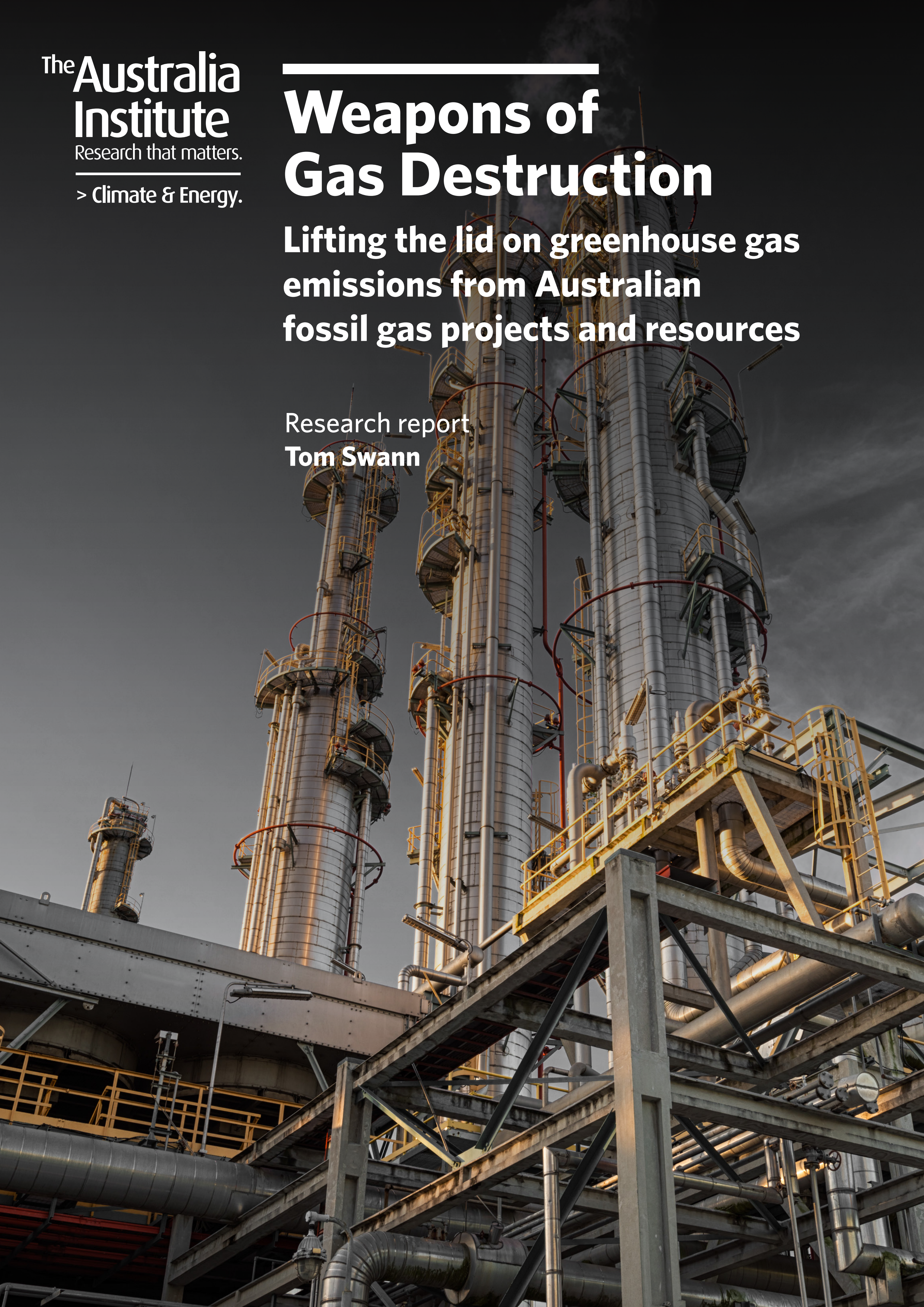
The Australia Institute
Research that matters.

> Climate & Energy.

Weapons of Gas Destruction

Lifting the lid on greenhouse gas emissions from Australian fossil gas projects and resources



Research report

Tom Swann

Weapons of gas destruction

Lifting the lid on greenhouse gas emissions from Australian fossil gas projects and resources

Fossil gas projects proposed in Australia represent an annual climate impact more than half of Australia's annual emissions. Australia's already identified gas resources, if burned, would have a climate impact larger than annual emissions from any country. Yet further resources pursued by governments and companies represent a climate impact larger than annual world emissions, taking up 28% of a 1.5°C carbon budget, or 8% of a 2°C budget. Such gas expansion is inconsistent with solving climate change.

Discussion paper

Tom Swann

September 2020

Commissioned by the Australian Conservation Foundation.

ABOUT THE AUSTRALIA INSTITUTE

The Australia Institute is an independent public policy think tank based in Canberra. It is funded by donations from philanthropic trusts and individuals and commissioned research. We barrack for ideas, not political parties or candidates. Since its launch in 1994, the Institute has carried out highly influential research on a broad range of economic, social and environmental issues.

OUR PHILOSOPHY

As we begin the 21st century, new dilemmas confront our society and our planet. Unprecedented levels of consumption co-exist with extreme poverty. Through new technology we are more connected than we have ever been, yet civic engagement is declining. Environmental neglect continues despite heightened ecological awareness. A better balance is urgently needed.

The Australia Institute's directors, staff and supporters represent a broad range of views and priorities. What unites us is a belief that through a combination of research and creativity we can promote new solutions and ways of thinking.

OUR PURPOSE – 'RESEARCH THAT MATTERS'

The Institute publishes research that contributes to a more just, sustainable and peaceful society. Our goal is to gather, interpret and communicate evidence in order to both diagnose the problems we face and propose new solutions to tackle them.

The Institute is wholly independent and not affiliated with any other organisation. Donations to its Research Fund are tax deductible for the donor. Anyone wishing to donate can do so via the website at https://www.tai.org.au or by calling the Institute on 02 6130 0530. Our secure and user-friendly website allows donors to make either one-off or regular monthly donations and we encourage everyone who can to donate in this way as it assists our research in the most significant manner.

Level 1, Endeavour House, 1 Franklin St
Canberra, ACT 2601
Tel: (02) 61300530
Email: mail@tai.org.au
Website: www.tai.org.au
ISSN: 1836-9014

Summary

The fossil gas industry in Australia tripled production from 1990 to 2010 and then from 2010 to 2019 production tripled again. Nearly all of the new production was exported. Australia has become the world's largest exporter of liquified natural gas (LNG) and one of the world's biggest gas producers. Australia's gas and coal exports make Australia's the third largest exporter of fossil fuels in the world, after Russia and Saudi Arabia.

Over the decade to 2018 Australia was responsible for most of the growth in LNG, and a third of the growth over the last 20 years, more than any other country Australia's share of global gas production soared in recent years, even as its share of global proven gas reserves levelled out.

Australian Government publications list 22 new gas production and export proposals across Australia with an estimated gas production capacity of 3,368 PJ pa. Goverments and companies are preparing to exploit further gas resources in the ground that are larger still.

Despite calls for decarbonisation be central to the economic recovery from the coronavirus pandemic, the Australia government is proposing policies and subsidies for what it calls a "gas fired recovery". From an economic and employment perspective, this makes little sense. There are many low cost ways to reduce gas consumption, and the industry, despite its size, employs few Australians. Expanding fossil gas production also threatens to release large amounts of greenhouse gases.

Burning fossil gas releases carbon dioxide (CO_2). In addition, extracting, processing transporting and exporting fossil gas is also highly emissions intensive, and already responsible for more than 10% of current Australian emissions, on official government data. A large portion of these emissions come from gas burned by LNG facilities. Australian LNG facilities burn around nine percent of all gas they receive to help liquify the remaining gas for export. Gas consumption in LNG facilities is double the size of whats consumed by Australian households and about as large as what is consumed by Australian manufacturing.

Another major climate impact is 'fugitive' emissions from flaring, venting and leakage. The true impact of these emissions is larger than officially reported. Fossil gas is made up mostly of methane, itself a greenhouse gas with much greater heat trapping potential than CO_2. While methane is more powerful than CO_2 over a 100 year timeframe, which is the conventional basis for comparison, methane traps far more heat over the nearer-term (a 20 years horizon). A small amount of methane loss greatly increases the climate impact of fossil gas.

Many recent studies show rates of methane loss much higher than the Australian government's official figures, especially in unconventional gas production, such as coal seam and shale gas where techniques like hydraulic fracturing are required. Methane loss at rates observed in recent studies of large US shale gas fields range from 2.3% to 3.7%, at the higher end delivering a near-term climate impact equivalent to doubling the emissions of the burnt gas. Reducing and avoiding the release of methane emissions is essential to meeting the Paris Agreement climate goals.

There are 22 major new gas projects proposed by companies and listed by the Australian Government's Office of the Chief Economist. The analysis here converts the supply capacity into common units for comparison and aggregation. The proposed projects are spread across the country and are of various sizes, types and stages. The largest projects are offshore fields designed for gas export, especially off Western Australia's coast. The single largest project, Woodside's Browse / Burrup Hub Extension, would involve piping gas from a large new gas field nearly 1000km through new undersea pipelines to an onshore facility for export.

In addition to the major projects, the report examines proposed unconventional (shale) gas production in the Beetaloo Basin in the Northern Territory and the Canning Basin in Western Australia. Official inquiries into the 'fracking' necessary to tap into these unconventional fields also explored the potential greenhouse gases involved based on production scenarios. The WA Inquiry used scenarios for the Canning Basin up to 402 PJ pa as "realistic for coming decades". The NT inquiry found that up to 1,240 PJ pa was "reasonable for risk assessment purposes". Government documents show officials are concerned such projects would threaten Australia's ability to meet commitments under the Paris Agreement.

The combined supply potential of these major projects with the Beetaloo and Canning Basins is 5,010 petajoules per annum (PJ pa). This is larger than current Australian gas exports and almost equal to Australia's current total gas production.

Beyond the pipeline of new gas projects, Australia has a lot more gas in the ground, that governments and the gas industry promote for extraction and use. These includes resources already 'identified' and those that are 'prospective' and subject to exploration.

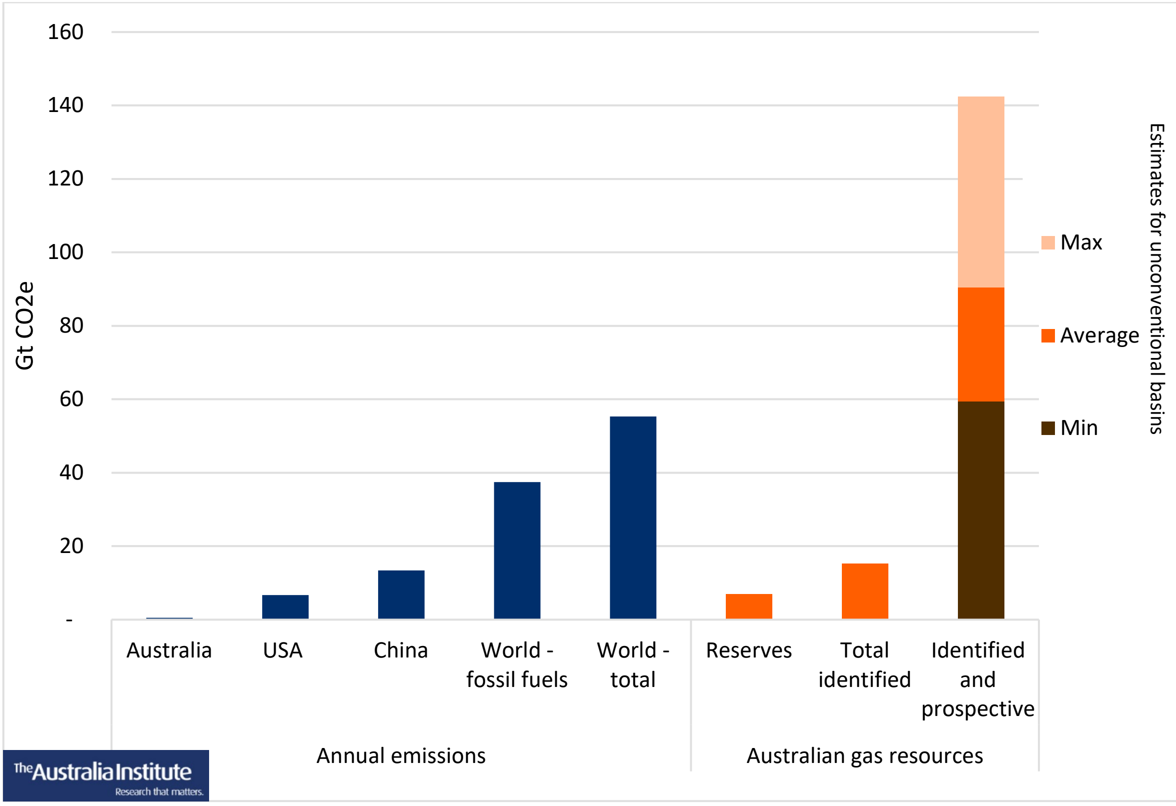
The analysis here compiles data presented by the Commonwealth agency Geoscience Australia, drawn from from a range of studies. This data shows total 'identified resources' are 273,000 PJ, five times larger than the 65,000 PJ of gas extracted to date in Australia. Within the identified resources deemed economic to extract (as at 2018), it was still twice as large as total historical extraction in Australia.

Yet resources that are 'prospective and potentially recoverable' are larger still. While assessments are varied and uncertain, using the average for each basin produces an estimated prospective gas resource of around 1 million PJ. The maximum and minimum estimates are between 0.5-2 million PJ. These are overwhelmingly unconventional shale gas. The largest by far is the Canning Basin in WA, although another four are also larger than all of Australia's gas production to date.

The report estimates the emissions potential of the flow of gas from proposed new projects, and from the gas in the ground as identified and prospective gas resources.

The combustion emissions potential of identified gas resources in Australia are 13 times larger than current annual Australian emissions, and larger than annual emissions from any country, including the USA and China. Even the project pipeline tapping into gas reserves, assessed in 2018, are larger than annual US emissions.

Figure: Australian gas resources vs world emissions



Combustion emissions potential from prospective resources is staggeringly large, almost three years of annual fossil fuel emissions from the entire world, and one year and eight months of global emissions from all sources.

At the higher end, Australia's potential carbon footprint from prospective fossil gas resources is equal to around three times the annual emissions from the entire world. Even on the minimum estimate, Australian gas resources represent greater CO_2 potential than annual world emissions.

The gas resources can also be compared to historical emissions from largest corporate polluters in human history. Total identified gas resources represent larger emissions potential than total fossil fuel emissions over 1988-2015 from Rio Tinto, BHP or Chevron. Identified and prospective gas resources have an emissions potential more than double the fossil emissions of Chevron, Exxon, BHP and Rio Tinto put together. They are larger than emissions from Saudi Aramco and Russia's Gazprom put together.

For a two in three chance of staying below the Paris Agreement goals, combustion emissions from total identified Australian gas resources would take up 5% of the global carbon budget for 1.5°C of warming, or 1.4% of the budget for 2°C. Including prospective resources, Australian gas resources represent 28% of the 1.5°C carbon budget, or 8% of the 2°C budget.

Despite the emissions from fossil gas, the industry and its supporters often claim gas reduces emissions. Such claims are generally made without evidence and do not withstand scrutiny. Gas can increase emissions by simply adding to coal use or displacing clean energy, which is likely in the absence of strong climate policies and even more likely when gas is being subsidised.

Energy system modelling from the International Energy Agency shows how to achieve global economic growth, modern energy access and success under climate goals. This requires gas production to stop growing and decline out to 2040. Similarly, the Australian Energy Market Operator's recent Integrated System Plan (AEMO ISP) shows the lowest cost pathways for the National Electricity Market involves a very large and ongoing increase in renewable energy and much less power from gas.

Most of the world's gas reserves, and most of Australia's, must stay in the ground to meet agreed climate goals. Despite this, governments and companies pursue new projects and development of even greater resources. The scale of potential emissions should be a concern for Australians and for international observers. Australia can either gas fire its recovery from the pandemic and exacerbate global warming, or keep the gas in the ground and support investment in a safer future.

Contents

Introduction

Gas is a fossil fuel. Extracting and burning fossil gas releases heat trapping gases that cause climate change. Gas has been a major source of growing greenhouse gas emissions globally and in Australia.

Fossil gas is used mainly to generate electricity and to produce heat in homes and factories. All of these applications have readily available, economic alternatives that enable elimination of gas consumption, or large reductions. A small share of fossil gas production is used as a feedstock for chemicals.

Over the last decade Australia has become the world's largest exporter of liquified natural gas (LNG) and one of the world's largest producers of fossil gas. On top of the emissions from burning the gas overseas, gas expansion has pushed up Australia's emissions, due both to gas burned in exporting gas and direct release of emissions into the atmosphere. Despite its large scale and emissions, Australia's gas industry employs a very small proportion of the workforce, around one in 500 jobs.[1]

The coronavirus pandemic has thrown global energy markets into chaos. Low gas prices have seen major gas projects delayed and assets written down. Yet despite the gas glut, and the jobs-poor nature of the gas industry, the Australian government is planning what it calls a 'gas fired recovery'. Instead of creating jobs by reducing gas use and switching to renewable electricity, the government is seeking to expand the gas industry.

The Prime Minister established a National COVID-19 Commission, chaired by a gas company director, who appointed a former petrochemical executive and current director of Saudi Aramco, the world's largest oil company, to advise on economic recovery. Not surprisingly, the Commission has told the government it should support the expansion of the gas industry. The Commission's leaked report recommends huge subsidies to gas production, provision of infrastructure, and cuts to environmental protections.

The Commission's gas advocacy stands alongside other policies and proposals that support gas expansion. The government's *Underwriting New Generation Investments* program (UNGI) is pursuing government support for new gas fired power, despite having no legal basis or program guidelines.[2] The government's review into the Emissions Reduction Fund, headed by a gas industry executive and initially kept secret, recommended expanding that scheme to pay facilities, presumably including gas facilities, to emit less. The government is seeking to remake the successful *Clean Energy Finance Corporation,* turning it from a body

[1] Ogge & Swann (2020) *Gas Fired Backfire*, https://www.tai.org.au/content/gas-fired-backfire
[2] Swann & Merzian (2020) *Problems with UNGI*, https://www.tai.org.au/content/problems-ungi

that produces a profit for the taxpayer by investing in clean energy, into a body that makes a loss funding projects like gas power stations.

As global temperatures rise, climate disruption will cause increasing harm to health, life, ecosystems and the economy. Increasing the extraction of fossil fuel will increase emissions, climate disruption and related harms. These harms can be limited only by sustained effort to drive emissions down.

The future of Australia's gas industry is difficult to predict. It will depend on a wide range of factors, including, crucially, government policies. Governments could subsidise gas expansion, locking in increased gas supply and consumption, or they could accelerate the shift to clean energy and lower gas consumption. While many governments, multilateral bodies and corporations are calling for coronavirus recovery plans that tackle the climate crisis at the same time, the Australian Government is preparing to do the opposite.

It is essential that plans for gas expansion are scrutinised in terms both of economics and emissions. This report assesses the emissions that would be released by currently proposed gas projects in Australia and the much larger resources that companies and Australian governments are seeking to exploit.

OUTLINE

This report begins by outlining the many sources of greenhouse gas emissions from fossil gas, from extraction to processing to tranport to burning it at the point of consumption. Burning gas produces CO2. In addition, methane leakage greatly increases the climate impacts from fossil gas.

The report then outlines trends in Australian gas production and export, showing the rapid increase in gas production has gone entirely to exports, including the large amount of gas burned in preparing gas for export as liquified natural gas (LNG). Australia's increased exports have been a significant factor behind increased global gas use.

The next section considers new gas supply projects that are currently proposed around Australia. While the analysis focuses on major projects proposed by companies, as listed by the Commonwealth Government, it also includes government proposals for major development of unconventional (shale) gas frontiers. The aggregate proposed gas supply is larger than current Australian exports.

Governments and the gas industry talk about extracting and burning some, if not all of the large volumes of gas from the frontier basins. So the report considers Australian gas resources – both 'identified' and 'prospective' – compiled from data released by the Commonwealth agency Geoscience Australia. Aggregated, these represent a staggering volume of gas, and therefore a comparably staggering volume of greenhouse gas emissions.

The report assesses emissions associated with proposed gas projects and Australian gas resources. Annual combustion emissions from proposed new gas projects would be more than half of Australia’s annual emissions. In the worst case scenario of methane leakage considered here, the emissions potential over coming decades would be almost as large as Australia’s annual emissions. Identified Australian gas resources represent potential combustion emissions larger than global annual emissions. The prospective resources are larger than the historical emissions of any major oil and gas company.

Finally the report critiques gas industry arguments that gas expansion is needed to reduce emissions. Evidence from a range of sources shows why claims that gas is a ‘transition fuel’, is needed to back up renewables, is needed for industry and displaces coal, simply do not stack up. In a decarbonising world, the role for gas is one that shrinks, not grows.

How fossil gas causes climate change

Fossil gas is a fuel extracted from underground reservoirs, transported and burned as an energy source. It is primarily methane (CH_4).

Gas extracted from geological reservoirs is often called 'natural gas', to contrast it from 'town gas', or 'synthetic gas', gaseous fuels converted from coal, oil or other feedstocks. The term 'natural' gas also contrasts with 'biogas' derived from biological processes. The gas industry uses 'natural gas' as part of marketing designed to make it seem environmentally friendly. The term 'fossil gas' is more descriptive and accurate.

Fossil gas is a major cause of climate change. The expansion of the fossil gas industry threatens higher global temperatures, more climate disruption and and damaging climate impacts. Decisions made now will determine whether that trend continues.

Like all fossil fuels, burning fossil gas produces carbon dioxide (CO_2), the greenhouse gas that is the main source of human-caused climate change. Fossil gas is burned in power generators, industrial facilities and residences in Australia and globally. All of this produces greenhouse gas emissions. However, the fossil gas industry also emits heat-trapping greenhouse gases in many other ways.

Drilling, extracting, processing, compressing and pumping gas through pipes are all very energy intensive activities. This energy is generally powered by using fossil fuels, primarily burning fossil gas or from the electricity grid, which in Australia is still mostly coal and gas power.

One of the largest gas consumers in Australia is the gas export industry itself. Exporting fossil gas as 'liquified natural gas' (LNG) requires compression and super-cooling, processes that are generally powered by burning large amounts of gas. The LNG export facilities in Australia use around 9% of the gas inflows to those facilities just in the process of preparing gas for export.[3] This is more than double the amount of gas used by Australian households and almost as much as used by manufacturing. Gas is also combusted in LNG shipping and regassification.

The fossil gas industry also releases greenhouse gases directly into the atmosphere through venting, flaring and leakage, known as fugitive emissions.

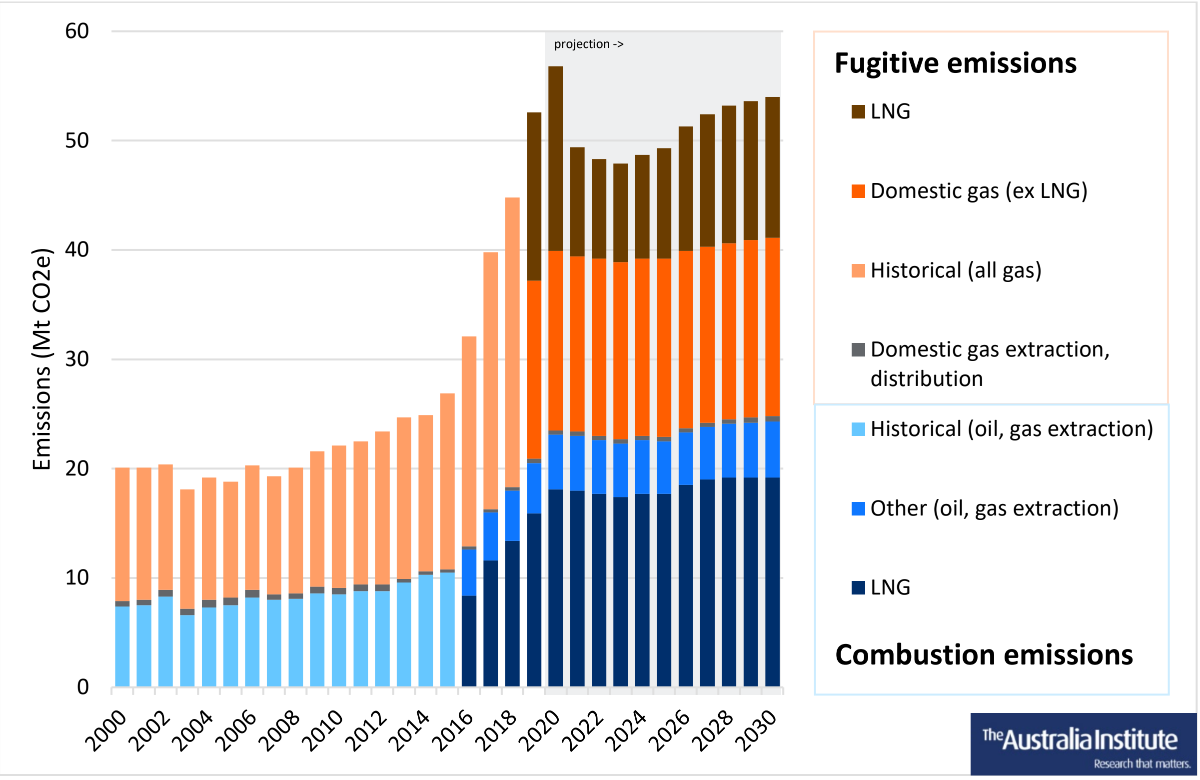
[3] Department of Industry, Science, Energy and Resources (2019) *Australian Energy Update 2019*, https://www.energy.gov.au/publications/australian-energy-update-2019

FUGITIVE EMISSIONS

Fossil gas reservoirs contain impurities, including CO_2. These are removed in gas processing and generally vented into the atmosphere. Methane is itself a powerful greenhouse gas and is released into the atmosphere during all stages of the supply chain, from exploration, to production, transport, distribution and in appliances that use gas. Some major releases are involuntary or unplanned, while some are vented intentionally. Because methane is highly flammable, instead of releasing it directly it is sometimes first flared or burned, mostly turning it into CO_2. Some methane is also released in flaring.

Emissions from all of these sources are reported by the Australian government. This data shows gas has become a major source of increased emissions in Australia. Figure 1 shows combustion and fugitive emissions in the gas industry, both reported historical emissions and projections for the coming decade.

Figure 1: Aust govt data shows gas expansion is pushing up Australia's emissions



Source: Department of Environment and Energy (2019) Australia's emissions projections 2019, https://publications.industry.gov.au/publications/climate-change/system/files/resources/4aa/australias-emissions-projections-2019-report.pdf Figure 8, Figure 10

Figure 1 shows that according to Australian Government data, direct combustion and fugitive emissions from the fossil gas industry together make up around 50 million tonnes per year of CO2 equivalent emissions, approximately 10% of Australia's total greenhouse gas emissions at present and projected for the coming decade.

It is likely that the reported emissions figures understate the impact of the gas industry on the climate. Methane emissions from fossil gas have been measured at rates far higher than officially reported by governments. This is concerning, as methane is a powerful greenhouse gas: compared with CO_2 on a per mass basis, methane traps substantially more heat. How much methane is released into the atmosphere is a major factor in how much climate change the fossil gas industry causes. Moreover, official reported emissions overlook fact that methane is an especially potent heat trapping gas over shorter time frames.

METHANE LOSS

There is an extensive research literature using a range of methods to assess rates of methane emissions from gas facilities, in particular from unconventional gas production involving hydraulic fracturing. Many studies have shown rates of methane emissions far higher than set out in official national emission inventories. This is a problem because a relatively small increase in methane emissions can dramatically increase the emissions footprint of fossil gas.

In 2016, researchers from Melbourne University's Energy Institute compared reported Australian methane emissions from unconventional gas with international studies.[4] The report showed that Australian reported emissions from methane 'loss' is equivalent to 0.5% of gross production, based on 'factors' derived from the US, not from Australian measurements. The report also noted methane loss at US shale gas sites had been measured higher than 2% and in extreme cases up to 17%.

There have been subsequent adjustments to Australian emissions factors. Nonetheless, current Australian reported emissions data suggests at most a small increase to reported methane loss rates, to around 0.7%.[5]

By comparison, the International Energy Agency (IEA) draws attention to rates of methane loss as a major concern, estimating methane loss as 1.7% of production across the global

[4] Lafleur, Forcey, Saddler, & Sandiford (2016) *A review of current and future methane emissions from Australian Unconventional oil and gas production*, https://energy.unimelb.edu.au/__data/assets/pdf_file/0019/2136223/MEI-Review-of-Methane-Emissions-26-October-2016.pdf

[5] The estimate here compares methane emissions from natural gas, venting and flaring, by total gas production. Figures for venting and flaring are not provided for gas separately, only for oil and gas. Nonetheless, most production is gas. Attributing all venting and flaring methane to gas production, the loss rate over the decade is around 0.7% in the decade to 2018. This is checked by calculating the increase of fugitives against increase in gas consumption over this time, which is also 0.7%.

Department of Industry, Science, Energy and Resources (2020) *AEGIS - National Greenhouse Gas Inventory – UNFCCC classifications*, https://ageis.climatechange.gov.au/, Department of Industry, Science, Energy and Resources (2019) *Australian Energy Update 2019* supply chain.[6] While the IEA does not present estimates for methane loss variation, the IEA average and broader research literature raises concerns about under reporting of emissions loss.

The Australian Government addresses concerns about fugitive emissions from fossil gas in the 2018 National Inventory Report (NIR), submitted for international scrutiny under UN climate treaties. The Australian approach, it reassures, is "anchored" in the approach by US Environmental Protection Agency (EPA). As a result, Australian reported fugitive emissions, CO_2 and CH_4 together, "are within 15–20 per cent of the estimate for the United States". At the same time, the NIR also claims the US EPA report methane emissions equivalent to loss rates of 1.3%, higher than reported for Australia. This discrepancy is not addressed. While noting some US studies show higher loss rates, NIR argues "irregular, high emission outcomes on the part of some wells are outweighing the effects of the vast majority of wells with negligible emissions in ways that significantly affect the overall emissions profile."[7]

The comments fail to address the substantial and growing literature showing rising atmospheric methane is linked to petroleum.

There are in fact many studies using a range of research methods showing higher methane emissions across large areas, especially associated with US shale gas production:

> "Methane emissions from the U.S. oil and natural gas supply chain were estimated by using **ground-based, facility-scale measurements and validated with aircraft observations** in areas accounting for ~30% of U.S. gas production. When scaled up nationally, our facility-based estimate [is] **2.3% of gross U.S. gas production**"[8]

> "The **methane in shale gas is somewhat depleted in ^{13}C [a carbon isotope]** relative to conventional natural gas, [from which] we conclude that shale-gas production in North America over the past decade may have contributed more than half of all of the increased [methane] emissions from fossil fuels globally… **the increase in methane emissions from shale gas represents 3.5% of the shale-gas production**".[9]

> "**Using new satellite observations and atmospheric inverse modeling**, we report methane emissions from the Permian Basin, which is among the world's most prolific oil-producing regions and accounts for >30% of total U.S. oil production… [The study

6 International Energy Agency (2017) *World Energy Outlook 2017*

7 Department of Industry (2020) *National Greenhouse Gas Inventory: December 2019*, pp. 152–154, https://www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-december-2019

8 Alvarez et al. (2018) *Assessment of methane emissions from the U.S. oil and gas supply chain*, p. 186, https://science.sciencemag.org/content/361/6398/186

9 Howarth (2019) *Ideas and perspectives: is shale gas a major driver of recent increase in global atmospheric methane?*, https://www.biogeosciences.net/16/3033/2019/

found] the largest methane flux ever reported from a U.S. oil/gas-producing region… This magnitude of emissions is **3.7% of the gross gas extracted** in the Permian...”[10]

Such loss rates are highly concerning because of the powerful global warming potential of methane.

GLOBAL WARMING POTENTIAL

To compare the Global Warming Potential (GWP) of different gasses, there needs to be an exchange rate into a common unit. The Intergovernmental Panel on Climate Change (IPCC) defines the GWP for methane and other gases in terms of CO_2, expressed as CO_2-equivalent (CO_2e).

Because different gases breakdown or are removed from the atmosphere at different rates, the GWPs are defined over a given timeframe. The standard GWP is over 100 years (GWP100). The IPCC also gives GWP over 20 years (GWP20). The IPCC presents these and many other metrics for analysis. GWP100 is widely used by governments, including Australia’s.

The most recent IPCC assessment report on GWPs, in 2014, found that one tonne of methane is equivalent to 28 tonnes of CO_2e over the 100 year horizon. On a 20-year horizon, one tonne of methane is equivalent to 84 tonnes of CO_2e.[11]

These GWPs have increased from previous estimates, being based on more recent research. While the Australian government has recently updated its factor for GWP100, even these factors are too low, according to best available science. IPCC gives a separate GWP100 for fossil gas of 30, as opposed to biogenic methane at 28. Later research found fossil methane is 34 times more powerful, and more recent research including carbon cycle feedbacks increases the GWP100 to 40. In addition, more recent research finds the methane GWP100 is 41.[12] Using the 28 factor is likely to be a dramatic underestimate of the carbon impact even over the century horizon.

More important, however, is powerful heat trapping role of methane in the nearer term, which is ignored by the focus on GWP100. The fact that methane emissions are more than

[10] Zhang et al. (2020) *Quantifying methane emissions from the largest oil-producing basin in the United States from space*, https://advances.sciencemag.org/content/6/17/eaaz5120

[11] Myhre et al. (2013) *Anthropogenic and Natural Radiative Forcing, Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf. p. 731

[12] Morton (2020) *Methane released in gas production means Australia’s emissions may be 10% higher than reported*, https://www.theguardian.com/environment/2020/aug/26/methane-released-in-gas-production-means-australias-emissions-may-be-10-higher-than-reported

three times more potent as a greenhouse gas over 20 years than they are over 100 years means there should increase the incentive to reduce methane emissions in the short term.

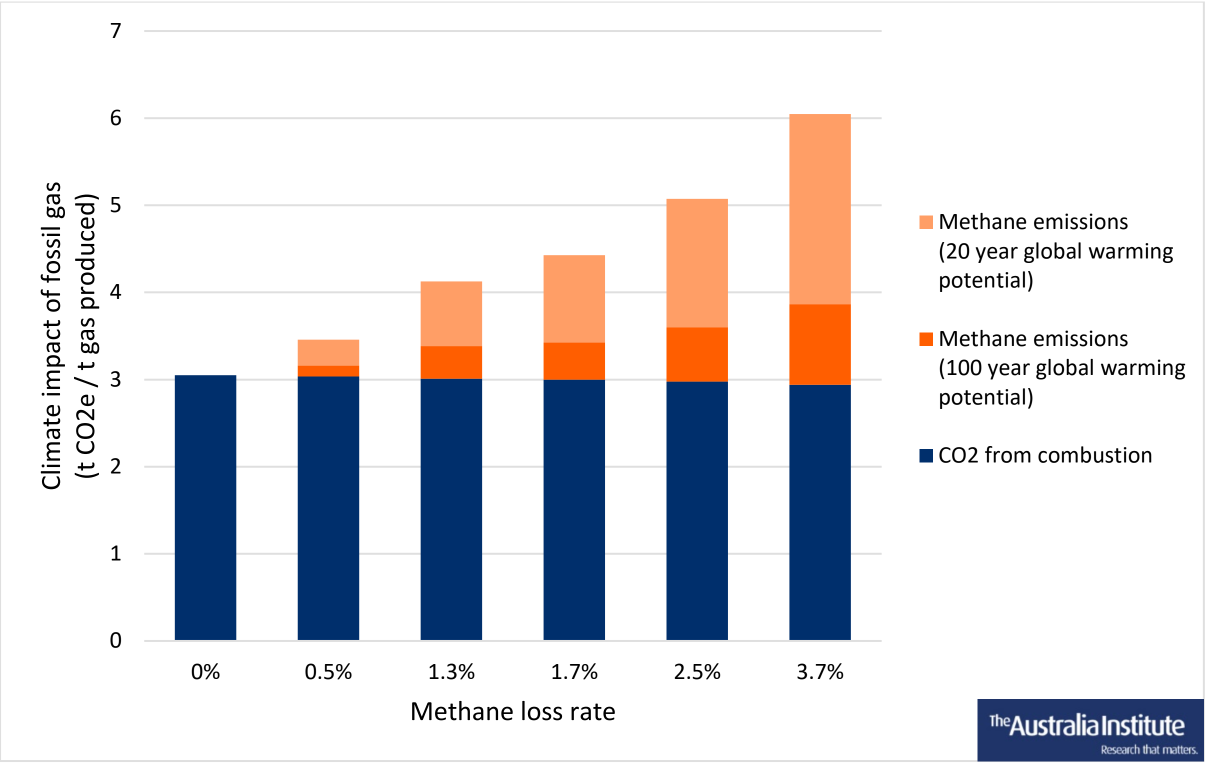
In other words, early action brings early reward, while increasing methane emissions increase near term climate feedbacks and tipping points.

COMBINED CLIMATE IMPACT

While burning methane produces CO_2, the climate impact from fossil gas can be greatly increased by methane emissions, even at relatively low rates of methane loss. This effect is most pronounced when viewed over the 20 year horizon.

Figure 2 shows the combined climate impact for loss rates mentioned above, at GWP100 and at GWP20. Note this uses the IPCC defaults for methane, not fossil methane and not including carbon cycle feedbacks. It is therefore conservative, based on current science.

Figure 2: Small amounts of methane loss greatly increase climate impacts from fossil gas



Source: author analysis from energy content and emission factors, see appendix. Note 'produced' is here as extracted. Losses additional to production increase the climate impact.

At the IEA's global average methane loss rate, the climate impact of fossil gas over the two decade horizon is nearly 50% higher than combustion emissions alone.

At 3.7% loss, the climate impact over the century is one third bigger than combustion emissions, and over the twenty year horizon is double combustion emissions.

This shows clearly the importance of measuring and minimising the rate of methane loss at existing facilities. Combined with the combustion emissions potential, it shows why limits on gas expansion are required to limit and reduce emissions.

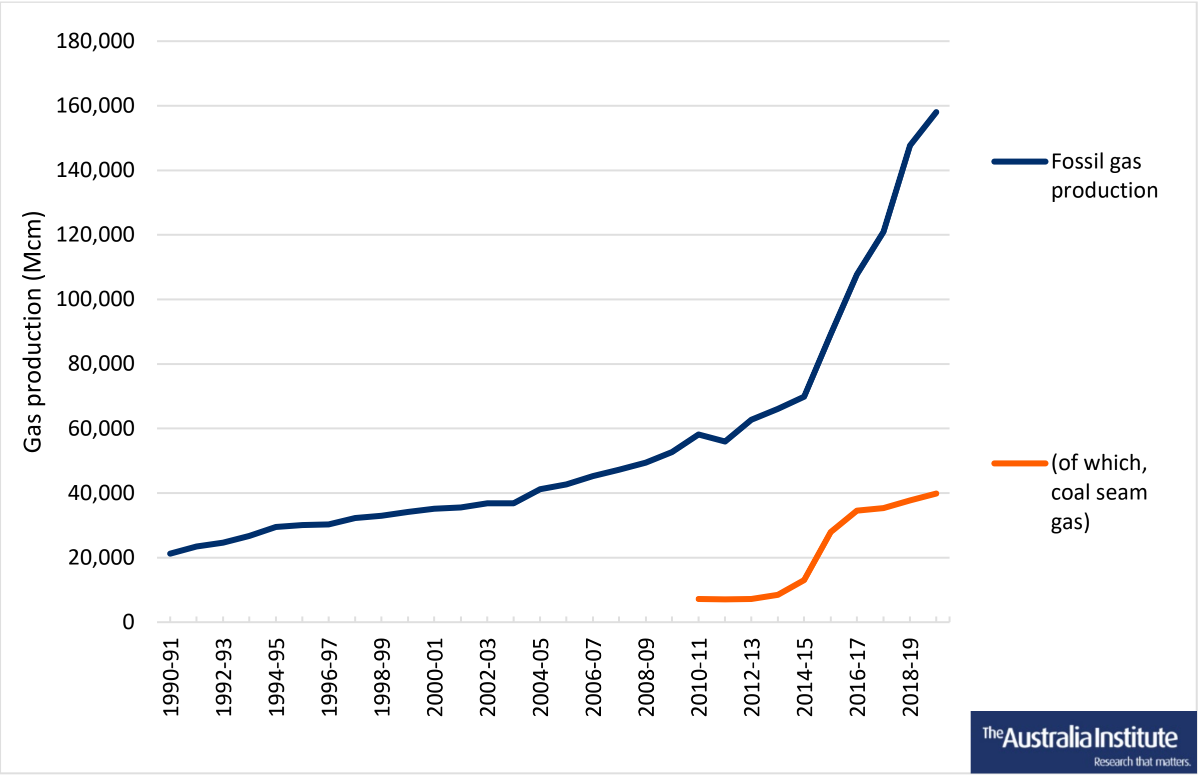
Fossil gas in Australia

This section outlines key trends in Australian gas production, consumption and exports.

EXPANDING PRODUCTION

Fossil gas production in Australia has seen a huge expansion over the last three decades. Figure 3 below shows total Australian gas production tripled from 1990 to 2010 and then from 2010 to 2019 it tripled again.

Figure 3: Fossil gas production in Australia

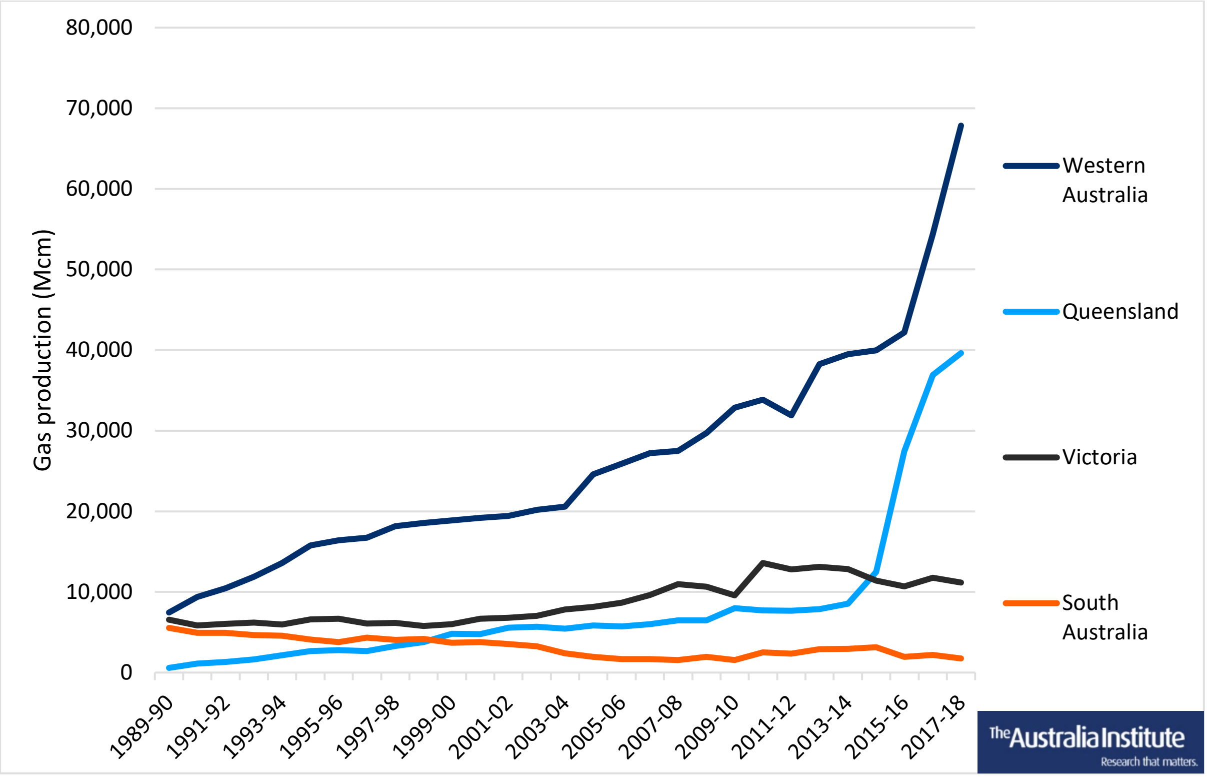


Source: Department of Industry, Science, Energy and Resources (2020) Australian Petroleum Statistics 2020 - April, https://www.energy.gov.au/publications/australian-petroleum-statistics-2020, Department of Industry, Science, Energy and Resources (2019) Australian Energy Update 2019, https://www.energy.gov.au/publications/australian-energy-update-2019

As shown above, a significant component of the growth over the last decade was coal seam gas, most of which is currently produced in Queensland. Nearly all of the remainder is ‘conventional’ gas. Australia’s gas production is concentrated in facilities offshore from

North West WA.[13] There is also declining production in Victoria and South Australia. Figure 4 shows the breakdown for these states, together making up the bulk of total production.

Figure 4: Gas production in Australia, by major producing state

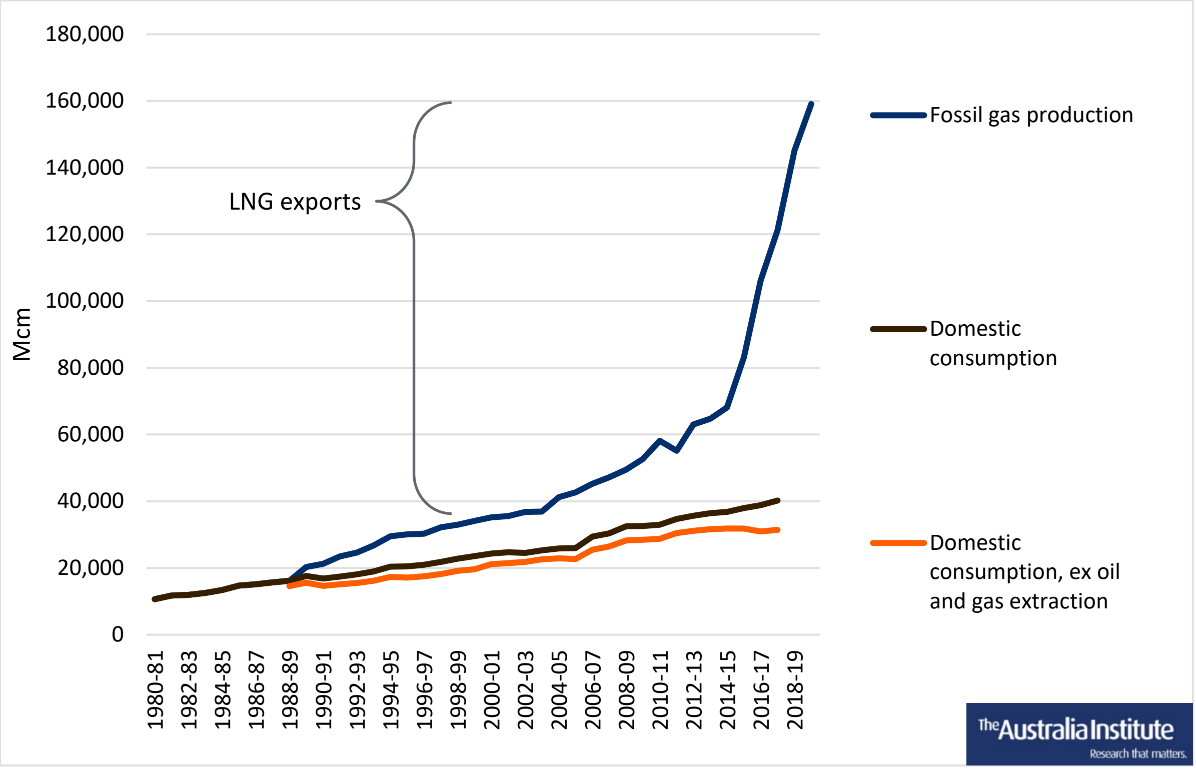


Source: Department of Industry, Science, Energy and Resources (2019) Australian Energy Update 2019, Table Q; Department of Industry, Science, Energy and Resources (2020) Australian Petroleum Statistics 2020 - April

There is clearly no shortage of gas in Australia. Gas production has increased dramatically in recent years and this growth has almost entirely gone to exports. Australian production is around four times as large as domestic consumption. Around three quarters of total production is exported (see Figure 5).

[13] Offshore production that is processed in Darwin appears to count towards WA in the Australian Energy Statistics. There is some onshore production in the NT but currently at low levels.

Figure 5: Gas production vs consumption, incl consumption by oil and gas industry

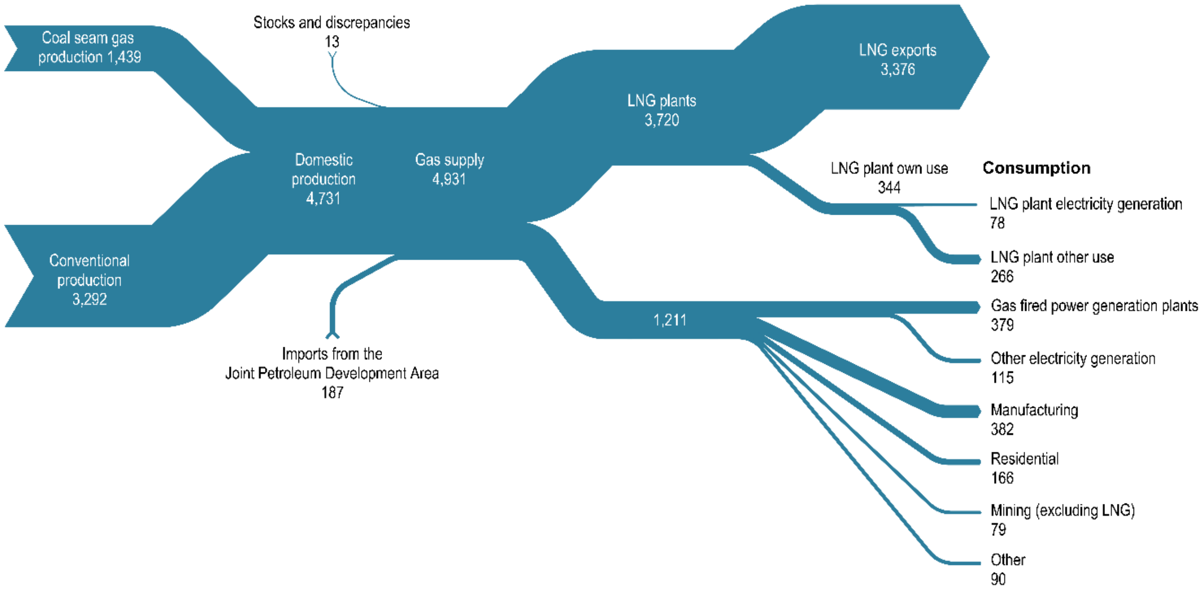


Source: Department of Industry, Science, Energy and Resources (2019) Australian Energy Update 2019; Department of Industry, Science, Energy and Resources (2020) Australian Petroleum Statistics 2020 - April;

Note: pre 2002-03, gas use by oil and gas mining is 'mining' as subsectors not given seperately; subsequent data shows almost all mining gas consumption is by oil and gas, and most of this for LNG.

Moreover, as shown above, the oil and gas industry is itself a major consumer of gas. Large amounts of gas is burned in the LNG facilities themselves to compress and cool the gas to make it suitable for export. This is 'domestic consumption' but solely to facilitate exports. More than twice as much gas is burnt in Australia to help export gas than is burnt in homes across Australia. This is shown in Figure 6 below.

Figure 6: Australian gas flows in 2017-18 (PJ)



Source: Department of Industry, Science, Energy and Resources (2019) Australian Energy Update 2019, p. 10

Figure 6 from the Australian Energy Statistics published by the Australian Government, is from 2017-18. In the subsequent years to 2020 Australian gas production increased 32%, with almost all of this going to exports.[14]

Figure 6 shows that LNG plant electricity generation consumes 78 petajoules while 'other use' in LNG plants consumes 266 PJ. In total this 344 PJ in 2017-18 represented more than double the 166 PJ used by Australian 'residential' households.

Gas used domestically also goes into electricity generation, process heat for manufacturing, and residential use. In all of these uses there are readily available and economic alternatives. This is especially the case on the east coast where, as The Australia Institute warned would happen, large increases in gas exports resulted in large increases in gas prices.[15]

LNG EXPANSION

Australian gas exports have been a significant factor behind increased gas use globally.

Australia exports gas in the form of LNG. Most gas is transported between countries by pipeline but over the last two decades LNG has greatly increased its share of exports. While

[14] Office of the Chief Economist (2020) *Resources and Energy Quarterly - June 2020*, https://publications.industry.gov.au/publications/resourcesandenergyquarterlyjune2020/index.html
[15] Matt Grudnoff (2013) *Cooking up a price rise*, https://www.tai.org.au/content/cooking-price-rise-0

gas supply by pipeline also expanded, by around a third since 2000, global LNG exports tripled over the same period. In 2000 LNG made up around a quarter of global exports. By 2019 it was close to half of global gas exports.

No other country played a bigger role in driving increased LNG exports over this period than Australia. Australia's LNG exports made up half global LNG growth since 2010, and close to third of the growth since 2000, more than any other country.

From around 7% of global LNG in 2000, Australian LNG exports grew to become to the world's largest at nearly one quarter of global LNG in 2019.[16] Australia and Qatar jostled for this position over the late 2010s. Australian LNG exports in 2019 were about as large as three quarters of total global LNG supply in 2000.

As a major gas exporter, Australia is among the largest producers of gas, 7th largest in total 2018. The largest are the US (22%) and Russia (17%). Australia's share of global gas production has increased from less than 1% in the late 1980s to nearly 4% in 2019.

While LNG has increased its global market share in recent years, most gas is transported between countries by pipelines. Russia's very large gas exports are overwhelmingly by pipeline. Some countries have access to gas by LNG and other means. China imports LNG while also importing gas by pipeline, including from Russia, and producing gas domestically.

Australian gas and coal exports make it the third largest fossil fuel exporter globally, by CO_2 potential.[17] Australia's role as a large fossil fuel exporter enables other countries to consume larger volumes of fossil fuel. Increased fossil fuel exports support the lock-in of high carbon infrastructure, both in supply and in consumption.

LNG is highly capital intensive, requiring large amounts of expensive equipment, and is highly emissions intensive. Liquefaction, shipping and regasification all consume huge amounts of energy, almost all of which is fuelled by gas. Continued expansion of LNG will increase greenhouse gas emissions, both in supply and end use combustion. Once facilities are built, covering financial commitments will require ongoing operation.

AUSTRALIAN RESERVES

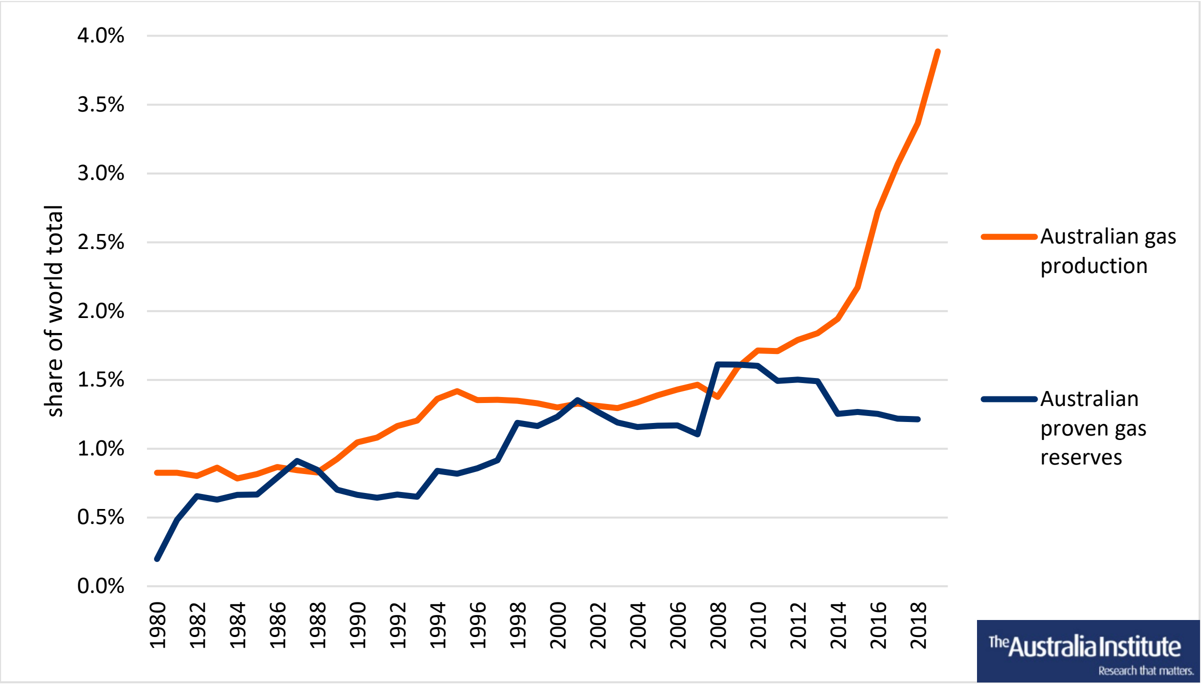
Where companies are confident they can extract a gas resources economically, they are generally called 'reserves'. Reserves assessed as most economic to extract are called 'proven reserves'.

[16] Office of the Chief Economist (2020) *Resources and Energy Quarterly - June 2020*, p. 73

[17] Swann (2019) *High Carbon from a Land Down Under*, https://www.tai.org.au/sites/default/files/P667%20High%20Carbon%20from%20a%20Land%20Down%20Under%20%5BWEB%5D_0.pdf

Australia has on average been more effective than other countries in turning proven reserves into production, demonstrated by Australia's increased share of global reserves and even faster growing share of global production.

Figure 7: Australian proven gas reserves vs production, as % of world total



Source: BP (2019) Statistical Review of World Energy 2019, https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

While Australia is now the world's largest LNG exporter and the seventh largest gas producer, Australian ranks 15th globally in terms of total proven gas reserves.

Until around 2010 Australian gas companies have added reserves and increased production at similar rates, and more quickly than the global average, increasing their share of the global total. Post 2010, while reserves growth stalled, Australian production growth far outpaced global production increases.

For reserves to increase again, companies would need to discover and assess resources that are economic to extract. As we will see, gas companies in Australia are currently seeking to do just that.

New gas production projects

Companies and governments have proposed a large number of major new gas projects across Australia. The size and nature of these projects varies greatly, but as this section shows, together the projects are comparable in capacity to current gas supply.

Which projects will go ahead and when will depend on developments and interactions across economics, finance, technology, and policy in Australia and overseas.

The recent pandemic, and the Saudi-Russian oil price war, has lead gas companies to writedown the value of assets and delay large projects. It remains to be seen whether any projects will be outright cancelled and which will be accelerated by subsidies and deregulation.

Consideration of these projects should include the scale of the emissions they might release. That is the goal of this section.

PROPOSED MAJOR PROJECTS

The Commonwealth Office of the Chief Economist (OCE) releases an annual 'Major Projects List' of resource project proposals. The list consists of specific proposals from specific companies, in various stages of design, approval and financial commitment. The December 2019 OCE Major Projects List includes 35 oil and gas projects.[18]

Analysis here excludes three "oil" projects, five "completed" gas projects[19] and five gas import terminals. The import terminals nonetheless require special comment (see below).

There are currently 22 gas production and export proposals across Australia. These are listed in Table 1. Some adjustments are made for updated information, or to adjust incomplete or erroneous information, as marked below.

[18] Office of the Chief Economist (2020) *Resources and Energy Quarterly - March 2020 - Major Projects*, https://publications.industry.gov.au/publications/resourcesandenergyquarterlydecember2019/documents/REQ-Dec-2019-Major-Projects-Data.xlsx

[19] NB treating as completed: Santos GLNG Roma East, Orbost Gas plant.

Table 1: Gas supply projects from Commonwealth Major Projects List

Project	State	Type	Status	Resource	Est Capacity	Unit	in PJ pa[20]
Browse and NWS extension	WA	New	Feasible	Gas/ LNG/ Condensate/ LPG	12	Mtpa[21]	**653**
Scarborough	WA	New	Feasible	Gas/ LNG	8	Mtpa[22]	**435**
Greater Sunrise	NT	New	Announced	Gas/ LNG	365	PJ pa	**365**
Gorgon (train 4)	WA	Expsn	Announced	LNG	5.2	Mtpa	**283**
Pluto expansion	WA	Expsn	Feasible	LNG	5	Mtpa	**272**
Surat Gas Project	QLD	New	Feasible	Gas	240	PJ pa	**240**
Crux LNG	WA	New	Feasible	LNG	3	Mtpa	**163**
Bowen Gas Project	QLD	New	Announced	Gas	147	PJ pa	**147**
Cash Maple	WA	New	Announced	LNG	2	Mtpa	**109**
Equus	WA	New	Feasible	Gas/ LNG/ Condensate	2	Mtpa	**109**
Waitsia Stage 2	WA	Expsn	Feasible	Gas	250	TJ pd	**91**
Narrabri Gas Project	NSW	New	Feasible	Gas	74	PJ pa[23]	**74**
Glenaras gas project	QLD	New	Announced	Gas	73	PJ pa	**73**
Transborder FLNG	WA	New	Announced	Gas/ LNG	1.2	Mtpa	**65**
Barossa backfill to Darwin LNG	NT	Expsn	Feasible	Gas/ LNG/ Condensate	9	mmboe pa	**55**
Tipton	QLD	Expsn	Feasible	Gas	80	TJ pd	**29**
Manta Gas Project	VIC	New	Feasible	Gas	23	PJ pa	**23**
Roma North	QLD	Expsn	Committed	Gas	48	TJ pd[24]	**18**
Clio-Acme	WA	New	Announced	Gas	n/a	n/a	**n/a**
Gorgon Stage 2	WA	Expsn	Committed	Gas	n/a	n/a	**n/a**
Julimar-Brunello II	WA	Expsn	Feasible	Gas/ LNG	n/a	n/a	**n/a**
Capex Qld LNG, 2040+	QLD	Expsn	Committed	Gas/ LNG	n/a	n/a	**n/a**

Source: Office of the Chief Economist (2020) Resources and Energy Quarterly - March 2020 - Major Projects, conversions as per appendix.

[20] Using conversions outlined in the appendix.

[21] The list currently states capacity of 2273 mmboe pa. OCE confirmed by email this is a typo. OCE cited 12 Mtpa as per proponent documentation: Woodside (2020) *Proposed Browse Project*, https://files.woodside/docs/default-source/our-business---documents-and-files/burrup-hub---documents-and-files/browse---documents-and-files/browse-brochure.pdf?sfvrsn=d08066ed_6
This has been checked against Browse EIS documentation.

[22] OCE lists a capacity of 7-9 Mtpa. The median is used here.

[23] Updated as per project documentation for environmental approval GHD (2016) *Narrabri Gas Project - Environmental Impact Statement Economic Assessment*, p. 74, https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-6456%2120190228T035910.643%20GMT

[24] Senex Energy (2020) *Roma North*, https://www.senexenergy.com.au/operations/surat-basin-gas/roma-north/

In the Major Projects list, thirteen are new projects and nine are expansions of existing projects.

Three projects are “committed”. These have “completed all commercial, engineering and environmental studies, received all necessary government regulatory approvals, and finalised the financing of the project to allow construction.”

Another 12 are “feasible”, where “initial feasibility study [has] been completed”.

Seven are “publicly announced” with only “preliminary information”.[25]

OCE emphasises no projects are guaranteed to proceed. This depends on financial, economic, regulatory and other factors, with higher uncertainty for less committed projects.

Many of the large projects have been delayed during the coronavirus pandemic. But to our knowledge none of these projects have been cancelled. In aggregate they represent a very large proposed increase in gas mining in Australia.

Most (12) are in or offshore of WA, including four of the five largest.

The single largest project is Woodside’s “Browse and NWS extension”. This involves developing the offshore Browse field and laying 900 km of ocean-floor pipelines to the existing North West Shelf LNG terminals, which must also be upgraded and their life extended. The massive project would produce a very large amount of LNG at among the highest emissions intensity in the world.[26]

There are also 7 gas projects proposed in Queensland, 2 in the NT (including gas from the ‘Joint Development Area’ with East Timor), 1 in Victoria, and 1 in NSW.

Ten projects would produce ‘gas’ generally feeding pipelines for consumption by other facilities, domestic or for export. Eight would supply ‘gas/LNG’, mostly for export. Four would produce ‘LNG’ alone, including use of feedstock gas from separate projects.

Three LNG projects would also produce ‘condensate’, a higher value fossil liquid product sometimes called ‘wet gas’. Government and energy authorities generally classify it as a form of oil.[27]

---

[25] Office of the Chief Economist (2019) *Resources and Energy Quarterly - December 2019*, p. 143, https://publications.industry.gov.au/publications/resourcesandenergyquarterlydecember2019/index.html

[26] Conservation Council WA (2019) *Burrup Hub: Australia’s most polluting fossil fuel project*

[27] Department of Industry, Science, Energy and Resources (2020) *Australian Petroleum Statistics 2020 - April*, https://www.energy.gov.au/publications/australian-petroleum-statistics-2020

Total new supply capacity

OCE gives estimated project capacities in a range of units. LNG projects capacities are expressed in terms of mass, as Mtpa (million tonnes per annum). Others project capacities are expressed in terms of energy content, generally as joules, or as Mmboe (million barrels of oil equivalent). For comparison these are all converted into a common unit, namely, petajoules per annum (PJ pa). These unit conversions are outlined in Appendix 1, with results shown above in Table 1.

Four projects are all listed without capacities. These are large projects that will supply seperate LNG facilities, including three fields offshore of WA, and ongoing drilling and fracking to 'sustain' the Queensland LNG terminals post 2040. These projects are also left out of subsequent analysis.

The total proposed additional capacity of new fossil gas projects is 3,204 PJ pa.

Note a small share of this total is expected to be condenstate and liquid petroleum gas (LPG). Analysis here assumes all energy content is fossil gas. This will underestimate combustion emissions as gas is less emissions intensive per energy content.

Total capacity at new or expanded LNG projects is 1,954 PJ pa. Note other listed gas supply projects would also feed separate LNG export facilities. Capacity for LNG projects is listed in terms of millions of tonnes of gas (Mt). This analysis assumes this is the capacity of the sold product, whether LNG or domestic gas. Assuming domestic use from LNG projects is 15% of project energy production, as is the case in WA for gas,[28] this gives LNG export capacity of 1,661 PJ pa.

Substantial volumes of gas would be consumed in producing LNG. While some of these projects would supply gas domestically, most of their output is LNG for export. The gas consumed by the LNG facilities is not included in the capacity figure above of 3,204 PJ pa. At current rates of gas consumption at Australian LNG facilities, additional required gas production and consumption is inferred at 164 PJ pa.

[28] Note not all projects are in WA, and not all of the energy content is gas.

Total additional capacity is therefore inferred at **3,368 PJ pa.** For comparison, this is more than half of current fossil gas Australian production. But there are yet further proposals to consider.

LNG import terminals

Australia is the world's largest LNG exporter. Around a third of Australian gas exports leave from three LNG export terminals in Queensland. These terminals are connected to the east coast gas pipeline network. They export three times the volume of east coast consumption.

There are now *five* separate proposals to build terminals to import LNG to south-eastern states.

Imports through these terminals would involve compressing and liquifying gas in other countries, or possibly north-western Australia, transporting it and then regasifiying it, all at substantial financial cost in terms of both infrastructure and energy consumption, with associated additional emissions.

That five of such terminals could be proposed is a damning indictment on Australian resource policymaking, both in terms of economic inefficiency, energy waste, and the additional heattrapping emissions it would cause.

SHALE GAS FRONTIERS

Further to the specific projects listed above, there are proposals to develop large new unconventional gas basins.

Two key examples are the Canning Basin in WA and the Beetaloo Basin in NT.

These are prospective shale gas basins where the resource is yet to be fully appraised and 'proven' for commercial production. Yet companies, governments and resource agencies have claimed there is potential for very large levels of unconventional gas production. There is significant political and policy attention on developing these resources.

In recent years both WA and NT governments went to and won elections promising bans on onshore unconventional gas techniques like hydraulic fracturing, until risks had been assessed. Both governments commissioned inquiries ('Fracking Inquiries') into health and environmental risks from fracking. These inquiries, both reporting in 2018, were used to provide justification for overturning the bans and allowing fracking for unconventional gas.[29]

[29] NT Fracking Inquiry (2018) *Scientific inquiry into hydraulic fracturing in the Northern Territory: final report.* WA Fracking Inquiry (2018) *Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in*

Origin Energy, a major Australian company exploring in the Beetaloo Basin, calls it "one of the most promising shale gas resources anywhere in the world".[30] Origin paused exploration during the initial phase of the coronavirus pandemic but plans to resume later in 2020. Other companies are also exploring in the area.

Buru Energy describes itself as "an ASX listed Australian oil and gas exploration and production company solely focused on exploring and developing the petroleum resources of the Canning Basin", which it has been doing since 2008 when established through acquisition of another company's assets.[31] Texan fracking company Black Mountain submitted plans for exploration in the Canning Basin in July 2020.[32] Weeks later the company publicly criticised what it saw as delays in assessment, which government explained were due to required regulations not being in place.[33]

These are not the only prospective new shale gas resources in Australia, or even the WA and NT. Nonetheless they have attracted much of the attention in resource policy debates.

Beetaloo Basin in NT

The NT Fracking Inquiry assessed risks and benefits by reference to a range of production scenarios. The economic assessment for the Inquiry considered four scenarios, from 'failure to commercialise' to production of 365 PJ pa. The assessment found the former was most likely, while the latter had "low" to "very low" probability.[34] Crucially, the economic assessment did not consider government subsidies nor did it consider project economics including potential condensate production.

The Fracking Inquiry itself also considered a higher production scenario at 1,240 PJ pa. This included increased domestic consumption as well as significant additional exports from

Western Australia - Final Report to the Western Australian Government, https://frackinginquiry.wa.gov.au/sites/default/files/final_report.pdf

[30] Origin Energy (2020) *Fracking Exploration in Australia - Beetaloo Origin*, https://www.originbeetaloo.com.au/about

[31] Buru Energy Limited (2020) *About Us*, https://www.buruenergy.com/site/about-us/company-overview

[32] Fowler (2020) *First fracking plans announced for Canning Basin since WA lifted moratorium*, https://www.abc.net.au/news/rural/2020-07-16/bennett-resources-submits-fracking-plan-for-canning-basin/12458082

[33] Collins & Fowler (2020) *"A fracking moratorium by stealth": WA gas industry frustrated by delays and restrictions*, https://www.abc.net.au/news/2020-08-06/wa-fracking-industry-frustrated-by-delays-and-restrictions/12517958

[34] ACIL Allen (2017) *The Economic Impacts Of A Potential Shale Gas Development In The Northern Territory*, https://frackinginquiry.nt.gov.au/news?a=456788

Darwin. The Inquiry considered this "plausible and relevant for the purposes of conducting the risk assessment".[35]

The NT Fracking Inquiry found that onshore unconventional gas development in the NT would have "unacceptable" climate impacts and should not go ahead unless all greenhouse gas emissions were offset in full, including domestic combustion emissions. The NT government agreed to implement this recommendation when overturning the moratorium.

At current low offset prices in Australia, the emissions would cost over half a billion dollars every year to offset. At projected Paris-aligned prices it would be closer to $4bn.[36]

Despite resumption of exploration, there is still no regulatory clarity on how offsets will be required. The NT Government states it intends to resolve this issue as late as December 2021. Crucially it remains unclear who will pay: gas companies or the NT taxpayer.

To put the emissions in context, gas production on this scale in the NT would produce more emissions than all coal fired stations expected to be operating in Australia's National Electricity Market when the project came on line. Documents released under Freedom of Information show Commonwealth government officials warned the Minister for Emissions Reduction that the Beetaloo Basin gas production would be so large it would threaten Australia's ability to meet its obligations under the Paris Agreement.[37]

Canning Basin in WA

The WA Government commissioned a similar Fracking Inquiry, which received submissions from gas companies outlining prospective developments in the Canning Basin as well as the upper Perth Basin. On this basis:

> The Inquiry considered the risks, where those risks are scale dependent, of development scenarios delivering between 100-200 TJ/d in the Perth and Canning Basins, and a higher scenario of 1,100 TJ/d (approximately the Western Australian domestic gas demand) if most of these envisioned gas fields were simultaneously realised.[38]

---

[35] NT Fracking Inquiry (2018) *Scientific inquiry into hydraulic fracturing in the Northern Territory: final report.*, p. 229

[36] Swann (2018) *Getting Offset: NT Climate Consultation*, https://www.tai.org.au/sites/default/files/P650%20NT%20Climate%20Consultation%20%5BFINAL%5D.pdf

[37] Swann (2020) *All It's Fracked Up to Be*, https://www.tai.org.au/sites/default/files/P875%20All%20it%27s%20Fracked%20Up%20to%20Be%20%5BWEB%5D.pdf

[38] WA Fracking Inquiry (2018) *Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia - Final Report to the Western Australian Government*, p. 151

The Inquiry also considered a separate scenario for the Perth Basin, as unlike the Canning Basin this area already has “much of the required infrastructure”. It found “A reasonable scenario… might consist of producing ~100 (TJ/d) of gas for 20 years for the domestic gas market”.[39] This gives a range from 37 to 402 PJ pa.

The WA Fracking Inquiry set an upper boundary at current levels of domestic demand and did not consider scenarios where unconventional gas feeds LNG terminals for export.

This is curious, given the numerous proposals for LNG expansion in WA, and experience in Queensland of using unconventional gas for export.

The Inquiry also noted “potential concerns that this scale of development” considered in the report “might only be the start of larger fields in the longer term”. The Inquiry appeared to anticipate concern was that it had underestimated the prospective scale of development, yet the Inquiry reassured readers that “these scenarios are realistic for the coming decades”.[40]

While the NT Fracking Inquiry excluded consideration of ‘liquids’, the WA Inquiry more closely considered potential for shale oil development, warning unique aspects of liquids production would pose additional greenhouse gas risks, especially if co-produced gas were not sold but flared or vented as waste. Nonetheless, the WA Inquiry concluded there was insufficient information for detailed scenario assessment.[41]

TOTAL PROPOSED NEW GAS CAPACITY

The total additional gas supply capacity set out above is summarised in Table 2.

Proposed gas supply projects total to additional capacity of **5,010 PJ pa.**

[39] Ibid.

[40] WA Fracking Inquiry (2018) *Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia - Final Report to the Western Australian Government*, p. 384

[41] WA Fracking Inquiry (2018) *Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia - Final Report to the Western Australian Government*, p. 384

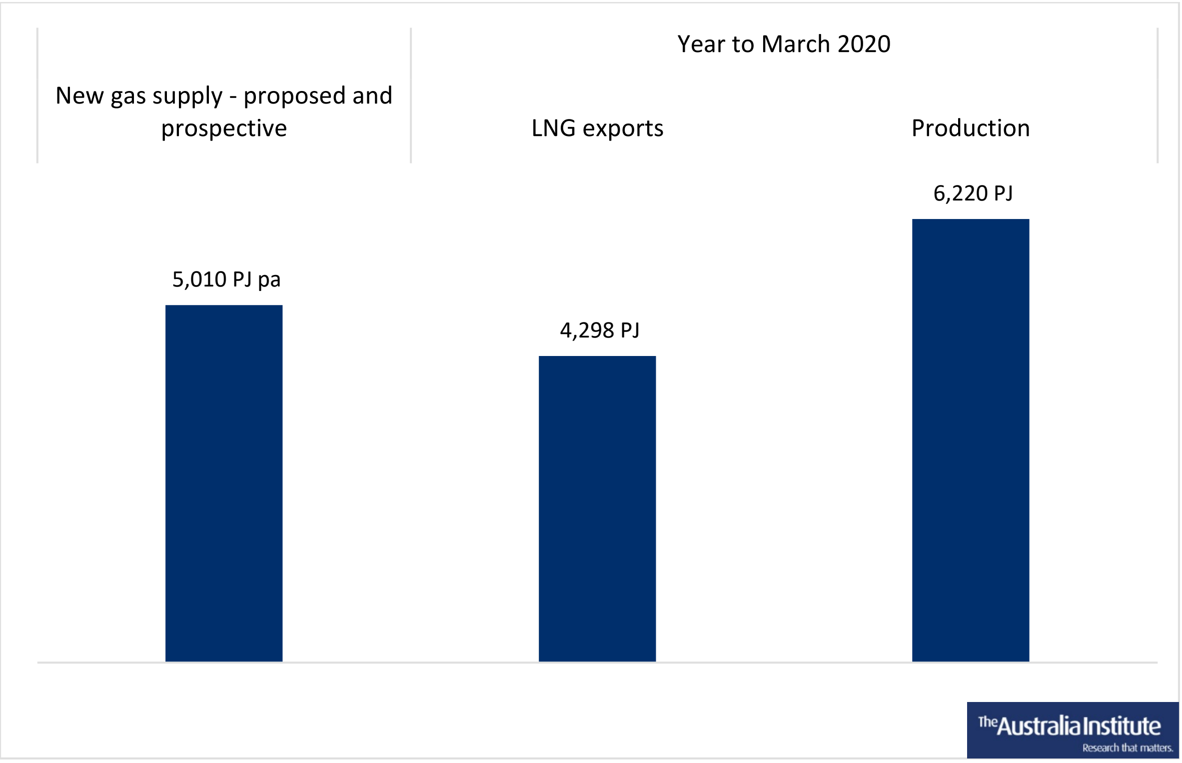
Table 2: Total proposed and prospective gas supply project capacity

Projects	Capacity (PJ pa)
Major Projects List	3,204
+ inferred use for LNG	164
Shale gas, high production scenarios	
Beetaloo Basin (NT)	1,240
Canning Basin (WA)	402
Total	**5,010**

Source: as explained above

For comparison, in the year to March 2020, total LNG exports were 4,298 PJ and production was 6,220 PJ.[42] Proposed new capacity is bigger than Australian LNG exports and around 80% of total production. This is shown in Figure 8.

Figure 8: New gas supply vs recent production and exports



Source: new capacity as explained above, year to March 2020 from Office of the Chief Economist (2020) Resources and Energy Quarterly - June 2020, https://publications.industry.gov.au/publications/resourcesandenergyquarterlyjune2020/index.html, converted to PJ as per appendix.

[42] Office of the Chief Economist (2020) *Resources and Energy Quarterly - June 2020*, converted to PJ using conversions outlined in appendix.

Emissions potential of Australian fossil gas resources

Current proposals for new gas supply projects, even if built in full, would extract only part of identified gas resources. This point is often made forcefully by the gas industry itself. The Australian Petroleum Production and Exploration Association (APPEA) claims

> Australia has more than 800 trillion cubic feet (TCF) of gas resources (including proven and contingent resources) – enough to power a city of 1 million people for 16,000 years. More discoveries are considered likely. Geologists are optimistic that exploration will uncover more gas to add to this base.[43]

Here APPEA envisages extracting and burning more than 800 tcf of gas, around 890,000 PJ, and discovering even more to extracted and burned. Similarly, Geoscience Australia (GA), a government body, presents estimates of Australian gas resources as equivalent to years of domestic gas consumption, again imagining that all of these resources are extracted and burned.

This section quantifies the emissions potential of Australian fossil gas resources.

Resources are categorised by companies and governments in the ground in terms of geological and economic assessments. These two dimensions define technical frameworks used in company accounts. While definitions may vary between countries or contexts, certain concepts are applied broadly. Resource assessments deemed most certain and likely extractable are called 'proven reserves'.

It is well understood that proven gas reserves exceed the 'carbon budget' consistent with internationally agreed climate goals. In other words, even current reserves cannot be combusted while remaining within the carbon budget. This is true globally and true of gas reserves in Australia.[44] With government support, gas companies continue to explore for new resources they can turn into reserves, and, they hope, extract for combustion.

GA presents data on gas resources by basin and type, in its Australian Energy Resources Assessment (AERA).

---

[43] APPEA (2020) *What is natural gas?*, https://web.archive.org/web/20200619134632/https://www.appea.com.au/oil-gas-explained/oil-and-gas/what-is-natural-gas/

[44] McGlade & Ekins (2015) *The geographical distribution of fossil fuels unused when limiting global warming to 2 °C*, https://www.nature.com/articles/nature14016, Table 1.

At the time of writing, two versions of the AERA are accessible from the GA website: the 2018 AERA[45] and what appears to be accidental pre-publication of 2020 updated figures.[46] This analysis draws on both to provide a more complete picture. The update itself presents figures from a range of existing studies, not from new analysis.

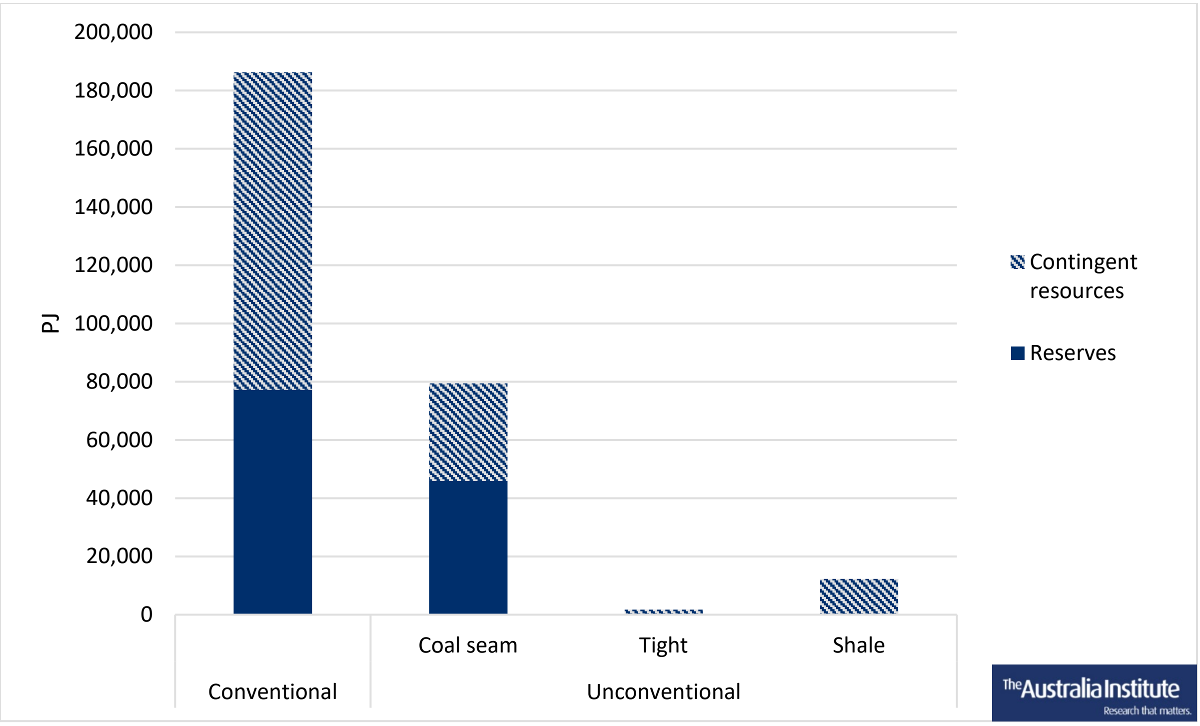
RESERVES AND CONTINGENT RESOURCES

GA defines 'identified' resources as either 'reserves' or 'contingent resources', follows:

> **Reserves** represent that part of resources which are commercially recoverable and have been justified for development …
>
> **Contingent resources** are less certain than reserves. These are resources that are potentially recoverable but not yet considered mature enough for commercial development due to technological or business hurdles [including approvals][47]

2018 GA data on total Australian reserves and contingent resources are shown in Figure 9. Note the data for unconventional gas are broken into different types: coal seam, tight and shale gas.

Figure 9: Identified gas resources, Geoscience Australia AERA 2018



[45] Geoscience Australia (2018) *Australian Energy Resources Assessment - Gas*, https://aera.ga.gov.au/#!/gas

[46] The 2018 version is still visible at the AERA website yet when saved through the author's referencing software, the 'snapshot' of the site showed a version 'updated' in July 2020. Available on reqeuest.

[47] Bold added. Geoscience Australia (2020) *Australian Energy Resources Assessment (AERA)*, https://aera.ga.gov.au/#!/resource-classification

> Source: Geoscience Australia (2018) Australian Energy Resources Assessment - Gas, https://aera.ga.gov.au/#!/gas

Most of Australia's proven reserves are conventional gas. There is an even larger volume of conventional contingent resources. A bit over a third of current reserves are coal seam gas. There are smaller volumes of shale and tight gas contingent resources. Note this does not include the Beetaloo and Canning Basins which are shale gas resources that have not yet been 'identified' or fully assessed; these are discussed below.

Curiously, the 2020 AERA gives total identified resources but does not distinguish reserves from contingent resources. GA claims the data is "currently only available for all offshore and onshore areas as aggregated identified remaining resources".[48] This obscures whether reserves have been revised down, or recategorised as contingent resources, as a result of current economic conditions. It may be that companies have been unwilling to provide this data. Nonetheless, the 2020 update shows total identified resources similar in size to 2018.

The 2020 AERA also compares remaining resources to what has already been extracted–in other words, the original resource vs what is left. 65,000 PJ of gas has been extracted in Australia. This is 19% of the original resource. Australia's remaining gas resources are four times larger than what has been extracted to date. Even reserves, as listed in 2018, are twice as large as what has been extracted.

PROSPECTIVE RESOURCES

Beyond resources that have been identified, there are vastly larger estimates of resources that are 'undiscovered' but 'prospective':

> **Prospective resources** are… estimated, as of a given date, to be potentially recoverable from oil and gas deposits identified on the basis of indirect evidence but which have not yet been drilled… For prospective resources to become classified as contingent resources, hydrocarbons must be discovered, the accumulations must be further evaluated and an estimate of quantities that would be recoverable under appropriate development projects prepared.[49]

The 2018 AERA shows a staggeringly large prospective gas resource of 12.5 billion PJ (12.5 yottajoules). This is twenty times larger than current global primary energy supply from all

[48] Geoscience Australia (2020) *Australian Energy Resources Assessment - Gas*, accessed via Zotero
[49] Bold added. Geoscience Australia (2020) *Australian Energy Resources Assessment (AERA)*

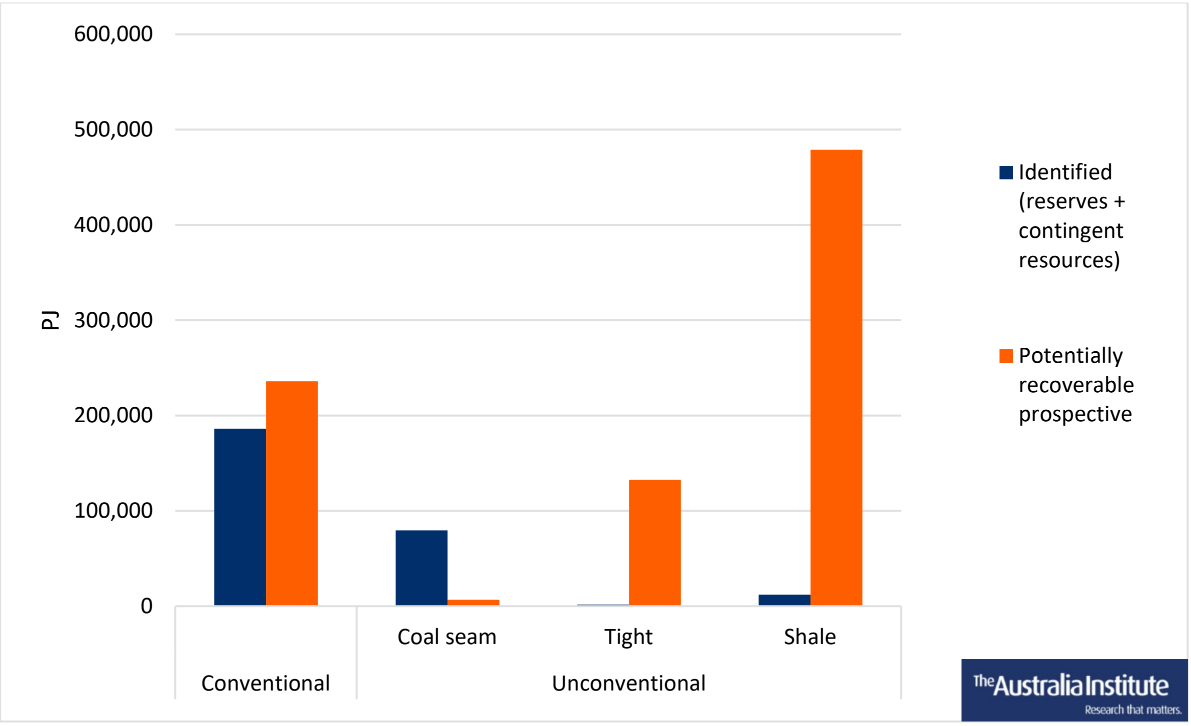
sources of energy, which was a bit less than 600,000 PJ.[50] The overwhelming majority of this is shale gas and mostly in the Canning Basin.

However, these figures cannot be taken at face value. As GA emphasises, the figures are subject to very large uncertainty.[51] Moreover, "not all the gas-in-place will be extractable", due to geological uncertainties and technological constraints. When discussing major shale basins, GA takes the median estimate from the resource estimates and adjusts by assuming only 5% is 'recoverable'.

GA is inconsistent with terminology here. It applies 'prospective' to bigger and smaller shale gas figures in different places.[52] Moreover, GA takes a different approach to prospective conventional resources, presenting only one figure, which it states is "yet-to-find recoverable conventional gas".

Nevertheless, focusing on the lower numbers, GA estimates very large potentially recoverable prospective gas resources, shown in Figure 10.

Figure 10: Identified vs prospective potentially recoverable gas, Geoscience Australia



[50] BP (2020) *Statistical Review of World Energy - Primary energy*, https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/primary-energy.html

[51] In the data file "Undiscovered conventional and unconventional gas resources at P50 confidence", meaning the estimation method gives 50% confidence of the resource being this large or greater. The report gives much higher and lower values for P10 and P90 (10% and 90% confidence) reflecting large uncertainty.

[52] GA initially calls the larger figures 'prospective', also in the data file. Later in the report these are 'gas in place', 5% of which are "potentially recoverable resources" that "can be treated as prospective resources".

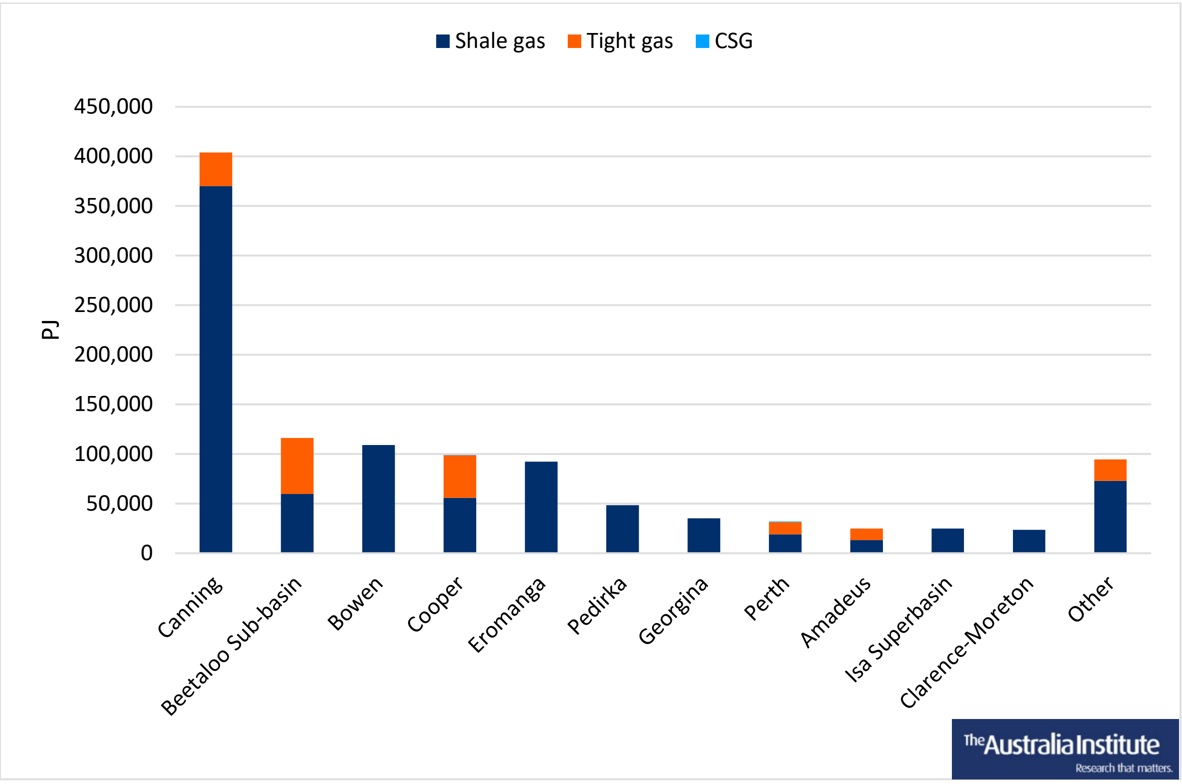
Source: Geoscience Australia (2018) Australian Energy Resources Assessment - Gas

Prospective conventional gas is larger than what has already been identified, and prospective unconventional gas is far larger than all identified fossil gas resources of any kind.

The 2020 AERA takes a different approach to prospective resources. GA notes “conventional gas resources continue to be discovered in well-explored basins” but does not give figures for prospective conventional gas resources. GA explains “there have been no recently published assessments”, and the previous assessments “are no longer included due to the significant exploration activities, discoveries and new play concepts that have developed over the past decade”. These two justifications seem in tension. It is unclear how new discoveries and ‘play concepts’ (extraction strategies) could result in a smaller resources estimate.

For unconventional basins, the 2020 AERA gives figures for potentially recoverable gas from a range of external research projects, including the US Geological Survey and earlier estimates from GA. Some basins are listed with with many estimates. The analysis here focuses on the average for each basin, shown by gas type in Figure 11.

Figure 11: Prospective unconventional gas, type by basin, averages from AERA 2020

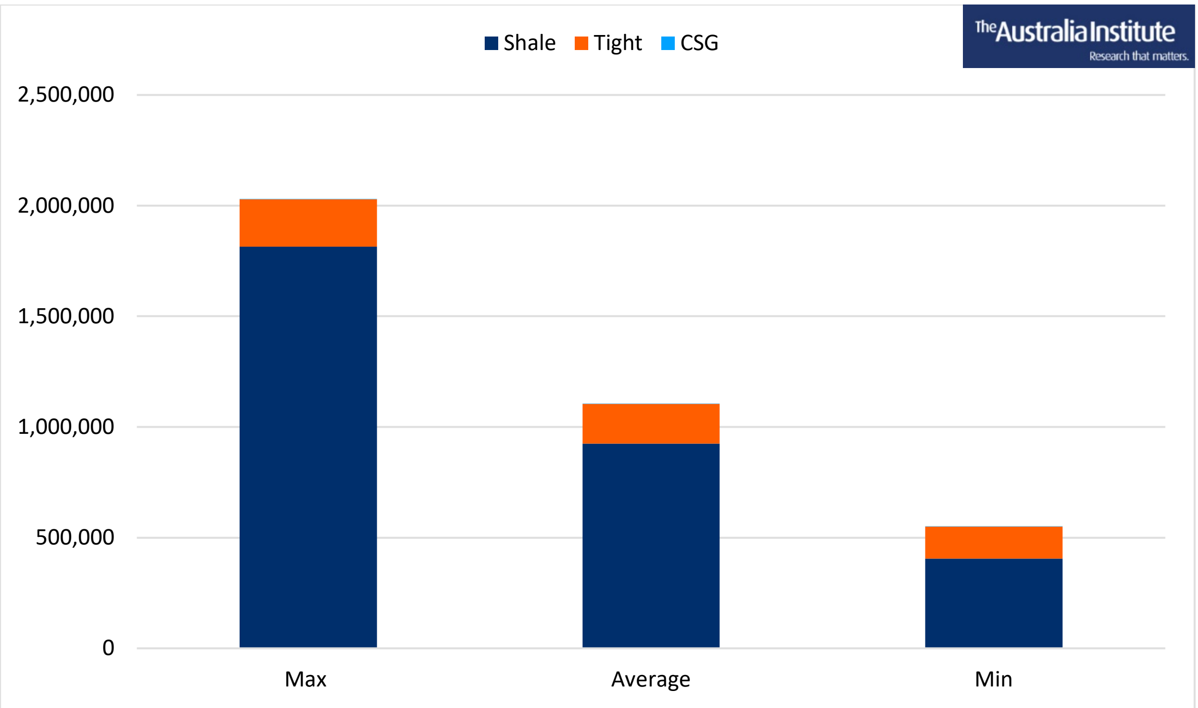


Source: Geoscience Australia (2020) *Australian Energy Resources Assessment - Gas*, via Zotero. NB Beetaloo Basin ‘basin centred gas’ here categorised as tight gas

GA presents estimates that reserves, when taken as an average for each basin, add up to 1,048,100 PJ in prospective unconventional gas resources. Again, shale gas in the Canning Basin is the largest by far, but there are more prospective resources outside of the Canning Basin, across a number of smaller basins. Note these basins are still large. Outside of the Canning Basin, four basins contain prospective resources each larger than total historical extraction in Australia.

There is significant uncertainty, shown in the different estimates between studies. Maximums and minimums together range from 0.5-2 million PJ in total, shown in Figure 12.

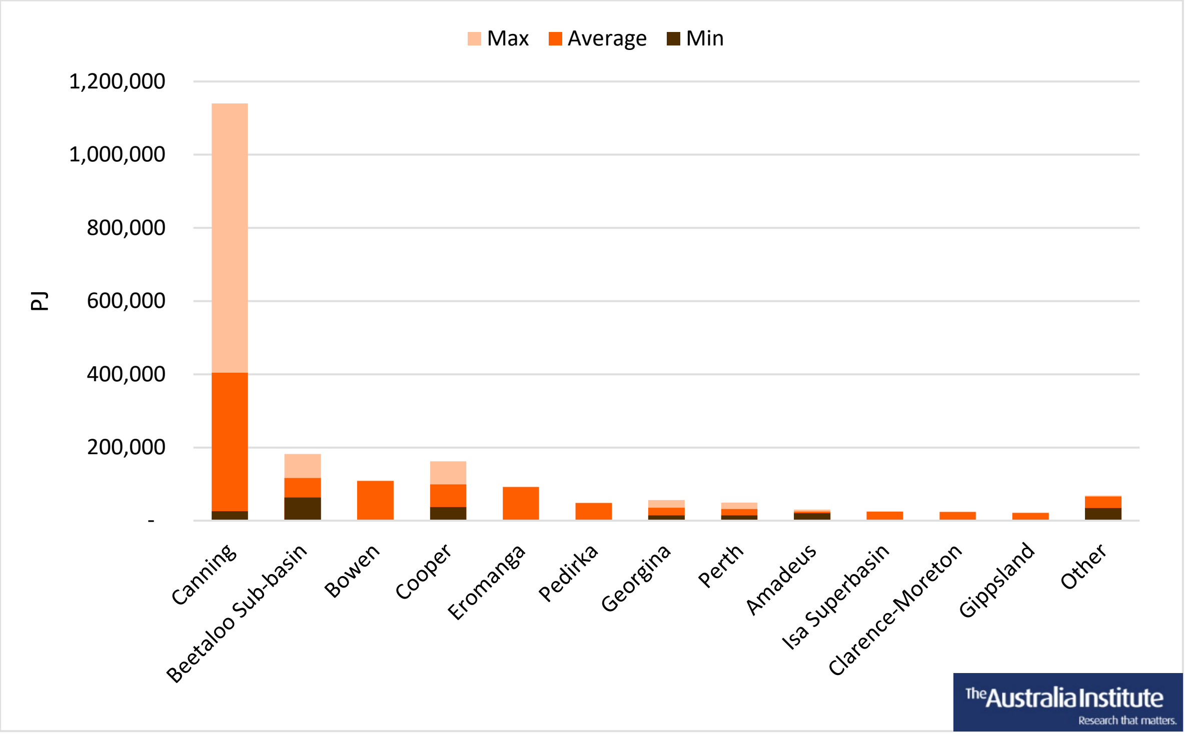
Figure 12: Total range in estimates of unconventional basin prospective gas resource



Source: Geoscience Australia (2020) *Australian Energy Resources Assessment - Gas*, via Zotero

The variation is driven largely by the range in estimates for the Canning Basin. Maximums and mimums for each basin are shown in Figure 13.

Figure 13: Range of estimates by basin, averages from AERA 2020



Source: Geoscience Australia (2020) *Australian Energy Resources Assessment - Gas*, accessed via Zotero

The mean estimate for the Canning Basin is 400,000 PJ. The large range in estimates again shows high uncertainty, with a maximum estimate of 1,140,000 PJ and a minimum of only 25,000 PJ. Nonetheless, outside of the Canning Basin the prospective resource estimates are very large, adding up to 640,000 PJ in total. The second largest is the Beetaloo Basin, with an average estimate of 116,000 PJ. Here the range is smaller, from 182,000 to 63,000 PJ. Even the lower estimate is large, equivalent to all fossil gas extracted in Australia to date.

TOTAL RESOURCES

Table 3 shows data compiled from the AERA reports, as discussed above.

The data used in subsequent emissions estimates are shown in bold, and in Figure 14.

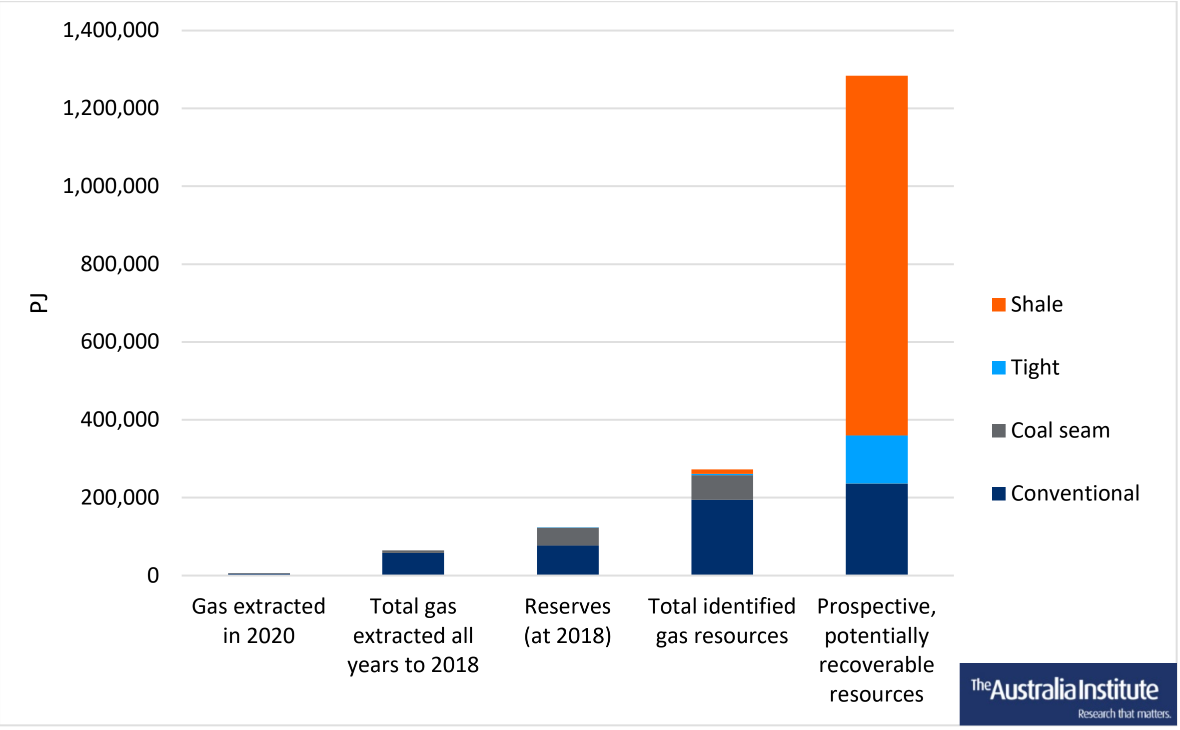
The same data is aggregated below in Figure 15, showing the range for unconventional basins.

Table 3: Gas resources in Australia, Geoscience Australia (PJ)

Category of resource	Conventional	Unconventional			Total
		Coal seam	Tight	Shale	
AERA 2020					
Identified	**194,239**	**63,732**	**3,038**	**11,857**	**272,866**
Prospective, potentially recoverable	-	**910**	**179,292**	**924,370**	**1,103,661**
AERA 2018					
Reserves	**77,253**	**45,895**	**39**	**0**	**123,187**
Contingent resources	108,982	33,555	1,709	12,252	156,498
Total identified	186,235	79,450	1,748	12,252	279,685
Prospective	235,913	6,890	2,650,622	9,577,353	12,470,778
of which potentially recoverable	**235,913**	6,890	132,531	478,868	854,202

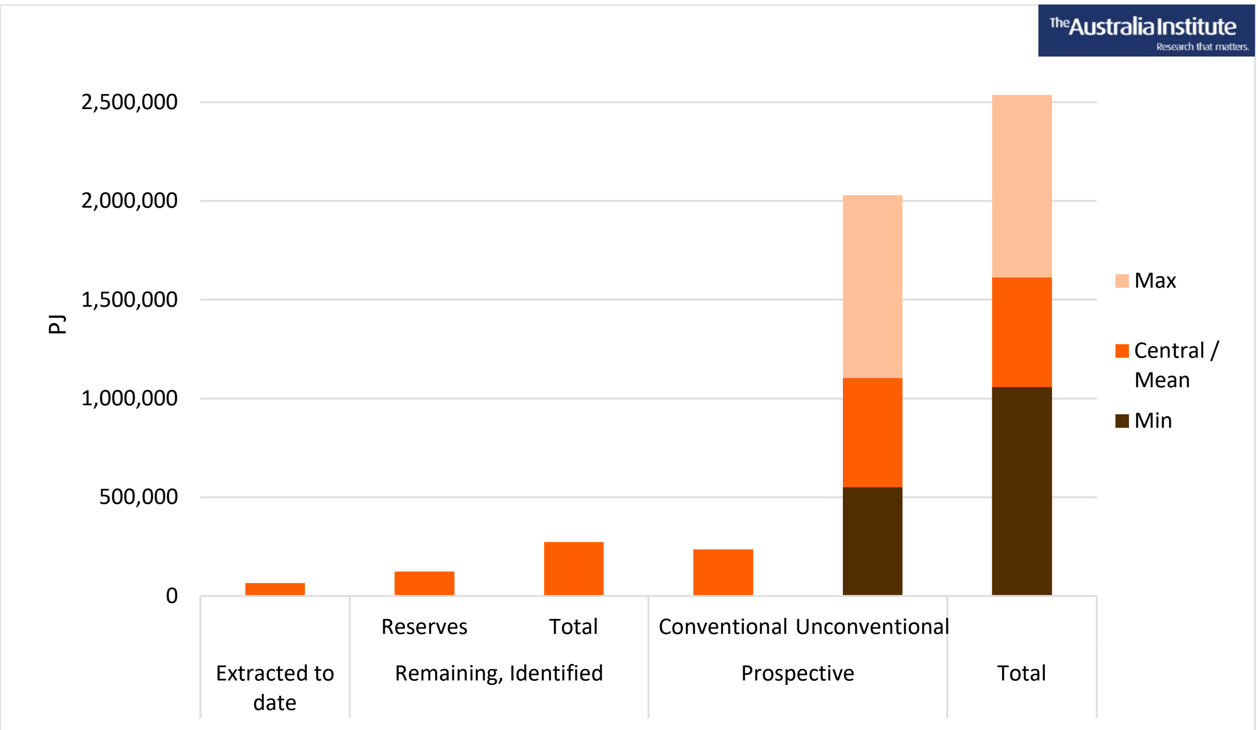
Source: Geoscience Australia (2018, 2020) *Australian Energy Resources Assessment - Gas*, https://aera.ga.gov.au/#!/gas

Figure 14: Australian gas resource estimates from Geoscience Australia



Source: discussed in text, Resources data compiled from Geoscience Australia (2020) *Australian Energy Resources Assessment (AERA)*, https://aera.ga.gov.au/. 2020 production from Office of the Chief Economist (2020) *Resources and Energy Quarterly - June 2020*,

Figure 15: Australian gas resources – from Geoscience Australia



Source: As described in text, Geoscience Australia (2020) *Australian Energy Resources Assessment (AERA)*

Estimating emissions

This section estimates the potential greenhouse gas emissions from the extraction and use of fossil gas from the proposed projects and resource numbers outlined above.

APPROACH

Aggregate combustion CO_2 is estimated using the “natural gas default emissions factor” from the Intergovernmental Panel on Climate Change (IPCC).[53] Where necessary, all energy content is assumed to be methane gas and to be fully combusted.[54] Non-CO_2 gases are excluded from assessment of combustion emissions.

CO_2 emissions from flaring, venting and other sources are included on the basis of the average CO_2 intensity of gas production over the decade to 2018. The increase in Australian CO_2 emissions in this period—for ‘natural gas’, ‘venting’ and ‘flaring’—is divided by the increase in Australian gas production.[55] The result is 2,910 tonnes of CO_2 emitted per petajoule of fossil gas produced (tCO_2/PJ). The average of the totals over the decade, rather than the increase, is 2,712 tCO_2/PJ. The lower number is used here.

Uncertainty about methane emissions is addressed by using a range of leakage metrics, to provide sensitivity:

- the Australian government’s reported methane emissions (0.7% gross production),
- the IEA’s methane loss over global supply chains (1.7% gross production), and
- for unconventional gas, a higher methane loss rate of 3.7%, based on a recent study of a US shale gas region.

Methane loss is treated as subtracted from project capacity, not additional.

---

[53] IPCC (2006) *2006 IPCC Guidelines for National Greenhouse Gas Inventories - Volume 2 Energy*, https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html Table 1.4

[54] This will tend to underestimate emissions from any associated liquids included in energy capacity figures. Natural gas combustion emissions are lower per energy content than liquids. Non-combustion uses of natural gas are a small minority of global gas consumption. Globally in 2017, non-energy consumption of natural gas was 6% of gas primary production and 12% of gas final consumption. Non-energy consumption also has substantial associated emissions.
International Energy Agency (2018) *IEA Sankey Diagram*, https://www.iea.org/sankey/

[55] Note the latter two emissions categories include some ‘oil’ production. The oil/gas split is confidential. This is accommodated by focusing on the growth over the decade, which was all in gas. Data from Department of Industry, Science, Energy and Resources (2020) *AEGIS - National Greenhouse Gas Inventory – UNFCCC classifications*

PROPOSED PROJECTS

The estimate of combustion emissions is shown in Table 4. This assumes full combustion.

Table 4: CO2 from full combustion of new gas supply

	Unit	Value	Source
Energy content	*PJ pa*	5,010	analysis above
	TJ	5.01×10^{6}	
CO2 / energy	*kg / TJ*	56,100	IPCC[56]
CO2 potential	*kg*	2.81×10^{11}	
	Mt pa	**281**	

Combustion emissions from proposed new fossil gas projects are estimated at **281 Mt CO_2 per year**.

This is more than half of Australia's total annual emissions (532 Mt CO_2e in 2019).[57]

Combustion emissions are combined with estimates of fugitive emissions in Table 5.

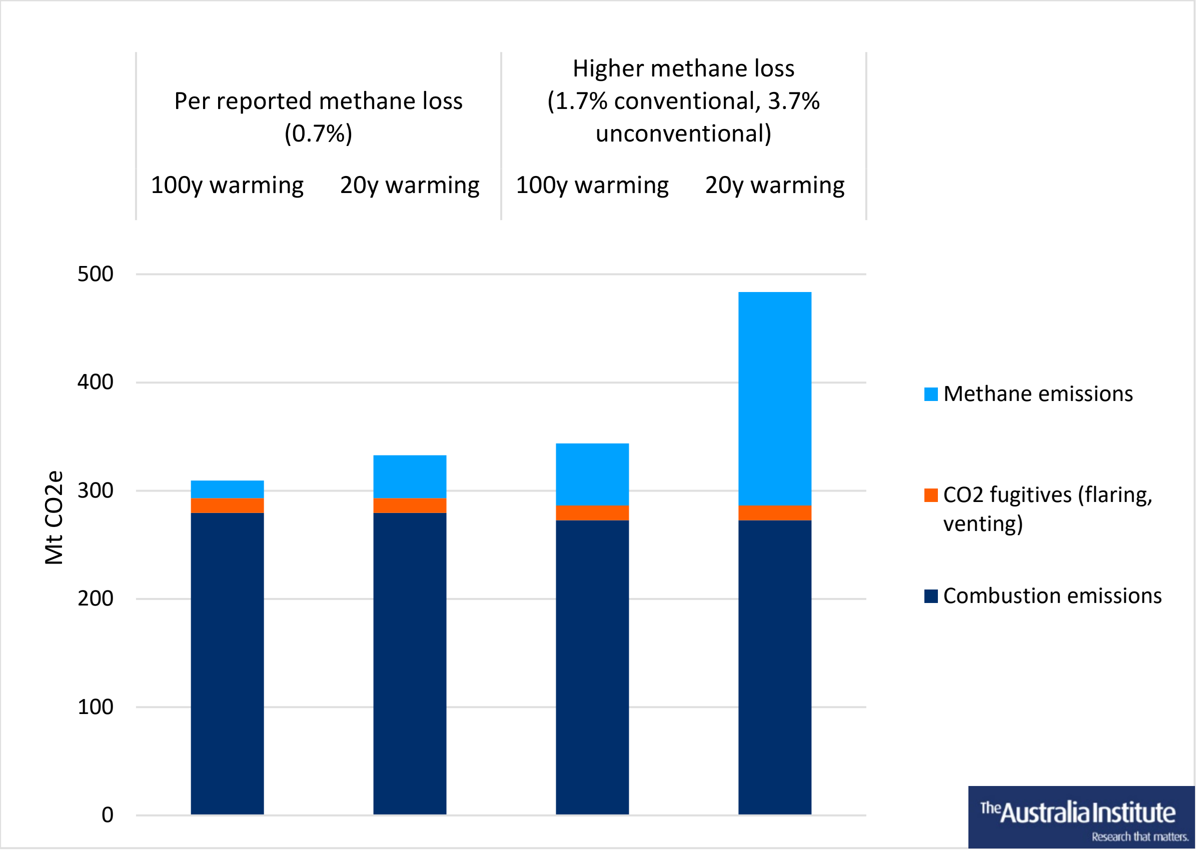
Table 5: Combustion and fugitive emissions from new gas supply

	Units	Conventional	CSG	Shale	Subtotal	Total (CO2e)
Project capacity	*PJ*	3,027	341	1,642		
	Mt	56	6	30		
Combustion emissions	*Mt CO2*	170	19	92	**281**	
CO2 fugitives	*Mt CO2*	8	1	4	**14**	
Methane fugitives	*Mt CO2e*					
Aust govt (0.7% loss)	*GWP100*	10	1	5	**16**	**309**
	GWP20	33	4	18	**40**	**332**
IEA (1.7% loss)	*GWP100*	24	3	13	**39**	**329**
	GWP20	81	9	44	**135**	**425**
High	*GWP100*	24	6	28	**57**	**342**
(3.7% unconventional loss)	*GWP20*	81	20	96	**197**	**482**

56 IPCC (2006) *2006 IPCC Guidelines for National Greenhouse Gas Inventories - Volume 2 Energy* Table 1.4

57 Department of Environment and Energy (2019) *Australia's emissions projections 2019*, p. 8, https://publications.industry.gov.au/publications/climate-change/system/files/resources/4aa/australias-emissions-projections-2019-report.pdf

Figure 16: Proposed gas projects: combustion and fugitive emission scenarios



Source: As described in text

With current reported methane loss rates, using the 100 GWP, proposed project capacity represents emissions potential of 309 Mt CO_2e per annum. Viewed over 20 years, this increases to 332 Mt CO_2e per annum.

In the higher methane loss scenario, emissions potential with 100 GWP are 342 Mt CO_2e – higher than the shorter term impact of methane loss based on reported emissions.

More alarmingly, over a 20 year horizon, the high methane loss scenario estimates a global warming potential of 482 Mt CO_2e per year. This is 60% higher than the impact assessed on the basis of government factors for emissions and warming potentials. It is larger than Australia's fossil fuel combustion emissions and close to Australia's total reported emissions for 2019 (equivalent to 91% of the total).

RESERVES AND RESOURCES

The same approach is taken to estimating the emissions potential of Australian resources.

Table 6: Combustion emissions CO_2 potential – millions of tonnes

		Energy content	CO2 potential
		PJ	*Mt CO2*
Reserves		123,187	6,911
Identified Resources (inc reserves)		272,866	15,308
Prospective			
Conventional		235,913	13,235
Unconventional	Max	2,028,593	113,804
	Mean	1,103,661	61,915
	Min	549,835	30,846
Total			
	Max	2,537,372	142,347
	Mean	**1,612,440**	**90,458**
	Min	1,058,614	59,388

Source: Emissions factors as in Table 4, resource data compiled from Geoscience Australia

Total combustion emissions potential of all identified resources is 15,308 Mt CO_2, or 15.3 billion tonnes of CO_2 (Gt CO_2). Burning reserves alone would produce 6.9 billion tonnes of CO_2 (Gt CO_2).

Prospective *conventional* resources represent a similar emissions potential, at 13 Gt CO_2.

Prospective *unconventional* resources, using the average of the estimates for each basin, have a combustion potential of 62 Gt CO_2.

On this basis, the total combustion CO_2 potential of all gas resources in Australia, identified and prospective, is 90.5 Gt CO_2. Considering the range of estimates for unconventional basins, the total resource ranges from 142 Gt CO_2 to 59 Gt CO_2.

This is just the combustion potential. Fugitive emissions, especially methane loss, would further increase the climate impact.

vs annual emissions of countries

Figure 17 puts this into context with other large sources of emissions. The combustion emissions potential of Austalian gas reserves is 13 times greater than current Australian emissions and slightly larger than annual emissions from the USA.

Figure 17: Australian identified gas resources combustion emissions vs annual emissions from large countries

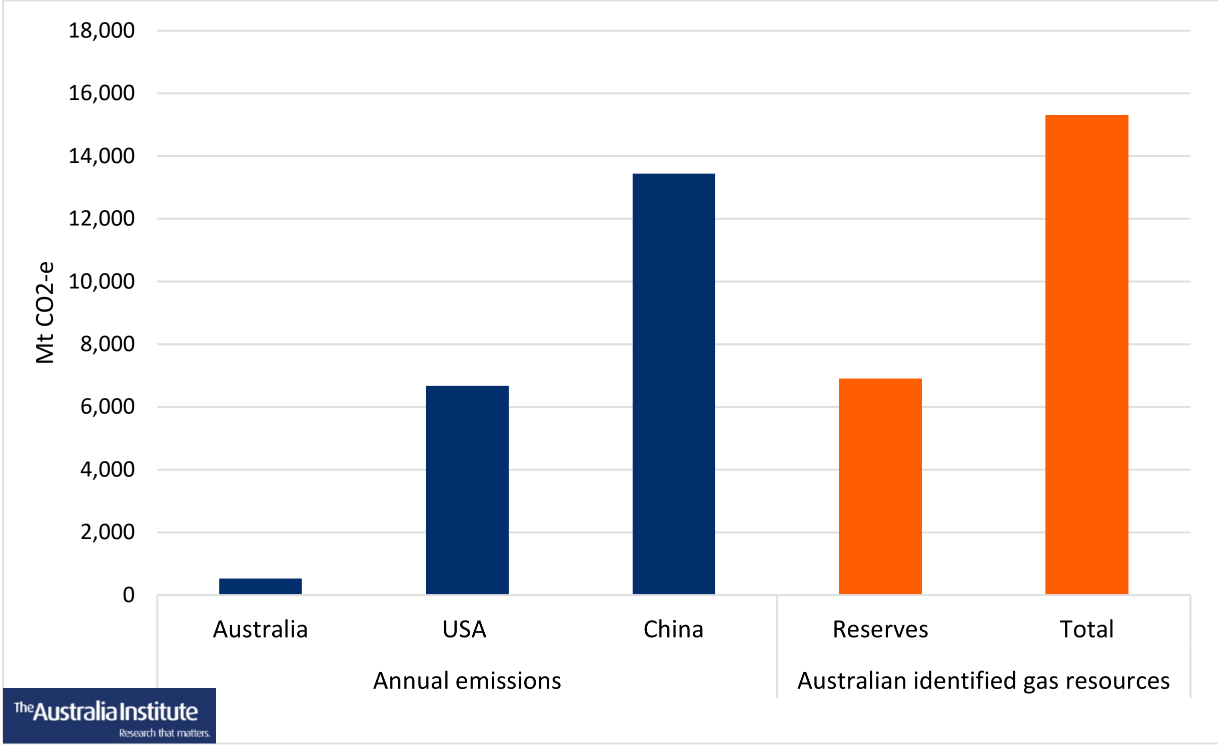
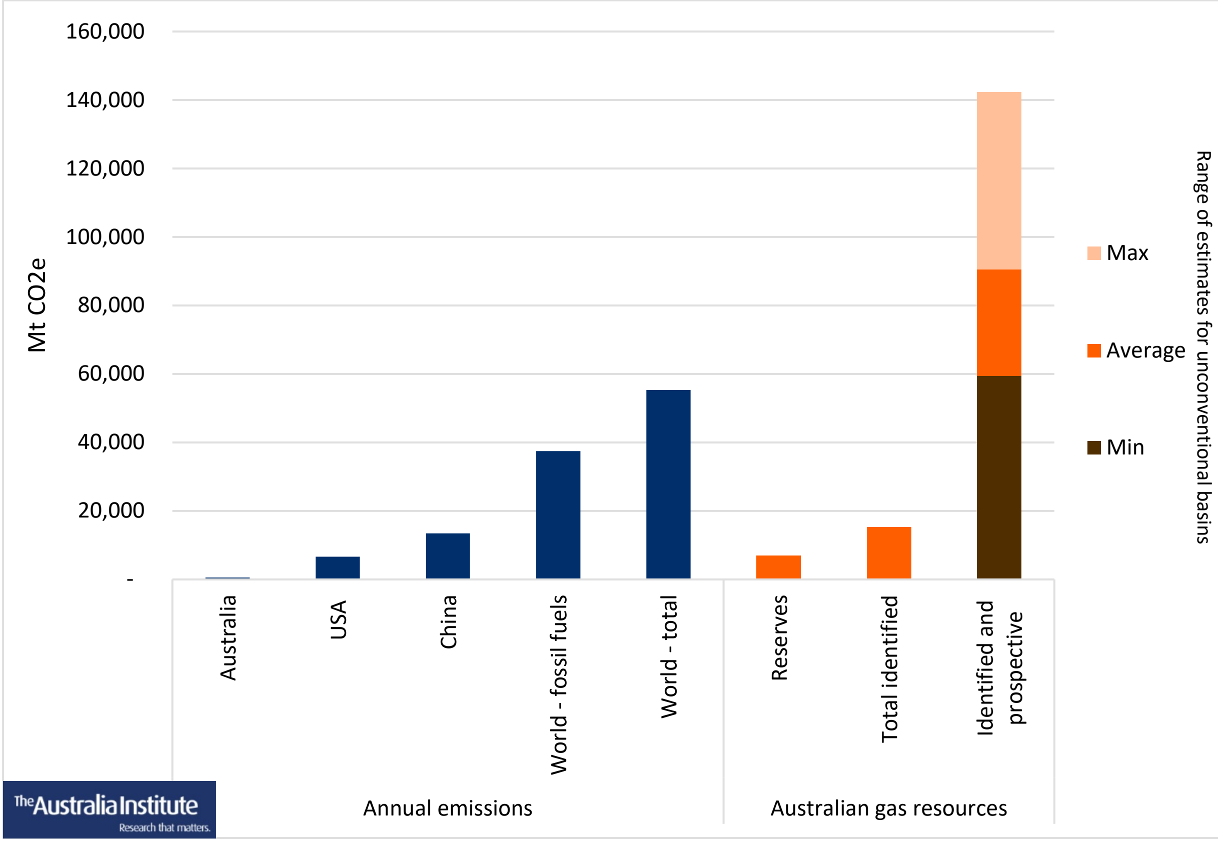


Figure 17 shows that the combustion of Australia's total identified gas resources would release a volume of CO_2 29 times larger than Australian annual emissions, more than twice as large as USA annual emissions and larger even than annual emissions from China.

Figure 18 shows the same data, but in comparison to emissions from the combustion of Australia's total prospective resources.

Figure 18: Australian gas resources vs world emissions



Source: National emissions from Climate Action Tracker (2020) Countries, https://climateactiontracker.org/countries/, Resources emissions as calculated above

The combustion emissions from total Australia gas resource, identified and prospective, are larger even than world annual emissions. Using the average prospective resource estimates for each basin, the combustion potential is almost three years of annual fossil fuel emissions from the entire world, and one year and eight months of global emissions from all sources.[58]

Even on the minimum estimates, total resources represent greater combustion emission potential than annual global emissions. Using the maximum estimate for unconventional basins, total resources are nearly four years worth of global fossil fuel emissions and more than two and a half years of total global emissions from all sources.

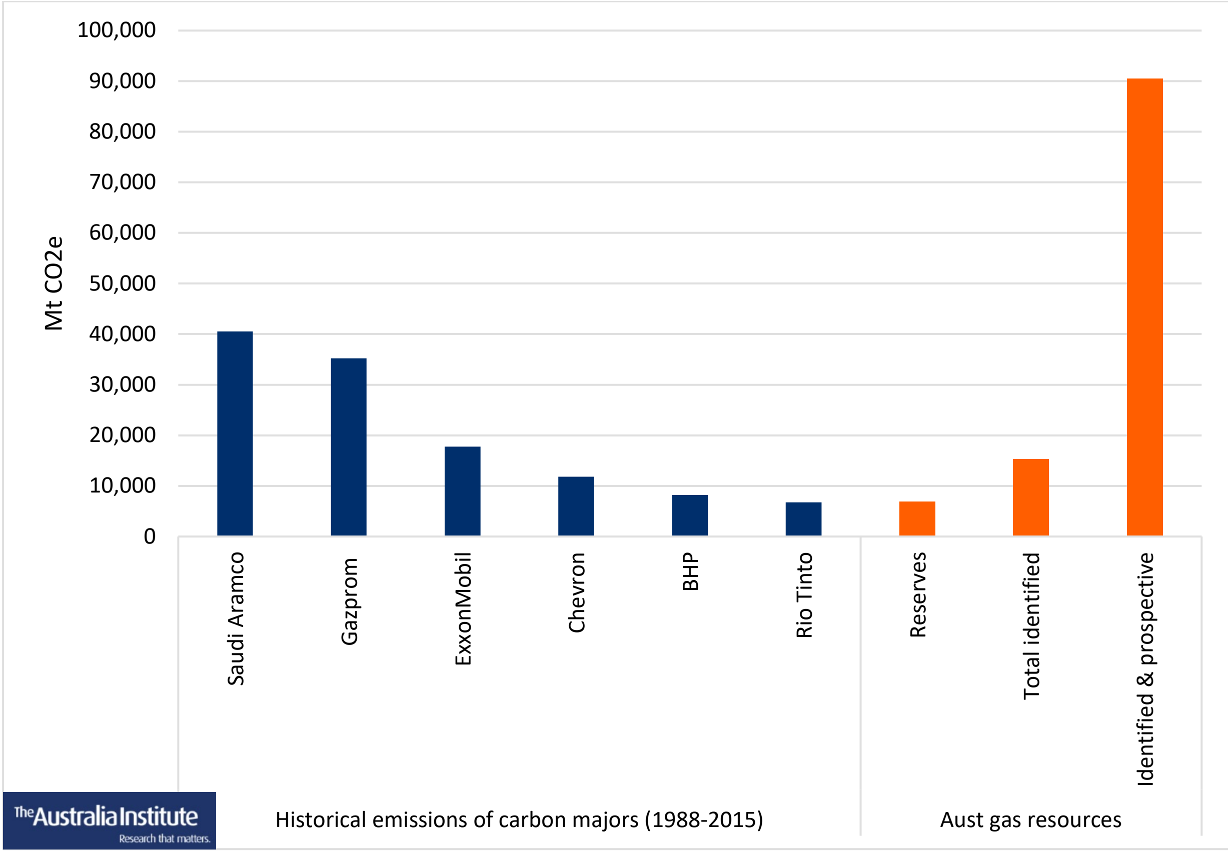
vs carbon majors historical emissions

A further useful comparison is with historical emissions from major oil and gas companies. Studies have examined historical emissions from carbon majors over different time frames. Figure 19 below draws on a 2017 study that examined fossil fuel emissions from 1988-2015,

[58] United Nations Environment Programme (2019) *The Emissions Gap Report 2019*, p. xiv, https://www.unenvironment.org/resources/emissions-gap-report-2019

a time frame starting with establishment of the IPCC.[59] Note that scientists were aware of climate dangers much earlier than 1988, including those working for some of global oil and gas corporations. Other studies examine longer time frames, including to the beginning of fossil fuelled industrialisation.

Figure 19: Aust gas resources vs historical fossil emissions from carbon majors (scope 1 & 3, 1988-2015) Mt CO2



Source: Griffin (2017) *CDP Carbon Majors Report 2017*, resources data as described above

[59] Griffin (2017) *CDP Carbon Majors Report 2017*

Table 7: Aust gas resources vs historical fossil emissions from carbon majors (scope 1 & 3) Mt CO2

	Historical emissions		Australian gas resources	
	fossil, 1988-2015	*fossil, cement 1854–2010*		
Saudi Aramco	40,561	46,033	**Reserves**	6,911
Gazprom	35,221	32,136	**All identified**	15,308
ExxonMobil	17,785	46,672	**& prospective**	90,458
Chevron	11,823	51,096		
BHP	8,183	7,606		
Rio Tinto	6,743			

Source: Source: Griffin (2017) *CDP Carbon Majors Report 2017*, Heede (2014) *Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers,* resources data as described above

Combustion emissions potential from Australian gas reserves are larger than historical fossil fuel emissions from Rio Tinto. Emissions potential from burning all identified resources would be close to twice as large as historical fossil emissions from BHP (8.1 Gt CO_2), and larger even than historical emissions from Chevron (11.8 Gt CO_2).

Identified and prospective gas resources have an emissions potential more than double the fossil emissions of Chevron, Exxon, BHP and Rio Tinto put together. They are larger than Saudi Aramco and Russia’s Gazprom put together.

Even assuming the minimum estimates for each prospespective Australian unconventional gas basin, Australian gas resources have larger combustion potential than fossil emissions.

vs carbon budget

CO_2 potential from combusting Australian gas resources can also be compared with a global carbon budget.

A carbon budget is the amount of CO_2 that may be released from all fossil fuels and all other sources, for a given probability of remaining under a given temperature target. Higher chances of meeting the target, or a more stringent target, will decrease the remaining carbon budget.

Table 7 sets out carbon budgets from a recent article in *Nature* and shows how much of these budgets would be taken up by combusting Australian gas resources.[60]

[60] Rogelj, Forster, Kriegler, Smith, & Séférian (2019) *Estimating and tracking the remaining carbon budget for stringent climate targets*, https://www.nature.com/articles/s41586-019-1368-z

Table 8: Australian gas resources as share of carbon budgets (Gt CO_2)

Temperature target	chance of remaining below target		
	33%	*50%*	*66%*
below 1.5°C	740	480	**320**
below 2°C	1,930	1,400	**1,070**
Identified gas resources (15.3 GtCO₂)			
below 1.5°C	2%	3%	**5%**
below 2°C	0.8%	1.1%	**1.4%**
Identified and prospective gas resources (90.5 GtCO₂)			
below 1.5°C	12%	19%	**28%**
below 2°C	5%	6%	**8%**

Source: Carbon budgets from Rogelj, Forster, Kriegler, Smith, & Séférian (2019) *Estimating and tracking the remaining carbon budget for stringent climate targets*, https://www.nature.com/articles/s41586-019-1368-z

Table 8 shows that for a two in three chance of staying below 1.5°C, identified Australian gas resources would take up 5% of the global carbon budget.

For a two in three chance of staying below 2°C, Australian identified gas resources are 1.4% of the global carbon budget.

Including prospective resources, Australian total gas resources are equivalent to 28% of the carbon budget for a two in three chance at a 1.5°C world, or 19% of the budget for a one in two chance.

Australian identified and prospective gas resources are equivalent to 8% for a two in three chance of remaining below 2°C.

Remember that the budget is for all countries, all fossil fuels and all other sources of CO_2.

To reiterate, these calculations assume full combustion of the resource.

Beyond combustion emissions, extracting and combusting resources would also produce fugitive emissions, both CO_2 and methane. High measured rates of methane loss from unconventional gas have the potential to double the climate impact.

More gas means more emissions

Despite the large and increasing emissions from the fossil gas industry in Australia and around the world, the industry routinely portrays itself as a climate solution. It claims more gas is needed to push emissions down, since gas is a less emissions intensive fuel than coal. These 'transition' and 'displacement' arguments are not supported by the evidence, as this section shows. In a low emissions future the role for fossil gas is using less of it, not more.

DISPLACING CLEAN ENERGY

The gas industry and its supporters often argue that gas reduces emissions by displacing coal. Remarkably, these claims are made presented without any evidence. Proponents usually give numbers that assume complete displacement and hide the lack of evidence by saying this 'could' happen. They fail to disclose that instead of displacing coal, gas can displace renewables or lead to additional energy consumption.

The claims about displacement also ignore the 'lock in' where gas locks in new high carbon infrastructure for decades in breach of climate goals. Limiting global heating in line with internationally agreed goals requires most fossil gas reserves to stay in the ground, including most reserves of fossil gas. That means preventing a large increase in gas extraction and combustion.

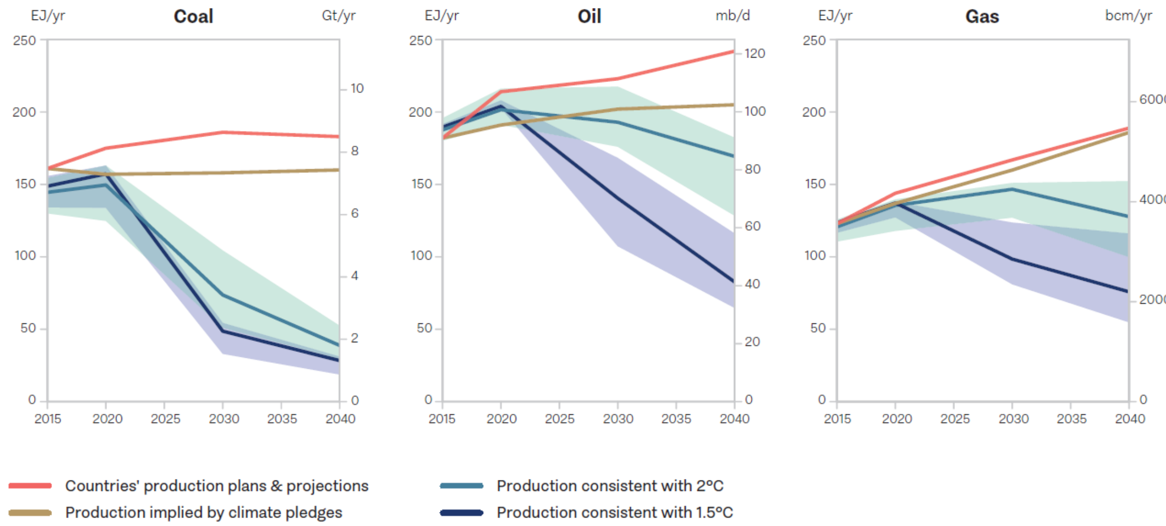
The IEA's 'sustainable development scenario' (SDS) involves global economic growth, widening energy access, and limiting warming to under the 2°C Paris goal. In the SDS, gas falls to 2040 to below current levels.[61] By comparison, in the IEA's 'stated policies scenario' (SPS), gas use continues to grow globally in coming decades, contributing to failure on climate goals.

The UN Environment Program goes further in their *Production Gap 2019* report, showing national plans for fossil fuel production greatly exceed both the IEA's SDS and a more stringent 1.5C scenario.[62]

[61] The SDS also assumes rates of carbon capture and storage (CCS) that seem very implausible in light of persistent failure of CCS deployment. Removing CCS requires emissions, and so gas use, to fall faster.

[62] United Nations Environment Programme (2019) *Production Gap Report 2019*, http://productiongap.org/

Figure 20: UNEP Production Gap 2019 – all fuels must decline under climate scenarios



Source: United Nations Environment Programme (2019) Production Gap Report 2019, http://productiongap.org/

Coal mining must fall fast, but gas extraction must also decline, to meet climate goals. New gas infrastructure could only be Paris-aligned if it were more than offset by the closure of coal infrastructure. A 2019 study in *Nature* showed that "little or no new CO_2-emitting infrastructure can be commissioned, and that existing infrastructure may need to be retired early (or be retrofitted with carbon capture and storage technology) in order to meet the Paris Agreement climate goals".[63] However, without climate policy this is unlikely to occur. It is even less likely to occur if subsidies and government capital further expand gas infrastructure.

While many gas companies claim to support climate goals, their displacement claim is generally intended as a counterfactual: if there was more gas supply there would be less coal consumption, *compared to what would have happened otherwise.* A 2014 paper in *Nature* attempted to assess the economic counterfactual through "simulations from five state-of-the-art integrated assessment models of energy–economy–climate systems". It found that "abundant gas" scenarios lead to "large additional natural gas consumption" but little displacement. The best outcome saw very little impact (2% reduction in warming) and at worst warming increased significantly (by 11%).[64] In other words, given the lack of climate policies, more gas is likely to make climate change worse.

[63] Tong et al. (2019) *Committed emissions from existing energy infrastructure jeopardize 1.5 °C climate target*, https://www.nature.com/articles/s41586-019-1364-3

[64] NB two authors were from BAEconomics, including Dr Brian Fisher.
McJeon et al. (2014) *Limited impact on decadal-scale climate change from increased use of natural gas*, https://www.nature.com/articles/nature13837

Even the IEA warned that gas "remains a source of emissions in its own right and new gas infrastructure can lock in these emissions for the future."[65] This report urged countries to constrain coal-to-gas switching to existing gas infrastructure, stressed that policy was needed to ensure this happens, and found that even if implemented in full, it would deliver only a 10% reduction in power sector emissions. The IEA's report looked at four key markets: USA, China, India and Europe. In each country, coal-to-gas switching made up a small share of power sector abatement, smaller than renewables and far smaller than 'structural economic changes and efficiency'. This was true even in the USA, the world's biggest gas producer.

Given the evidence against the displacement argument, it is not surprising the industry so rarely manages to provide evidence in favour.

TRANSITION AWAY FROM GAS

The gas industry argument that gas is a 'transition' fuel has traditionally framed gas as a 'bridge' between coal and renewables. The idea has been that investing in new gas to replace coal is a necessary or cost-effective step to reduce emissions now while improving and ramping up renewables.

Now that renewable energy is the lowest cost source of new-build electricity generation, the gas industry has shifted to claiming that more gas is needed to 'back up' or 'firm' renewables. Gas is 'dispatchable' and unlike coal it is 'flexible': it can play a balancing role by ramping up and down quickly to fill gaps in generation 'when the sun doesn't shine or the wind doesn't blow'.

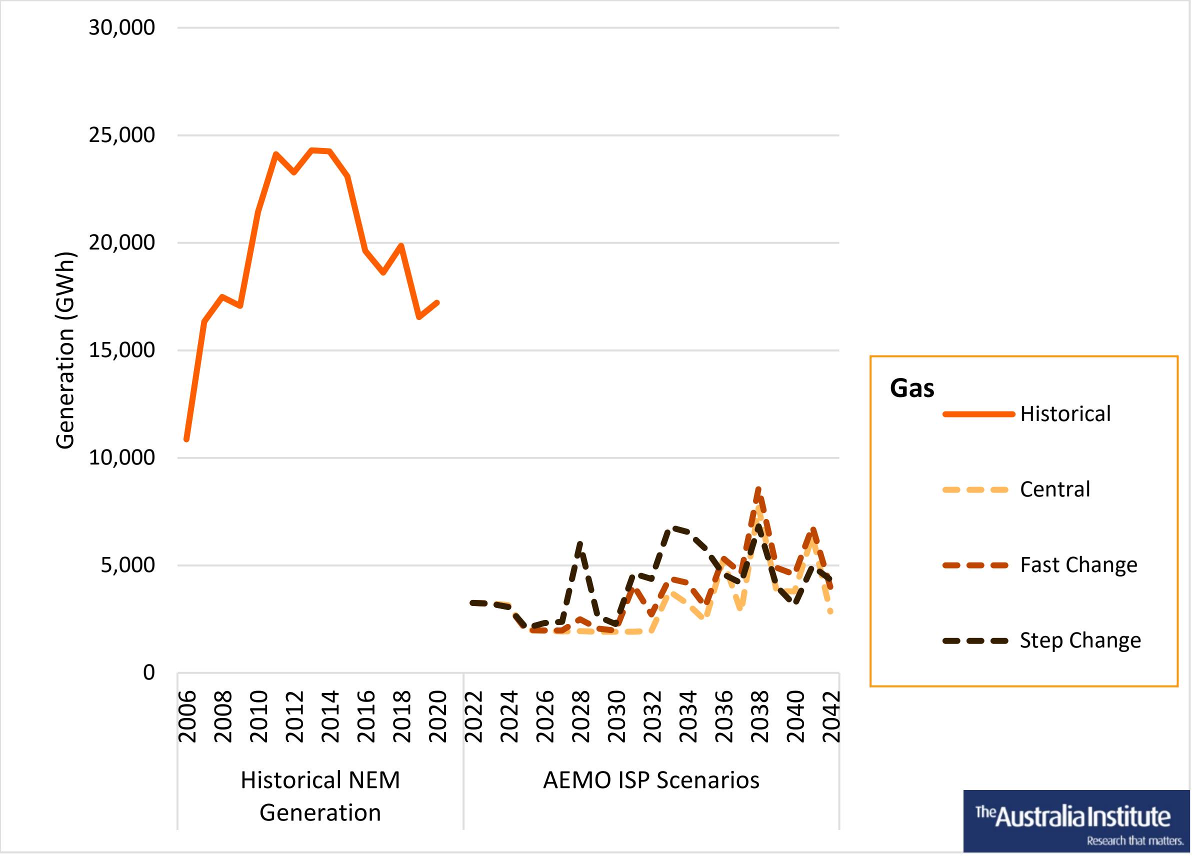
Gas is not the only way to provide firming and is evidently not the lowest emissions. Cleaner alternatives include transmission interconnection, demand management, spare renewable capacity and storage such as pumped hydro and batteries.

These options are examined by the Australian Electricity Market Operator (AEMO) its Integrated System Plan (ISP). AEMO runs the National Electricity Market (NEM) from north Queensland, through NSW and Victoria to Tasmania and west to South Australia. Starting in 2018, AEMO's biannual ISP examines challenges and opportunities in designing a grid that integrates a wide range of generation sources, increasingly wind and solar. The AEMO ISP shows gas generation is likely to play a smaller, not bigger role in the NEM under many scenarios for integrating large amounts of low cost renewable energy.

[65] International Energy Agency (2019) *The Role of Gas in Today's Energy Transitions*, https://www.iea.org/reports/the-role-of-gas-in-todays-energy-transitions

Figure 21 shows gas power generation in the NEM over the last 15 years, compared to gas power generation in key scenarios from the 2020 ISP.[66] It includes the 'Central' or reference scenario, as well as 'Fast' and 'Step Change' scenarios involving faster decarbonisation.[67]

Figure 21: Gas power in National Electricity Market – historical & AEMO ISP scenarios



Source: OpenNEM (2020) OpenNEM: An Open Platform for National Electricity Market Data, AEMO (2020) 2020 Integrated System Plan (ISP), 2020 ISP Generation Outlooks, Scenario 2 for "optimal path" in each case, optimal development pathway for each scenario, as per Table 10 in ISP report.

Gas power generation in the NEM grew to mid 2010s, then fell.[68] The AEMO ISP shows gas collapsing immediately and staying low over coming decades. The AEMO scenarios are "derived by minimising total system cost". AEMO notes that "in practice" gas use may be higher for a range of reasons, like emergency events and "contract positions and strategic

[66] OpenNEM (2020) *OpenNEM: An Open Platform for National Electricity Market Data,* https://opennem.org.au/energy/nem/, Generation by year across NEM, CCGT, all other gas and liquids combined;
AEMO (2020) *2020 Integrated System Plan (ISP),* https://aemo.com.au/Energy systems/Major publications/Integrated System Plan ISP/2020 Integrated System Plan ISP, Draft 2020 ISP Generation Outlooks, Scenario 2 for "optimal path" in each case, optimal development pathway for each scenario, as per Table 10 in ISP report

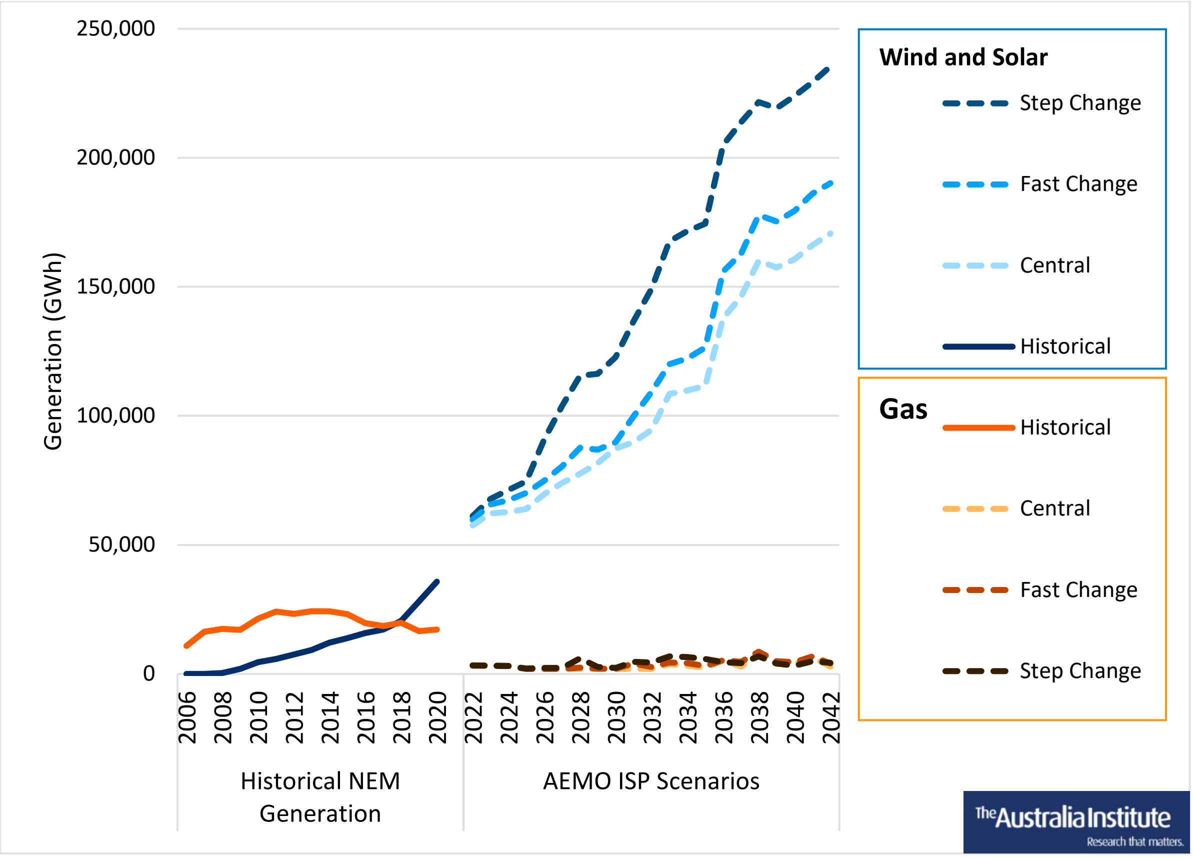
[67] In the ISP, each scenario is tested under a range of parameters to find the 'optimal development pathways' (DP) for the scenarios that lead to the lowest cost. The figure shows the optimal DPs for that scenario.

[68] CCGT, OCGT, Steam, Reciprocating, and Distillate / liquids.

bidding by generators", but adds where these factors increase gas generation they also "increase costs to consumers".[69] The immediate reduction of gas use in the ISP modelling shows gas consumption is associated with higher system costs.

By contrast with gas, renewable energy generation grows very strongly in each of these lowest cost scenarios.

Figure 22: Gas vs renewables in the NEM – historical & AEMO ISP optimal scenarios



Source: OpenNEM (2020) OpenNEM: An Open Platform for National Electricity Market Data, AEMO (2020) 2020 Integrated System Plan (ISP), 2020 ISP Generation Outlooks, Scenario 2 for "optimal path" in each case, optimal development pathway for each scenario, as per Table 10 in ISP report.

Across the NEM, since the beginning of the decade, gas use has fallen and wind and solar have grown dramatically, overtaking gas in 2018. In each of these scenarios, wind and solar generation continue to grow rapidly to 2042, while gas use falls dramatically.

This is possible because the technology is cost effective. CSIRO's GenCost study shows renewables with 6 hours of storage are already comparable in cost to closed cycle gas and far cheaper than peaking gas, and will get cheaper still in later years. Renewables are far cheaper on a standalone basis. Not all renewables will need storage and overbuilding renewable capacity will often be cheaper than storage.

[69] AEMO (2020) *2020 Integrated System Plan (ISP)* Report, p. 56

Similarly, in 2018 a major ARENA-commissioned study by energy analysts at ITP examined "the cost of firm energy from dispatchable renewable generation" from a range of sources and, when considered together at a system level, "found it comparable to new build fossil-fired generation." They concluded "a range of proven and affordable options is available to more than adequately cater for significantly increased levels of renewable energy in the Australian electricity mix" including "an eventual net zero emission technology mix by 2050".[70]

There is clearly little need for increased gas extraction to 'transition' Australia's electricity system.

[70] Lovegrove et al. (2018) *Comparison of dispatchable renewable electricity options*, p. 107, https://www.arena.gov.au/assets/2018/10/Comparison-Of-Dispatchable-Renewable-Electricity-Options-ITP-et-al-for-ARENA-2018.pdf

Conclusion

Fossil gas is a major source of heat trapping emissions both in Australia and globally. Until the COVID-19 crisis, gas emissions were steadily increasing, and Australia was playing a substantial role. Australia is already the world's largest LNG exporter and one of the largest gas producers. Government and company proposals to expand the gas industry threaten to increase heat trapping emissions, when Australia and the world must reduce them in order to avoid escalating climate disruption.

Current market disruptions create uncertainty about future gas development, which will depend in part on government policy. As discussed, there are economic ways to reduce emissions while using less gas, not more. However the Australian government is pursuing a 'gas fired recovery' and major gas projects, while delayed, remain in the pipeline. Given the incomplete, failed or absent nature of climate policies, increased gas supply and consumption is likely to increase emissions, not reduce them.

The analysis in this report has focused on emissions potential. It is essential that debate about a 'gas fired recovery' and the future of the gas industry is informed by its potential to fuel climate change. Australians, and global observers, should appreciate the very large scale of potential gas expansion in Australia.

This report has quantified the scale of emissions from proposed fossil gas projects in Australia, from combustion and additional impacts from methane loss and other fugitive emissions. Taken together these projects respresent a larger volume of gas, each year, than current Australian exports, with emissions at least half of current Australian reported emissions. Depending on methane loss, looking over the next 20 years the climate impact of the aggregate proposed supply could approach Australia's current reported emissions.

The report has also considered the emissions potential of Australia's gas resources, showing that even identified resources are larger than most countries annual emissions, and prospective resources are larger than world annual emissions and even the historical emissions of global petroleum corporations.

There is no space in a world tackling climate change for a large increase in gas production. Most of Australia's reserves, and nearly all of Australia's further resources, must stay in the ground. Yet governments and companies continue to support exploration and development to turn as yet 'prospective' or 'contingent' resources into further reserves.

Government agencies should be required to assess fossil fuel projects and resources against stated climate goals under the Paris Agreement. As this report has shown, if they were to do so, they would make plain the scale of gas expansion they present are not consistent with climate goals, but would fuel climate change and its many forms of human destruction.

Appendix - energy and emissions factors

This section outlines the conversions used in this report. Data presents fossil gas in various ways:

Category	Units	Abbreviation
Energy content	Joules Barrels of oil equivalent Tonnes of oil equivalent British Thermal Unit	*J* *boe* *toe* *BTU*
Mass	tonnes grams	*t* *g*
Volume	cubic feet cubic meters	*cf* *cm or m3*

The units are scaled with standard prefixes:

Prefix	Symbol	Scale	Word
kilo	*k*	x 10^3	thousand
mega	*M / m*	x 10^6	million
giga	*G / b*	x 10^9	billion
tera	*T / t*	x 10^{12}	trillion
peta	*P*	x 10^{15}	quadrillion
exa	*E*	x 10^{18}	quintillion

The conversions used in this report and their sources are outlined in the table below.

	Ratio	Units	Source
energy per mass	*GJ / t gas*	54.4	Aust Energy Statistics[71]
	TJ / t gas	0.0544	
	GJ / Mt gas	54400000	
	PJ / Mt gas	54.4	
mass per energy	*Mt gas / PJ*	0.018382	Inverted
energy per volume	*MJ / m^3*	39.3	Aust Energy Statistics[72]
	PJ / m^3	3.93×10^{-8}	
	PJ / Mcm	0.0393	
	PJ / bcm	39.3	
mass per volume	*Mt / Mcm*	0.000722	From above
energy per energy	*BTU / boe*	5,800,000	US IRS[73]
	mBTU / mmboe	5,800,000	
	PJ / mBTU	1.055×10^{6}	
	PJ / mmboe	6.120	
CO2 per energy	*kg CO2 / TJ*	56100	IPCC[74]
	kg CO2 / PJ	56.1	
	t CO2 / PJ	0.0561	
CO2 per mass	*kg CO2 / t*	3051.84	From above
	t CO2 / t gas	3.05	

[71] Department of Environment and Energy (2017) *Guide to the Australian Energy Statistics 2017*, p. 29, https://www.energy.gov.au/sites/default/files/guide-to-australian-energy-statistics-2017.pdf

[72] Using national average, Department of Environment and Energy (2017) *Guide to the Australian Energy Statistics 2017*, p. 28

[73] IRS (1998) *Part III - Administrative, Procedural, and Miscellaneous Nonconventional Source Fuel Credit, § 29 Inflation Adjustment Factor, and § 29 Reference Price*, p. 3, https://www.irs.gov/pub/irs-drop/n-99-18.pdf

[74] IPCC (2006) *2006 IPCC Guidelines for National Greenhouse Gas Inventories - Volume 2 Energy* Table 1.4

The Australia Institute
Research that matters.

> Climate & Energy.