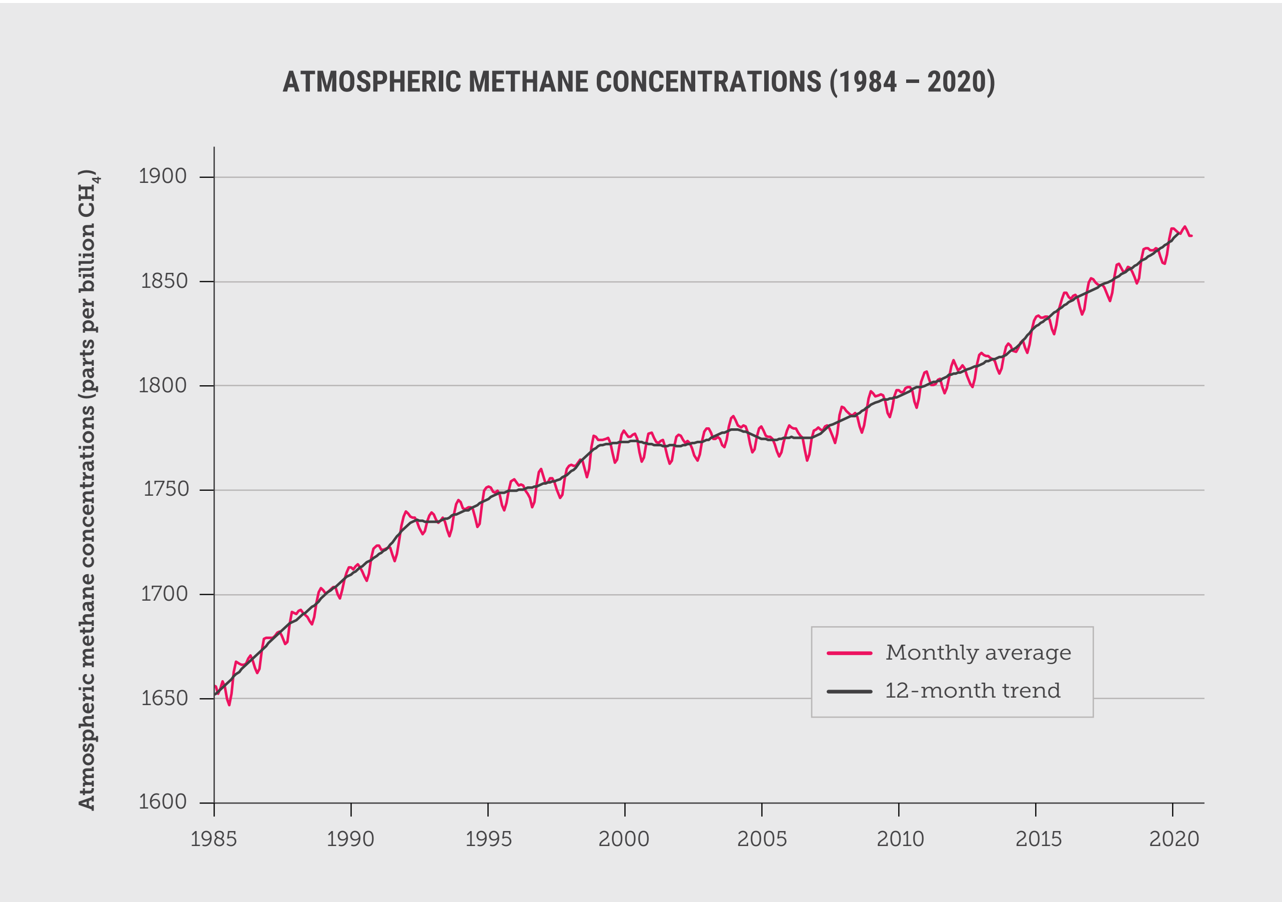
* Federal government's preferred value for all sources of methane.

half a million tonnes of methane were released directly into the atmosphere by the gas industry in the most recent reported year (Department of Industry, Science, Energy and Resources 2020b). These emissions are rapidly growing.

When put into the context of a large emitter like Australia this may seem to be a small amount. However, on a carbon dioxide equivalent basis, the Australian gas industry's emissions of just one greenhouse gas are equivalent to the total emissions of Lithuania, a developed European nation (Gütschow et al. 2019). To make matters worse, as will be discussed in section 3.4, these official figures are very likely to be underestimates for reasons unrelated to the GWP of methane.

This makes recent trends in global atmospheric methane concentrations even more worrying. As shown below in Figure 7, while methane concentrations stabilised early this century, they are trending upward again. Attributing this increase in global methane concentrations to a single cause is difficult (Nisbet et al. 2019), but it is notable that it comes at a time of considerable growth in the gas industry – both in Australia and around the world (International Energy Agency 2020b; Office of the Chief Economist 2020). As has been noted elsewhere, gas is now the fastest growing fossil fuel, and so one of the fastest growing sources of greenhouse gas pollution.

Figure 7: Atmospheric methane concentrations (1984 – 2020). **Data source:** National Oceanographic and Atmospheric Administration (2020).



3.3 The impacts of gas extraction depend on the method used

Not all sources of gas are equal when it comes to assessing the climate and other impacts of gas across the supply chain. Different sources of gas come with different risks, and different rates of greenhouse gas pollution. While each individual gas field will have unique features that determine its overall climate impact, one of the key points of difference is between conventional and unconventional gas. This section steps through the various forms of gas extraction with a view to providing greater clarity on the topic.

While the word 'gas' is sometimes used to describe biogas – which is produced from vegetation and waste – or town-gas – which is produced in some countries from coal – most gas burned today is most accurately described as 'fossil methane'. This term applies to all gas produced from oil, gas or coal deposits. While the gas burned in power stations and homes contains some additives and impurities, this substance is mostly derived from naturally-occurring reserves deep underground. It can occur on its own, or alongside coal and oil, but is ultimately derived from deposits that are at least tens of millions of years old. The presence of methane in coal seams and oil reservoirs, and the inevitability of producing it at the same time that coal and oil are extracted, means that coal and oil extraction facilities often emit or flare large quantities of methane through routine operations (see section 3.4).

Reservoirs containing methane deep underground are frequently described as being either "conventional" or "unconventional". While these terms are often used as a shorthand to describe the technical aspects of extracting gas from a reservoir, or even as a proxy to describe the cost effectiveness of producing the gas, in a strict sense the terms merely describe whether the gas can be extracted using traditional methods. If extracting the gas requires newer methods, it is "unconventional". Generally, unconventional gas extraction is more risky than conventional – though there are exceptions, particularly with deep sea conventional gas extraction.

In conventional gas reservoirs, the methane sits in a naturally porous rock formation that is capped by a type of rock that does not allow the gas to escape naturally. If the impenetrable layer is drilled through then high pressures underground will push gas up to the surface. Australia's existing offshore gas reservoirs, such as those found in Bass Strait or off the coast of Western Australia, are all conventional, as are several of the onshore resources in Western Australia, South Australia and Queensland.

Different gas extraction processes involve very different levels of risk.

Unconventional gas describes methane extracted from more complex geological formations that require greater intervention. In Australia, the three main types of unconventional gas formation that are either being used, or being considered, are coal seam gas, shale gas, and tight gas.

- **Coal seam gas** (CSG) holds methane adsorbed on underground coal seams. This gas is often held in place by rock and ancient groundwater ('fossil water'). This water must be removed to access the gas, in a process known as 'de-watering'. As a result, CSG poses significant risks for local users of groundwater, including farmers and sensitive environments downstream, if the water is extracted from the aquifers that farmers use or if produced water is not managed appropriately. CSG extraction often uses fracking to increase the supply of gas (see below), but this is not always required. The large quantities of gas being extracted from Queensland's Surat Basin is CSG, as is the recently approved Narrabri Gas Project.
- **Shale gas** holds methane in clay-rich, layered rock formations known as shales. Within these shales, the gas is contained in small pores that do not allow the gas to flow freely. Fracking is almost always required to access shale gas in economically viable quantities. The proposed Betaloo Basin development in the Northern Territory contains shale gas.
- **Tight gas** is similar to shale gas in most ways, but the methane is found in sandstone or limestone rather than shales. As with shale gas, tight gas extraction almost always requires fracking. There is very little tight gas production in Australia, but several potential reserves have been identified, including in the Darling Basin in western New South Wales. The Cooper Basin, which extends across the border of South Australia and Queensland and currently produces significant quantities of conventional gas, also holds significant amounts of tight gas. Some of this tight gas is being extracted.

Figure 8: Unconventional gas extraction, such as that which is occurring in Queensland's Western Downs, poses significant new risks to the local environment.

Unconventional gas presents major risks to local communities.

While the consumption of fossil gas always causes significant climate harm through the release of greenhouse gases (see 3.4), unconventional gas projects, which rely on extra steps such as de-watering, come with additional direct risks to the communities relying on the land and waters nearby (Peduzzi & Harding Rohr Reis 2013). One of these processes is fracking. Fracking is a process that injects immense quantities of water, loaded with sand and potentially harmful chemicals underground to crack open otherwise inaccessible gas reservoirs. This process can pose significant risks to local communities.

If catastrophic incidents occur – such as a compromised well contaminating an aquifer as a result of negligence or accident – these may not be detected or even detectable until after the effects have already occurred and are irreparable. Alongside more dramatic risks - such as the risk of permanent groundwater contamination - there are also insidious and chronic risks to communities living near unconventional gas operations that could be of even greater concern. There are now several studies from Australia and around the world that show clear associations between a diverse range of health impacts and proximity to unconventional gas production hotspots including the Surat Basin in Queensland (Jemielita et al. 2015; Werner et al. 2016; Busby & Mangano 2017). These include higher incidence of congenital heart defects, increases in rates of asthma and a host of other issues (Adgate, Goldstein & McKenzie 2014; Burton et al. 2014; McCarron 2018).

Industry-led studies that rely on assessing the impact of unconventional gas extraction at a handful of cherry-picked wells misrepresent the problem (Australia Institute 2020b). Such studies cannot be relied upon and there is an urgent need for comprehensive, well-funded and truly independent basin-wide studies to understand the risks of unconventional gas.

3.4 What are 'fugitive emissions' and why are they so important in understanding the impact of gas?

Large releases of carbon dioxide and methane are a routine aspect of operating most forms of gas infrastructure. Cumulatively, this results in a large additional burden on the global atmosphere. As noted in Box 1, carbon dioxide is the most important greenhouse gas causing climate change. However, as noted in Section 3.2, methane is itself an extremely potent warming agent and is the second most important greenhouse gas. Even small amounts of methane have an outsized effect on the climate impacts that we are seeing today. The myriad of intentional and inadvertent releases of greenhouse gas from the gas industry create a significant extra climate burden as a result of gas extraction, processing, transport and use.

The term '**fugitive emissions**' has two quite distinct – and at times mutually-exclusive – definitions. In the language used by the gas industry, the term is often limited to inadvertent releases of greenhouse gas, such as leaks (see, for example, American Petroleum Institute 2009). In the language of international climate science and diplomacy, the term tends to refer to any unproductive release of greenhouse gases along the fossil fuel supply chain, whether intentional or inadvertent (see, for example, Department of Environment and Energy 2019).

Regardless of which definition is used, it is a simple fact that along the gas supply chain, carbon dioxide and methane are released in very large quantities: from production and processing, to transport and end-use. Extracting any of the three major fossil fuels – coal, oil and gas – releases significant greenhouse gas emissions even before the fuel is burned (see Section 3.3). Proportionally speaking, the gas supply chain emits significantly more pre-combustion greenhouse gas per unit of energy in Australia than coal.

Even before gas is burned, large quantities of greenhouse gas pollution are released at every stage of the gas supply chain.

This section describes how the pre-combustion emissions from gas are poorly recorded in Australia's climate accounting. However, as will be shown in section 3.5, even using these incomplete assessments the mismatch between the proportionally high levels of upstream emissions in gas and the smaller – though still large – amount emitted from coal significantly reduces the claimed climate benefit of shifting to gas in many instances.

There are four main kinds of upstream emission in gas operations:

- **Venting** is the intentional release of greenhouse gases directly to the atmosphere at various stages of the gas production cycle. The mix of gases released varies depending on the type of venting, but the target for release is most often carbon dioxide, which naturally occurs alongside methane in underground reservoirs. In these instances, carbon dioxide must be removed from the methane to create saleable gas. When this occurs, the process that extracts the carbon dioxide also releases some methane at the same time. If gas reservoirs have a high concentration of carbon dioxide, the total volume of greenhouse gas released by venting can be substantial.

- **Flaring** burns gas at various points along the supply chain for various operational reasons. Ordinarily, flaring occurs to reduce workplace hazards and other risks. Performed perfectly, flaring releases large amounts of carbon dioxide as the methane is burned, though small amounts of unburned methane will always be present. As with all industrial process, reality may not always match expectation. Imperfectly configured flares can result in significant quantities of methane being released to the atmosphere unburned.

- **Leakage** is the result of accidental escapes of greenhouse gas, such as from cracked pipes or improperly maintained infrastructure. The official Federal Government methodologies for assessing the climate impact of leaks from the gas industry ultimately rely on standard account factors rather than direct measurement (see below).

- **Migratory emissions** are a poorly understood phenomenon where methane is released through natural fissures in the earth, far from the wellhead. These are a particular risk for unconventional gas extraction (Lafleur et al. 2016). The existence of migratory emissions is ignored in Australia's official greenhouse gas emissions data.

Figure 9: Emissions of greenhouse gas occur along the full gas supply chain, from extraction to consumption.

Emissions of methane, both operational and inadvertent, occur at every stage of the gas supply chain; from extraction, to processing, transport, and even at the point of combustion. The reported quantity of greenhouse gas pollution released by the gas industry is substantial. In the 2018 calendar year, the Australian gas industry released at least half a million tonnes of methane directly to the atmosphere unburned, directly released seven-and-a-half million tonnes of carbon dioxide, and produced another six-and-a-half million tonnes of carbon dioxide as a result of flaring (Department of Industry, Science, Energy and Resources 2020b). This is separate to the nearly three hundred million tonnes of carbon dioxide produced when Australian gas is burned at its final destination.

Australia emits far more than its share of greenhouse gases each year (Robiou du Pont et al. 2016). On these official numbers, one twentieth – or 5% – of Australia's total contribution to climate change comes from the gas industry's venting and flaring operations (Department of Industry, Science, Energy and Resources 2020b).

But this does not tell the full story, and may be a significant underestimate. The impact of upstream emissions of greenhouse gases from the gas industry are poorly reported in Australia. In part, this is because instead of directly measuring the climate impact of the industry, official estimates of the gas industry's emissions ultimately rely on assessments conducted decades ago, on a different continent, at a time when the unconventional gas industry was in its infancy. The Federal Government's National Greenhouse Account Factors, which are used to determine project-level and national-scale emissions from the gas sector, are based on the American Petroleum Institute's Compendium of Greenhouse Account Factors for the Oil and Gas Industry, which was last updated more than a decade ago (American Petroleum Institute 2009; Department of Energy and Environment 2019). While some more recent assessments are included in the compendium, emissions from the gas industry are largely determined by a single report from the United States Environmental Protection Agency which assessed the climate impact of the US gas industry in the 1992 calendar year (Environmental Protection Agency (US) 1996).

Recent studies have shown that the proportion of methane in the atmosphere as a result of fossil fuel extraction is far higher than previously estimated (Hmiel et al. 2020). This finding points to systemic under-reporting of fossil fuel industry emissions of methane across the world.

At a tiny handful of gas processing facilities around the world, the amount of greenhouse gas vented to the atmosphere is reduced through processes that re-inject carbon dioxide into geological formations – referred to as carbon capture and storage. For example, some of the carbon dioxide stripped at the Gorgon liquefied gas facility in Western Australia is re-injected in this way. This project has been plagued by technical delays (Milne 2020) and is underdelivering on its promised emissions reductions (Kilvert 2020). Even if the facility's sequestration activities become fully operational, it will nonetheless capture less than half of its overall emissions, and continue to emit millions of tonnes of greenhouse gas each year (Chevron 2015).

Ultimately, as both a greenhouse gas and a fossil fuel, gas is worsening climate change.

3.5 Gas-powered electricity generation in Australia

In Australia, there are several different gas-powered electricity generation technologies in operation. These can be broadly classified as:

- **Steam turbine gas generators:** This older generation of power stations is designed to operate continuously at either full or part load. Since the retirement of the Kwinana power station in Western Australia, there are two remaining generators of this kind in operation: Newport in Victoria and Torrens Island in South Australia (Australian Energy Market Operator 2020b).

- **Combined cycle gas turbines:** While these stations still burn gas and contribute to climate change, they are relatively efficient and their greenhouse gas emissions per unit of energy are substantially lower than steam, open-cycle or reciprocating gas turbines. Such turbines are an improvement over coal, even after upstream emissions are considered. While combined cycle is considerably more efficient than steam turbines, they are also ill-suited to responding to rapid changes in electricity supply or demand. This limits their ability to support a grid with a high penetration of wind and solar power. Under AEMO's modelling (see section 4.1), most Australian combined cycle gas generators are expected to retire over the coming decades without being replaced near the end of their service lives.

- **Open-cycle gas turbines:** These gas generators are far more flexible, and able to respond to peaks in electricity supply or demand. However, their flexibility comes at a climate cost as these generators are relatively inefficient compared to steam and combined cycle generators. As shown in Table 2 and Table 3, while the average emissions of the current fleet are lower than Australia's existing coal fleet, once upstream emissions are accounted for several of Australia's existing open-cycle generators are far more polluting, per unit of electricity generated, than coal (see Table 3). With a few exceptions, these high emitters tend to be used to manage extreme peaks in electricity demand and so produce few emissions in total.

- **Reciprocating engines:** Australia has only one large gas-powered reciprocating engine: the new Barker Inlet power station co-located with the remaining units at Torrens Island in South Australia, though many smaller reciprocating engines are in service around the country. Reciprocating engines are even more flexible than conventional open-cycle generators, and have a similar emissions intensity to newer open-cycle generators (AGL Energy 2017; Skinner 2020).

The relative emissions intensity of each power station technology is shown below in Table 2, including direct and indirect emissions.

Table 2: Average emissions intensity of Australian power stations by fuel, including direct (scope 1) and indirect (scope 3) emissions. **Source:** Clean Energy Regulator (2020) and ACIL Allen (2016).[2]

Power station type	Average direct emissions intensity (kg CO_2-e/MWh)	Average direct and indirect emissions intensity (kg CO_2-e/MWh)
Brown coal (subcritical)[3]	1,204	1,209
Black coal (subcritical)	890	921
Black coal (supercritical)	858	869
Gas-fired steam turbine	562	692
Open cycle gas turbine	616	672
Reciprocating gas engine[4]	*560*	*672*
Combined cycle gas turbine	411	471
Hydro	0.6	0.6
Solar	0.6	0.6
Wind	0.4	0.4

Even setting aside that these emissions intensities rely on the official data and so – as discussed in section 3.4 – very likely underestimate indirect emissions from the facilities, it is immediately clear that not all gas generators are created equal.

2 Emissions intensities calculated using volume-weighted averages over the most recent four-year period, and including partial coverage of scope 3 emissions. Due to the lack of reliable data for the scope 3 emissions of generators operating on smaller grids, or used off-grid, this data includes only currently operating large generators connected to the National Electricity Market and Southwest Interconnected System.

3 The terms subcritical and supercritical – as well as the latest generation of 'ultrasupercritical' generators that do not exist in Australia – refers to the pressure of the water that is used to generate steam in a power station. Generally-speaking, higher pressures require higher temperatures and the higher temperatures mean that a station is more greenhouse gas efficient. While all coal-fired generators produce very significant quantities of greenhouse gas, there is some improvement between sub- and supercritical coal, and a further improvement between super- and ultrasupercritical. This improvement is insufficient to justify any new coal power stations in a carbon constrained world.

4 Barker Inlet Power Station, Australia's one large gas-fired reciprocating engine, began operating in 2019, and is yet to report to the Clean Energy Regulator. These figures are taken from the project's environmental impact statement (AGL Energy 2017). The relatively high contribution of upstream emissions for this generator is an artefact of the facts that the gas field supplying it has high carbon dioxide concentrations and because this generator is located very far from the gas fields that supply it. This is not an indication of anything specific to the technology.

Figure 10: Australia's fleet of open-cycle generators, like Jeeralang B shown above, are very significantly less efficient than other forms of generation, and can be as emissions intensive as coal-fired generators.

The oft-repeated claim that gas can produce electricity at half of the emissions intensity of coal and support the deployment of renewables can only be true when certain kinds of coal are compared to certain kinds of gas. Currently, some existing gas is required to firm up renewables, and the generators that are best able to ramp up and down to meet peaks and troughs in renewable energy supply, like open-cycle gas turbines and reciprocating engines, have higher emissions per unit of electricity generated. Fortunately, they produce less emissions overall simply because they are not run often. On top of this, while the average emissions intensity of different technologies provides some context, even within individual technologies, the performance of individual generators varies considerably.

Table 3 shows the emissions intensity of Australia's ten least efficient open-cycle gas turbines. All of these are comparable to Australia's fleet of coal fired power stations.

Each of these generators are open cycle turbines and all except Pinjar A and B operate as true 'peaking' facilities – meaning they backup the grid in case of shortfalls in supply, and are not often used. These generators are expensive to run. Australian electricity is among the most emissions intensive in the world (International Energy Agency 2020a) (Australian Energy Market Operator 2020c).

These peaking power stations, which are expected to be rarely used over the next 20 years and so do not require large quantities of gas, can be run using existing gas supplies (Australian Energy Market Operator 2020a). With Australia exporting three times as much gas as it uses in any given year (see section 3.1), they do not require new gas fields.

Table 3: A comparison of Australia's least efficient gas-fired power stations and the existing coal fleet. **Data source:** Clean Energy Regulator (2020), ACIL Allen Consulting (2016).[5]

Name	Ultimate owner	State	Emissions intensity (kg CO_2 e/MWh)[6]	Notes
Barcaldine	Queensland Government[(1)]	Qld	2,430	**Australia's dirtiest gas power station**
Yallourn	Energy Australia	Vic	1,320	**Australia's dirtiest coal-fired power station**
Dry Creek	Engie/Mitsui	SA	1,227	
Hallet	Energy Australia	SA	1,167	
West Kalgoorlie	WA Government[(2)]	WA	1,078	
Mintaro	Engie/Mitsui	SA	923	
Pinjar A & B	WA Government[(2)]	WA	869	
Mungarra	WA Government[(2)]	WA	845	
Valley Power	Federal Government[(3)]	Vic	840	
Millmerran	InterGen	Qld	832	**Australia's most efficient coal-fired power station**
Jeeralang A & B	Energy Australia	Vic	819	
Somerton	AGL	Vic	791	

[(1)] Via Ergon Energy [(2)] Via Synergy [(3)] Via Snowy Hydro

5 This list only includes power stations connected to either the National Electricity Market or the South West Interconnected System.

6 Emissions intensities determined using cumulative generation and emissions data for financial year 2016–2019 as reported by Clean Energy Regulator (2020). Scope 3 emissions intensities used from ACIL Allen Consulting (2016).

BOX 2: THE TRANSITION FUEL MYTH

Hypothetically, a coal-to-gas transition could deliver a slight, one time reduction in annual greenhouse gas emissions from the electricity sector (International Energy Agency 2019) using Federal Government estimates of the impact of gas. However, if the full climate impact of gas is considered – including accurate measurement of indirect emissions as well as accurately calculating the total contribution of released methane to the warming of the atmosphere – this would substantially reduce the claimed climate benefit. In many cases it would eliminate it.

What proponents of the coal-to-gas switch also overlook is that coal is already in structural decline in Australia. Every second year, the Australian Energy Market Operator extensively models the future of Australia's largest grid – the National Electricity Market – to produce roadmaps for the possible future of the grid over the next two decades. The most recent iteration of this Integrated System Plan forecasts that between 40% and 95% of coal-fired generation capacity will retire over the next 20 years, with no new coal-fired generator built to replace it. At the same time, the amount of gas-fired generation capacity in the grid, and the use of those generators, is expected to decrease over time.

On top of this, building new gas generators, without taking additional steps to close coal-fired generators, can only add to the total greenhouse gas emissions from the electricity sector. For gas to play a transitioning role, there would need to be a plan to close coal-fired generators. And as will be shown in the next section, there are more than enough gas-fired generators currently available to support the grid as renewables rapidly increase and more zero-emissions dispatchable supply – such as batteries and pumped hydro – comes online.

If there is competition today among the fossil fuel generators it is between existing gas generators and proposed new facilities. As shown in Table 3, many in Australia's fleet of existing generators are relatively greenhouse gas intensive. However, most of these have been fully paid off, and can be closed as soon as the zero emissions alternatives are ready. In contrast, any new generator will be built with the expectation that it will continue operation for several decades in order to pay for the costs of construction.

Taken together, this shows that even where a marginal improvement in emissions efficiency between old and new exists, newer and notionally more efficient gas generators will likely emit more than old generators over their remaining operating lives. A one-off reduction in emissions from replacing a coal-fired power station with a gas replacement counts for little if the replacement has an operating life that is twice as long. Chasing such negligible benefits will most likely stall, rather than facilitate, the necessary transition to zero emissions.

4. A better way to support wind and solar

In latest Integrated System Plan for the National Electricity Market (NEM), the Australian Energy Market Operator forecasts a steadily shrinking role for gas over the next 20 years (Australian Energy Market Operator 2020a). The plan outlines a series of future options for the grid across a range of different possible futures. Five scenarios are outlined for the NEM - Australia's largest electricity grid, which supplies all of Victoria, Tasmania and the Australian Capital Territory, along with the major populated regions of New South Wales, Queensland and South Australia.

The gas prices required for gas to outcompete zero emissions firming solutions appear unachievable.

As wind and solar generation rapidly increases, driving emission reductions across the grid, most of Australia's fleet of relatively inflexible combined cycle gas turbines and gas-fired steam generators will retire. In most scenarios, the cheapest way to manage the grid results in more than two-thirds of these generators retiring within the next 20 years. In four out of five scenarios, the least-cost path is for this to occur relatively soon and without replacement. The one scenario that does include new combined cycle generators still forecasts that overall installed capacity of these generators falls by more than one-third (Australian Energy Market Operator 2020a).

The relatively high-emitting, but more flexible, open cycle generators remain under most scenarios, but are only used in short bursts to meet peaks in demand and occasional troughs in supply. This loosely matches the way most of these generators operate today, though they are likely to be used much less often (Australian Energy Market Operator 2020a).

While concerns about wind and solar power variability are often exaggerated, managing this presents genuine challenges. Luckily, these are challenges with obvious solutions. The Australian Energy Market Operator notes that gas would only play an increased role in firming the grid if it can outcompete zero emissions solution, such as batteries and pumped hydro, on price (Australian Energy Market Operator 2020a). Such gas prices – which must remain in the $4-6 per gigajoule range and be sustained over decades – appear to be unachievable in the regions connected to Australia's largest grid.

The Australian Petroleum Production and Exploration Association – the main lobby group representing gas producers – has described the possibility of prices ever returning to this level as a 'myth' and noted that 90% of proven and provable gas reserves across the east of the country have a lifecycle cost higher than this (Australian Petroleum Production and Exploration Association 2020).

Along with careful planning of new infrastructure – particularly the construction of new transmission to ensure energy is moved around the grid efficiently – the 2020 Integrated System Plan prefers an array of zero emissions solutions including:

1. Pumped hydroelectricity,
2. Large-scale battery energy storage systems,
3. Distributed batteries,
4. Virtual power plants, and
5. Other demand side participation.

These five options allow electricity supply and demand to be intelligently managed throughout the day so that daily peaks and troughs in supply and demand are smoothed. Dispatchable storage solutions such as large-scale batteries and pumped hydro smooth spikes in electricity supply by storing electricity when it is in excess, and returning it to the grid at times when it is needed most. Demand side participation options, including distributed batteries, virtual power plants and smart devices, shift the demand for electricity to match periods of higher supply.

Under the scenarios in the Integrated System Plan, the principal periods where gas might still be required would be to manage periods when several days of calm, cloudy weather affects a large share of the grid's wind and solar generators.

Zero emissions solutions such as those listed above are expected to drastically reduce the role for gas in the electricity grid. Incentivising gas-powered generation will add costs and provide disincentives to smarter and more affordable solutions for managing a large electricity network in the 21st century.

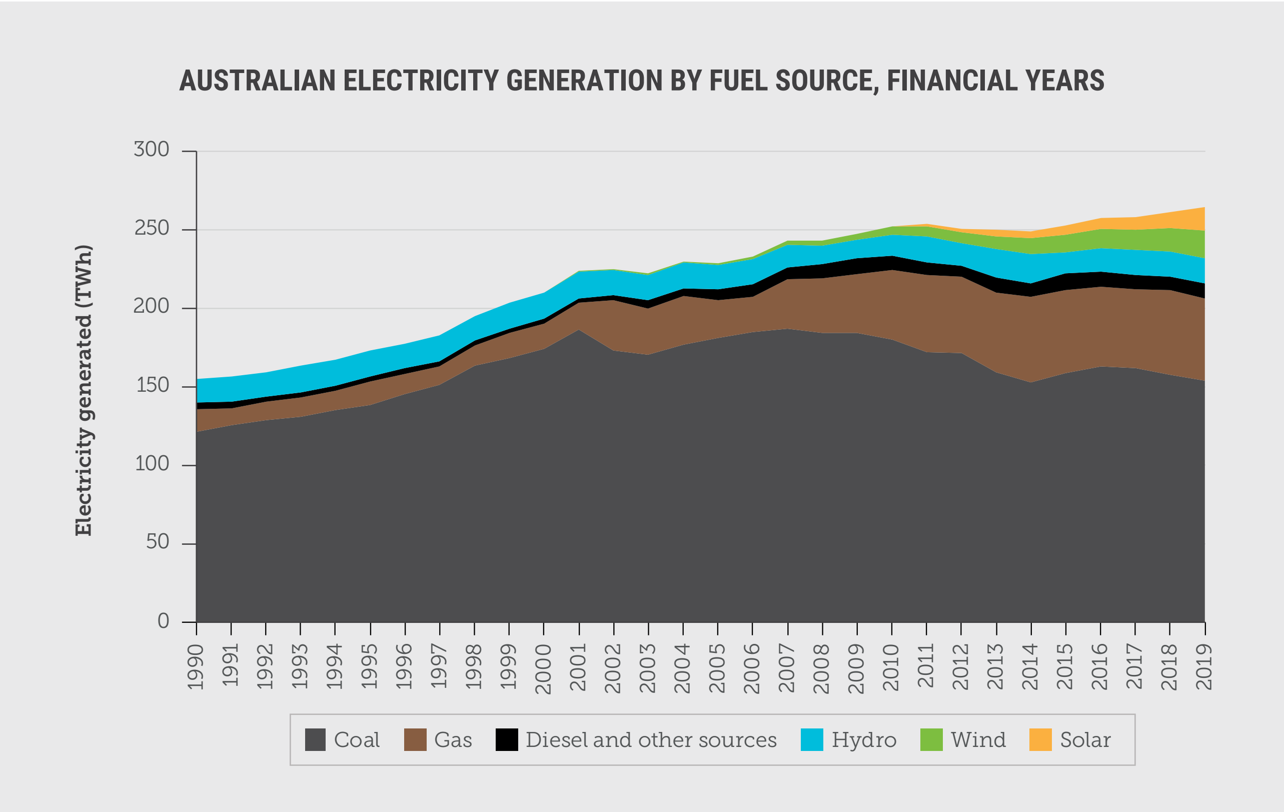
4.1 The declining role of gas

The role of gas in Australia's electricity grid will shrink as renewable energy increases. In the long-term, renewables and storage will meet almost all of Australia's electricity needs. The key question today is: 'How fast can the required transition occur?'

Australia's energy supply is currently dominated by fossil fuels (Department of Industry, Science, Energy and Resources 2020a). While gas is used in many other sectors of Australia's overall energy mix (see section 3.1), the largest share of domestic gas consumption occurs in the electricity sector. This sector is responsible for nearly one third of Australia's overall gas consumption (Department of Industry, Science, Energy and Resources 2020a).

Despite record levels of deployment of renewables in recent years (Clean Energy Council 2020), black and brown coal still provide most of the power travelling through Australia's electricity networks at 56%. Gas provides 21% and 2% comes from the consumption of liquid fossil fuels like diesel. More than one-fifth of Australia's electricity comes from wind, solar and hydro-electric generation (Department of Industry, Science, Energy and Resources 2020d). This can be seen below in Figure 11.[7]

Figure 11: Australian electricity generation by fuel source, financial years. **Data source:** Department of Industry, Science, Energy and Resources (2020d).



7 This data includes all of Australia's small grid and off-grid generation, much of which is gas.

Not so long ago, virtually all plans to transition to a zero-emissions world included a temporary growth in gas-powered generation. However, more recent analyses – such as the scenarios developed by the Australian Energy Market Operator – paint a very different picture. The seismic shift in the economics of renewables and storage has re-written the rules. In the sunniest and windiest inhabited continent (Geosciences Australia 2019), wind and solar powered generation is the cheapest form of new electricity generating infrastructure, and remains so even when factoring in storage (Graham et al. 2018).

There are many individual factors that underpin this new reality. The cost of wind and solar generation infrastructure has rapidly reduced and the options to manage the high penetration of renewables have improved (Australian Energy Market Operator 2020a). The cost of the core components of lithium ion batteries, used for battery storage, have fallen by nearly 90% in the past decade, from $1,100 per kilowatt hour in 2010 to $156/kWh in 2019 (BloombergNEF 2019).

It may once have been thought necessary to shift from a coal-dominated electricity grid to a gas-dominated electricity grid in Australia on the way to a zero-emissions future. These transitions have occurred elsewhere in the world, such as in the UK and USA. For Australia, as we head further into the 21st century, making such a transition is not only unnecessary, but far more expensive than choosing a lower emissions pathway (Australian Energy Market Operator 2020a). There are other, significantly cheaper ways to stabilise the electricity grid in 2020 than by increasing the share of fossil fuel use.

For the most part, Australia's energy market operator forecasts the cheapest paths will bypass new coal and gas infrastructure (Australian Energy Market Operator 2020a). The most ambitious scenario results in nearly 95% of coal-fired generation capacity retiring within the next two decades, as wind and solar generation capacity more than triples. Storage capacity in the grid increases nearly ten times over. Around half of all gas-powered generators would retire over the same period, with those that remain only used in short bursts during peak periods.

Under this scenario, greenhouse gas emissions from the generation of electricity for the National Electricity Market are 95% lower than today. The relative proportion of installed electricity generators in Australia's largest grid is shown below in Figure 12.

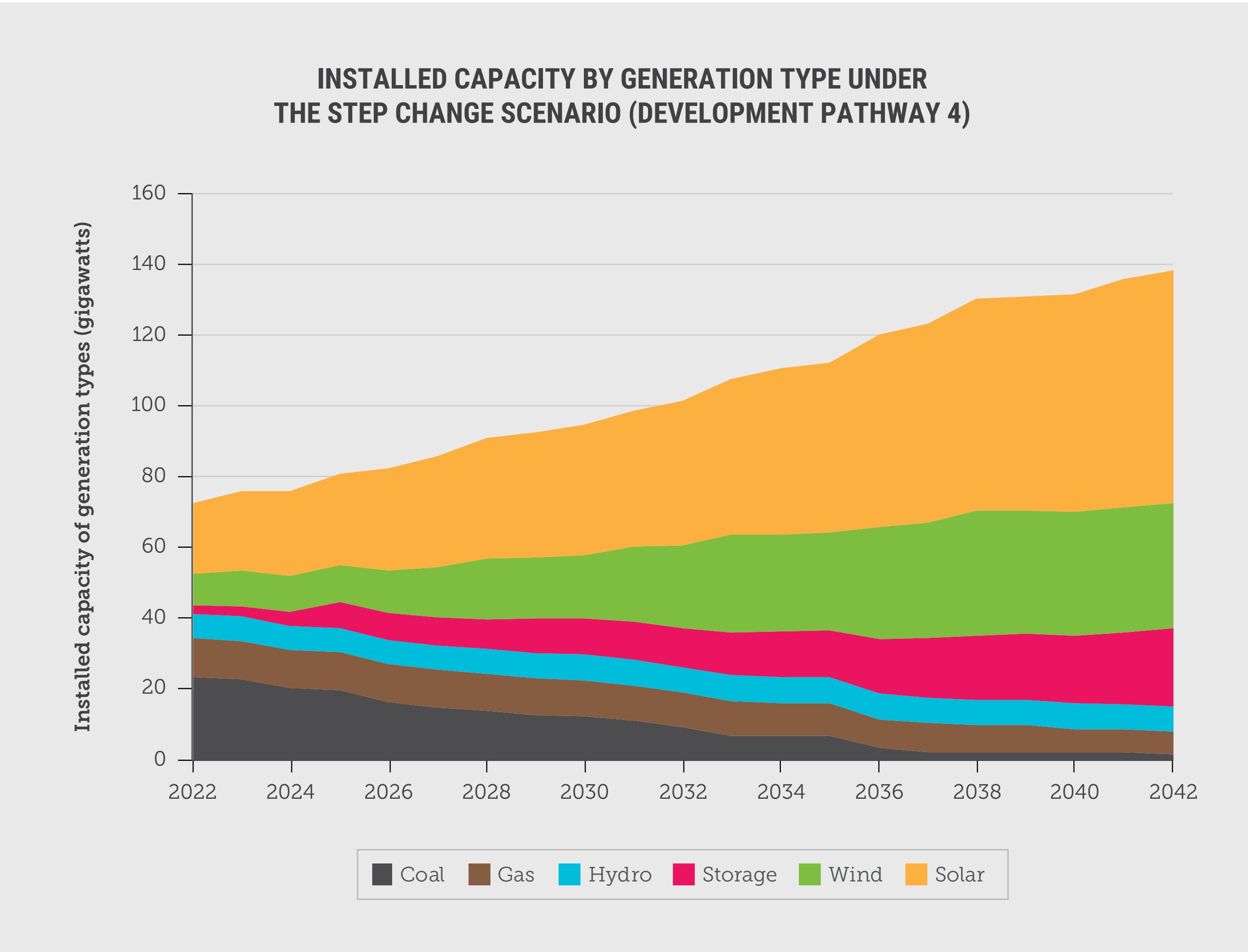
A seismic shift in the economics of energy has made gas redundant in the energy transition.

The reality is that a well-managed transition to zero emissions firming solutions in the electricity grid will be significantly cheaper than a gas powered route. In the long term, this will require fewer gas generators than are connected to the grid today, and these generators will likely be operating much less often. Managing this transition will not be simple, but will be simpler if planning begins now, rather than on an ad hoc basis over the next several decades.

Managing the transition to renewables in Australia's smaller grids like the South West Interconnected System – powering Perth and the southwest of Western Australia – or the Darwin Katherine Interconnected System – powering the most heavily populated regions of the Northern Territory – presents other challenges and opportunities, but the same economics apply there as in Australia's largest grid.

Decarbonising Australia's electricity networks is now a matter of co-ordination, planning and political will. In a country that has already lost so much to the impacts of climate change, and that stands to lose much more if we don't address this crisis, there is a pressing need to get on with the job.

Figure 12: Installed capacity by generation type under the Integrated System Plan's most ambitious scenario.
Source: Australian Energy Market Operator (2020a).



BOX 3: SOUTH AUSTRALIA LEADS THE WAY

Between 2005 and 2025, South Australia will have transformed its electricity system from having virtually no solar or wind generation to having more than 85%; resulting in cheaper and cleaner power for its residents. This makes South Australia a global leader, and shows the rest of the country what can be achieved with sustained leadership.

Fifteen years ago, South Australia was completely reliant on coal and gas for its electricity supply. Today, while the state still uses some gas, more than 57% of its electricity already comes from renewable sources (OpenNEM 2020), with much more on the way (Australian Energy Market Operator 2020a).

Industry has invested more than $7 billion since 2004 (RenewEconomy 2019) and built 2500 megawatts (MW) of large-scale wind and solar in the state, an amount that is more than enough to compensate for the complete closure of the state's coal industry. While the state used to rely on importing Victoria's coal electricity, since 2017 South Australia has become a net electricity exporter (OpenNEM 2020). Recently, the average wholesale electricity price was lower in South Australia than in New South Wales, Victoria or Tasmania (Australian Energy Market Operator 2020d).

To shore up reliable power supplies, the state again led the world by installing the largest-ever grid scale battery at Hornsdale in 2017. Since its installation the battery has been further expanded by 50% (Australian Renewable Energy Agency 2020). This battery reduced South Australian electricity consumers costs by $116 million in 2019 (Aurecon 2020). Several synchronous condensers[8] to enhance grid security are currently being added, further reducing gas power needs and costs by over $20 million per year (ElectraNet 2019).

On a per person basis, the state is a leader in household solar with over 1200 MW installed and leads the nation in the rollout of household battery systems to create a virtual power plant[9] (RenewEconomy 2019).

After an interconnector is built to NSW in 2024, renewable electricity facilities in South Australia will supply 85% – 90% of the state's annual electricity demand, reducing gas consumption for power generation by 80% (Australian Energy Market Operator 2020a). These renewable power stations will also export considerable volumes of surplus electricity into New South Wales. Fuel cost savings will exceed $200-300 million per year, overall electricity costs will be $180 million lower per year for NSW customers, and SA consumers will each save $100 per year on their power bills (Project Energy Connect 2020a, 2020b).

South Australian governments of both major political parties have recognised the considerable advantages arising from being an early mover on renewable energy, and have provided a continuous, stable policy and investment framework for industry and consumers in the state (Climate Council 2019b). All have reaped the benefits.

South Australia's transition to renewable energy is dramatically reducing the price of energy for consumers today.

8 A synchronous condenser is essentially a large spinning machine connected to the grid, similar in function to a free spinning motor. Synchronous condensers are one solution to ensuring a stable supply of electricity through the network. While there are other means to achieve this stability in grids with a high share of renewables, synchronous condensers are one important solution. Other options, such as inverters, are able to play a similar role.

9 In a virtual power plant, the operation of a large number of solar and battery storage systems is controlled through software by an electricity retailer. This enables the generation, charge and discharge of the solar panels and batteries to be coordinated so that, together, the systems effectively operate as a power plant.

4.2 Australians pay a high price for gas

Despite promises from the Federal Government of economic benefits from gas, price volatility and the industry's low levels of employment mean the industry is not delivering clear benefits to Australians. Unprecedented growth in the export gas industry has driven up the price of gas in Australia over the past few years. Today, after a gas price crash, the global gas industry is reeling from historically low prices, and yet these savings are not being passed on to Australian consumers.

Relying on the gas industry for employment would be unwise even under the best economic conditions. Australia has just sufferred its first recession in 29 years as a result of the response to COVID-19 (BBC News 2020). The gas industry employs very few Australians, both on an absolute basis and as a share of revenues compared to other industries (Australia Institute 2020a). In contrast, pursuing a clean recovery with good, sustainable jobs that also solve long term problems like climate change would provide far more economic benefits (AlphaBeta & Climate Council 2020).

BOOM AND BUST

Australia's enlarged gas industry has increasingly exposed the country to the boom-and-bust cycles that affect the global oil and gas market. The wholesale price of gas reached record highs for most Australians between 2016 and 2019 (Australian Energy Regulator 2020a, 2020b), before plummeting as a result of a global supply glut in late 2019 (International Energy Agency 2020c).

As a result of this, gas cannot be relied on to provide stable energy prices. The growth in gas exports and Australia's increased exposure to the international market doubled the price of gas in Australia between the 2016 and 2017 calendar years in Queensland, New South Wales, Victoria and South Australia (Australian Energy Regulator 2020a, 2020b). The entry into the market of three new liquefied gas export terminals on Curtis Island, near Gladstone, was a major factor. These terminals immediately began to buy large quantities of gas from the domestic market in order to top up their own supply shortfalls (Llewellyn-Smith 2020; ABC News 2020). This sudden price spike placed Australia's manufacturing sector under immense pressure and threatened thousands of previously stable Australian jobs (ABC News 2020).

Most Australians were hit by record high energy prices in recent years due to spikes in the price of gas.

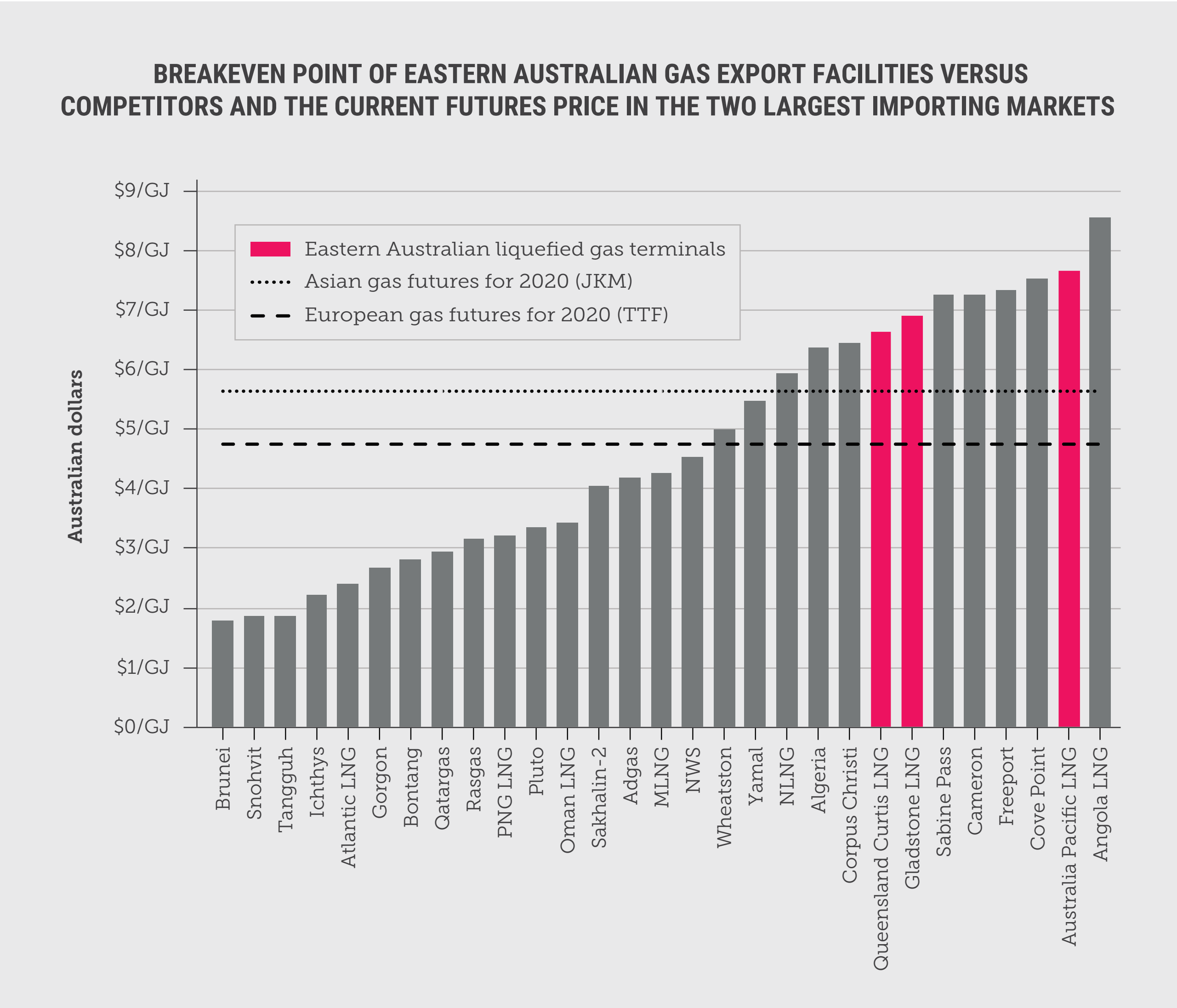
Figure 13: Opening up Australia's gas export industry exposed Australian jobs in gas-industry reliant sectors to the boom and bust cycle of the global market. These jobs are now inherently vulnerable.

In the first half of 2020, the global gas market went into 'meltdown' (International Energy Agency 2020c) as a global glut in the supply of gas took hold (HSBC Global Research 2020). This was exacerbated by an oil price war between Saudi Arabia and Russia which further drove down the global price of gas (Padilla 2020). The combined impact of these factors, along with COVID-19, resulted in 40% of Australian oil and gas jobs being lost in the space of a month in 2020 (Australian Bureau of Statistics 2020). This rate of job loss meant the oil and gas sector was the hardest hit in the immediate aftermath of COVID-19. In the months since this initial shock, some of these jobs have returned. However, this hints at a core vulnerability of the Australian gas sector today.

Prominent analysts of the global market expect the oversupply of gas to continue through most of the next decade (HSBC Global Research 2020). This oversupply has been predicted for several years, with the International Energy Agency raising the risk as far back as 2017 in its annual World Energy Outlook. The gas exported from Australia's east coast terminals is among the most expensive to produce in the world, and is unlikely to be profitable at projected prices (see Figure 14, below). Across the world, hundreds of billions of dollars have been sunk into liquefied gas infrastructure, and this investment is now in jeopardy (Plante et al. 2020).

The three Curtis Island liquefied gas facilities are, in the words of one of the world's largest banks, 'at risk' (HSBC Global Research 2020). The first signs of this are evident in a record drop in Australia's gas exports. Between April and June this year, liquefied gas exports declined by 16% (Department of Industry, Science, Energy and Resources 2020e). While this is clearly linked to COVID-19, and there has been some recovery in exported volumes since it remains to be seen whether – and by how much – the price will recover given that several of the trends driving low gas prices appear to be long-term and systemic.

Figure 14: Breakeven point of eastern Australian gas export facilities (red) versus competitors (grey) and the current futures price in the two largest importing markets. **Converted from:** HSBC (2020).



The volatility of the gas price, which went from boom to bust in just a few years, shows precisely why gas cannot be relied on for economic recovery in Australia as the country navigates a path out of COVID-19 (Climate Council 2020a). All Australian jobs that are reliant on gas – whether in extraction of the fossil fuel or in sectors that are significant users of gas – are now increasingly vulnerable to the volatile international market for oil and gas.

Historically, Australian households and businesses have been insulated from the volatile international market for oil and gas, but the recent boom in liquefied gas exports means that the country's economy is exposed like never before to these global forces (McConnell & Sandiford 2020). There is no good reason that Australians should continue to suffer exposure to high priced electricity and gas when there are cheaper, cleaner alternatives, such as wind and solar, backed by storage.

Furthermore, recent analysis by the Australian Competition and Consumer Commission found worrying signs that Australians are being overcharged when buying Australian gas (Australian Competition and Consumer Commission 2020). In a trend the Commission's most recent interim report described as 'extremely concerning', Australian gas producers operating on the east coast charged Australian gas consumers significantly more than they would receive from selling that same gas overseas (Australian Competition and Consumer Commission 2020). The Commission's report also identified that since global gas prices began to fall, the gap between the prices paid by international and domestic users of Australian gas has been growing. That is, while the global crash in gas prices has significantly reduced prices for overseas users of Australian gas, the drop in price for Australian users of Australian gas has been much smaller.

Ultimately, this directly affects all energy users, even those that do not use significant quantities of gas. The price of gas is one of the strongest influences on the wholesale price of electricity in Australia (Australian Energy Market Operator 2020e). Where the price of gas goes, the price of electricity tends to follow (McConnell & Sandiford 2020).

Exposure to the international gas market means Australian jobs that rely on gas are now inherently vulnerable.

5. A cheaper, cleaner, more reliable future

Globally, the use of gas has grown significantly in recent decades (International Energy Agency 2020d). Annual consumption of the fossil fuel has been rapidly approaching coal and it is now one of the fastest growing sources of greenhouse gas pollution (International Energy Agency 2020c; Saunois et al. 2020).

Thankfully, given the contribution gas makes to driving climate change, this looks set to change. As outlined in section 4.1, recent modelling by the Australian Energy Market Operator shows that domestic use of gas for electricity is likely to steadily decline over the next two decades (Australian Energy Market Operator 2020a).

At a time when Australia is already experiencing the devastating impacts of climate change there is a powerful need for the country to move away from the use of coal, oil and gas. In industries where gas can be replaced by zero emissions sources, such as the electricity sector (Australian Energy Market Operator 2020a) and in many industrial heat applications (Lord 2018), gas consumption should be eliminated wherever possible.

While a full transition will take time, many Australian homes are already able to move completely away from fossil fuels by taking cost-saving energy efficiency measures and replacing household appliances with more efficient electric alternatives (Domain 2019). These alternatives include induction cooktops, heat pumps for space and water heating or a combination of solar hot water and reverse cycle heating.

Australia needs to urgently move away from all fossil fuels, including gas.

Figure 15: Limiting future climate harm means no new gas in Australia.

Australia is one of the world's biggest greenhouse gas polluters, both at home and overseas. On an absolute basis, it is the world's 14th highest emitter, meaning Australia adds more to the global climate burden than 181 other countries each year (Gütschow et al. 2019). Per person, Australia emits more than any other developed country in the world (Climate Council 2020a).

Alongside the massive climate harm done within its shores, Australia is also a globally significant exporter of fossil fuels. In 2019, Australia was the largest exporter of liquefied gas, the largest exporter of metallurgical coal and the second largest exporter of thermal coal (Office of the Chief Economist 2020). On an extraction basis – that is by assigning to each country the emissions of all fossil fuels extracted on its shores – Australia is the fifth largest climate polluter in the world (Australia Institute 2019) despite having less than 0.3% percent of the world's population.

Despite frequently overstated claims of a climate benefit from using gas, as shown in section 3, the reality is that over its life cycle gas can be more polluting than other fossil fuels. Even where short-term benefits might exist, building new gas infrastructure locks in decades of pollution, and delays zero-emission alternatives. The debate around the relative benefit of gas to coal obscures a vital point: gas has no more of a role to play in Australia's zero emissions future than any other fossil fuel.

The sooner the world reaches net zero emissions, and the less greenhouse gas that is emitted along the way, the less heating will be experienced (Rogelj et al. 2018) and, ultimately, the less harm done to the ecosystems that underpin human wellbeing (Hoegh-Guldberg et al. 2018). Minimising climate harm requires moving away from all fossil fuels. While countries like Australia – with considerable wealth and every possible natural advantage – continue to burn, produce and export fossil fuels, devastating climate impacts are intensifying. This adversely affects Australians, their economy and the natural environment.

The Black Summer of 2019/20 was a stark reminder of the deadly consequences of the failure to drive down global greenhouse gas emissions. Australia has a unique opportunity to set itself up for the future by creating clean jobs and investing in climate solutions that kick-start the economy and tackle climate change simultaneously.

New or expanded gas infrastructure has no role to play in this future.

Big emitters like Australia need to lead the charge to a net zero emissions future.

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