CLIMATE ANALYTICS

Fracking the Kimberley: Climate implications

The Canning Basin development plans

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Climate Analytics Australia Ltd acknowledges the Traditional Custodians of the lands where we work and live, the Whadjuk people of the Noongar nation. We pay our respect to their Elders past and present and extend that respect to all Aboriginal and Torres Strait Islander peoples today.

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Key findings

Four companies, Black Mountain, Buru Energy, Theia Energy and Rey Resources, have petroleum leases where fracking is currently allowed in the Canning Basin in Western Australia's outstanding Kimberley region.

This report finds that greenhouse gas emissions from fracking would be massive and contradict Australia's commitment to reduce emissions.

Fracking the Canning Basin would seriously undermine Western Australia, Australia, and the world's ability to achieve their climate goals.

We examined three scenarios – "an appraisal scenario", a "proposed development" scenario based on submissions to the WA fracking inquiry in 2018 and a "large scale development scenario".

Fracking dramatically damage the landscape of the Kimberley region with 2,000 wells being drilled under the proposed development scenario in the first 20 years and close to 8,700 wells being drilled under the large-scale development scenario, also in the first 20 years.

The proposed development scenario would support around seven million tonnes of LNG per year (Mtpa) and the large-scale development scenario would support about 29 Mtpa of LNG.

Impacts of proposed development scenario

- Assumed 1350 TJ/day production.
    - Equivalent to about 7 Mt LNG p.a., assuming 15% of production reserved for domestic use.
- Lifecycle global emissions of up to 0.9 gigatonnes $GtCO_2e$ over 20 years, equivalent to 1.9 times Australia's 2020 GHG emissions.
- Increase Australia's domestic emissions by ca. 4% above 2005 Australian emissions.
- Would use close to half of Western Australia's remaining carbon budget and 9% of Australia's remaining carbon budget.
- Would need 200 wells in the first year at full production, about 1,400 wells in first ten years and 2,000 wells in 20 years to maintain constant production at 1350 TJ/day.

Impacts of large-scale development scenario

- Assumed 5,700 TJ/day production to supply LNG plant.
    - Equivalent to about 29 Mt LNG p.a., assuming 15% of production reserved for domestic use.
- Lifecycle global emissions over 20 years up to 3.9 GtCO2e, equivalent to eight years of Australia's greenhouse gas emissions in 2020.
- Consume over 1% of the remaining 1.5°C global carbon budget from 2024.
- Increase Australia's domestic emissions up to 17% above 2005 emissions.
- Domestic emissions would use up to 36% of Australia's remaining carbon budget and more than double WA's remaining carbon budget.
- Would need 890 wells in the first year at full production, 5,900 wells in first ten years and 8,700 wells in 20 years to maintain constant production.

Development would contradict 2018 Western Australia Independent Scientific Panel recommendations on fracking.

The 2018 Western Australia Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation recommended that "*the contribution to Australian anthropogenic upstream GHG emissions from onshore fields in WA must be 0.5 percent or less of 2016 Australian GHG emissions*".

This report shows upstream emissions would generate up to 16% of Australia's 2016 emissions, 30 times the recommendation from the fracking inquiry.

Fracking of the Kimberley and Woodside's Burrup Hub.

Supply of a large volume of gas of the scale of the large-scale development scenario appears to be important to the survival of Woodside's Burrup Hub. Gas resources for the Woodside's Burrup Hub are projected to run down over the next decade. Even if the Browse gas field is developed, there will be a shortfall of gas to maintain production levels.

Woodside has expressed interest in taking resource from the Canning Basin, indicating potential for the large-scale development proposal outlined here to become a reality, absent government decisions to the contrary. The potential volume of gas available from the large-scale development proposal is of the same order needed to maintain constant production from Woodside's Burrup Hub.

Executive summary

This report assesses the greenhouse gas emissions from the potential development of unconventional gas fracking in the Western Australian Kimberley region's Canning Basin.

The Kimberley region and the Canning Basin

The remote Kimberley region constitutes an area of about 422,000 km^2. It is one of the world's largest remaining intact tropical savannahs, a place of outstanding natural beauty, and deep cultural significance for Aboriginal people. It is the only region of the Australian mainland not to have experienced species extinctions and is a refuge for marsupial species such as the bilby.

Image 1: Greater Bilby, a threatened species listed as vulnerable, found in the Kimberley Basin. © Damian Kelly

The Canning Basin covers a total area of 640,000 km^2 (on and offshore) and is one of the world's largest potential gas resources (Government of Western Australia 2022a).[1] The onshore Canning Basin has an area of around 530,000 km^2, covering much of the south western half of the Kimberley region over much of the Martuwarra/Fitzroy River catchment and into the western Pilbara region of Western Australia.

This region is now at risk from potential large-scale fracking operations that will bring huge greenhouse gas emissions and require extensive and intrusive land use for gas wells and related infrastructure. The current onshore exploration licences cover around 36,000 km^2, equivalent to about 8.5% of the Kimberley region.

Canning Basin unconventional gas resources

The Canning Basin contains very large volumes of unconventional hydrocarbons, which would involve extracting natural gas resources through the process of hydraulic fracturing, also known as fracking, which is a significantly more intense industrial activity than conventional oil and gas extraction.

There are a wide range of estimates for the Canning Basin. A median resource estimate for this area is around 265 exajoules (EJ), which is about 89% of Western Australia's total unconventional gas resources. This estimate of the Canning Basin unconventional gas resources is equivalent to about 80 years of all gas use in WA for both domestic consumption and LNG export – or about 50 years of Australia's present annual domestic gas use and LNG export.

The Canning Basin unconventional gas resource estimates are nearly four times larger than WA's conventional gas reserves – and 50% bigger than the energy content estimated for the Beetaloo Basin in the Northern Territory.[2]

At present, WA is exploiting conventional gas reserves that do not require fracking. WA's total conventional gas reserves amount to almost 70 EJ of energy – equivalent[3] to about 24 years of all gas use in WA for both domestic consumption and LNG export, or from a national perspective, about 45 years of Australia's present domestic gas use.[4]

1 The Canning Basin covers an area which is both onshore and offshore. The onshore area is around 530,000 km^2 while the offshore area is around 110,000 km2.
2 Hydrocarbons Technology (2019) Beetaloo Gas Field.
3 From Table 1, Gas, Geoscience Australia
4 According to the DCCEEW, total energy consumption in 2019-20 was 6,014 PJ. The Australian Bureau of Statistics states that the average Australian household uses about 125 GJ of energy annually. As such, WA's conventional gas reserves would equate to 57 years of energy use from Australia 9.8 million households.

Gas development scenarios in the Canning Basin

In this report we estimate the emissions resulting from three unconventional gas development scenarios in the Canning Basin:

1. **Appraisal Scenario:** based on proposals submitted to the Environmental Protection Authority of Western Australia (EPA).

2. **Proposed Development Scenario,** based on presently available information on company plans.

3. **Large-scale Development Scenario,** which supposes a level of development similar to what occurred in the 13,000 km^2 Barnett Shale gas field in Texas, USA over recent decades.

We also estimate the emissions that could result from exploitation of the entire unconventional resource which the basin potentially contains. This updates Climate Analytics' 2018 Gas Gamble report and specifically the top-level gas resource figures for the Canning Basin and resulting emissions if these were fully exploited. The resource estimates for the whole of the Canning Basin are largely unproven, and full exploitation of the Canning Basin's unconventional gas resources may be unlikely.

Appraisal scenario

Black Mountain and Theia Energy have referred proposals for fracking to the WA Environmental Protection Authority for assessment. Theia Energy withdrew their appraisal proposal in July 2022. The estimated emissions from Theia's appraisal project are dwarfed by that of Black Mountain.

Black Mountain is proposing an unconventional exploration drilling and hydraulic fracture stimulation programme, the Valhalla appraisal project, using up to 20 wells at 10 well pads over 7 years.

The total emissions from appraisal activities to date equate to around 1.9% of Western Australia's 2020 emissions (including land use, land-use change and forestry).

Proposed Development Scenario

Black Mountain, Theia Energy, Buru Energy and Rey Resources have oil and gas leases in the Kimberley totalling around 36,000km^2. At present, these potential resources could support 1350 terajoules (TJ)/day of gas. This volume of gas is about 25% above WA's 2023 domestic gas demand of around 1,070 TJ/d. If fully allocated to LNG production,

1350 TJ/day would be equivalent to around 8 Mt LNG/year – about 15% of current WA LNG capacity.

In 2017 the WA government commissioned an 'Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia' (referred to as the Independent Scientific Panel Inquiry in the rest of this report).[5] The final report estimated that development plans at around 930 TJ/d would require an initial 73 well pads with about 610 wells.

Under this scenario, around 9.9 EJ of energy would be produced over 20 years, or about 4% of the median resource estimate for the Canning Basin. We estimate total global emissions over 20 years under this scenario would be in the range of 0.8-0.9 GtCO2e, equivalent to 1.6-1.9 times Australia's 2020 GHG emissions.

Large-scale Development Scenario

The Proposed Development Scenario is not the maximum that could be envisaged for the Canning Basin gas resource. A development of this scale, similar to the development in Texas's Barnett Shale, would produce 5,700 TJ/d. It would supply sufficient gas to manufacture about 29 Mt LNG per year, including the share allocated to domestic consumption, or more than half of the projected total WA LNG capacity of 55 Mt LNG/yr once Pluto Train 2 is online from 2026.[6] This volume of gas would supply about twice the capacity of the Woodside NWS Karratha plant, and more than the total capacity of Woodside's Burrup Hub of 27-28 Mtpa from 2026.[7]

Over 20 years a total of 42 EJ of gas would be produced under this Large-scale Development Scenario, equivalent to about 16% of the median resource estimate for the Canning Basin. We estimate total global emissions over 20 years would be in the range of 3.2-3.9 GtCO2e, equivalent to 7-8 years of Australian GHG emissions in 2020.

Implications for Australia's 2030 targets

Australia has a 2030 target of reducing emissions 43% below 2005 levels by 2030 including LULUCF. With current policy emissions projections, Australia will miss the mark. The 2023 Government projections indicated that the country is on track to reduce

[5] See WA Government Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia.

[6] Assuming about 10% of gas supplied is used in the manufacturing process.

[7] Woodside's Burrup Hub consists of the North West Shelf plant and the nearby Pluto Plant. The NWS plant produces at present around 16.9 Mtpa and is authorised up to 18.5 Mtpa. The inter-connected Pluto plant will have a capacity from around 10 Mtpa from 2026, giving a total of 26.8-28.4 Mtpa for the Burrup Hub.

emissions by about 37% below 2005 levels by 2030, including LULUCF.[8] If the government's 82% renewable target for the power sector by 2030 is achieved along with the implementation of a fuel efficiency standards for light vehicles, this figure will improve to 42% below 2005 levels. Emissions reductions achieved thanks to the Safeguard Mechanism and modelled by the government in its projections are uncertain as they depend on offsets use by private industrial facilities.

The exploitation of gas resources in the Canning Basin would add to Australia's emissions through the upstream emissions from gas production, and downstream emissions from gas distribution, LNG manufacture and domestic use of the gas produced. In addition, the development would add to global emissions through the export of LNG.

Under the Proposed Development Scenario, domestic emissions equivalent to 3 - 4% of 2005 Australian emissions could occur. This would mean that to meet Australia's 43% target the rest of the Australian economy would need to make a 46-47% reduction. Compared to Government's 2023 current policy projections this could mean Australia may only reach 33-34% below 2005 levels by 2030 rather than 37%.

With the Large-scale Development Scenario, additional emissions equivalent to 12-17% of 2005 emissions would occur. To meet Australia's 43% reduction by 2030 target, the rest of the Australian economy may need to make a 55-60% reduction to compensate. Compared to the Government's 2023 current policy projections, this could mean Australia may only reach 20-25% below 2005 levels by 2030 rather than 37%. Fracking the Canning Basin will significantly add to Australia's mitigation burden and compromise its ability to meet its 2030 target.

Implications for the Safeguard Mechanism

The Safeguard Mechanism (SGM), which was reformed in April 2023, introduces binding declining baselines to reduce covered emissions from 136 $MtCO_2e$ in 2021 to 100 $MtCO_2e$ in 2030. However, the proposed exploitation of Canning Basin gas, which was not accounted for in the government's emissions projections, poses a significant threat to the scheme's ability to achieve its emission reduction goals. If fracking proceeds in the Kimberley, it could undermine the scheme's ability to reduce emissions from large industrial facilities.

[8] The Federal Government's 2022 projections indicated a reduction of about 32% below 2005 levels of emissions in its baseline scenario. This scenario did not include some measures that are currently worked on by the government, such as the Safeguard Mechanism reform.

Under the Proposed Development scenario, the Safeguard Mechanism total gross emissions limit could be exceeded by 11 to 18% in 2030.

Under the Large-scale Development scenario, the Safeguard Mechanism total emissions limit under the proposed reform could be exceeded by 47 to 79% in 2030.

WA Independent Scientific Panel Inquiry: 0.5% of Australian emissions limit for fracking projects.

The 2018 Western Australia Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation Report explicitly recognised the need to evaluate the risks of gas development against Australia's ability to meet its commitments under the Paris Agreement, as well as to minimise global temperature increases. In doing so it focused on upstream emissions, stating that:[9]

> *"GHG emissions from onshore oil and gas fields developed with hydraulic fracture stimulation must be minimised. The contribution to Australian anthropogenic upstream GHG emissions from onshore fields in Western Australia must be 0.5 percent or less of 2016 Australian GHG emissions"*

Translated to the global level, this domestic limit of 0.5% of 2016 emissions corresponds to a global limit of 0.01% or less of annual global GHG emissions.

The **Proposed Development Scenario** would have upstream emissions equivalent to 2-4% of Australia's 2016 emissions, significantly above the 0.5% limit proposed by the WA Scientific Panel.

Upstream emissions from the **Large-scale Development Scenario** are estimated to be much higher, at 10-16% of Australia's 2016 emissions. This is far above the 0.5% limit proposed by the WA Scientific Panel.

[9] See page 370 of the Independent Scientific Panel Inquiry report. Note that the inquiry gives Australia's 2016 emissions as 550 MtCO2e/yr. Here we use the more recent value of 491 MtCO2e/yr (including LULUCF) from the 2022 Inventory Report for methodological consistency.

Carbon budget implications

We have assessed the implications of these scenarios exploiting the Canning Basin's unconventional gas resources for the remaining Australian, Western Australian, and global Paris Agreement compatible carbon budgets.[10]

The IPCC AR6 WGI report estimated the remaining carbon budget to limit warming to 1.5°C with a 50% probability to be 420 $GtCO_2$ from 2020. This has been updated considering the emissions that have occurred since the IPCC AR6 estimations and other changes in the science, to around 200 GtCO2 from 2024 onwards. To limit warming to 1.5°C with a 67% probability it would be a lot smaller, at around 150 $GtCO_2$.

We have estimated that the cumulative carbon emissions from 2022 to 2050 for Australia, consistent with reaching net zero by 2050 and limiting warming to 1.5°C, would be about 3.6 $GtCO_2$. This is close to 2% of the remaining global carbon budget.

The GHG emissions from exploiting the Canning Basin reported above include methane and a small fraction of other greenhouse gases, in addition to CO_2. With the methane loss assumptions adopted in this report, the emissions from fracking in the basin have a ratio of CO_2 to GHG of around 76%. We apply this factor in calculating the carbon component of these emissions for the purposes of comparing to global carbon budgets.

Cumulative domestic CO_2 emissions from the Proposed Development Scenario would consume about 42% to 50% of the remaining West Australian carbon budget, and about 7 to 9% of the remaining Australian carbon budget. Total emissions globally from the Proposed Development Scenario would consume 0.3% of the remaining global carbon budget.

The domestic emissions from the Large-scale Development Scenario would consume 2-2.5 times the remaining WA budget and 31-36% of the Australian budget. Total emissions globally from the Large-scale Development Scenario would consume over 1% of the remaining global carbon budget. Full exploitation of the unconventional gas resources of the Canning Basin, which is unlikely, would use 7-8% of the remaining global carbon budget.

[10] The Australian and Western Australian carbon budgets used in this study cover the fossil fuel and industry sectors over the period 2022 - 2050 and are an update of carbon budgets used in (Climate Action Tracker 2020). The earlier report gave carbon budgets for the period 2018-2050 based on emissions levels which would limit warming levels in year 2100 to below 1.5°C with a 50 - 67% chance. See (Climate Action Tracker 2020) for further details. The global carbon budget used in this report is based on the IPCC's sixth assessment report and covers carbon emissions from all sectors.

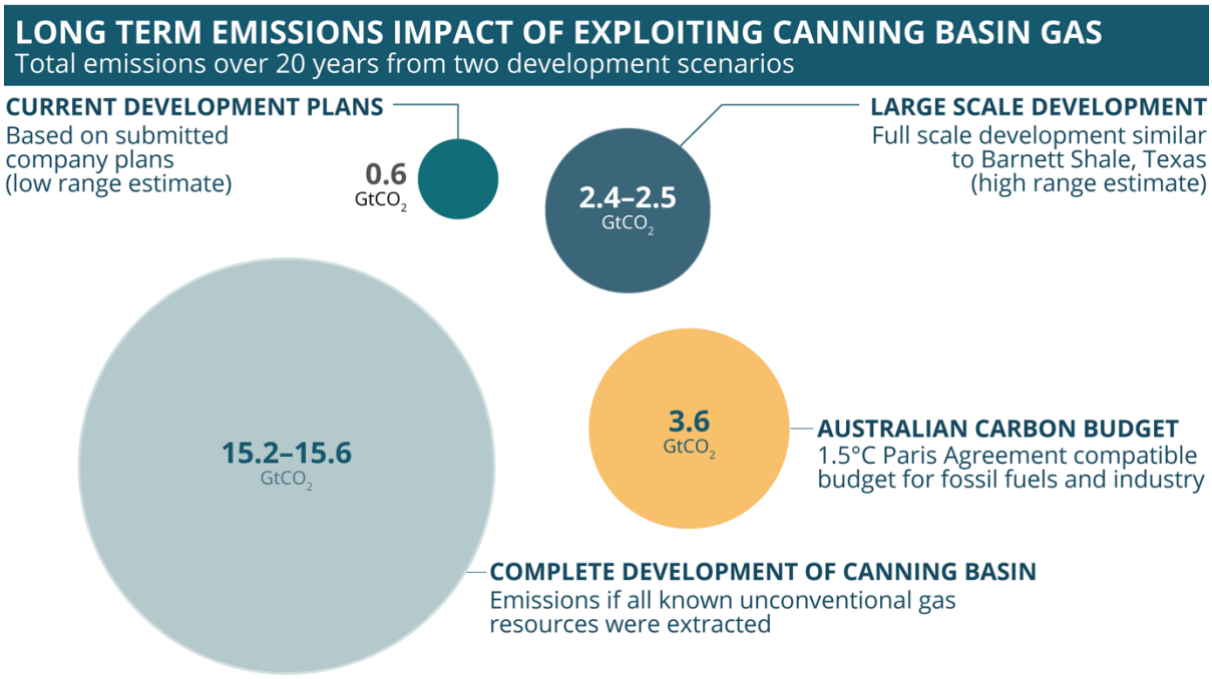


Figure 1: Scenario comparison of CO_2 emissions implications of exploiting unconventional gas. Australian carbon budget is for industry and energy related CO_2 emissions.

Impact on land

Fracking is a massively more extensive industrial activity than conventional oil and gas extraction, involving large areas of land over which to establish infrastructure, well pads and drilling.

Maintaining gas production with fracking necessitates continued drilling of new wells due to the loss of well productivity over time. This has been the case for similar fracking projects across Australia, the U.S. and around the world.

For the 1,350 TJ/d produced in the Proposed Development Scenario, using the assumptions from the WA Independent Scientific Inquiry, around 950 wells from 90-95 well pads would be needed.

The productivity of shale wells decreases geometrically. Using the median decline rate from Guo et al (2017), which analysed fracking in the Barnett Shale gas field, and the average initial production of new wells drilled in the United States of 6.5 Tj/d in the past year, we estimate that 200 wells would be required in the first year of full-scale production of 1,350 TJ/d for the Proposed Development scenario.

To maintain the assumed production level over ten years, 1,400 wells would be needed, and after 20 years about 2,000 wells.[11]

Still using these figures, the larger scale scenario of 5700 TJ/day would initially need 890 wells. With the expected decline in well productivity, maintaining this level of production after ten years would require 8,700 wells.

Beyond greenhouse gas emissions, the Proposed Development Scenario would present a radical intrusion into a relatively intact landscape. The image below is an example of land use for fracking developments in Texas. Such development would cause significant damage to the globally significant tropical savannah of the Kimberley. As it is, the Kimberley has very high value to First Nations people, tourism, residents, and all who care about an intact natural environment.

Image 2: Ongoing development of oil and gas wells in the Permian's Midland Basin, Texas, United States.

[11] Based on EIA's (2024) Short-Term Energy Outlook. if the well productivity in the Canning Basin were similar to that of the most productive plays in the U.S., fewer wells would be required. Conversely, if the well productivity were lower, more wells would be needed.

Wider gas plans in Western Australia

Fracking in the Kimberley to obtain large volumes of fossil gas for decades, as conventional gas resources run down for LNG export and domestic consumption, appears to be part of a larger plan for LNG plant lifetime extension by WA LNG exporters and domestic gas companies.

The Kimberley fracking projects, if they go ahead, could either be connected by a gas pipeline from the Canning Basin to an existing pipeline near Port Hedland, or directly to the existing LNG gas infrastructure for the North West Shelf and Pluto LNG plants. A proposed pipeline could also link WA to Darwin and its LNG export facilities and the east coast for domestic use or LNG export (See Figure 2). The various fossil gas companies operating in the Kimberley have put forward publicly various options to get gas to market, which include a floating LNG facility in King Sound and a pipeline to Darwin.[12]

In other words, development of the Canning Basin's unconventional gas resources, which are massive by any standards, would contribute to a lock-in of fossil fuel extraction activity and infrastructure for decades in WA and beyond.

Exploitation of the Canning Basin's unconventional gas resources would significantly add to the difficulties for Australia being able to meet its domestic emissions reductions target for 2030, and beyond, as well as getting to net zero emissions by 2050. This would further undermine global efforts to reduce emissions to levels consistent with meeting the Paris Agreement's 1.5°C limit, and further increase Australia's emissions mitigation burden.

[12] S, this and that ASX press releases from Buru Energy and this presentation from Black Mountain.
These are, for example, discussed or mentioned in press releases from Buru Energy (1, 2) and in an investor presentation from Black Mountain.

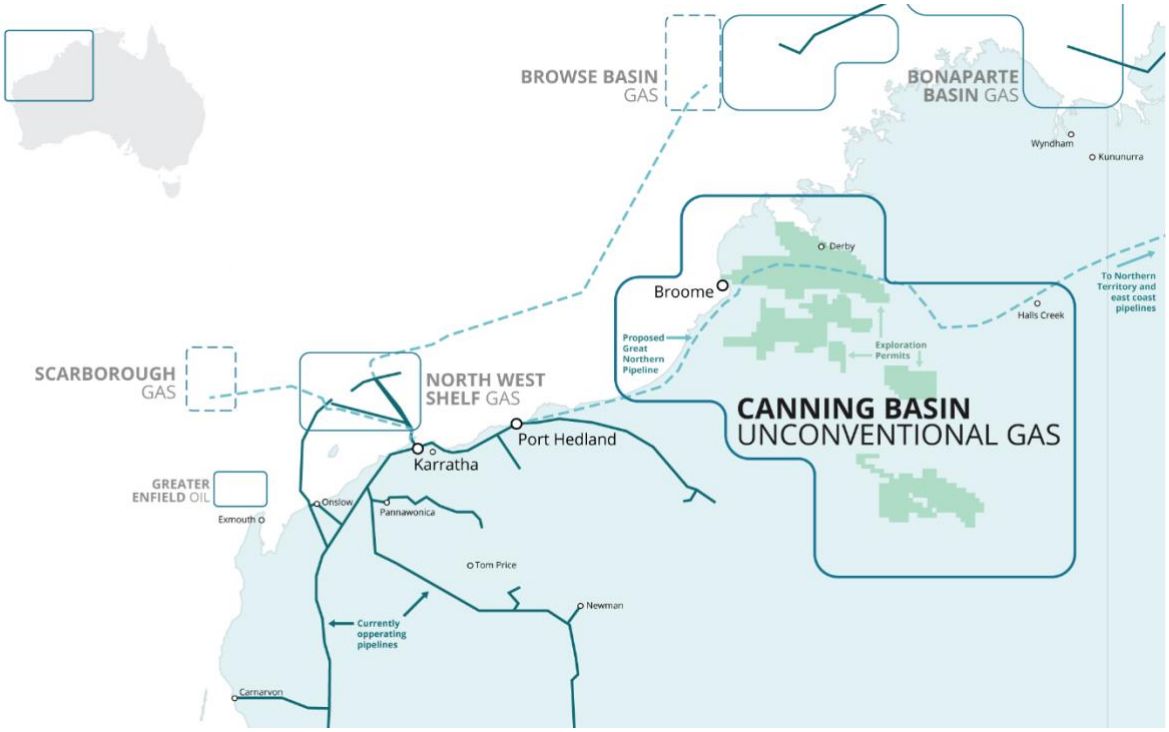


Figure 2: Map of Western Australian oil and gas resources including Canning Basin petroleum leases, showing a proposed pipeline route that would connect to existing pipelines in Western Australia and Northern Territory that link with the east coast. Existing oil and gas areas and pipelines are marked with solid lines and proposed expansions with dotted lines.

Global implications

A consensus has emerged around the fact that ending new fossil fuel developments is critical for the Paris Agreement's goal of limiting warming to 1.5°C. This was recognised in the International Energy Agency's 2021 Net Zero Emissions Roadmap which clearly stated that to meet the Paris Agreement's 1.5˚C limit, there needs to be no new exploration for – nor development of – fossil fuel reserves (oil, gas and coal) (IEA 2021).

In 2021, Climate Analytics showed that in 1.5°C compatible energy transition scenarios from the IPCC Special Report on 1.5°C, unabated use of natural gas in primary energy supply globally should already have peaked and be declining, and that it needs to drop by more than 30% below 2020 levels by 2030, and 65% below 2020 levels by 2040.[13]

[13] Climate Analytics. (2021a). Why gas is the new coal.

The 2022 IPCC Sixth Assessment Report WGIII showed that new planned coal, oil and gas developments would lead to emissions that exceeded the global carbon budget for 1.5 degrees Celsius by about 190 $GtCO_2$ - over 35%.[14]

Conclusions

In this analysis we have looked at the total effect of the gas developments proposed, not just on upstream emissions but on total domestic emissions in relation to Australia's 2030 emission reduction targets.

From our calculations, **it is abundantly clear that the exploitation of the Canning Basin gas resources, as proposed, is not consistent with Western Australia and Australia implementing the Paris Agreement**. The resulting emissions would seriously impede the ability of Western Australia and Australia to achieve 2030 emission reduction targets and net zero by 2050 goals. It is also antithetical to the globally agreed aim of limiting warming to 1.5°C.

It is also clear that the scale of landscape intrusion has not been adequately assessed. The **proposed development scenario** would have up to at least 2,200 wells after 20 years, far above the 950 wells inferred from the WA Independent Scientific Inquiry report. For the **large scale development scenario**, which is at the scale needed by Woodside Energy to maintain production at its Burrup Hub, even after accounting for the development of the Browse Basin, after 20 years at least 8,700 wells would be needed.

Exploiting the Canning Basin's unconventional fossil gas resources would result in greater land degradation, lifecycle emissions, and risk of methane leakage at the expense of the Kimberley region, the State, Australia and the globe.

Given the local and global environmental impacts of unconventional gas exploitation in the Kimberley region, the Western Australian government should update its current fracking ban areas, covering parts of the South West of WA, to cover 100% of the state.

[14] See Figure TS.8 in Shukla, P. R., Skea, J., Slade, R., Khourdajie, A. al, Diemen, R. van, Mccollum, D., Pathak, M., Some, S., Fradera, R., Belkacemi, M., Hasija, A., Lisboa, G., Luz, S., & Malley, J. (2022). Working Group III Contribution to the IPCC Sixth Assessment Report

Introduction

The Kimberley, an area in North-western Australia, is at risk from hydraulic fracking. At more than 420,000 square kilometres, the area is the largest remaining intact tropical savannah in the world. The Kimberley is home to a variety of native birds, mammals and reptiles including the threatened Greater Bilby: it could be home to the largest remaining bilby population in the world. (NESP 2021; Government of Western Australia 2011).

The Martuwarra/Fitzroy River catchment spans almost 94,000 square kilometres covering more than 20 percent of the Kimberley region. The river itself is on the Commonwealth National Heritage list as part of the West Kimberley National Heritage Place. The Kimberley is also home to the Canning Basin, one of the largest potential unconventional gas reserves in the world (Government of Western Australia 2022a).

While petroleum exploration in the Canning Basin began in the early 1920's, up until recently most wells were not commercially viable. Until now, gas reserves of the Canning Basin have remained largely speculative due to the limited seismic and drilling data available.

The advent of horizontal drilling and hydraulic fracturing technology utilised in fields such as the Barnett Shale gas field in Texas have sparked renewed interest in the Kimberley. The potentially recoverable gas resource of the Canning Basin has been estimated to be up to seven times that of the Barnett Shale field in Texas,[15] and 50% larger than the Beetaloo Basin in the Northern Territory.

In 2017 the Western Australian Minister for Mines announced a moratorium on fracking in Western Australia pending an independent review (Dawson 2017). In 2018 the Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia found there was likely to be limited harm to persons or the environment from fracking (Independent Scientific Panel Inquiry 2018).

Following the release of the report, WA Premier Mark McGowan lifted the moratorium on fracking for current petroleum leases in the Kimberley and Mid-West, but banned fracking in the South West, Peel and Perth Metro regions as well as Broome and the

[15] Geoscience Australia gives several estimates for potentially recoverable unconventional gas resources in the Canning Basin (Geoscience Australia 2021). Recent estimates, from 2018, range from 12,174 to 438,599 PJ (10.82 to 389.97 Tcf). A 2015 assessment of the Barnett Shale formation by the United States Geological Survey estimates a mean technically recoverable unconventional resource of 53 Tcf (with 95th and 5th percentiles of 39.7 and 69.2 Tcf, respectively) (USGS 2015b) or 59,597 PJ.

Dampier Peninsula (Johnston 2019). This was presented as a fracking ban on '98% of WA' by referring to the 98% of the state that doesn't hold petroleum leases (Johnston 2019). Currently, all petroleum exploration and appraisal drilling involving fracking requires assessment by the WA EPA (Johnston 2019).

There are currently four companies with petroleum leases in the Kimberley where fracking is allowed, subject to EPA assessment and government approval, Black Mountain, Buru Energy, Theia Energy and Rey Resources. Detailed company profiles are found in the report below.

In this report we estimate the emissions resulting from three unconventional gas exploitation scenarios in the Canning Basin:

1. **Appraisal Scenario:** based on proposals submitted to the Environmental Protection Authority of Western Australia (EPA).
2. **Proposed Development Scenario:** based on company submissions to the 2018 Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia and more recent information, including the pathway to commercialization concept of Black Mountain.
3. **Large-scale Development Scenario:** which supposes a level of development like that which occurred in the Barnett Shale gas field in Texas, USA.

We use the emissions estimates from these three scenarios to assess the implications of exploiting the Canning Basin's unconventional gas resources for Australia's 2030 emission target.

In addition, we evaluate the total cumulative emissions from these scenarios against Paris Agreement compatible carbon budgets for Western Australia, Australia, and the world. Finally, we estimate the carbon budget implications if all the unconventional gas resource of the Canning Basin were exploited.

Western Australia gas resources

In this section, we update our earlier analysis from the Western Australia's Gas Gamble report to provide more accurate estimates of the potential emissions from exploiting the full conventional and unconventional reserves and contingent resources found in Western Australia and the Canning Basin. As this is an update of previous work, our intention is to provide a context, based on government documents, for the main analysis in this report: the emissions estimated to results from fracking projects and plans in the Kimberley.

Conventional gas reserves and resources

There are several gas basins in Western Australia, with a mix of conventional and unconventional gas. In addition to the Canning Basin, there are the Bonaparte/Browse, Carnarvon, and Perth Basins.

The conventional reserves and resources from all four basins amount to an estimated 185,131 PJ. This is the sum of proven and probable reserves, and the "best guess" estimates for the contingent resources (known but not commercially viable at present).

Full exploitation of Western Australia's conventional reserves and resources would result in carbon emissions about three times larger than Australia's remaining carbon budget, and about 15 times WA's carbon budget – Table 1. Together these reserves and resources add up to about 2.3% of the remaining global carbon budget.

These comparisons give an indication that moving into exploitation of unconventional gas resource is unlikely to fit within the national or global emission limitations of the Paris Agreement.

Table 1: Conventional gas reserves (proven and probable) and resources (best estimate contingent resources) in Western Australia

Basin	Conventional reserves and resources				
	Reserves PJ	Resources PJ	$GtCO_2e$ 1.7% IEA CH_4 leakage	Fraction of 1.5°C Australia's budget	Fraction of 1.5°C WA's budget
Bonaparte/Browse	16,911	57,541	3.9	107%	621%
Canning	0	0	0.00	0%	0%
Carnarvon	51,778	56,649	5.6	157%	905%
Perth	1,178	1,074	0.1	3%	19%
Total	69,867	115,264	9.6	267%	1544%

*Source: (Geoscience Australia 2021). See **Global carbon budget** sector for details of carbon budget calculations. The WA LNG Profile provides different estimates of reserves and resources across these fields, with contingent resources reported as 260 PJ for the Canning Basin. However, it does not include an assessment of unconventional resources. To ensure consistency in our analysis and avoid discrepancies that may arise from reconciling different sources, we have relied on the values published by Geoscience Australia.*

Unconventional gas resources

Western Australia's unconventional gas resources are estimated to be within the range of 30,770 to 492,247 PJ with a median estimated of about 300,733 PJ. The Canning Basin accounts for not only most potentially recoverable unconventional resources but also, due to uncertainty, the large range in the estimate. The carbon contained in these unconventional gas resources is equivalent to about 4.2% of the remaining global carbon budget – the Canning Basin around 3.6%.

Table 2: Median resource estimates for unconventional gas in Western Australia

Basin	Unconventional resources			
	PJ	$GtCO_2e$ 3.5% CH_4 leakage	Fraction of 1.5°C Australia's budget	Fraction of 1.5°C WA's budget
	Median resource	Median resource	Median resource	Median resource
Bonaparte/Browse	6,748	0.4	11%	64%
Canning	264,754	15.53	432%	2498%
Carnarvon	10,122	0.59	17%	96%
Perth	19,109	1.12	31%	180%
Total	300,733	18	491%	2838%

*Source: (Geoscience Australia 2021). See **Global carbon budget** sector for details of carbon budget calculations.*

The Canning Basin

The Canning Basin, including offshore, covers around 640,000 km^2 and remains one of the largest unproven underexplored potential basins in the world (Government of Western Australia 2022a).[16] It has the largest estimates for unconventional resources in Australia, between 12,174 to 438,599 PJ, with a median of 264,754 PJ. As can be seen from Table 2 above, the Basin accounts for 88% of the total unconventional resources in Western Australia, given median resource estimates.

[16] The Canning Basin covers an area which is both onshore and offshore. The onshore area is around 530,000 km^2 while the offshore area is around 110,000 km^2.

Gas resource assessments indicate the basin has large potential unconventional and tight gas resources.[17] While estimates are uncertain due to limited drilling and exploration data, industry and government analysis indicates large potentially recoverable gas resources exist. Current geological surveys indicate there are three major trends in the Canning Basin.[18] The Laurel Gas Province, the Ungani Trend and the Goldwyer Shale Oil prospect (Rey Resources 2021).

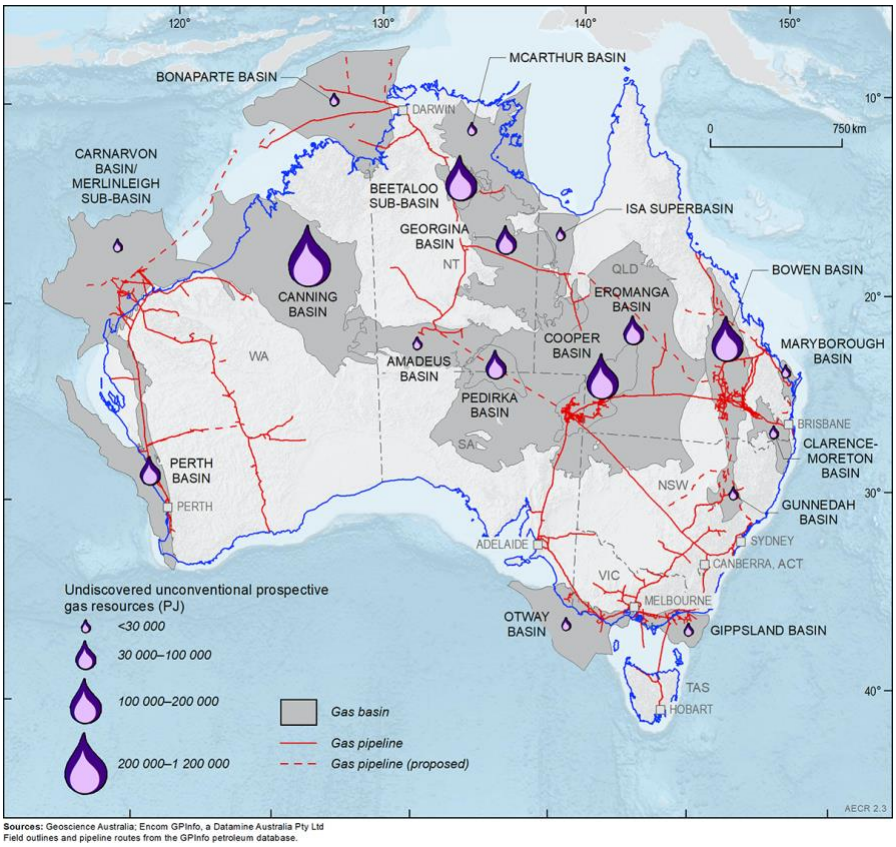


Figure 3: Map of Australia's unconventional gas reserves. Source: (Geosciences 2017)

Estimated potentially recoverable unconventional gas resources in the Canning Basin may be compared to estimates of technically recoverable shale gas resources in other countries. According to the US Energy Information Agency (EIA), the largest resource of shale gas is in China with around 1,275 Tcf (1,434,105 PJ). The US and Argentina hold 862 and 774 Tcf respectively (969,568 PJ and 870,586 PJ respectively) (EIA 2011a).

17 There are three main types of unconventional gas: coal seam gas found in shallow coal seams, tight gas found in low permeability sandstone layers, and shale gas found in rocky layers below sandstone (Commonwealth of Australia).

18 In geology, the term trend is used synonymously with the term play and is used to refer to a group of oil and gas fields controlled by the same set of geological circumstances.

The Canning Basin has been divided into prospective petroleum leases by the Western Australian Government. These are differentiated as production and exploration licences. Current licence holders include Black Mountain, Buru Energy, Rey Resources and Theia Energy. The current exploration and production plans of the major players is analysed further in the next section of this report.

Proposed plans of major fossil fuel companies' projects in the Kimberley

In this section we examine the four main companies with petroleum leases in the Kimberley's Canning Basin where fracking is allowed, subject to EPA assessment and government approval: Black Mountain Energy, Theia Energy, Buru Energy, and Rey Resources.

This section unpacks details from company documents submitted to the Western Australian government (e.g., the Environmental Protection Authority and the Department of Mines, Industry Regulation and Safety), as well as company documents such as presentations to potential investors.

Investigation of the four companies' plans allow for a determination of the number of fracking wells resulting from the proposed development. Noting that hydraulic fracturing is a significantly more intense industrial activity than conventional oil and gas activities.

Black Mountain Energy

Black Mountain is based in Fort Worth Texas and has operations in the US gas basins. Its subsidiary, Bennett Resources, holds exploration lease EP 371 in the Canning Basin. For the purposes of this report we use the parent company name, Black Mountain Energy, which claims to have drilled and fracked 3,000 wells.[19] The company acquired EP 371 from MC Resources, a subsidiary of Mitsubishi Corporation, in 2019 (Upstream 2021).

[19] Black Mountain Energy (2023). Energy Investment Opportunity in Australia's Canning Basin and in the U.S. Permian Basin.

In the near term, Black Mountain Energy plans to drill 20 wells at 10 sites within EP 371 at the so-called Valhalla Gas Province,[20] to appraise the tight gas resources within the Laurel Formation. This exploration and appraisal programme was expected to commence in 2023 and last seven years (Bennett Resources 2020). The wells will be horizontally drilled and fracked at a depth of 2,000 to 4,000m below ground level. The wells are located 123 km to the southeast of Derby.

The company's long term field development indicates supply to existing regional LNG facilities, the WA gas market, potential 'greenfield LNG opportunities', the East coast gas market, and other downstream production opportunities such as blue hydrogen and methanol (Black Mountain Energy 2021).

Previous estimates of the full-scale development of the Valhalla gas area use production estimates of 200 TJ/d for 20 years, for a total of 1,460 PJ (1.30 Tcf)[21], for which 20 well pads and 170 horizontal wells would be required (Independent Scientific Panel Inquiry 2018).

In 2022, Black Mountain Energy modified its EPA proposal to increase groundwater usage and fracks stages per well (Bennett Resources 2020, EPA 2022a). The proposal indicates a 20 well fracking campaign, clearing more than 100 hectares of natural vegetation and releasing more than 1.6 Mt CO_2e into the atmosphere (EPA 2022a).

In its Initial Public Offering presentation, Black Mountain provides an estimate of 11.8 Tcf (13,269 PJ) and 1.5 Tcf (1,687 PJ) for prospective and contingent resources, respectively, in EP 371 where Valhalla is located (Black Mountain Energy 2021). Prospective resources refer to the quantity of gas that may be recoverable in the future, including undiscovered deposits. On the other hand, contingent resources provide an estimate of gas reserves that have already been discovered and are potentially recoverable, even if they are not currently considered commercially viable.

In discussing potential pathways to commercialisation, the company states that, once fully developed, the Valhalla Project could provide around 170 TJ/day, for a 20-year period, to meet gas demand at industrial centres in Port Hedland, 400 TJ/day (equivalent to production of about 2.4 Mt LNG/year), for a period of five years or more, to supply existing LNG Facilities, and 5-50 TJ/day for domestic gas sales. This would be a total flow rate of 575-620 TJ/day.

[20] Valhalla Gas province refers to an area along the northeastern flank of the Fitzroy Trough. The site contains to Hydraulic Fracturing Stimulation wells (Asgard 1 and Valhalla North 1) previously drilled by the MC Resources.
[21] Using the 1 Tcf = 1125 PJ conversion factor derived from the values in Table 4 of Geoscience Australia 2021.

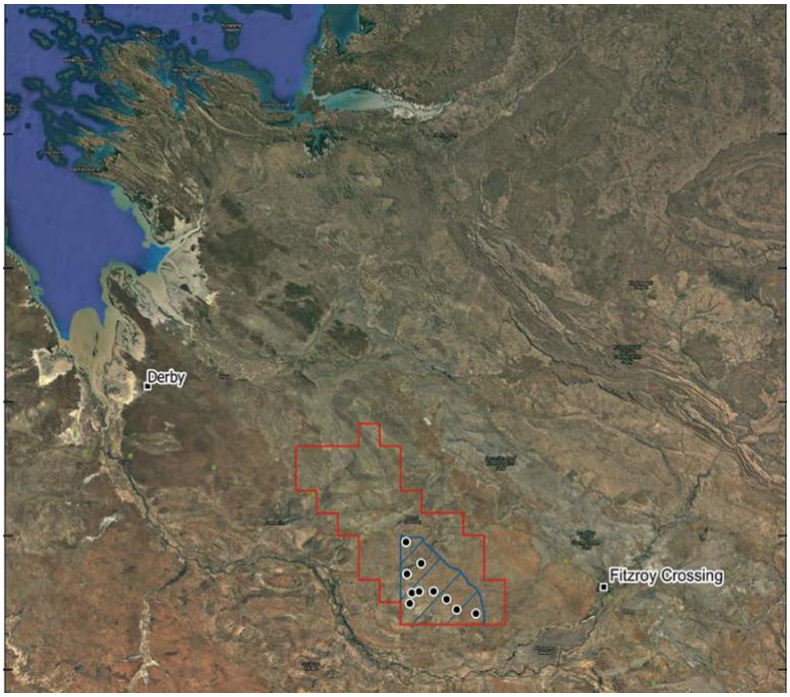
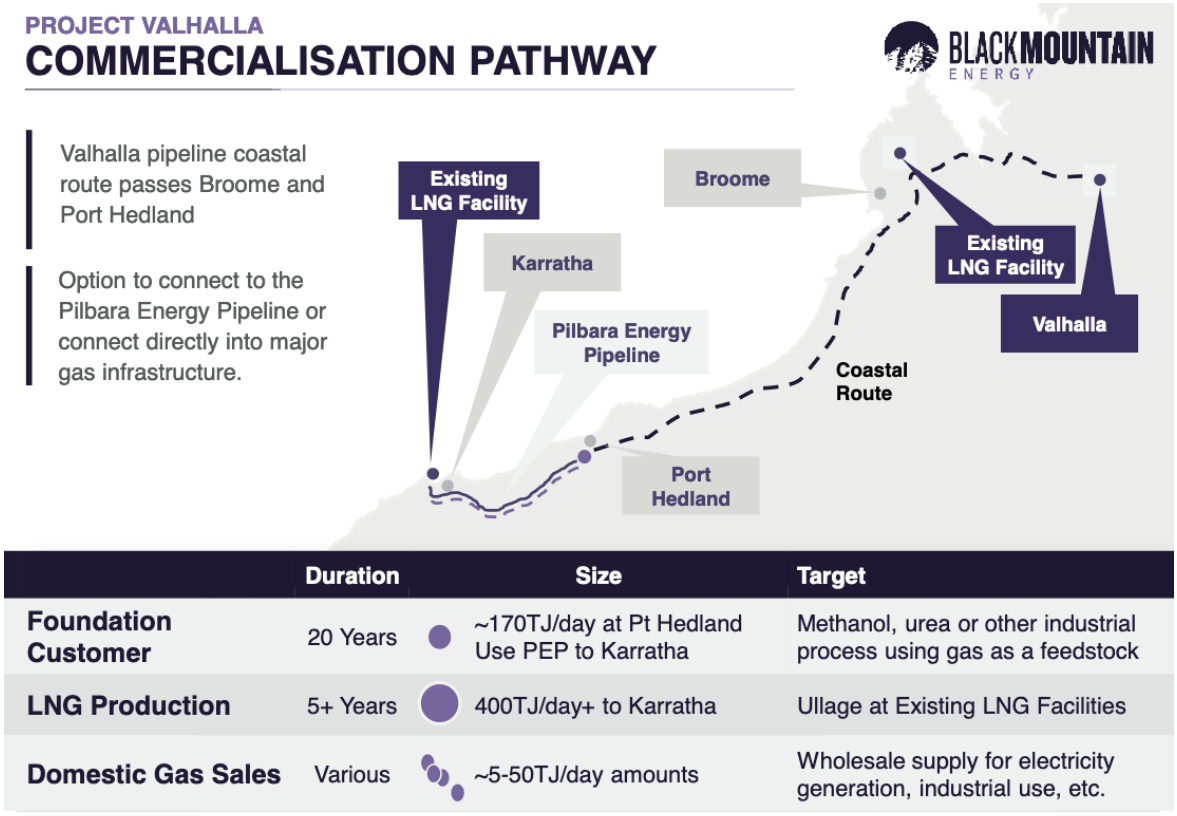


Figure 4: Black Mountain Development Envelope. Source: (Bennett Resources 2020).



	Duration	Size	Target
Foundation Customer	20 Years	~170TJ/day at Pt Hedland Use PEP to Karratha	Methanol, urea or other industrial process using gas as a feedstock
LNG Production	5+ Years	400TJ/day+ to Karratha	Ullage at Existing LNG Facilities
Domestic Gas Sales	Various	~5-50TJ/day amounts	Wholesale supply for electricity generation, industrial use, etc.

Figure 5: Black Mountain commercialisation Pathway. Source: (Black Mountain Energy 2021). The LNG facility is gas a storage facility for the Broome power station.

Theia Energy

Theia Energy is a privately-owned Australian company, created in 2018 when Finder Energy split into Finder Energy for its offshore assets, and Theia Energy for the onshore Kimberley oil and gas resources (Collins 2019).

Theia Energy holds lease EP 493, south of Broome near the Edgar Range, which is estimated to contain a resource of 26,000 PJ (24.6 Tcf) of gas and 35 billion barrels of oil (bboe).

An aspirational daily flow rate of 600 TJ/d of gas is stated in Finder Shale s submission to the Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia (Independent Scientific Panel Inquiry 2018).

In October 2021, Theia Energy submitted a proposal to drill two exploration wells, Theia-2V and Theia-3H for hydraulic fracture stimulation (HFS) and flow test (Theia Energy 2021) to the EPA. Finder Shale had previously expressed a full development may involve 45 well sites supporting 360 wells developed over 20 years. It is estimated the project would require the clearing of 600 hectares (Independent Scientific Panel Inquiry 2018).

Early in 2022, Theia Energy submitted a proposal to the EPA for an exploration program for two horizontally fracked wells (Theia Energy 2021), however Theia withdrew the proposal in July 2022 (Theia Energy 2022). We include Theia's proposal in this assessment assuming they will revisit the plans later.[22]

Buru Energy

Buru Energy is an Australian exploration and production permit holder in the Canning Basin. Buru Energy has conventional oil production wells, as well as exploration permits for potential future tight gas discoveries. As of June 2024, Buru Energy holds the following leases:[23]

- Buru: L 6, L 8 (Production Leases)
- Buru: L 20, L 21 (Production Leases)
- Buru: EP 391, EP 428, EP 436

[22] On 28 November 2022, the company is quoted as saying "Theia Energy remains committed to continuing exploration of the vast resources held in the Canning Basin and it has been assured by the government of its commitment to seeing these strategically important resources developed",

[23] Buru Energy (2024) Interim Financial Report for the six months ended 30 June 2024.

Buru's response to the Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in WA indicated 80 horizontal wells from eight well pads over a 20-year project life delivering 130 TJ/d of gas. This development would involve a pipeline to the Pilbara, and possibly through to the South-West, to deliver gas for domestic use (Independent Scientific Panel Inquiry 2018).

In 2021, Buru Energy began a drilling campaign to drill an additional well for the Ungani oilfield development as well as two exploration wells targeting conventional oil targets, Rafael 1 (Buru Energy 2022), and Currajong 1 (Buru Energy 2021). Buru confirmed a wet conventional gas discovery at Rafael which is on the border between exploration leases EP 391 and EP 457. The reservoir is estimated to contain 1 Tcf recoverable gas (1,125 PJ) and 20.5 million barrels of condensate (Buru Energy 2022). The company foresees the establishment of a major pipeline to the Pilbara and Northwest Shelf LNG processing facilities as part of the development of the conventional resource (Buru Energy 2022). It also announced pre-feasibility study of another development option of floating LNG (FLNG) in King Sound.[24]

Rey Resources

Rey Resources has petroleum leases in the region and has shares in other companies projects (Rey Resources 2021). Rey (ASX: REY) is an Australian company 'focused on exploring and developing energy resources in Western Australia's Canning Basin (Rey Resources 2021). Rey has a 100% interest in EP 487 which contains the wet gas play 'Butler' and shares in EP 457 and EP 458 which contain the unconventional Laurel Shale. The Derby Block (EP 487) is believed to contain 28.4 Tcf of recoverable gas (Rey Resources 2021).

Leases include EP 487 (Derby Block) and Buru F / Rey: EP 457, EP 458 (Fitzroy Blocks).

Current plans include seismic testing with Buru Energy in the Fitzroy blocks and 60km of new seismic planned in the 100% owned Rey Resources lease. The purpose of the seismic is to optimise future well planning.

[24] AGR (April 2023) Transborders Energy and Buru Energy conclude FLNG pre-feasibility study, Add Energy to work on next phase

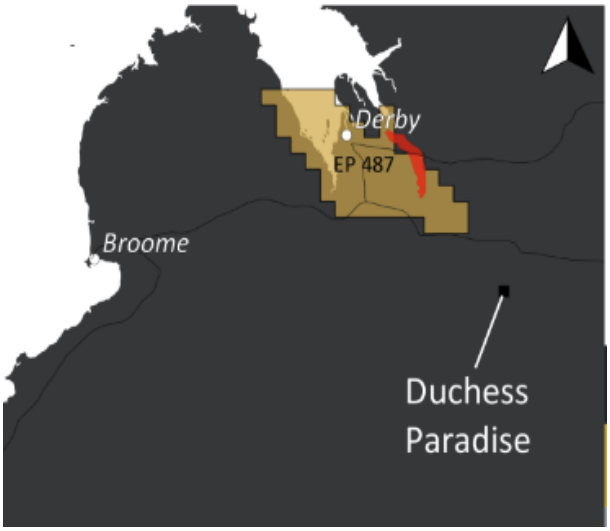


Figure 6: Rey Resources Lease EP 487

Summary of Development Plans

Table 3 below provides a summary of the submitted exploration and development plans for the blocks under management by the four companies. Development Plans draw from information submitted to the Independent Scientific Panel Inquiry, the EPA, and more recent information where available.

These plans were first assessed by the WA Government at the time of the Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation (see pages 148-151 of inquiry report). Note that company names may have changed, or oil and gas leases may have changed hands. This is the case with Theia Energy (previously Finder Shale) and Bennett Resources referred to as Black Mountain in this report (which acquired MC Resources holdings). Some leases have changed hands since development plans were submitted to the inquiry (EPA 2022b; Buru Energy 2022; Rey Resources 2021; Independent Scientific Panel Inquiry 2018).

The main change since the WA fracking inquiry is the release of Black Mountain Energy's December 2021 IPO document outlining its pathway to commercialisation, which significantly increases the scale of possible development in their lease area. This brings the total of the current development plans to up to 1350 TJ/day.

Beyond summarising the information from the 2018 WA fracking inquiry, the table below include re-estimates of the well numbers needed, which are further detailed later in this report. These estimates give an indication of the total land footprint and landscape intrusion. The table includes projections for years 1, 10, and 20 of the proposed development scenarios, based on the median decline rate determined by Guo et al. (2017) under various well productivity assumptions. After 20 years, the number of wells required is approximately nine times the number needed in year 1 to maintain constant production.

Table 3: Summary of Canning Basin Exploration and Development Plans.

	Lease area (km^2)	Appraisal Plans	Proposed Development Plans in the WA fracking inquiry	Revised well estimates
Black Mountain (Bennett Resources)	3,663	20 Wells	575-620 TJ/d, 20 years 47-51 well pads 470-510 horizontal wells	- Year 1: 100-340 wells - Year 10 : 640-2250 wells - Year 20 : 940-3300 wells To maintain constant production of 620 TJ/day
Theia Energy	4,610	2 Wells	600 TJ/d, 20 years 45 wells pads 360 horizontal wells 600 hectares Up to 250,000 bbl oil per day	- Year 1 : 90-330 wells - Year 10 : 620-2180 wells - Year 20 : 910-3200 wells To maintain constant production of 600 TJ/day
Buru	22,554	Conventional Exploration Completed 2022	130 TJ/d, 20 years 8 well pads 80 horizontal wells	- Year 1 : 20-70 wells - Year 10 : 140-470 wells - Year 20 : 200-700 wells To maintain constant production of 130 TJ/day
Rey Resources	5,058	Seismic	Undisclosed	
Total	35,886		1,305-1,350 TJ/d, 20 years 100-104 well pads 910-950 horizontal wells	- Year 1 : 210-740 wells - Year 10 : 1400-4900 wells - Year 20 : 2050-7200 wells To maintain constant production of 1350 TJ/day

*Notes: Except for Black Mountain, the estimates of production, well pads and horizontal wells are taken from the company submissions to the WA 2018 scientific inquiry. Black Mountain has updated their estimate of likely development in the December 2021 pathway to commercialization proposal. The number of wells and well pads estimated in the column "Proposed Development Plans in the WA fracking inquiry" has been scaled in this case to the original relationships WA 2018 scientific inquiry. The "**Revised well estimates this report**" are based on observed relationship between the number of wells needed over time to maintain constant production as described elsewhere in this report. Lease areas have been taken from DMIRS' petroleum & geothermal title search. The lease area held by Buru include leases held jointly with Rey Resources. The given lease for Rey Resources is for leases held solely by that company.*

Greenhouse gas emissions from fracking the Kimberley

In this section we analyse the emissions arising from the scenarios described above ranging from the appraisal wells through to a large-scale development which supposes a level of development as has occurred in the Barnett Shale gas field in Texas, USA.

First, we step through the basis for estimating emissions from fracking and compare relevant emission factors to earlier estimates applied in WA. In doing this, we take account of the potential for methane release and or leakage from the gas development proposals, CO_2 reservoir content, and plausible upstream and downstream emissions associated with production and transport of gas.

In the second step we estimate the greenhouse gas emissions, principally carbon dioxide and methane, that would occur from the development scenarios analysed in this report. For the purposes of estimating implications for global carbon budgets we will also estimate the fraction of CO_2 emissions compared to total greenhouse gas emission estimates for each of the scenarios and underlying assumptions as to methane loss rates and CO_2 reservoir content.

Emissions from fracking

Methane leakage and loss rates

The leakage, or loss of methane from gas production, including from fracking, is potentially the largest greenhouse gas impact of this activity. Methane (CH_4) is a powerful GHG and is responsible for about 30% of human induced warming since the industrial revolution. It has a much higher global warming potential (GWP) than CO_2 - over a 20 year timeframe, a unit mass of methane has about 82.5 times the warming effect of the same mass of CO_2, and over the conventional 100-year timeframe for estimating global warming potential (GWP100) fossil methane CH_4 has about a 30 times greater effect (Forster et al. 2021).

For the purposes of this study, we will use a fossil methane GWP of 30, based on the latest IPCC assessment (AR6), a significant increase on the previous GWP assumed of 25, which was based on the IPCC AR4.

Scientific concern has risen in relation to the climate implications of methane because of the observed, accelerating growth of emissions (and hence concentration) driven by fossil fuel sourced methane and agriculture.

There is evidence based on the changes in the stable carbon isotope content of atmospheric methane that shale gas production via fracking in North America may have contributed over 50% of the increased CH_4 emissions from fossil fuels globally and about one third of the total increase in CH_4 emissions in the decade to 2019 (Howarth 2019).

The International Energy Agency's Global Methane Tracker has reported that its estimates of methane emissions are higher than those reported under UNFCCC reporting guidelines (IEA 2022).

For estimating emissions from exploitation of the Canning Basin unconventional gas reserves, an estimation of the loss of methane from the production process is needed.

Historically, the IEA has estimated a global average loss rate of 1.7% from gas supply chain.[25] However, the evidence above and below points to this being an underestimate and not clearly able to differentiate between the methane loss rates – both involuntary or part of business-as-usual operations like venting and flaring - in conventional versus unconventional gas production.

[25] IEA (2017). The environmental case for natural gas.

The 2018 Independent Scientific Panel Inquiry noted estimated methane leakage rates of 1.4% of production, broadly consistent with U.S. EPA and Australian Government guidelines at the time as a "justifiable basis" for estimating GHG emissions from unconventional gas development. The same document highlighted that the peer-reviewed literature has found a wide range of leakage rate across the past decade.

In our 2018 Gas Gamble report, based on earlier lifecycle assessments that indicated 3.6-7.9% methane loss rates (Howarth et al. 2011), we assumed methane leakage of 6.5% from unconventional gas production, and adopted the IEA 1.7% loss rate for conventional gas.[26] At that time, a range of 2% to 17% loss rates was observed in lifecycle emissions studies of unconventional gas.

Since 2018 there has been an "explosion of new measurements on methane emissions", particularly from unconventional gas extraction in the United States.[27] A bottom-up study found that for the entire U.S. oil natural gas supply chain the loss rate was in the order of 2.3% in 2015. While this figure already represents a 60% increase compared to the estimates provided by the US EPA, the authors noted the significant disparity between bottom-up and top-down approaches (Alvarez et al. 2018). Top-down estimates are typically 1.5 times higher than bottom-up estimates.[28] Commentaries on the work from Alvarez and colleagues found it used an underestimated factor for methane leakage in local gas networks.[29]

In 2021, researchers estimated that the methane loss rate was up to double what was reported in the US National Emissions Inventory and Greenhouse Gas Inventory (Francoeur et al. 2021). A 2020 study specifically on the extraction of gas from the Permian Basin – one of the largest oil and gas extracting region in the U.S. - indicated an average loss rate of around 3.7% (Zhang et al. 2020). A literature review published in December 2022 found an overall average methane leakage rate of 4.8% from the U.S. natural gas industry. Of this, 2.6% was attributed to upstream and midstream operations, while 2.2% was associated with downstream activities.[27]

A 2024 study consolidating nearly one million aerial U.S. site measurements, called by Dr. Howarth the "best synthesis to date of methane emissions from natural gas in the U.S.", found a weighted average methane leakage rate of 2.95% in the six regions studied, when

[26] Climate Analytics (2018). Western Australia's gas gamble - implications of natural gas extraction in WA. It should be noted that the Howarth study uses a 100-year GWP for methane of 33, higher than the 25 in AR4.
[27] R.W. Howarth (2022). Methane Emissions from the Production and Use of Natural Gas.
[28] Vaughn, T. L., Bell, C. S., Pickering, C. K., Schwietzke, S., Heath, G. A., Pétron, G., Zimmerle, D. J., Schnell, R. C., & Nummedal, D. (2018). Temporal variability largely explains top-down/bottom-up difference in methane emission estimates from a natural gas production region. Proceedings of the National Academy of Sciences, 115(46), 11712–11717.
[29] Howarth, R. W. (2019). Ideas and perspectives: Is shale gas a major driver of recent increase in global atmospheric methane? *Biogeosciences*, *16*(15), 3033–3046.

assuming a conservative 90% methane content for the gas extracted.[30] The leakage rate rises to 4.6% when excluding the Pennsylvania region. Their study does not account for emissions from local distribution and LNG operations.

For the purposes of this report, we use a conservative lower bound of methane losses from unconventional gas extraction of 3.5%, corresponding to the lower bound figure found for shale gas by Howarth and his colleagues. They consider this estimate to be "perhaps even low", considering the high leakages in distribution systems.[31,29] This value sits below the Permian Basin estimate of (Zhang et al. 2020).

As an upper bound, we use the 6.5% loss rate from the 2018 Gas Gamble report, based on earlier work from Bistas et al.[32] This value is among the higher estimates reported in the literature. It is exceeded by recent top-down estimates in the United States, such as findings of a methane losses rate of 9.6% from fracking operations in the New Mexico Permian Basin.[30] Given the increasing evidence supporting higher loss rates than those currently assumed in greenhouse gas inventory calculations, this upper limit offers an estimate accounting for potential variance in loss rates under different operational conditions or less efficient practices.

We retain the conservative IEA's 1.7% loss rate for conventional gas extraction as most robust studies on methane leakage rate focus on the United States, where shale gas extraction is prevalent, and research on methane leakage rates in Australia is limited.

[30] Sherwin, E. D., Rutherford, J. S., Zhang, Z., Chen, Y., Wetherley, E. B., Yakovlev, P. V., Berman, E. S. F., Jones, B. B., Cusworth, D. H., Thorpe, A. K., Ayasse, A. K., Duren, R. M., & Brandt, A. R. (2024). US oil and gas system emissions from nearly one million aerial site measurements. *Nature*, *627*(8003), 328–334.
Howarth, R. W. (2024). Twitter/X.

[31] Howarth, R. W. (2021). Chapter 6: Methane and Climate Change.

[32] Bista, S., Jennings, P., & Anda, M. (2017). Cradle to grave GHG emissions analysis of shale gas hydraulic fracking in Western Australia. Renewable Energy and Environmental Sustainability, 45, 1–8., and Bista, S., Jennings, P., & Anda, M. (2019). Carbon footprint management of unconventional natural gas development in the export scenario. *Renew. Energy Environ. Sustain.*, *4*.

CO_2 reservoir content

The CO_2 content of gas fields is an important consideration and can significantly effect total emissions. There is not a lot of public information around the likely CO_2 content of Canning Basin unconventional gas resources. The 2018 Independent Scientific Panel Inquiry estimated between 1 and 3.4 % of CO_2 was present in the field gas composition (Independent Scientific Panel Inquiry 2018).[33] At present the best estimate we can find is the information published by Buru in 2016 which indicates CO_2 content in the range of 2-5% (Buru Energy 2016). We use the middle of this range as our best estimate of 3.5%, whilst exploring lower and higher ranges of 2% and 5% CO_2 content. Black Mountain claims that their Valhalla project gas has 2% CO_2 content.[34]

Upstream emissions

Upstream emissions include losses of methane during the production process as well as energy used to run the fracking process and infrastructure. Due to the limited availability of lifecycle studies on fracking in Australia, we have applied fundamental physical chemistry principles, assuming gas composition similar to that reported by Buru Energy: approximately 87% methane, 5.5% ethane, and 2.7% propane. We then applied lifecycle studies from Europe to plausible upstream production related emissions, i.e., (Hauck et al. 2019). By far, the largest upstream emissions come from methane losses.

The 2018 WA scientific inquiry used a factor of 11 gCO_2e/MJ for upstream emissions from unconventional gas development.[35] We estimate most of this would have come from the assumed methane loss of 1.4%, and the production related emissions are inferred to account for around 4.9 gCO_2e/MJ. Work in Europe on potential life cycle emissions from fracking across the continent, which assumed a methane loss of 0.77% (Hauck et al. 2019), lead to an inference of an average production emission factor of about 6 gCO_2e/MJ, which is the estimate that we have used in this report.

The total upstream emission intensity we assume here is around 22.5 gCO_2e/MJ for a CH_4 loss rate of 3.5% and around 37.8 gCO_2e/MJ for the high end CH_4 loss rate of 6.5%. Most of the difference between the 11 gCO_2e/MJ upstream emission intensity assumed in the 2018 WA scientific inquiry is due to the higher assumed methane loss rate.

[33] Specifically, the report states that samples taken of type I and III Goldwyer shale had a mean CO2 content of 3.4%. Gas samples from the Laurel formation has a mean CO_2 content of 1%. See page 373 of Independent Scientific Panel Inquiry report.

[34] Black Mountain (May 2022) Investor Update Project Overview

[35] The upstream emissions factor is implicit following values in Table 10.1 of the report (pg. 386): 4.4 MtCO2e per year from 1,100 TJ/day of production. The annual emissions estimate in the table uses a 100-year global warming potential (GWP) of 25 for methane, in line with the 4th Assessment Report (AR4) from the IPCC.

Downstream emissions

Downstream emissions come from energy used in transmission and any related processing of the gas, as well as combustion at the point of end use.

The 2018 Independent Scientific Panel Inquiry uses a value of 57 gCO_2e/MJ but did not provide a breakdown of its sources.[36] For the combustion related emissions, and assuming a low CO_2 content in the gas, the Australian Government's National Greenhouse Accounts Factors (Australian Government 2021) provides one estimate of around 51.5 gCO_2e/MJ, implying that the transmission and process related emissions for the gas downstream was assumed to be around 5.5 gCO_2e/MJ.

For the purposes of this study we have drawn up on the work cited above in Europe by (Hauck et al. 2019) from which we infer downstream emissions of around 2.5 gCO_2e/MJ. For combustion emissions we calculate around 52.4 gCO_2e/MJ considering the assumed content of the gas and reservoir CO_2, giving a total of around 54.9 gCO_2e/MJ, slightly lower than that assumed in the Independent Scientific Panel Inquiry.

Overall emission factors

For this report we have calculated a central case emission factor, assuming a methane leakage of 3.5%, of around 77.5 gCO_2e/MJ, of which about 76% are CO_2 emissions. This is about 14% higher than the overall emission factor assumed in the 2018 WA scientific inquiry of around 68 gCO_2e/MJ, with most of the difference as noted above due to the higher CH_4 emission factor assumed here. For the high-end methane loss estimate of 6.5% assumed in this report, the emission factor is around 92.7 gCO_2e/MJ, with about 62% of this due to CO_2 only.[37]

[36] The downstream emissions factor is stated explicitly in the inquiry report (pg. 386, footnote 5).

[37] In our 2018 study, the emission factor we used for this methane loss rate was about 88 gCO_2e/MJ, with the main difference being due the use of a higher GWP of 30 for methane based on the most recent IPCC science.

Table 4: Emission factors for upstream and downstream emissions

	WA Scientific inquiry	Kimberley study Best estimate	Kimberley study High estimate
CH_4 loss rate	1.40%	3.50%	6.50%
CH_4 GWP	25	30	30
CO_2	1-3.4%	3.5%	3.5%
	gCO2e/MJ	gCO2e/MJ	gCO2e/MJ
Upstream	11.0	22.5	37.8
CH_4 loss	6.1	16.6	31.8
Production	4.9	6.0	6.0
Downstream	57.0	54.9	54.9
Combustion		52.4	52.4
Distribution		2.5	2.5
Total CO2e/MJ	68.0	77.5	92.7
CO_2/CO_2e	89%	76%	62%

Canning Basin Gas development scenarios

We have developed new scenarios for the development of the Canning Basin taking into account the full context of gas industry plans in WA. The Proposed Development Scenario is consistent with the anticipated production of 1,350 TJ/day stated in the various publicly-available company plans. We have also explored a Large-scale Development Scenario that could be consistent with attempts to replace declining offshore gas for present LNG plants with onshore gas from the Canning Basin. For this scenario, we have drawn on an analogue of large-scale 'Barnett shale' fracking development in Texas. We have also estimated the immediate effect of greenhouse gas emissions from proposed fracking appraisal operations.

Fracking Appraisals Plans

To date both Black Mountain and Theia Energy have provided projects referrals to the Environmental Protection Authority (EPA) for fracking assessment.

Theia proposed to drill two exploration wells, one horizontal and one vertical, with the former used to undertake hydraulic fracturing. This drilling and exploration would have a land footprint of 6 ha including 4 ha of native vegetation clearing. The company estimates that the proposed activities would result in 27.7 $ktCO_2e$ total emissions, 95% of which would be Scope 1 emissions from flow testing (Theia Energy 2021).

Theia withdrew their proposal in July 2022. We include this proposed appraisal project in our scenario here, as we assume they will revisit fracking plans in the future. It is also important to note that the estimated emissions from Theia's project are dwarfed by that of Black Mountain.

Black Mountain has proposed an unconventional exploration drilling and fracking programme, using up to 20 wells at 10 well pads. The proposed program would last seven years and result in up to 110 ha of land clearing. The company estimates that the proposed activities would result in emissions of 1.6 $MtCO_2e$, assuming 20 wells (six exploration and 14 appraisal) (EPA 2022a).[38]

The emissions from these activities have been estimated as 1.6 Mt CO_2e for Black Mountain and 28 kt CO_2e for Theia. The total emissions from Black Mountain proposed activities equate to around 2% of Western Australia's 2020 emissions (81.5 $MtCO_2e$/yr including LULUCF).[39] These are emissions estimates submitted to the EPA by the companies and are not based on the emissions factors given in Table 4 above.

[38] Black Mountain emissions estimate assumes no Scope 3 emissions from operations. However, it notes that if it were to sell condensate collected during the well test programme to third parties, it could avoid Scope 1 emissions from flaring condensate. Still, while condensate flaring emissions are estimated to be 0.129 MtCO2e, Scope 3 emissions from selling condensate are estimated to be 0.158 MtCO2e. Both these estimates assume a 90-day flaring period (the total condensate collected over the 90 days would be sold).

[39] Note the WA's 2020 emissions here are in terms of AR5 GWPs, whereas 'Black Mountain use the AR4 GWP for methane (as evidenced by the fact that it notes that "carbon dioxide has a global warming potential 25 times lower than methane over a 100-year span") (Bennett Resources 2020). Converting Black Mountain to AR5 or AR6 GWPs would likely increase this fraction of the States emissions.

Table 5: Emissions from Fracking Appraisals ($ktCO_2e$).

Emissions from current appraisal proposals (ktCO2e)	Well construction	Operation	Total
Black Mountain	1.37	1,596	1,598
Theia Energy	1.33	26	28
Total			1,626

Notes: Emissions numbers taken from *(Bennett Resouces 2022)* and *(Theia Energy 2021)*. Construction emissions include emissions from vegetation clearing, equipment use, site preparation. Scope 1 emissions from "operation elements" include on-site diesel emissions, flaring emissions, and fugitive emissions.

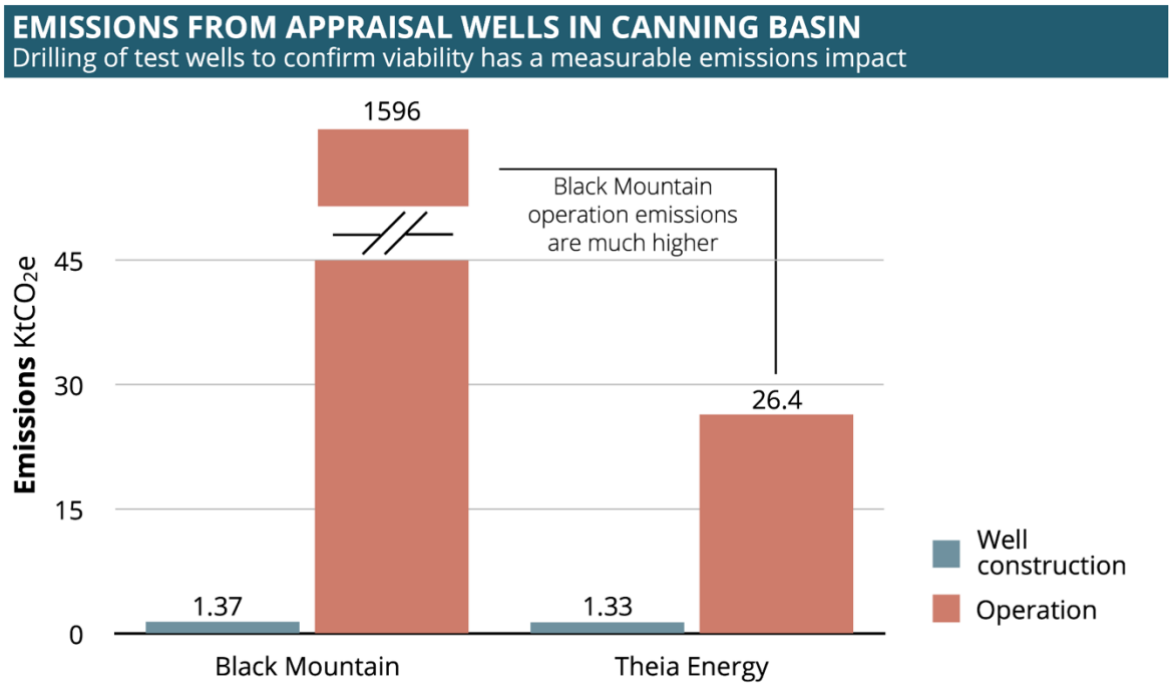


Figure 7: Emissions from fracking appraisal wells in the Canning Basin. Values taken from (Bennett Resouces 2022) and (Theia Energy 2021).

Proposed Development Scenario

Stakeholders in the Canning Basin provided submissions to the 2018 Independent Scientific Panel Inquiry. Petroleum lease owners provided estimates for well production and quantity:

- Buru Energy estimated a development approach using 10 horizontal wells from each of eight well pads (a total of 80 wells), producing 130 TJ/d of gas over 20 years.
- Finder Shale, which later divested its onshore gas assets to Theia Energy, estimated eight horizontal wells from each of 45 well pads (a total of 360 wells), producing 600 TJ/day over 20 years.
- MC Resources (a subsidiary of Mitsubishi Corp) anticipated a development approach using 170 wells over 20 well pads, delivering 200 TJ/d of gas per day over 20 years. MC Resources, which owned stakes in lease EP-371, was acquired by Black Mountain Energy in 2019 (Upstream 2021).

At that time the total estimate from submissions was for 610 wells with a combined production of 930 TJ/day. This is just under the 1,100 TJ/day domestic gas supply scenario used in the inquiry report.

In December 2021, Black Mountain tabled larger development concepts for its leases as part of its pathway to commercialization proposal which would bring the total amount of production from all proposed development up to 1,305-1,350 TJ/day with a consequent increase in the number of wells to over 900 and well pads to at least 100 (See table 3 above for details).

We estimate emissions based on the emission factors in Table 4 above. The low end is based on the central estimate of methane losses assumed here of 3.5% and the higher is based on a high end CH_4 loss rate of 6.5%.

To calculate the emissions that would occur domestically, it is necessary to estimate how much gas is used in WA (or Australia), and overseas. Once gas producers fulfil their mandatory domestic gas requirements, they are likely to prioritize selling gas on the more profitable export market, rather than the domestic market. For both the Proposed Development Scenario and the Large-scale Development Scenario we assume 15% of production would be allocated to domestic use and remainder would be applied to LNG manufacture, in line with the current domestic reservation policy.

For the Proposed Development Scenario, domestic emissions would add up to approximately 17 - 25 $MtCO_2e/yr$ - in the range of 3.5 to 5% of Australia's 2020 greenhouse gas emissions. Over 20 years the cumulative domestic emissions would be around 348 to 498 $MtCO_2e$. This scenario would correspond to around 200 TJ/day supplied to domestic consumption with the remainder going into approximately 7 Mt LNG export per year.

The Proposed Development Scenario would lead to emissions of at least 21 $MtCO_2e$ per year occurring outside Australia with total global annual emissions of 38-46 $MtCO_2e$ per year. Table 6 below summarises the results of this scenario for domestic emissions.

Table 6: Estimated domestic emissions from Proposed Development scenario

Proposing Company	TJ/day	Upstream MtCO2e/yr	Downstream MtCO2e/yr	Total Domestic emissions MtCO2e/yr	Share of WA's 2020 emissions incl. LULUCF	Share of AUS 2020 emissions incl. LULUCF
Black Mountain	620	5.1 – 8.5	2.9	8 – 11.4	9.8 - 14%	1.7 - 2.4%
Theia Energy	600	4.9 - 8.3	2.8	7.7 – 11.1	9.5 - 13.6%	1.6 - 2.3%
Buru Energy	130	1.1 - 1.8	0.6	1.7 – 2.4	2.1 - 2.9%	0.4 - 0.5%
Rey Resources		undisclosed	undisclosed	-		
Totals	1,350	11.1 - 18.6	6.3	17.4 – 24.9	21.3 - 30.5%	3.7 – 5.2%

Note: Domestic emissions are the emissions from domestic use and consumption of gas in LNG manufacture. This scenario assumes 15% of gas production is used domestically and the remainder exported as LNG.

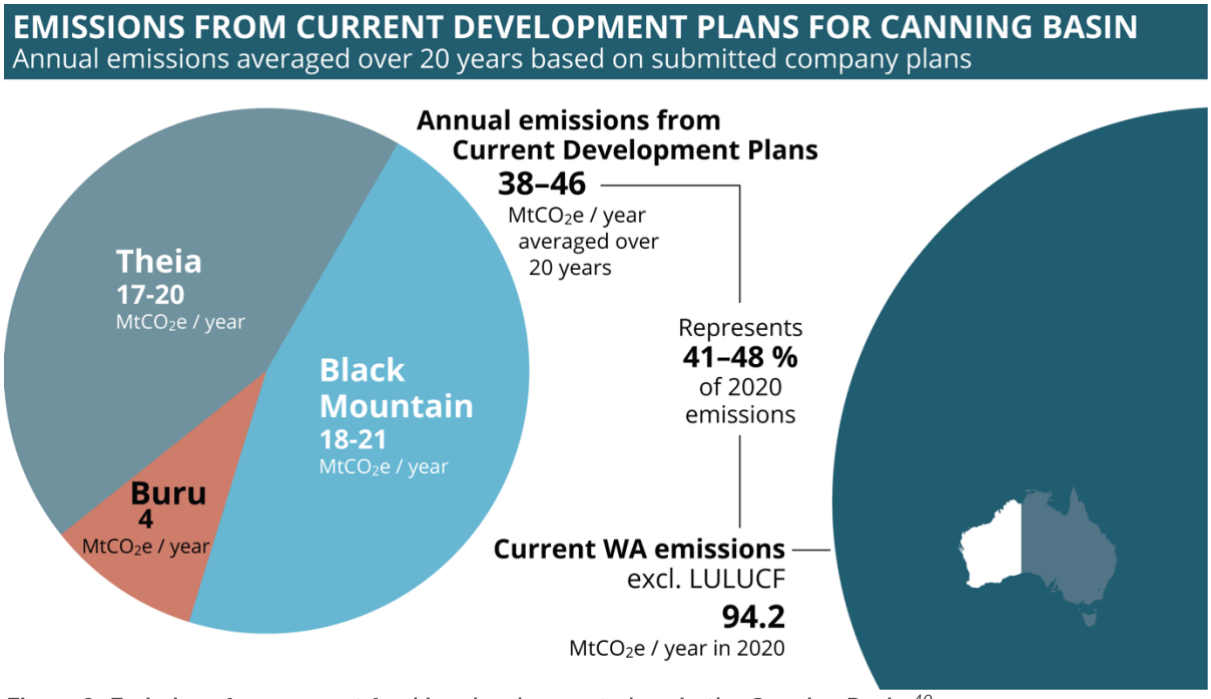


Figure 8: Emissions from current fracking development plans in the Canning Basin.[40]

Large-scale Development Scenario

The LNG industry in Western Australia is seeking additional gas resources as their current conventional supplies are depleting. Considering this, and the vast potential gas resources in the Canning Basin, we examine a larger development scenario than the one characterised by companies' proposed development plans. With WA's LNG export production capacity expected to reach close to 55 Mt LNG per year from 2026, we investigate a development scenario that would meet more than half of this capacity.[41]

The Barnett Shale development in Texas can be used as an analogue for such a development. This region covers an area of around 13,000 square kilometres, significantly smaller than the present leases in the Canning Basin, but at its peak, in 2012, produced around 5,700 TJ/day of unconventional gas from around 9,000 wells.

With 15% of gas development earmarked for domestic consumption and the remainder to LNG, this scale of development would support manufacture of around 29 Mt LNG per year and domestic supply of about 855 TJ/day. The latter is close to 80% of present WA domestic gas market supply.

40 Note that the figures in this table are compared to WA emissions excluding land use, land use change in forestry (LULUCF).

41 WA's current total LNG export capacity is 50 Mt LNG/yr. Woodside's Pluto Train 2 is expected to begin exporting LNG in 2026 and adds 5 Mt LNG/yr to WA's current export capacity. (Government of Western Australia 2022b).

For the large scale scenario, domestic emissions would add up to approximately 47-79 $MtCO_2e$ per year in the range of 10 to 17% of Australia's 2020 greenhouse gas emission with at least 114 $MtCO_2e$/yr occurring outside Australia, with total global annual emissions of 161-193 $MtCO_2e$/yr.

We estimate total cumulative global emissions over 20 years would be in the range of 3.2 - 3.9 $GtCO_2e$.

Table 7: Cumulative global emissions from fracking development scenarios

	Appraisal 22 Wells (Black Mountain and Theia Energy)	Proposed Development scenario 1, 350TJ/d / 20 years	Large Scale Development 5,700 TJ/d / 20 years
Total (MtCO2e)	1.63	763 – 913	3,224 - 3,856

Comparison with estimates of the Independent Scientific Panel Inquiry

In 2018, the WA Government's Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia released its report (Independent Scientific Panel Inquiry 2018). In assessing the oil and gas potential of the Canning Basin, the panel drew upon previously established estimates for unconventional resources provided by WA's Department of Mines, Industry, Regulation and Saftey (DMIRS): 1,000 Tcf of shale gas, of which about 73 – 147 Tcf (82-165 TJ)[42] may be recoverable, and additional tight gas resources from the Laurel formation.

The inquiry examined two development scenarios for hydraulic fracturing in WA: one where between 100-200 TJ/day were delivered from the Canning and Perth Basins and another where 1,100 TJ/day (400 PJ/year), approximately equal to WA's domestic gas market demand, were delivered. Both scenarios consider a 20 year lifetime.

[42] Using the 1 Tcf = 1125 PJ conversion factor derived from the values in Table 4 of Geoscience Australia (Geoscience Australia 2021)

The inquiry report estimated total emissions of 24.7-26.7 Mt CO_2e per year (5.0%-5.4% of Australia's 2016 emissions) for the scenario in which 1,100 TJ/ day are produced. The range in the inquiry report is due to different 100-year global warming potentials used for methane. The 100-year GWP of 25 from the IPCC AR4 was used for the lower end and the upper was taken from the IPAC AR5 100-year GWP range of 28-36.

Methane has a very high climate warming effect compared to CO_2 but has a much lower lifetime in the atmosphere. Consequently, when comparing the warming effect of a unit of emissions over the short-to-medium run term, methane has a much higher impact than CO_2.

This means that the 20-year GWP of this gas is far greater, with a GWP of 82.5 (Forster et al. 2021). Given the critical need to reduce greenhouse gas emissions over the short and medium term, it is important to consider the 20-year as well as 100-year effects of fossil methane in the atmosphere. This is acknowledged in the inquiry report which estimates emissions from its 1,100 TJ/day unconventional gas scenario to be 31.6 MtCO_2e per year.

Throughout this report we have, however, remained with the 100-year GWP standard, unless otherwise stated, as this provides a direct comparison with the emissions reporting framework of the Paris Agreement and hence Australia's national emissions inventory.

As is the case with the 2018 Climate Analytics' estimate, the inquiry report estimate includes emissions from anticipated upstream methane leakage and downstream combustion of pipeline gas.

Comparison of Canning Basin and Barnett Shale Formation

The Barnett Shale formation in Texas, USA, contains an estimated mean volume of natural gas with a recoverable energy content of around 60 EJ, as well as additional shale oil and other natural gas liquids (USGS 2015a).

The 2018 Independent Scientific Panel estimated that the Canning Basin contains 1,125 EJ of gas, of which 82 to 165 EJ may be recoverable (Independent Scientific Panel Inquiry 2018). Geoscience Australia estimated the potentially recoverable unconventional resource from the Canning Basin to be up to 439 EJ.
This equates to seven times that of the Barnett Shale formation (Geoscience Australia 2021). Given the wide range of estimates, we have used the median of about 265 EJ and as the central estimate for recoverable unconventional gas resources in the Canning Basin.

Production decline rate models based on data from a large sample of wells in the Barnett Shale show that, at the median level, well productivity declines about 60% from initial value after one year, and declines about 75% after two years (Guo et al. 2017). Therefore, as noted in the inquiry report, "to maintain constant production, an unconventional oil or gas field requires ongoing drilling and completion of new wells, due to the initial rapid decline of gas flow from individual well" (Independent Scientific Panel Inquiry 2018).

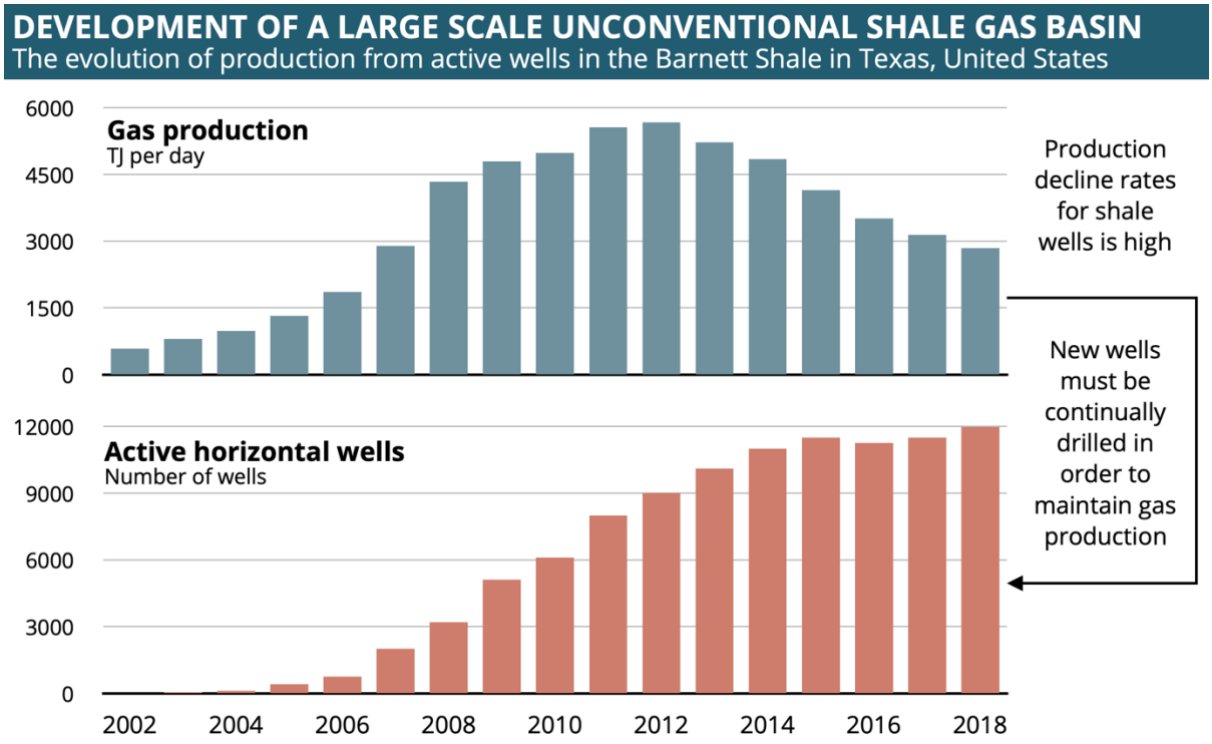


Figure 9: Production of unconventional gas (average TJ/day) and active horizontal wells per year at Barnett Shale formation.

Production data from US Energy Information Administration (EIA 2022) and well data based on (Patzek et al. 2019).

We can also get a sense of the land use from unconventional gas development by looking at the number of horizontal wells drilled over time. As can be seen in Figure 10, horizontal well sites expanded dramatically over the period 2003-2010, moving well beyond the dense area of vertical conventional wells.

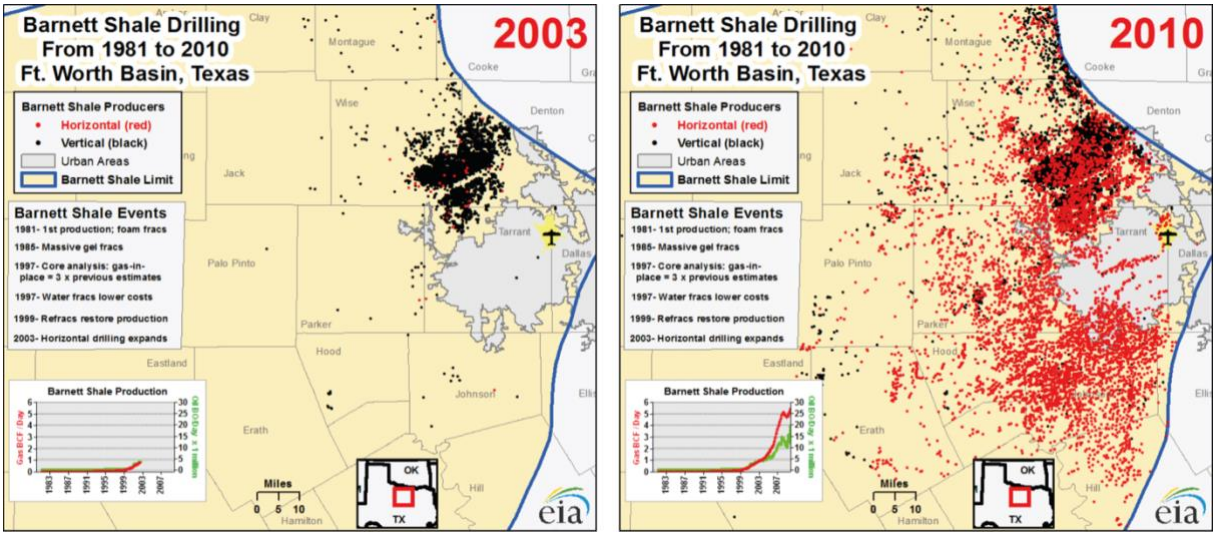


Figure 10: Barnett Shale drilling in 2003 and 2010.

Black dots indicate conventional (vertical) wells while red dot indicate unconventional (horizontal) wells. Source (EIA 2011b)

The Independent Scientific Panel Inquiry indicates that around 910-950 wells from 100-104 well pads would be needed to produce 1,305-1,350 TJ/d production assumed.

To derive an estimate of the number of wells needed, we used the hyperbolic model based on the parameters provided by (Guo et al., 2017), determined from a sample of wells from the Barnett Shale. Initial well production is a determining factor for its lifetime productivity. The median initial energy production per well as found by Guo and colleagues, is about 1.8 TJ/d/well (suggesting that more than 700 wells would be needed in the first year in the Proposed Development scenario).

However, this value was determined for wells drilled between 2000 and 2014. It should be noted that, as Guo and colleagues mention, "there is a clear trend towards higher IP [*initial production*] levels. That is to say, newer wells tend to have higher IP than older wells. This could be explained by technological developments such as increased horizontal lengths of wells and the increased number of fracturing stages." The cumulative first-year production per well in the Haynesville and Marcellus plays, for example, has more than doubled between 2014 and 2020.[43]

For more recent estimates reflecting technological improvements, we used the average initial production of newly completed wells in the United States between July 2023 and July 2024, equating to 6.5 Tj/d, as an upper bound for initial well productivity, and retained Guo and colleagues' median results as a conservative lower bound.

[43] EIA (2022) Natural Gas Weekly Update for week ending June 22, 2022.

This upper bound aggregates the discrepancies in productivity across different plays in the United States, reflecting the uncertainties around the actual geology and potential of the Canning Basin. Newly completed wells in Haynesville, for instance, have an initial gas production rate 6 times higher than those in the liquid-rich Eagle Ford region.[44]

After 10 years, to maintain the assumed production level, between 1,400 and 4,900 wells would be needed for the Proposed Development scenario. This figure increases to 2,000-7,200 after 20 years.

Table 8: Number of wells needed per scenario, to maintain constant production over a given time period, using the decline curve from Guo et al. (2017).

The upper bound is calculated based on the median initial distribution found by Guo and colleagues for the Barnett Shale. The lower bound is derived using the average productivity of newly completed wells in the United States between July 2023 and July 2024.

Scenario	Initial number of wells	10 years	20 years
Proposed Development Scenario	200-730	1,400-4,900	2,000-7,200
Larger Scale Development Scenario	890-3,100	5,900-21,000	8,700-30,200

The Proposed Development Scenario would present a radical intrusion into a presently relatively untouched landscape. Figure 10 above shows as an example of land use for fracking developments in Texas. Such development would cause significant damage to the tropical savannah of the Kimberley region. For the Canning Basin to support only 950 wells over 20 years of exploitation, which would already disrupt a fragile ecosystem, completed well productivity would need to be comparable to that seen in the most productive plays in the United States.

The larger scale scenario of 5700 TJ/day would initially require around 880 to 3,100 wells, growing to about 4,100 to 14,300 after five years. With the expected decline in well productivity, maintaining this level of production after 10 years would require between 5,900 to 20,700 wells.

[44] Extracted from EIA's August 2024 Short-Term Energy Outlook.

Implications for Australia's 2030 target

The emissions from developing the Canning Basin can be broken into emissions attributable to Australia, and emissions accounted for internationally. Emissions attributable to Australia are from direct well construction and operational requirements to install the gas wells and move the product to market.

Additionally, where there is any domestic consumption of the gas for power or other uses these are attributable to Australia's domestic emissions. Emissions from the transport and combustion of the gas internationally, once shipped, are considered under global emissions estimates.

Emissions, disaggregated to show the domestic and international components, from the two development scenarios described above are given in

Table 9. As can be seen, for the proposed development scenario, domestic and international emissions are somewhat comparable.

As a result, international downstream emissions are significantly greater than total domestic emissions.

Table 9: Implications of fracking development for Australia's emissions and 2030 targets.

	Proposed Development Scenario	Large-scale Development Scenario
Annual upstream emissions	11.1 - 18.6 $MtCO_2e/yr$	46.9 - 78.6 $MtCO_2e/yr$
Upstream emissions as percentage of Australia's 2016 emissions (the Independent Scientific Inquiry set a limit of 0.5% of 2016 levels)	2 - 4%	9 – 16%
Upstream emissions as % of WA 2020 emissions	14 – 23%	58 - 96%
Total annual emissions (domestic)	17 - 25 $MtCO_2e/yr$	73 - 105 $MtCO_2e/yr$
Emission reductions in 2030 with fracking developments (incl. LULUCF) compared to a baseline reduction of -37%	-34 to -33% below 2005	-25 to -20% below 2005
Degradation of 2030 target	3 - 4%	12 - 17%
Percentage of WA annual emissions (incl. LULUCF)	21 - 31%	90 - 129%
Percentage of Australia's 2020 emissions	4 - 5%	16 - 22%
Total annual emissions (domestic and international)	38 - 46 $MtCO_2e/yr$	161 - 193 $MtCO_2e/yr$
Total global emissions over 20-year lifetime	763 - 913 $MtCO_2e$	3,224 - 3,856 $MtCO_2e$
Years of 2020 Australian emissions	1.6-1.9 Years	6.8 – 8.1 Years

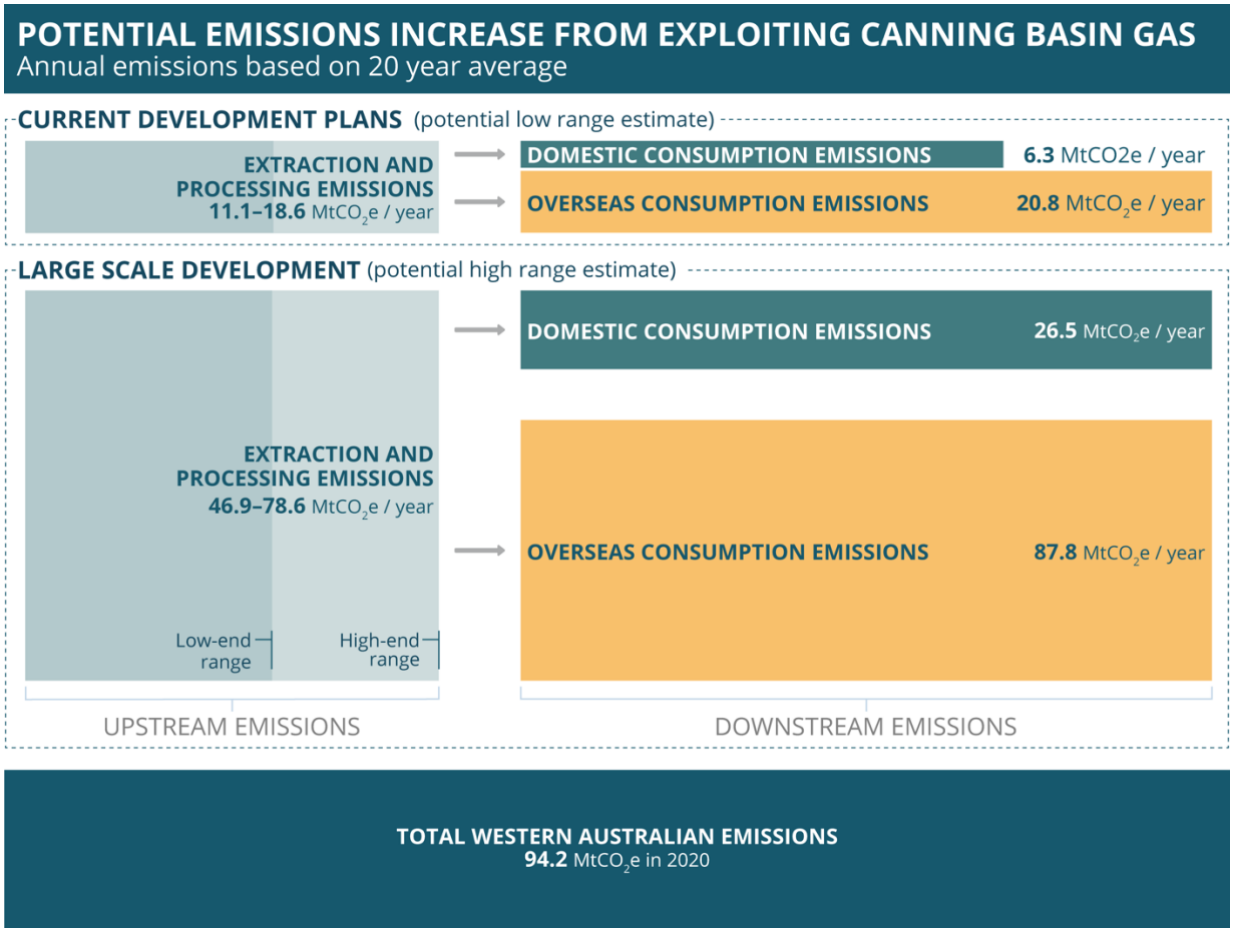


Figure 11: Canning Basin unconventional gas development scenarios emissions estimates, for extraction and processing, domestic consumption, and overseas consumption emissions.

Emission limits proposed in the Independent Scientific Panel Inquiry

The WA Independent Scientific Panel Inquiry accepted that GHG emissions limits need to be relevant to the achievement of Australia's domestic Paris agreement emission reduction targets. It recommended that the contribution to Australian anthropogenic upstream GHG emissions from onshore fields in Western Australia must be 0.5 percent or less of Australia's 2016 levels, with the Independent Scientific Panel Inquiry stating that:[45]

[45] See page 370 of the Independent Scientific Panel Inquiry report. Note that the inquiry gives Australia's 2016 emissions as 550.2 $MtCO_2e/yr$ (including LULUCF). For methodological consistency, we used the latest inventory value of 491 $MtCO_2e/yr$.

"GHG emissions from onshore oil and gas fields developed with hydraulic fracture stimulation must be minimised. The contribution to Australian anthropogenic upstream GHG emissions from onshore fields in Western Australia must be 0.5 percent or less of 2016 Australian GHG emissions".

Translated to the global level, this domestic limit of 0.5% of 2016 emissions corresponds to a global limit of 0.01% or less of annual global GHG emissions.

The Proposed Development Scenario would have upstream emissions equivalent to 2.2 - 3.6% of Australia's 2016 emissions, significantly above the limit proposed by the WA Scientific Panel. Upstream emissions from the Large-scale Development Scenario are estimated to be much higher.

At the individual company level estimated upstream emissions from the Black Mountain and Theia Energy current development proposals substantially exceed the 0.5% threshold proposed by the WA scientific inquiry (See table below).

Table 10: Upstream GHG emissions from Proposed Development Scenario as fraction of 2016 Australian GHG emissions

	Upstream low	Upstream high
Black Mountain	1.0%	1.7%
Theia Energy	1.0%	1.6%
Buru Energy	0.2%	0.3%
Total %	2.2%	3.6%

The Northern Territory inquiry suggested the contribution to global anthropogenic GHG and methane emissions from a new gas field in the Northern Territory must be 0.1% or less of global emissions. Contributions of 0.5% and 1% were considered to be serious and major, respectively (Pepper et al. 2018).

Given that Australia's emissions are about 1.2% of global emissions, the Northern Territory Inquiry 0.1% limit would translate into a domestic limit of around 8% of national emissions from any new gas field. This would clearly pose a major risk to any attempt by Australia to meet domestic emission reduction targets. The level at which this inquiry identified "serious" and "major" risks, translates into domestic emissions equivalence of around 42% and 83% respectively.

Recent estimates of supply and demand for gas in Western Australia in the absence of policies to implement the Paris Agreement indicate there could be a potential shortfall of up to 362 TJ/day between now and 2033 (AEMO 2022). This quantity would represent 6% and 26% of the gas production from the Canning Basin in the proposed development and large-scale development scenarios respectively.[46]

The Western Australian domestic gas reservation policy stipulates that an LNG producer must make an amount of gas equivalent to 15% of their exports available for consumers in the state (Government of Western Australia 2021).

Under the proposed development scenario, the anticipated peak gas shortfall is greater than the amount of production the Kimberly gas producers are required to be reserved for the domestic market. It means that even if gas producers exploiting the Canning Basin delivers an amount of gas equivalent to 15% of their exports to the domestic market, it would not be enough to fulfill the anticipated 2030 shortfall.

In the large-scale development scenario, the gap between gas supply and demand in 2030 is lower than the reservation policy threshold for the Canning Basin.

Exporting LNG remains a more lucrative option for gas producers compared to selling it on the state market. Analysis of existing data from the WA government reveals that LNG facilities that face capacity constraints often fall short of fully complying with their domestic market obligations.[47] We assume that gas producers reserve enough gas for the domestic market to comply with the reservation policy and export the rest.

[46] AEMO's supply and demand forecasts for gas demand in Western Australia vary considerably. The high estimates project a peak demand of 1,438 TJ/d for the year 2028, compared to 958 TJ/d for the same year in the Low scenario. The highest anticipated shortfall occurs in the Expected scenario, where in 2033, 963 TJ/d of gas are supplied for a demand of 1,325 TJ/d (AEMO, 2023).

[47] Parliament of Western Australia (2024) Domestic Gas Security in a Changing World: Inquiry into the WA Domestic Gas Policy Final Report.

Implications for the Safeguard Mechanism

The Safeguard Mechanism is a policy that sets emissions baselines for large industrial facilities in Australia. Following the change of the Australian government in 2022, the Safeguard Mechanism reform is at the centre of the Labor Government's climate agenda.

Under the proposed reform project presented in the January 2023 position paper, carbon-intensive facilities must adhere to binding emissions baselines. These baselines will be reduced by an average of 4.9% per year from 2024 to 2030, in order to make the Safeguard Mechanism emission decrease from 136 $MtCO_2e$ per year in 2021 to 100 in 2030. To fulfil this requirement, facilities can either reduce their emissions, purchase safeguard mechanism credits (SMCs) from companies or facilities that have reduced their emissions below their baselines, or buy offsets in the form of Australian Carbon Credit Units (ACCUs) (Australian Government 2023).

Several issues with the initial reform proposal have been raised (Climate Analytics 2023a,b). Among them are the unfettered use of offsets to meet the decreasing baselines and the potential for pipeline coal and gas projects to blow the overall scheme's emission limit. The fossil fuel industry represents more than half of the emissions covered by the Safeguard Mechanism.

In March 2023, the Greens and the Labor agreed to a revision of the Safeguard Mechanism reform proposal (Parliament of Australia 2023). The adopted bill requires, among others, the rolling five-year emission average from facilities under the scheme to decline. This measure represents *de facto* a cap on offset use.

A 2023 analysis from Climate Analytics showed that the emissions from existing, committed and proposed new and expanded LNG and coal mining projects would lead to emissions between 83 to 112 $MtCO_2e$ per year in 2030, making up most or more than the total 100$MtCO_2e$ emission limit posited by the government (Climate Analytics 2023b). The government projected business-as-usual Safeguard emissions to reach 144 $MtCO_2e$ by 2030.[48] None of these estimates take into account the exploitation of the gas from the Canning Basin, as it is not included in the Energy and Resources major project database held by the Department of Climate Change (DISER 2022).

[48] DCCEEW (2023) 2023 Emissions Projections

Emissions from the Canning Basin would be divided between upstream emissions, occurring in the Kimberley, and downstream emissions, occurring at the LNG facilities.

The annual upstream emissions from the Canning Basin in the Proposed Development and Large-Scale Development scenarios would range between 11.1-18.6 $MtCO_2e$ and 46.9-78.6 $MtCO_2e$, respectively. This alone represents emissions equivalent to between 11% and 79% of the legislated Safeguard Mechanism's total emissions target in 2030.

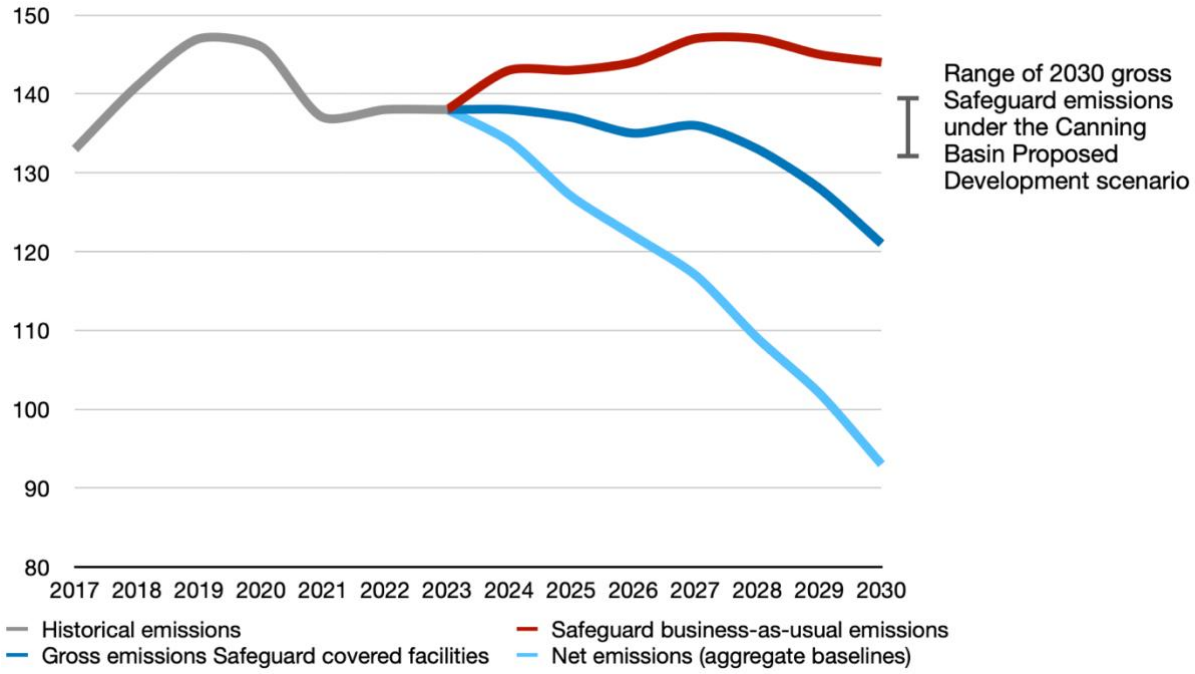


Figure 12: Impact of the Proposed Development Scenario on the Safeguard Mechanism.

The hard lines show the results of the modeling from the government's 2023 projections for Safeguard emissions. The range on the right side indicates 2030 Safeguard gross emissions in the case of the Proposed Development Scenario being implemented. This figure only includes upstream emissions. Downstream emissions would occur at the LNG plants. While they would be accounted for as part of the Safeguard Mechanism, their responsibility would therefore fall on the plant's owner or operator. Considering the uncertainties involved with downstream emissions – which will depend on various factors such as whether additional processing is required, or whether gas from the Canning Basin displaces other fields – they are not included. An exploitation of the Canning Basin like in the Proposed Development Scenario would largely cancel the gains from the reform compared to a business-as-usual scenario. Source: DCCEEEW, 2023.

Various mitigation options can be implemented in the Canning Basin to reduce upstream emissions from day one, such as leak detection and repair systems, as well as best practices for pneumatic controllers, compressor stations, flaring equipment, and storage vessels use.

Evaluating the effectiveness of these options in reducing emissions from the Canning Basin is beyond the scope of this report. However, although these measures can contribute to mitigating emissions, companies would rely on offsets rather than reduce or avoid direct emission to the atmosphere if the former are more financially attractive.

It is possible to estimate the percent of revenues that would need to be redirected towards the purchase of offsets. In this assessment, we compare the Canning Basin with Barossa and Beetaloo, two gas fields yet to be developed. The Barossa project is an offshore gas development in the Timor Sea, north of Darwin. It is led by Santos and its partners and aims to supply gas to the Darwin LNG plant. With its high CO_2 reservoir content, it is set to become the country's most carbon-intensive gas project – the Institute for Energy Economics and Financial Analysis called it "an emission factory with an LNG by-product" (Robert 2021). The project involves a new floating production facility, new underwater wells and a new pipeline connection.

The Beetaloo gas project is a proposed development of the Beetaloo Sub-basin, located 500 kilometres south-east of Darwin in the Northern Territory. According to the Department of Industry, the basin "has the potential to rival the world's biggest and best gas resources" (Department of Industry Science and Resources 2021). Reputex and the CSIRO's Gas Industry Social and Environmental Research Alliance have separately assessed the potential emissions from the development of the sub-basin (RepuTex 2021; Baynes et al. 2022).

The two different gas price levels assumed for comparison are the $12/GJ price cap applied in Australia for domestic gas on the East Coast, and the IEA's estimated spot price for LNG in Europe and Asia in 2023 of around $24/GJ (IEA 2023).

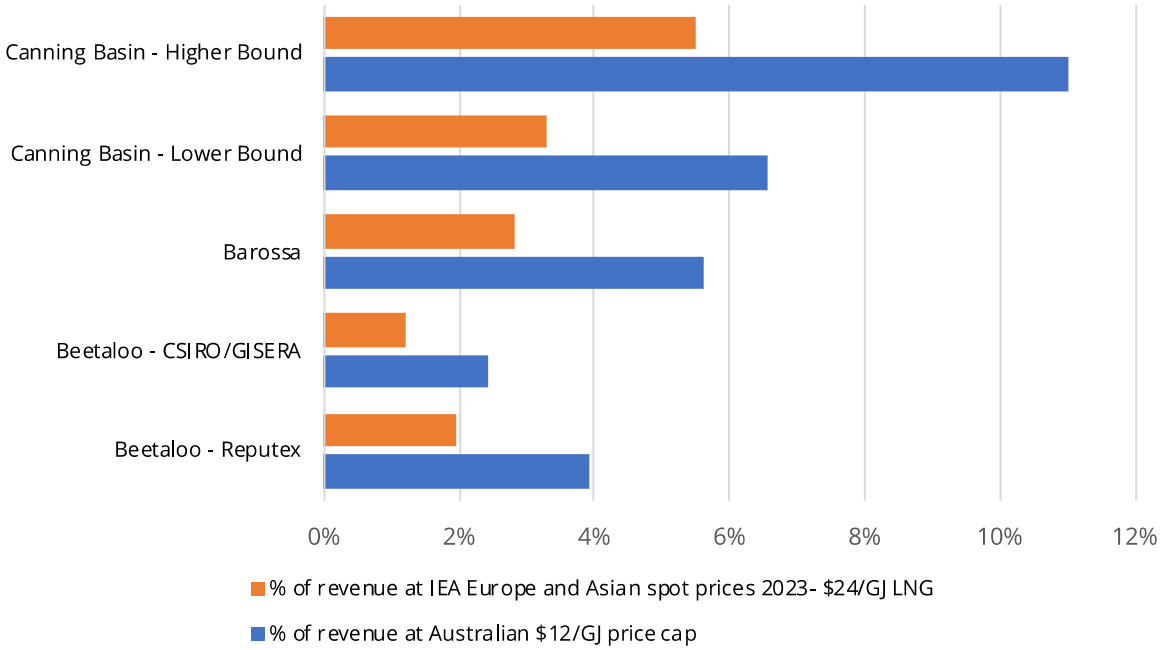


Figure 13: Share of revenue diverted to purchase of ACCUs, under different gas price assumptions, assuming an ACCU price of $35.

Source: (Baynes et al. 2023; RepuTex 2021; ConocoPhillips 2018)

The fraction of revenue diverted due to the obligation to purchase offsets at the current domestic price ranges from 6 to 11%. These figures are halved under the IEA spot LNG price assumption. This represents a heavy financial load that might affect the economic viability of the basin development.

It is uncertain which LNG facilities would process gas from the Canning Basin. Proximity and processing capacity are the key determinants. The Gorgon and Wheatstone LNG facilities, plants with respective capacities of 15.6 and 8.9 Mtpa, are located further west and south-west on Barrow Island and at Onslow respectively. The Prelude facility is a floating 3.6 Mtpa LNG plant 475 km off the coast of Western Australia north, north-east of Broome, exploiting the eastern part of the Browse gas basin.

Half of Australia's LNG plants will undergo changes in backfill or expansions over the next decade. The Canning Sub-basin could replace fields yet to be developed. However, most of these projects are at more advanced stage than fracking in Western Australia.

Implications for carbon budgets

This section will compare the Canning Basin development plans with the remaining carbon budgets at global, national, and state level.

Global carbon budget

The IPCC has found that there is a strong relationship between cumulative CO_2 emissions and global mean temperature increase. This means that remaining global carbon budgets can be determined so that if met would limit warming to 1.5°C with a certain probability.

There are important caveats on carbon budgets, however, given the very substantial uncertainties in their determination. One large uncertainty relates to the scenarios used to generate the carbon budget and in particular the emissions of non-CO_2 gases, such as methane, as well as their effect on the climate system. There are also a range of geophysical uncertainties that are quite large. If a given carbon budget is not met, it means that the likelihood of limiting warming to the target warming level will be lower and that there would be a greater need for negative CO_2 emissions in the future.

The IPCC's Sixth Assessment Report (AR6) in 2021 provided updated estimates of carbon budgets. For a 50% probability of limiting warming to 1.5°C the remaining carbon budget from the beginning of 2020 was estimated at 500 $GtCO_2$, and with a likely chance about 400 $GtCO_2$. These results were similar to the carbon budget estimates in the 2018 IPCC special report on 1.5°C (IPCC SR1.5).

These results have been updated taking into account emissions emitted since the IPCC completed its work and updates in scientific understand of the climate response to carbon dioxide emissions. Accounting for CO_2 emissions until and including 2023, the remaining carbon budget from 2024 for 50% probability of limiting warming to 1.5 degrees is around 200 $GtCO_2$ and for a likely chance 150 $GtCO_2$.[Error! Bookmark not defined.]

The Proposed Development Scenario over a 20-year life would result in total CO_2 emissions (domestic and international) equivalent to about 0.3% of the remaining global 1.5°C compatible carbon budget.

The Large-scale Development Scenario over a 20-year life would result in total emissions (domestic and international) equivalent to about 1.2-1.3% of the remaining global 1.5°C compatible carbon budget.

All the carbon implied in the median estimate of the Canning Basin's unconventional gas resources amounts to about 7.4% of the remaining global carbon budget.

Australian carbon budget

There have been several studies which attempt to develop carbon budgets for Australia and have generally ended up in a similar range of the global fraction of the carbon budget that can be used by Australia. In earlier work Climate Analytics has evaluated emission pathways and budgets that align with the Paris Agreement's 1.5°C warming limit.

Full details can be found in 'Scaling up Climate Action: Australia' (Climate Action Tracker 2020) and 'A 1.5°C Compatible Carbon Budget for Western Australia' (Climate Analytics 2019). Climate Analytics estimated Australia's carbon at 5 $GtCO_2$ from 2018-2050 (Climate Action Tracker 2020).[49]

Considering Australian Government reported carbon emissions for the years 2018 – 2021 of about 1.4 $GtCO_2$ for Australia, the remaining budget from 2022 is around 3.6 $GtCO_2$.[50]

We have estimated the cumulative carbon emissions from 2022 for Australia consistent with reaching net zero by 2050 and limiting warming to 1.5 degrees to be about 3.6 $GtCO_2$. This is in the range of 0.9% to 1.1% of the global carbon budget range for 1.5˚C and brackets the fractional Australian share of a global emissions budget put forward by the Climate Change Authority in 2014 of around 0.97%.

The emissions from exploiting the Canning Basin reported above include methane and a small fraction of other greenhouse gases, in addition to CO_2. The average CO_2 component of these estimates is around 76% for the central case with 3.5% methane loss. We apply this in calculating the carbon component of these emissions for the purposes of comparing to global carbon budgets.

Domestic CO_2 emissions from the Proposed Development Scenario would consume about 7-9% of the remaining Australian carbon budget.

Domestic CO_2 emissions from the Large-scale Development Scenario would consume 31-36% of the Australian budget.

[49] Note that Australia's total Paris Agreement compatible GHG emissions budget for the period 2018 -2050 is 6.4 GtCO2e. The carbon budget for fossil fuel and industry makes up 78% of the total GHG budget.
[50] The historical emissions for 2018 - 2021 are taken from the Paris Agreement inventory in Australia's National Greenhouse Accounts.

WA carbon budget

In 2019 Climate Analytics estimated 1.5°C compatible fossil fuel and industry CO_2 budget for Western Australia at 950 $MtCO_2$ from 2018 to 2050 (Climate Analytics 2019). The report noted that this budget would be depleted by 2030 at Western Australia's 2017 GHG emissions rate of 94.8 $MtCO_2e$ per annum (excl. LULUCF). With emissions between 2018 and 2021, the estimated 2022-2050 carbon budget for WA from fossil fuel industry CO_2 is now around 620 $MtCO_2$. The Proposed Development Scenario would consume around 42-50% of this budget and the Large-scale Development Scenario would consume twice the remaining WA budget.

Global carbon budget Implications of the Canning Basin's unconventional gas resource

The carbon embedded in the Canning Basin on the median estimates for unconventional gas is around 15.5 $GtCO_2$ equivalent to 3.7% of the remaining global carbon budget. This over four times Australia's remaining carbon budget and 24 times WA's remaining carbon budget.

Table 11: Carbon budget implications of fracking scenarios.

	Proposed Development Scenario	Large-scale Development Scenario
Total domestic CO_2 emissions over 20 years	264-308 $MtCO_2$	1,115-1,302 $MtCO_2$
Faction of Western Australian carbon budget	42-50%	179-209%
Fraction of Australian 2022-2050 carbon budget	7% - 9%	31% - 36%
Total CO_2 emissions over 20 years (domestic and international)	573 $MtCO_2$	2,419 $MtCO_2$
Percentage of 1.5°C remaining carbon budget from 2024	0.3%	1.3%

Note: Cumulative emissions are estimated over the 20-year time frame adopted in the WA fracking inquiry. Total CO_2 emissions over 20 years (domestic and international) provided as average of the range.

Emissions from Canning Basin unconventional gas development as a percentage of 1.5°C compatible carbon budgets for Western Australia, Australia, and global.

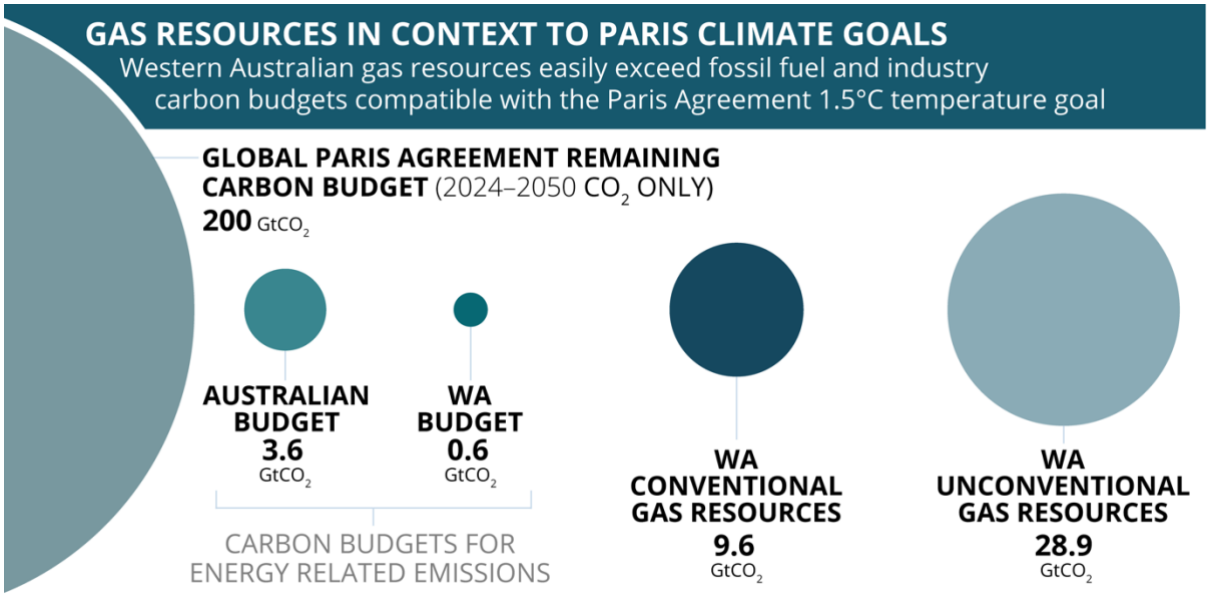


Figure 14: Western Australia's gas reserves in the context of the Paris Agreement.

Carbon budgets are for industry and energy related CO2 emissions. In comparison, in the Proposed Development Scenario, total emissions from the Canning Basin range between 0.8 GtCO2e and 0.9 GtCO2e. In the Large-Scale Development scenario, they range between 3.2 GtCO2e and 3.9 GtCO2e.

The Bigger Picture

Fracking in the Kimberley is part of a larger rollout of plans by gas companies in WA. Fracking projects would be connected by a gas pipeline from the Canning Basin to a current pipeline near Port Hedland or directly to the current gas infrastructure in Karratha that the Scarborough gas field supply. Plans also link WA to the Northern Territory and the east coast, with a planned pipeline.

In August 2020, the WA Premier updated the WA Domestic Gas Policy to prevent gas exports from existing gas pipelines, but companies operating in the Canning Basin were all exempted, meaning that developments from this region could be used for export LNG.[51]

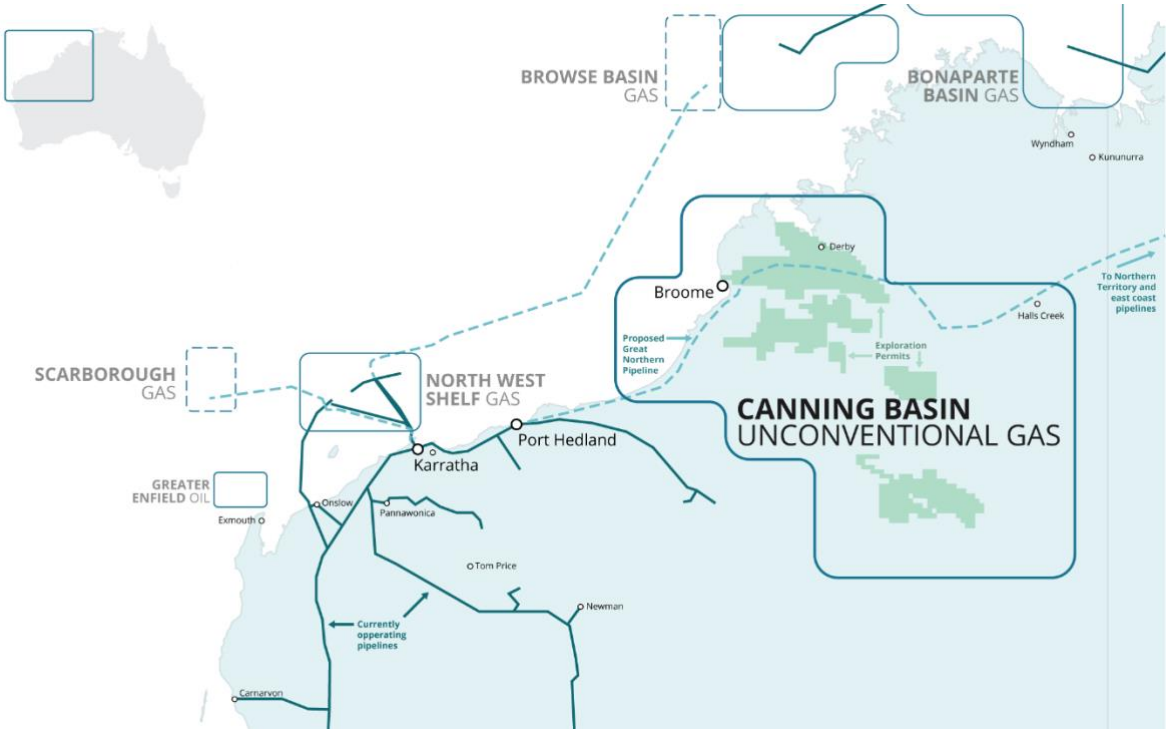


Figure 15: Map of Western Australian oil and gas resources including Canning Basin exploration permit areas.

[51] WA Government (2023). Implementation of the WA Domestic Gas Policy.

Woodside Energy's Scarborough offshore development involves commercialisation of the Scarborough and North Scarborough gas fields involving the construction of several gas wells on a floating production unit connected by pipeline to the Burrup Hub for processing (Climate Analytics 2021).

The development has been granted key approvals from state and federal governments, which allows Woodside to commence construction (Packham 2022). The development is designed to provide gas to supply two processing facilities: Pluto Train 2 and part of Pluto Train 1 (Climate Analytics 2021). Developments include the construction of Pluto train 2, enhanced capacity of Pluto train 1, and construction of an interconnector between Pluto and the Northwest Shelf Karratha Gas Plan. The Pluto Train expansion increases gas supply from 25TJ/day to 250TJ/day via the Dampier to Bunbury Natural Gas Pipeline. The expansion of domestic gas is due to a Perdaman Urea project, H2Perth Project to produce hydrogen from natural gas.

The total cumulative Scope 1 and 3 emissions from the Scarborough offshore development projects are estimated at 1.37 billion tonnes of GHG emissions from 2021-2055, of which close to 20% is projected to be emitted in Western Australia (Climate Analytics 2021).

Additionally, Woodside claims the global transition away from Russian energy sources strengthens the case for Browse, a proposed gas development north of Broome WA (Woodside 2022).

As noted previously, Woodside's Burrup Hub will have a total capacity of 27-28 Mtpa of LNG. It is clear that even with the development of Browse, the Burrup Hub's projected supply would ultimately be insufficient to keep this plant going at full scale through to 2070. Woodside has expressed interest in also taking resource is from the Canning Basin.

This points to the potential for the large-scale development proposal outlined in this report to become a reality, absent government decisions to the contrary. The gas industry in Western Australia is pursuing all means to expand gas, despite the Paris Agreement and state and federal government net zero targets.

Conclusions

We have estimated the emissions from three scenarios for unconventional gas in Western Australia's Canning Basin: (1) Appraisal, (2) a Proposed Development Scenario (3) a Large-scale Development Scenario. In addition, we estimate the emissions which could result from exploitation of the entire unconventional resource in the basin.

Implications of Canning Basin development scenarios for Australia's 2030 target

Australia has a 2030 target of reducing emissions 43% below 2005 levels by 2030 including LULUCF. With current policy emissions projections, Australia will miss the mark. The 2023 Government projections indicated that the country is on track for about 37% below 2005 levels by 2030, including LULUCF.

The development of gas resources in the Canning Basin will add to Australia's emissions through the upstream emissions from gas production, and downstream emissions from gas distribution, LNG manufacture and domestic use of the gas produced.

Under the **Proposed Development Scenario,** emissions equivalent to 3 - 4% of 2005 Australian emissions could occur. This would mean that to meet Australia's 43% target the rest of the Australian economy would need to make a 46-47% reduction. Compared to current policy projections this could mean **Australia may only reach 34-35% below 2005 levels by 2030 rather than 37%.**

With the **Large-scale development Scenario,** additional emissions equivalent to 12-17% of 2005 emissions would occur. To meet Australia's 43% reduction by 2030 target the rest of the Australian economy may need to make a 55-60% reduction. Compared to current policy projections this could mean **Australia may only reach 21-26% below 2005 levels by 2030 rather than 37%**.

Fracking the Canning Basin will significantly add to Australia's mitigation burden and compromise its ability to meet its 2030 target.

Significance of upstream emissions – application of WA Scientific Panel recommendations

The Western Australia Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation assessed the risk of oil and gas development using hydraulic fracturing against the contribution to Australian national emissions from upstream GHG emissions from onshore fields in Western Australia. It explicitly recognised the need to evaluate the risks of development, including that from fracking, against Australia's ability to meet its commitments under the Paris Agreement, as well as to minimise global warming. In doing so it focused on upstream emissions stating that:[52]

> *"GHG emissions from onshore oil and gas fields developed with hydraulic fracture stimulation must be minimised. The contribution to Australian anthropogenic upstream GHG emissions from onshore fields in Western Australia must be 0.5 percent or less of 2016 Australian GHG emissions".*

Translated to the global level, this would mean under the terms of the recommendation from this inquiry, that the global contribution should be 0.01% or less.

For the **Proposed Development Scenario,** upstream annual emissions of 11-19 $MtCO_2e/yr$ would amount to 2% - 4% of Australia's 2016 emissions levels. So, even the plans submitted to the inquiry go beyond the panel's environmental criteria.

For the **Large-scale Development Scenario**, upstream annual emissions of 47 - 79 MtCO2e/yr would amount to 10% - 16% of Australia's 2016 emissions levels.

It should be noted that by comparison the recommendation from the Northern Territory fracking inquiry stated, "*the contribution to global anthropogenic GHG and methane emissions from a new gas field … must be 0.1% or less.*" Given that Australia's emissions are about 1.2% of global emissions this would translates into a domestic limit of around 7-8% of national emissions from any new gas field which would clearly pose a major risk to any attempt by Australia to meet domestic emission reduction targets.

[52] See page 370. Note that the inquiry gives Australia's 2016 emissions as 550.2 MtCO2e/yr. Here we use the latest value of 491 MtCO2e/yr (including LULUCF) for methodological consistency with other emissions estimates in this report.

Implications for WA, Australian and global carbon budgets

We have assessed the total emissions from the development scenarios over an assumed 20-year lifetimes relative to remaining Paris Agreement aligned carbon budgets for WA and Australian from 2022.

Lifetime domestic emissions from the Proposed Development Scenario would constitute 42-50% of WA's carbon budget and 7-9% of Australia's remaining carbon budget.

Lifetime domestic emissions from the Large-scale Development Scenario would constitute 179-209% of WA's carbon budget and 31-36% of Australia's carbon budget.

In relation to the remaining global carbon budget, the **Proposed Development Scenario** would consume about 0.3% of the remaining global carbon budget and **Large-scale Development Scenario** around 1.2%.

A consensus has emerged around the fact that ending new fossil fuel developments is critical for the Paris Agreement's goal of limiting warming to 1.5°C. Indeed, this was recognised last year in a landmark report by the traditionally conservative IEA, the Net Zero Emissions scenario clearly stated that to meet the Paris Agreement's 1.5˚C limit, there should be no new exploration for – nor development of – fossil fuel reserves (oil, gas and coal) (IEA 2021). Policy recommendations along these lines have been made by The IPCC (IPCC 2018, 2021) and others (SEI et al. 2021).

The State of the Environment report released by the Australian Government details how ecosystems are showing signs of collapse, with climate change playing a major role (Australian Government 2022a). The Great Barrier Reef has suffered mass coral bleaching events, including in 2022. Other reefs continue to deteriorate. Extensive bushfires devastated several states in 2019, 2020, followed by severe flooding in 2021 and 2022.

Beyond greenhouse gas emissions the landscape damage anticipated from a large-scale fracking development appear beyond what would be acceptable for the Kimberley, given its value to First Nations people, tourism, residents, and conservation groups.

Given the local and global environmental impacts of unconventional gas development in the Kimberley region, Western Australia should update the current fracking moratorium to cover 100% of the state.

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