WARMING WESTERN AUSTRALIA

How Woodside's Scarborough and Pluto Project undermines the Paris Agreement

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Cover photo: Dampier Archipelago, Karratha, Western Australia. Photo by Matt Deakin

KEY TAKEAWAYS

- Woodside's proposed Scarborough to Pluto LNG project in Western Australia represents a bet against the world implementing the Paris Agreement. This report shows the company's arguments - that the project is Paris Agreement consistent - are incorrect.
- This is the first study that puts together the total greenhouse gas implications of the entire Scarborough-Pluto project, including its associated and interlinked projects. The results show the emissions are significantly larger than either the company or the state government estimates indicate. To analyse the total greenhouse gas implications for Woodside and for Western Australia (WA), it is important to look at the entire picture.
- Estimates of the total greenhouse gas implications of the Scarborough-Pluto expansion project are spread across several different reports and documents. This report assembles these for the first time.
- The Scarborough to Pluto project is not 1.5°C consistent and consequently is a major stranded asset risk. The project would result in a substantial increase in Western Australia's greenhouse gas emissions, and a significant lock-in of carbon intensive activity well beyond that of the LNG plant itself.
- Overall, the Scarborough to Pluto project will results in huge domestic emissions increases, rather than decreases. The project scope itself is much larger than the expansion of Pluto LNG capacity, as it involves a massive expansion of domestic gas availability from the Pluto facility from the present maximum 25 T/day to 250 TJ/day, adding more than 20% to Western Australia's projected gas supply over the next decade.
- The bottom line is that by 2026 the Pluto expansion project, including Scope 1 and Scope 3 emissions, its linked additional domestic gas supply and the co-related H2 Perth project would be emitting about 9.2 $MtCO_2e$/yr, equivalent to around 12.1% of 2005 WA emissions.
- The sheer scale of the Scope 1 and 3 emissions from the Scarborough-Pluto project and in projects linked to it will make achieving 2030 emission targets much harder for Western Australia.
- Unlike other States, Western Australia does not have a 2030 emission reduction, but the State Government has indicated it will develop a target following COP26 in Glasgow. The present Australian target is a 26-28% reduction.
- If a WA target were set as an economy wide 50% reduction in emissions by 2030 below 2005 levels, and the Scarborough-Pluto project emitted at the level estimated in this report the average reduction for the rest of the WA economy would need to be around 60%.
- The total cumulative Scope 1 and 3 emissions from the project 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. These emissions are equivalent to 18 and 3.6 years respectively of WA's 2005 emissions.
- These total cumulative Scope 1 and 3 emissions are 60% larger than the 878 $MtCO_2e$ Woodside has reported for the Scarborough project.

Flawed abatement, offset and reduction plans

- Woodside's proposed "Greenhouse Gas Abatement Plan" (GGAP), accepted by the WA government, does little to reduce emissions in any substantive sense and instead will contribute to increasing emissions in WA.
- A significant fraction of Woodside's reductions set out in the GGAP are "hot air" as they are taken from an emissions baseline from an earlier, larger project approve in 2006 that was scaled down by 15%, making a substantial part of the claimed reductions a nonsense.
- Much of the proposed emissions reductions are through offsets, without any guarantee that the offsets reduce emissions additionally to what would otherwise have happened.
- Carbon offsets are often used to greenwash fossil fuels, diverting the focus from the critical need to rapidly reduced CO_2 emissions from fossil fuels. Evidence suggests offsetting CO_2 from burning fossil fuels through tree planting is scientifically flawed.
- Woodside has seemingly not accounted for the expected globally rising price of carbon, and hence a rapidly increasing cost of offsets consistent with Paris Agreement implementation.
- The company's GGAP results in nearly two thirds - 64% - of emission reductions/offsets not occurring until after 2040, allowing Woodside to produce LNG from Scarborough, effectively unencumbered by emissions reductions restrictions, for most of the field's 30-year expected life.
- Woodside plans to rely mostly on the use of carbon offsets to meet its Scope 1 emissions reduction targets which would be extremely costly. By 2050, the cost of offsets could range from 21% to 71% of Woodside's LNG export revenue, indicating a likely non-viability of this operation.
- Implicitly, Woodside is essentially asking policymakers, the finance sector, and governments to bet on a massive rollout of carbon capture and storage (CCS), an essentially unproven technology with a history of failures, cost overruns and major deployment delays.
- Woodside does not account for the substantial Scope 3 emissions in its emissions reduction plan.
- Woodside is not factoring in and is in fact massively discounting the likely large Scope 3 emissions' effect on demand for their fossil fuel products, specifically exported LNG.
- Scope 3 emissions are some nine times larger than the Scope 1 emissions from the LNG Plant itself.

Paris Agreement - and IEA net zero - inconsistency

- Woodside incorrectly claims the expansion of gas is consistent with the 1.5°C Paris Agreement goal and for the global movement towards net zero by 2050, also incorrectly justified by using International Energy Agency (IEA) scenario data.
- We show that introducing Scarborough LNG into electricity grids of countries decarbonising at a rate consistent with the Paris Agreement would likely raise emissions by several hundred MtCO2e over the period 2026-2040.

- The latest IEA Net Zero Emissions (NZE) scenario data makes it clear that no fossil fuel exploration is required, and this applies to the Scarborough project. (These issues are unpacked in our related "Why gas is the new coal" report).
- Consulting companies have wrongly contributed to the narrative that natural gas has an important and increasing role to play in future energy systems, while avoiding discussion on climate and emissions reductions. Governments have bought into this narrative, which has now been roundly dispelled by the IEA's NZE scenario.

This report unpacks the role of natural gas in 1.5°C compatible energy transitions using IPCC 1.5°C compatible pathways and the IEA Net Zero and shows that LNG does not have a significant role in decarbonizing major economies, and indeed would slow that down.

- The IEA Net Zero report indicates the potential for a collapse in the LNG market from Australia as its major markets begin to implement the Paris agreement.
- Recent developments in Japan and Korea signal and move away from LNG in favour of green hydrogen and removals, confirming the timing of the risks identified in the IEA Net Zero report.
- Policymakers and governments have uncritically approved Woodside's controversial proposals. The Western Australian government has recently approved the Greenhouse Gas Abatement Program (GGAP) for the Pluto LNG facility, which comprises Pluto's Train 1 and the proposed Train 2.

Woodside is misreading the international context for LNG under the Paris Agreement

- On the demand side, Woodside's main LNG markets - Japan, South Korea and China - would phase out gas, following Paris compatible pathways. All three countries would need to drastically reduce their natural gas consumption under pathways which limit warming to 1.5°C, in some cases immediately, but in all cases rapidly after 2030.
- On the supply side, Woodside faces competition from LNG suppliers with lower costs and who are also likely facing further environmental regulations from importing countries with net zero emissions targets and are already investing in other emissions reductions measures.
- Softening, or even collapse in demand for LNG as countries moved towards green hydrogen and renewables would amplify this risk.

Woodside's Pluto expansions is a bet against Paris Agreement implementation

- Woodside is banking on the world failing to meet the Paris Agreement. The company is asking its investors to bet against the successful implementation of the Paris Agreement. This, in turn, is a bet against the climate.
- Current renewable energy technologies, energy efficiency measures and a rollout of green hydrogen together offer a viable alternative to fossil gas and meet the long-term temperature goal. Such a pathway would present major economic opportunities for Australia.

EXECUTIVE SUMMARY

The Woodside Scarborough-Pluto project

This is the first study that puts together the total greenhouse gas implications of the entire Scarborough-Pluto project, including its associated and interlinked projects. The results show the emissions are significantly larger than either company or state government estimates indicate. To analyse the total greenhouse gas implications for the company and for Western Australia (WA), it is important to look at the entire picture.

Estimates of the total greenhouse gas implications of the Scarborough-Pluto expansion project are spread across several different reports and documents. This report assembles these for the first time.

While much of the focus has been on the LNG implications, the project would effectively add 20% to the domestic gas (DomGas) supply in WA, well above the projected demand throughout the next decade. These additional fossil gas resources lock-in a significant new demand for gas that does not presently exist, adding substantially to state emissions. These demand sources could use green hydrogen (H2).

Woodside plans to expand its Western Australia export LNG and domestic gas production by developing the Scarborough gas field 375km offshore from the Burrup Peninsula and expanding its current Pluto LNG facility on the Burrup to process fossil gas from this resource.

This development is proposed in the context of the company's larger Burrup Hub liquefied natural gas (LNG) projects, including the Karratha North West Shelf (KGP) LNG plant. Woodside has switched from the Browse gas basin to Scarborough, which has a substantially lower reservoir CO_2 content, but as we show in this report this change does not fundamentally alter the picture of the Paris Agreement compatibility of this project.

The Scarborough offshore development is designed to provide fossil gas needed to support 8 Mtpa LNG production - to fully supply Pluto Train 2 and a substantial part of Pluto Train 1 - and support a massive expansion of domestic gas supply. It has several interlocking dimensions:

- The Scarborough offshore development involves commercialisation of the Scarborough and North Scarborough gas fields via a 430 km pipeline to onshore processing on the Burrup.
- The construction of Pluto Train 2, with a production capacity of about 5.3 Mtpa LNG.
- Enhanced capacity of Pluto Train 1, which has a capacity of 4.9 Mtpa LNG to process Scarborough gas.
- Construction of an interconnector between Pluto and the NWS Project's Karratha Gas Plant (KGP), to enable supply of gas to KGP with a transport capacity of more than 5 Mtpa LNG production equivalent.
- A tenfold expansion of domestic gas supply capacity from the present 25 TJ/day from the Pluto Train 1 facility to 250 TJ/day, an increase of 225 TJ/day, via the Dampier to Bunbury Natural Gas Pipeline.

The additional gas supply of 225 TJ/day has a substantial market earmarked including

- Perdaman urea project on the Burrup peninsula to take 125 TJ/day
- H2Perth project is to use initially 40 TJ/day of fossil gas to produce hydrogen from gas using a steam methane reforming (SMR) process from around 2023/4, which is to be expanded to 60 TJ/day of fossil gas

In this report we estimate all Scope 1 and Scope 3 emissions[1] from the entirety of the Scarborough-Pluto project. Emissions estimated in this report will differ from Woodside's estimates as the company has partial estimates across different reports. For example, Woodside's Scarborough Offshore Project Proposal includes only part of Pluto supplied by Scarborough gas. In this report we account for the entirety of this project.

Findings

Scarborough-Pluto Scope 1 emissions will lead to a significant increase in WA emissions

The Pluto project Scope 1 emissions accounted for about 2.7% of 2005 state emissions in 2020, and would rise to about 5% from 2026, an increase in emissions equivalent to around 2.3% of 2005 WA emissions.

In 2030, if unabated, the Pluto project Scope 1 emissions would be 80% above 2020 levels. Even if Woodside's reductions were achieved in practice, emissions would still be nearly 50% above 2020 levels.

Woodside's greenhouse gas abatement plan (GGAP) is too little too late

In 2006, Woodside was granted approval to build a two-train LNG processing facility with a production capacity of 12 Mtpa LNG and at an emissions level of 4.1 $MtCO_2e$ p.a. (Woodside, 2006). The Western Australian government has recently approved Woodside's Greenhouse Gas Abatement Program (GGAP) for the Pluto LNG facility, which comprises Pluto's Train 1 and the proposed Pluto Train 2.

The Pluto LNG Facility currently produces around 4.9 Mtpa LNG, utilising one train, from natural gas sourced from the Pluto and Xena fields[2]. The company is proposing to develop a second train that will increase the production capacity to 10.2 Mtpa LNG, some 15% smaller than the original project size.[3]

It is important to note that Woodside has only committed to its 2030 and 2050 emissions reductions targets, stating that subsequent interim targets will be "established in future revisions" of the Pluto LNG Facility GGAP. Given that a gradual emissions reduction is uncertain, the actual "reduction and abatement" could be significantly less.

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1 Under corporate standards for emissions accounting, GHG emissions are classified under three scopes:
Scope 1 category encompasses direct emissions from assets owned or operated by the company.
Scope 2 emissions are indirect emissions resulting from the conversion of energy, e.g., for power generation, purchased by the company.
Scope 3 emissions are indirect emissions which occur in the company's value chain (e.g., as a result upstream and downstream activities) and which are not included under the scope 2 category (WRI & WBCSD, 2011).

2 The Pluto LNG facility also currently produces 25 TJ/day of domestic gas, as reported in (Woodside, 2021c). Note that this reported amount is inconsistent with the 250 TJ/day reported to investors in (Woodside, 2021d).

3 Note that the Pluto LNG Facility capacity given in the GHG Abatement Program document released in June 2021, i.e., 10.2 MtLNG p.a. (Woodside, 2021c), is inconsistent with that reported to investors in August 2021, 8 Mt LNG p.a. (Woodside, 2021d).

GGAP reductions are much smaller than claimed

To comply with Western Australia's Greenhouse Gas Emissions Policy for Major Projects, the company is proposing to gradually "reduce or abate" the Pluto LNG Facility's scope 1 emissions so as to achieve a 30% reduction by 2030, and a 100% scope 1 emissions offset by 2050 (Woodside, 2021c).

But these targets are based on the 15-year-old approval of a 12 Mtpa LNG capacity plant, not on the real and actual Scarborough-Pluto project that is 15% smaller, so a substantial fraction of the GGAP emissions reduction targets is simply "hot air."

The GGAP proposes emissions reductions of 12% in 2026; 30% in 2030; 40% in 2040; 65% in 2045 and 100% in 2050. However, when the reduced scale of the project is factored in, the real additional reductions are nowhere near these levels.

In 2026 the GGAP approved emissions limit allows a 4% increase above the emissions that would come from the real Scarborough-Pluto project of 10.2 Mtpa LNG with emissions at the same GHG intensity of the original proposal of 0.34 $tCO_2e/tLNG$.

The real reductions in 2030 with respect to the originally-approved GHG intensity would be an 18% reduction in 2030, 29% by 2040, 59% by 2045 and 100% by 2050. But this is unlikely.

One third of claimed cumulative GGAP emissions reductions are 'hot air'

Over the period 2026-2050 close to one third of the cumulative claimed GGAP emissions reductions of about 46 $MtCO_2$ are from 'hot air' - reductions that relate solely to the reduction in scale from the original scale of a project approved in 2006, 20 years before the project reaches full scale in 2026.

In 2026, Woodside's claimed GGAP reduction results in allowed emissions higher than inferred from the 2006 approved emissions intensity.

In 2030 half of the claimed reductions under the GGAP come solely from the reduction in the scale of the project from 12 Mt LNG p.a. to 10.2 Mt LNG p.a.

Table ES 1: Scope 1 emissions and targets for the Pluto LNG Project

	2026	2030	2035	2040	2045	2050
Emissions approved in 2006 $MtCO_2e/yr$	4.1	4.1	4.1	4.1	4.1	4.1
Emissions intensity at 2006 approved emissions levels $tCO_2e/tLNG$	0.34	0.34	0.34	0.34	0.34	0.34
Woodside claimed %- Reduction from 2006 approved emissions level	-12%	-30%	-35%	-40%	-65%	-100%
% of Woodside's claimed reductions due to reduced scale	125%	50%	43%	38%	23%	15%
Real reductions % need by GGAP after accounting for scale reduction	4%	-18%	-24%	-29%	-59%	-100%
Woodside's allowed emissions from GGAP	3.61	2.87	2.67	2.46	1.44	0.00
Emissions at 2021 reduced scale (using 2006 approved emissions levels GHG intensity)	3.49	3.49	3.49	3.49	3.49	3.49
Real reductions needed by GGAP after accounting for scale reduction	0.12	-0.62	-0.82	-1.03	-2.05	-3.49
Projected emissions in 2026 after all actions and changes	3.78	3.78	3.78	3.78	3.78	3.78
2026 intensity	0.37					
Offsets or reductions needed to meet GGAP targets $MtCO_2e$ p.a.	(0.17)	(0.91)	(1.11)	(1.32)	(2.34)	(3.78)

GGAP reductions are too late for a 1.5˚C pathway, as 64% occur after 2040

The bulk of the emission reductions under the GGAP occur after 2040, allowing Woodside to produce LNG from Scarborough, largely unencumbered by emissions reductions restrictions, for most of the field's 30-year expected life.

Of the estimated 38 $MtCO_2e$ of abatement that the GGAP has in the period 2026-2050, about 24 $MtCO_2e$ - close to 64% - occurs after 2040.

By pushing back the bulk of the emissions reductions to the end of the project's life, time-adjusted costs arising from these efforts will appear lower on the company's balance sheets, allowing Woodside to present the project to investors as having a higher net-present value.

Given such a large fraction of emission reductions won't happen for 20 years, there is a serious risk that Woodside will not comply and the state will bear the brunt of the costly emission reductions

With most of the emission reductions from the project not required for 20 years there will have to be significant concerns of a risk that the projected reductions would never be achieved, particularly if, as is shown in this report, the financial viability of the Scarborough-Pluto project is seriously compromised by the expected implementation by other countries of Paris Agreement.

It can be realistically expected that on that timeframe Australia's own emission reduction targets would be well on the way towards the reductions needed for zero and hence the burden of replacing the emission reductions that were not made would likely fall upon the state of Western Australia.

Carbon offsets are used to greenwash fossil fuels, diverting the focus from the critical need to rapidly reduce real emissions to zero.

It is unclear how exactly Woodside plans to achieve the GGAP emissions reductions, outside of carbon offsets, which are unreliable and often unverifiable. Offsets do not effectively reduce emissions yet are used to justify emissions released.

Carbon offsets from tree planting do not effectively offset fossil fuel CO_2 emissions

Woodside is planning a heavy reliance on carbon sequestration and vegetation and soils for its offset plans. Such reliance is contradicted by scientific understanding of the operation of the carbon cycle and the very long lifetime of fossil fuels in the atmosphere.

Evidence suggests offsetting CO_2 from burning fossil fuels through tree planting is scientifically flawed. It creates several social and economic risks, and it is not cost effective when compared to decarbonising industry at source.

Woodside is underestimating the future likely cost of emission offsets

We have calculated the cost of carbon offsetting for Scope 1 emissions from the Pluto LNG facility at a range of different international carbon price levels consistent with emissions reductions compatible with the Paris Agreement.

Woodside proposes to utilise Australian Carbon Credit Units (ACCUs) in reaching its emissions reductions targets for the Pluto LNG facility. But these particular offset units have been criticised for their lack of integrity in the associated accounting methods.

The price of ACCUs has increased by over 50% since the beginning of 2021, driven in part by investor pressure on companies to reduce carbon emissions, and likely increased price uncertainty with the recently-concluded Article 6 rules under the Paris Agreement, which now means stricter regulations of global offset markets than many companies assumed.

Internationally, EU-ETS prices have risen from around USD 40/tonne to almost USD 80/tonne since January 2021, driven by the increasing pace of climate policy implementation in the EU-27 and its enhanced target of a 55% reduction by 2030.

The carbon offset prices assumed by Woodside are not consistent with the implementation of the Paris agreement, either internationally or within Australia over the next 30 years.

The company assumes that a long-term carbon price for Australia is USD 80/ tonne, in other words that the Australian market will not have to reduce emissions consistent with the Paris Agreement.

In this study we assume future carbon price trajectories consistent with Paris agreement implementation pathways and reaching net zero globally by 2050. There is a significant range of carbon prices in the literature, but they are all much higher and rise much faster than Woodside assumes. In a world that implements the Paris Agreement, including in Australia, companies and actors will increasingly be exposed to these kinds of prices.

We apply the IEA's NZE carbon price scenarios for major emerging economies and advanced economies where carbon prices reach USD 90/tonne in 2030 and increase to USD 200/tonne by 2050 in the emerging economies, and in advanced economies to USD 130 and 250/tonne in 2030 and 2050. We also use projections from the Network for Greening the Financial System (NGFS) climate scenarios used by Central Banks and Supervisors reaching 190 USD/tonne in 2030 and up to 680 USD/tonne in 2050.

The GGAP defers the largest cost of abatement of its Scope 1 emissions until after 2040 and allows Woodside to defer 73-79% of the costs of abating these emissions until after 2040

By 2050, the cost offsets for abatement to meet the GGAP targets could range from 21% to 71% of export revenue, or, in absolute terms, from USD 700m to USD 2.4 bn a year by 2050. These costs could have a major impact on the project's bottom line, particularly after the mid-2030s, and would seriously and adversely affect the competitiveness of LNG from the project.

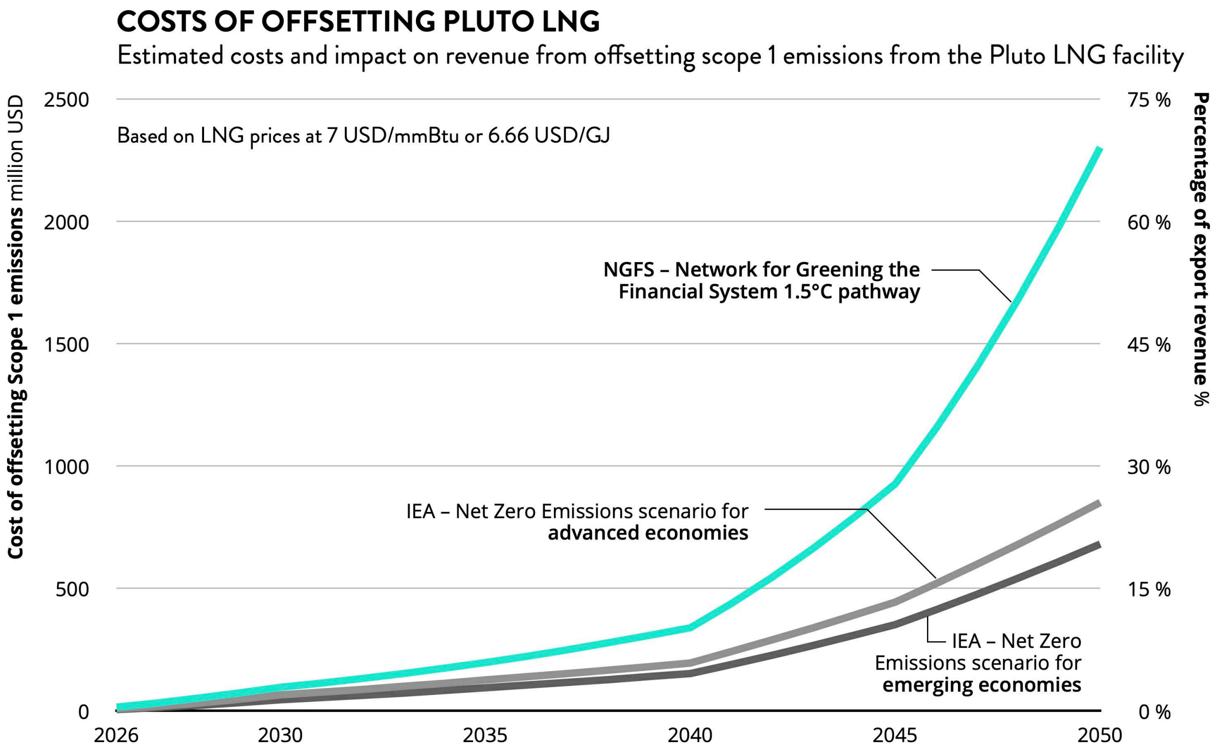

Figure ES 1: Cost of offsetting Scope 1 emissions from Pluto LNG plant under the Woodside abatement plan

Carbon prices from IEA NZE scenario for advanced and emerging economies and from NGFS – Network for Greening the Financial System 1.5°C pathway

The magnitude of Scope 3 emissions are nine times more than the direct Scope 1 emissions.

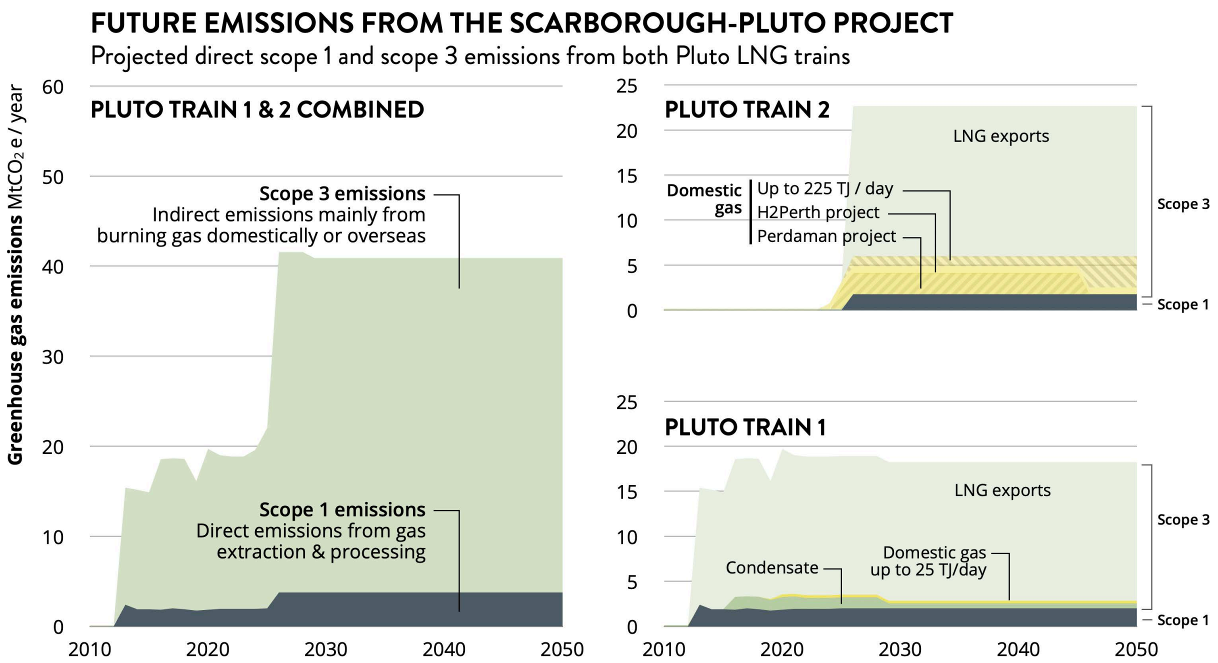

Figure ES 2: Scope 1 and Scope 3 state and international emissions from Pluto LNG project

The Scarborough-Pluto project Scope 1 and Scope 3 emissions would increase WA total emissions above 2020 levels by 6 $MtCO_2e$/year, equivalent to an increase of 7.9% above 2005 levels from 2026.

When including all locked in emissions of the Scarborough-Pluto project (H2 Perth and additional domestic gas supply), emissions would be 9.2 $MtCO_2e$, equivalent to around 12.1% of WA emissions in 2005.

To break this figure down:

Scope 1

The Pluto LNG plant at full-scale will likely emit Scope 1 emissions of about 3.8 $MtCO_2e$/year, equivalent to around 5% of 2005 WA emissions. This is an increase from the present of around 2 $MtCO_2e$/year, hence adding emissions equivalent to around 2.3% of 2005 WA emissions.

Scope 3

Currently emissions due to the combustion of domestic gas from Pluto train 1 are about 0.3 $MtCO_2e$/year.

The additional domestic gas from the Scarborough-Pluto would add Scope 3 emissions of about 4.2 $MtCO_2e$/year, equivalent to around 5.6% of 2005 WA emissions.

At least 73% of this is already earmarked for two projects for which the sale or use of the gas appears to be linked to the financial viability of the Pluto expansion:

- The Perdaman urea project on the Burrup peninsula, which would result in emissions of 2.4 $MtCO_2e$/year, equivalent to around 3.1% of 2005 WA emissions.
- The H2Perth project would result in emissions from gas use of at least 0.8 $MtCO_2e$/year, equivalent to around 1% of 2005 WA emissions.

Additionally unallocated additional domestic gas from Pluto train 1 expansion and Pluto train 2 would result in another 1.1 $MtCO_2e$/yr, equivalent to 1.5% of 2005 emissions.

The Scarborough-Pluto project Scope 1 and Scope 3 emissions within WA will amount to 8.3 $MtCO_2e$, equivalent to around 10.9% of WA emissions in 2005.

Beyond Scope 3 emissions, but intrinsically linked to the H2Perth project is a 250 MW H2 electrolyser drawing power from the SWIS. With generous assumptions this would add about 0.9 $MtCO_2e$/year, equivalent to around 1.2% of 2005 WA emissions.

When including the co-related H2 Perth project, emissions are higher, at 9.2 $MtCO_2e$/year, equivalent to around 12.1% of 2005 WA emissions.

The GGAP reductions, even if fully effective - which is doubtful - will reduce this by only 1.2%.

Table ES 2: Summary of emissions breakdown

			2020 $MtCO_2e$	% of 2005 emissions	2026 $MtCO_2e$	% of 2005 emissions
Pluto Scope 1 and Scope 3 in WA	Train 1 & 2 Scope 1		2	3%	3.8	5%
	Train 1 Scope 3 emissions (domestic gas)		0.3	0.40%	0.3	0.40%
	Train 2 expansion (domestic gas)	*Scope 3 Perdaman*	*0*	*0%*	*2.4*	*3.10%*
		Scope 3 H2Perth	*0*	*0%*	*0.8*	*1%*
		Domestic gas up to 250TJ/day	*0*	*0%*	*1.1*	*1.50%*
		Subtotal	0	0%	4.2	5.6%
	Subtotal Scope 1 & Scope 3 in WA		**2.3**	**2.50%**	**8.3**	**10.90%**
H2Perth power from South West Power grid SWIS			0	0%	0.9	1.20%
Total locked in Emissions			**2.3**	**3.10%**	**9.2**	**12.10%**

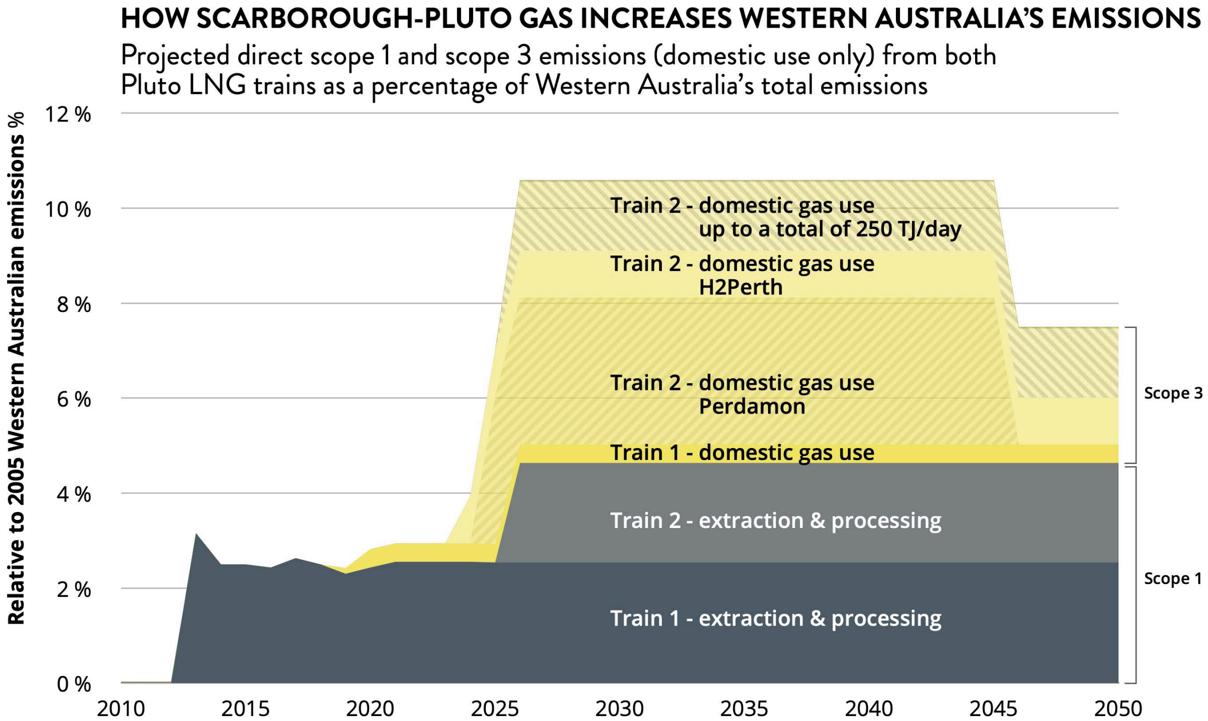

Figure ES 3 Total Pluto Scope 1 and 3 emissions occurring in Western Australia

Scope 1 and 3 emissions will make it much harder for the WA economy to reduce emissions by 2030

To take two examples of how much more difficult it will be to reach a greenhouse gas target for Western Australia, we consider the implications of the Scarborough-Pluto project for reaching a 28% reduction, the high end of the federal government's 2030 target, and the Business Council of Australia's 45% reduction by 2030 proposal for Australia. Neither of these are Paris Agreement compatible 2030 reductions for Australia as a whole.

- **A Western Australia state target of a 28% reduction from 2005 levels by 2030** would mean emissions would need to be reduced to 55 MtCO_2e/year by that year. With a total estimated locked-in emissions in Western Australia of around 9.2 MtCO_2e, the rest of the economy would need to reduce emissions to around 45.6 MtCO_2e, a reduction of 40% from 2005 state emission levels.
- A Western Australia state target of a 45% reduction from 2005 levels by 2030 would mean emissions would need to be reduced to 39.4 Mt CO_2e/year by that year. With a total estimated locked-in emissions in Western Australia of around 9.2 Mt CO_2e, the rest of the economy would need to reduce emissions to around 30.2 Mt CO_2e, a reduction of 60% from 2005 state emission levels.

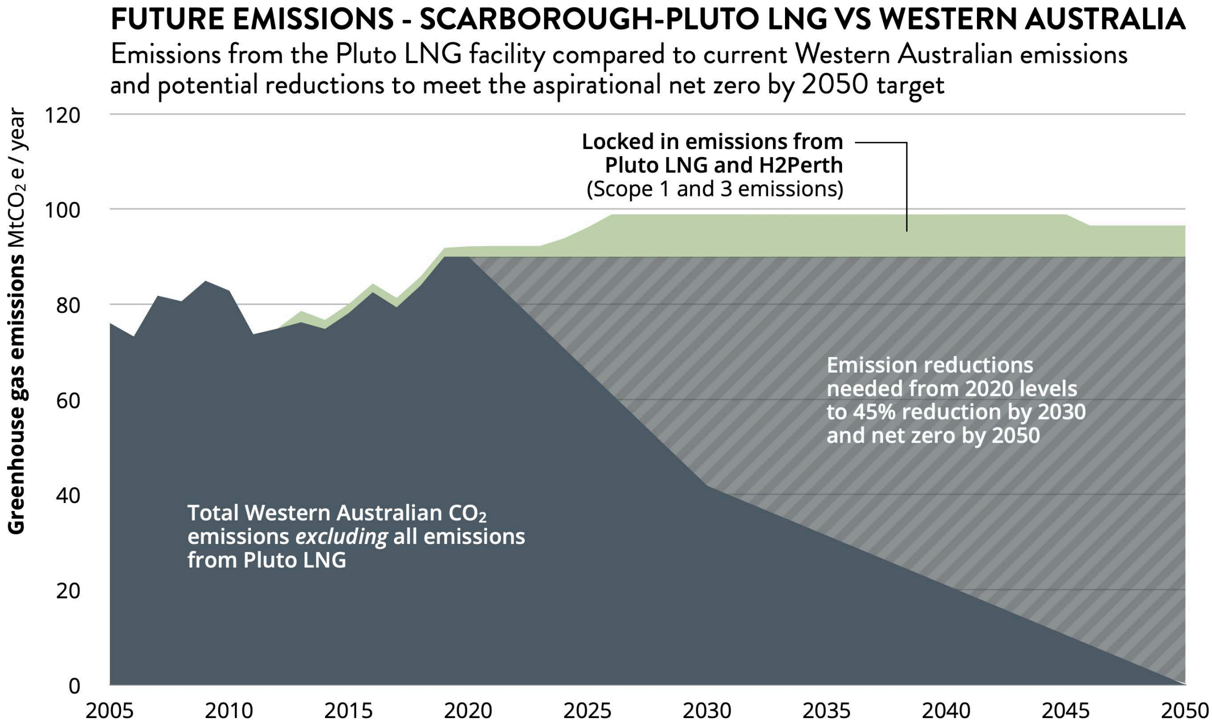

Figure ES 4: Emission's reductions needed in Western Australia from 2020 levels to meet a (hypothetical) 45% reduction target by 2030 and the state's aspirational target of net zero by 2050.

The total cumulative Scope 1 and 3 emissions from the project 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. These emissions are equivalent to 18 and 3.6 years respectively of WA's 2005 emissions.

These total cumulative Scope 1 and 3 emissions are 60% larger than the 878 Mt CO_2e Woodside has reported for the Scarborough project.

Woodside is not factoring in the large Scope 3 emissions' effect on demand for its fossil fuel products, specifically exported LNG, not does it account for the substantial risk from its Scope 3 emissions in its emissions reduction plans.

From an investment risk perspective Woodside does not appear to account for the effect of such a large amount of Scope 3 emissions on demand for its fossil fuel products, specifically exported LNG or domestic gas. It is these emissions that will translate into direct costs for Woodside's customers, given their very likely strengthening of climate-related legislation, and particularly carbon pricing, over the proposed lifetime of the Scarborough development.

From both a climate perspective and an investment perspective, Woodside's scope 3 emissions are of a much greater magnitude than Scope 1 emissions. The company does assume a USD 80/tonne carbon price in the valuation of its assets (Woodside, 2021a)[4].

4 Note that recent analysis of the EU-ETS shows that carbon prices could reach to EUR 90/tonne (over USD 100/tonne) by 2030 (Simon, 2021).

Using the estimated Scope 3 emissions intensity of Woodside's LNG production, 3.1 $tCO_2e/tLNG$, and if this applies to exported LNG, the carbon price translates to around USD 248/t LNG, or, in units commonly used for LNG prices, USD 4.87/mmBTU[5].

For the Scarborough-Pluto project Woodside assumes that a cost of supply below USD 6.8/mmBtu would make LNG from this project globally competitive (Woodside, 2019b, 2021f)[6]. So, if the USD 80/tonne carbon price were encountered it would represent a 72% increase in the globally competitive LNG price. This would clearly render the project non-viable.

Woodside's claims that its gas expansion plans are consistent with the Paris Agreement are not supported by science.

Woodside's claims that the Scarborough- Pluto expansion is consistent with, and indeed supported by, the Paris agreement and the International Energy Agency is incorrect and does not withstand scientific scrutiny.

Demand for fossil gas in fully 1.5°C compatible scenarios is very close to the available supply from existing gas fields – for the 2021 to 2050 period estimated supply from existing gas fields exceeds gas use and 1.5°C pathways by close to 20% (Figure ES 5).

Woodside claims the International Energy Agency's Sustainable Development (SDS) and Net Zero (NZE) scenario support, and even provide a mandate for, expanding gas supply. This does not stand up to factual scrutiny.

Total fossil gas demand in the IEA SDS scenario between 2021-2050, covering much of the life of the Scarborough project, is more than double the gas demand in the median of the IPCC 1.5 compatible scenarios.

It is well established that the IEA SDS scenario is not consistent with the Paris Agreement's 1.5°C limit - which is precisely why the IEA produced its NZE scenario.

IEA SDS scenario has a high probability of exceeding the 1.5˚C temperature limit, so it cannot be used to justify the Paris Agreement compatibility of gas.

The picture that is falsely created by using the IEA SDS scenario is that the available gas supply in terms of existing and planned gas fields is insufficient from the mid 2020s for global demand consistent with a sustainable world (see Figure ES 5).

The IEA Net Zero scenario is closer to Paris Agreement compatibility than the SDS scenario, and presents a more nuanced picture, but still one that does not support Woodside's claims that new gas fields need to be developed to enable the Paris Agreement transition. Two demand curves are shown in Figure ES 5 below - one including carbon capture and storage (CCS) and one that does not.

The NZE scenario total gas with CCS use exceeds the fully 1.5˚C compatible pathway median gas use by 45% and NZE gas use excluding CCS exceeds this by 11% over the period 2021-2050.

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5 Here we have used the conversion factor 1 tonne LNG = 51.56 million btu (mmBTU) taken from (Australian Government, 2021a). Other sources have a lower conversion rate of 1 tonne LNG = 46.405 mmBTU (BP, 2021). This would result in a higher LNG price.

6 his is based on an integrated cost of supply "delivered ex-ship" to Northeast Asian ports. There is no indication that these prices include the cost of abatement by CCS or other means.

The IEA NZE gas demand is higher than for fully 1.5-degree Paris Agreement compatible pathways but still very close to the available gas from existing gas fields and does not support the need for new fields such as Scarborough, nor new LNG capacity.

Gas demand in the NZE scenario is likely higher than it will be in practice because of reducing costs and higher availability of renewable energy and storage for power production, and the expansion of cost-effective alternatives such as green hydrogen in the so-called hard-to-abate sectors in industry such as steel and fertiliser manufacture.

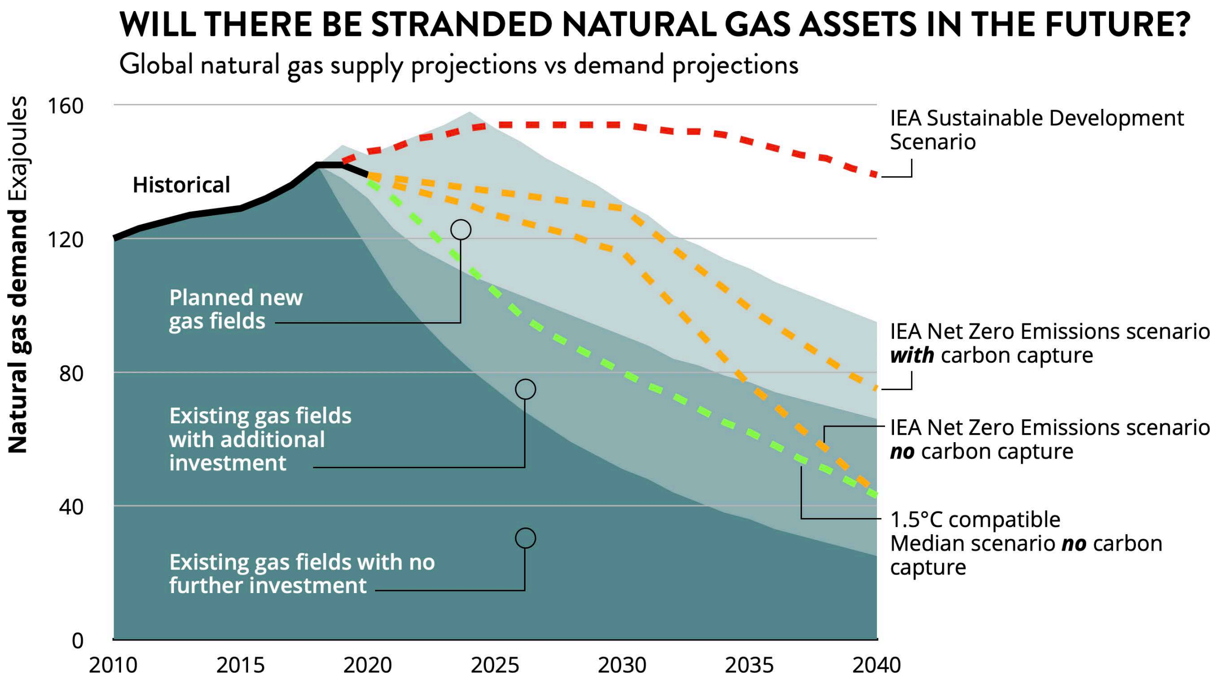

Figure ES 5: Gas demand vs supply under 1.5°C scenarios and the IEA's Net Zero (NZE) and Sustainable Development Scenarios (SDS).

Introducing Scarborough-Pluto LNG into electricity grids of countries decarbonising at a rate consistent with the Paris Agreement and reaching net zero by 2050 would raise emissions by several hundred MtCO2e over the period 2026-2040.

Overall this study confirms the IEA statement that "*the rapid drop in oil and natural gas demand in the NZE means that no fossil fuel exploration is required and no new oil and natural gas fields are required beyond those that have already been approved for development*" (IEA, 2021d). This shows that Woodside's Scarborough project is no exception.

Relying on carbon capture and storage is unsafe, very expensive and unlikely to work

A critical part of Woodside's argument for why natural gas fits within a Paris Agreement world is a reliance on the rollout a massive scale of carbon capture and storage.

Paris Agreement compatible energy transition pathways show a rapidly declining use of unabated natural gas in the power sector. The IPCC 1.5°C compatible pathways show around 10% of power sector use of gas being subject to CCS by 2030 (Figure ES 6) There is absolutely no sign of this scale of CCS capacity in the global CCS pipeline.

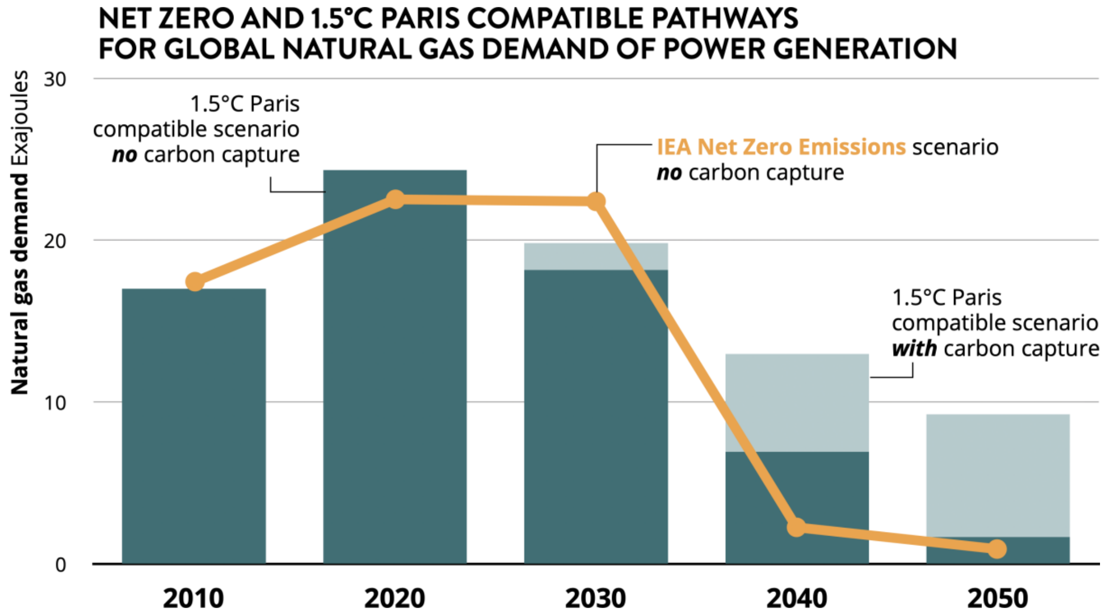

Figure ES 6: Gas powered generation under Paris compatible pathways with and without CCS. The indicated NZE pathway is for unabated natural gas generation.

There are still many barriers towards the very large-scale rollout of CCS implied by the IEA scenarios, with cost being the most significant. This stands in sharp contrast to solar energy, wind energy and electric storage, which have all witnessed dramatic cost reductions over the past decade, and which produce little to no emissions. The cost of renewables is now well below the cost of fossil fuel power, including with CCS.

Under Paris Agreement implementation, a collapse in demand for Australian LNG is likely by 2030

Australia's projected exports of LNG under the IEA's NZE study are projected to peak by the mid 2020s and drop substantially to be at or below 2018 levels by 2030, and below 2015 levels by the late 2030s.

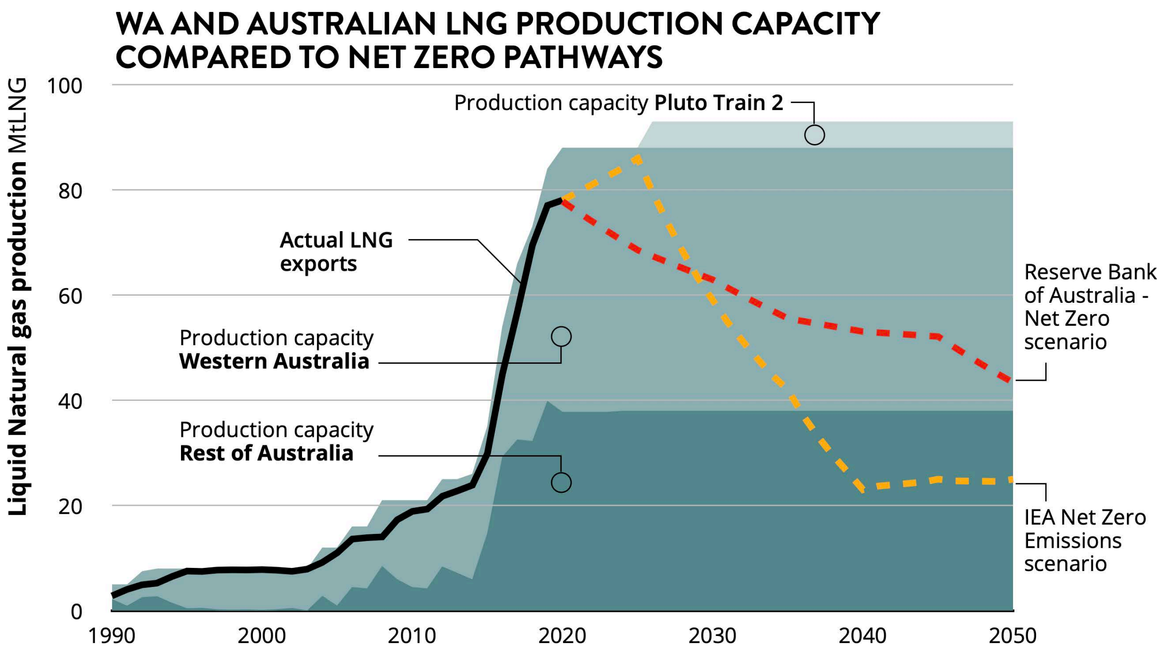

Figure ES 7: Australia and Western Australia's LNG production export capacity compared to Paris Agreement Scenarios

LNG actuals until around 2020 and then at capacity levels of 90% beyond that time compared to the IEA Net Zero and Reserve Bank of Australia projections for Australian LNG exports

Figure ES 7 shows the history of West Australian and Australian LNG exports against the IEA NZE historical and projected demand for the country. It clearly shows that under the IEA's NZE pathway, LNG exports can be expected to peak in the mid 2020s and begin a rapid decline, almost as fast as the growth since 2010-2015, to levels not seen since that. The Reserve Bank of Australia Net Zero pathway begins a decline earlier but not as deeply; however, it is not based on energy system model that includes trade in energy commodities.

The Scarborough-Pluto expansion of LNG capacity in Western Australia from 2026, which would add about 6% to Australia's total LNG production capacity, is timed to coincide with beginning of a collapse in Australia's LNG exports in a world that is implementing the Paris Agreement.

At the least this signals a very difficult market environment for LNG exporters and could signal the collapse of quite a number of them.

Following 1.5°C scenarios, demand for natural gas is projected to largely decline for Japan and South Korea immediately in most scenarios, whereas in China demand drops within the next decades.

China, India, South Korea, and Japan are key markets for Woodside's Scarborough project.

It is important to note that the largest levels of gas consumption occur under the range of 1.5°C scenarios in the scientific literature assume either reliance on high carbon dioxide removal (CDR) or low energy efficiency and hence high energy demand.

Recently, South Korea and Japan have signaled urgency in transitioning their energy systems away from LNG, with preference for hydrogen and renewable energy.

There is supply side risk for the Western Australia LNG in the global market under Paris Agreement implementation.

The bottom line from this overview is that several major competitors are also expanding their production, also without apparent consideration of Paris Agreement compatibility, meaning that there is a significant likelihood that if the world implements the Paris Agreement, the Scarborough project would be exporting LNG into a market flooded with surplus LNG capacity.

Given the current outlook on supply, price, and very low prospects for CCS deployment at scale, it is not at all certain that Woodside would be among the low-cost producers who would survive a rapidly declining market.

There is increasing risk of stranded assets and carbon lock-in with LNG infrastructure.

The high internal rate of return and short payback period suggest that the Scarborough-to-Pluto project is not a suitable candidate for investors interested in infrastructure projects. As part of its pitch to investors, Woodside makes claims that there is a long-term market demand for LNG, and that the project has a below average emissions intensity. As we have shown here, on both counts, the claims are, at best, dubious.

Woodside is essentially betting that the world will not implement the Paris agreement, and will simultaneously roll out carbon capture and storage technology at a scale and rate that is nowhere visible in the present deployment pathways for this technology.

The Scarborough to Pluto project is not 1.5°C consistent and consequently is a stranded asset risk

Climate Analytics has previously found that the Woodside Burrup Hub LNG project was inconsistent with Western Australia's carbon budget under the Paris Agreement and the State's goal of net zero emission by 2050 (Climate Analytics, 2020). Woodside has altered its plans from the Browse gas basin to the Scarborough project with substantially lower reservoir CO_2 content. Despite this, we still estimate the emissions intensity of LNG for the project to be inconsistent with the Paris Agreement 1.5°C goal.

LNG is not green: misleading narratives by gas and industry consulting companies have encouraged governments to support extremely risky investments that contradict the Paris Agreement goals.

Consulting companies such as McKinsey & Company and Wood Mackenzie contribute to the false narrative that natural gas has an important and increasing role to play in future energy systems over the next several decades by projecting significant increases in gas demand, while generally avoiding discussion on climate and emissions reductions.

These publications are found to have had adverse impacts on the understanding from governments and policymakers about the role of natural gas in the Paris Agreement transition. One example is Wood Mackenzie referring to LNG as "green," which dangerously brush aside the real risks of carbon lock-in and the crowding out of investment in actual "green" renewables and battery storage.

INTRODUCTION

This report provides an assessment on whether Woodside Energy's Scarborough to Pluto gas project in Western Australia is consistent with the Paris Agreement and its goal to limit global mean warming to 1.5°C above pre-industrial levels. As the Paris Agreement has serious implications for the timing and focus of national and global energy transitions, it has a direct impact on the viability of the Scarborough to Pluto project.

The development of the Scarborough gas field project is proposed in the context of Woodside Energy's larger Burrup Hub liquefied natural gas (LNG) projects, including the Browse Basin to North West Shelf and North West Shelf expansion proposals. The project arose as a result the need for gas resources to supply both the existing - and planned expansion of - LNG manufacture with Pluto Train 2.

In 2020 we (Climate Analytics, 2020) analysed the impact of the Burrup Hub LNG project for Western Australia's carbon budget under the Paris Agreement and the state's goal of net zero emissions by 2050. It built upon an earlier, comprehensive study of a 1.5°C compatible pathway for Western Australia (Climate Analytics, 2019).

Our 2020 Burrup Hub report found that these LNG projects, as proposed at the time, were neither consistent with Western Australia implementing the Paris Agreement, nor with the national and global emissions reductions necessary to implement the Paris Agreement.

Woodside Energy has changed direction away from the Browse gas basin to Scarborough, which has a substantially lower reservoir CO_2 content, which has implications for both the total volume of greenhouse gas emissions and the GHG intensity of LNG production. We show in this report that this change does not fundamentally alter the picture of the Paris compatibility of this project.

The focus of this report is to ask the fundamental question about whether the Scarborough development fits into Paris Agreement implementation both globally and regionally, in terms of the LNG industry's contemporary markets, principally in East Asia.

This report we will evaluate the Scope 1 greenhouse gas emissions, the recently approved Greenhouse Gas Abatement program, and Scope 3 emissions, both domestic and international. Together these results are used to evaluate the implications of this project for Western Australia in the context of 2030 Paris Agreement targets and reaching net zero by 2050.

Of particular interest in this context will be the emerging role of the Pluto expansion project for the locking of very large levels of greenhouse gas emissions over many decades in Western Australia going far beyond the Scope 1 emissions of the plant.

Report also looks at the fundamental Paris compatibility of the project, based on new results for 1.5C compatible pathways and the International Energy Agency's Net Zero roadmap scenario - and the implications for LNG demand both globally and from Australia.

This perspective is fundamentally important because the gas industry, and Woodside in particular, is relying heavily on arguments that natural gas has a long-term role in reaching net-zero emissions. As will be shown, the evidence points in the opposite direction, which means the fundamental energy market assumptions on which the project is based appear flawed, to say the least. This aspect is highly relevant to those investing in the industry, as the commodity it generates could very shortly become subject to very high carbon prices in the markets where it is sold.

Woodside lists the Scarborough to Pluto LNG development as one of its key “growth projects” which will be part of the “solution as the world transitions to a lower-carbon economy.”[7]

We look specifically at the risks to the LNG market coming from the implementation of the Paris agreement and how this can affect the Pluto-Scarborough project.

This first sections of this report will critically unpack the greenhouse gas emissions from the Scarborough-Pluto LNG project, including the expansion plans - both approved and underway - as they relate to Woodside Energy itself, to the State of Western Australia and at the global scale.

The analysis will first step through the scope of the project, including the emissions from the LNG facilities themselves (Scope 1 emissions), the related emissions that will, or are very likely occur as a consequence of the project (Scope 3 emissions that will occur in Western Australia), including locked-in domestic demand for natural gas, as well as the global implications (Scope 3 international emissions). It will critically evaluate Woodside’s emission reduction claims under the terms of its Greenhouse Gas Action Plan (GGAP) which has been approved by the West Australian government.

7 https://www.woodside.com.au/sustainability/environment/australian-growth-greenhouse-gas-emissions

FULL CONTEXT OF THE SCARBOROUGH AND PLUTO LNG PROJECT EXPANSION

The present Scarborough gas field development and expansion proposal for Pluto LNG plant [8] includes several interlocking dimensions which are relevant to the full analysis of the total greenhouse gas emissions from the completion of this project:

- The Scarborough offshore development involves commercialisation of the Scarborough and North Scarborough gas fields through the construction of several gas wells tied back to a semi-submersible Floating Production Unit (FPU) moored in approximately 900 m of water and connected via a 430 km pipeline to onshore processing on the Burrup.
- The Scarborough offshore development is designed to provide fossil gas needed to support 8 Mtpa LNG production- to fully supply Pluto Train 2 and a substantial part of Pluto Train 1 - and support a massive expansion of domestic gas supply.
- Construction of Pluto Train 2 production capacity to about 5.3Mtpa LNG.
- Enhanced capacity of Pluto Train 1 to process Scarborough gas.
- Construction of an interconnector between Pluto and the NWS Project's Karratha Gas Plant (KGP), to enable supply of gas to KGP, with new gas conditioning facilities at Pluto LNG with a transport capacity of more than 5 Mtpa LNG production equivalent.
- A tenfold expansion of domestic gas supply capacity from the present 25 TJ/day from the Pluto Train 1 facility to 250 TJ/day, an increase of 225 TJ/day, via the Dampier to Bunbury Natural Gas Pipeline (DBNGP). Market for the expanded gas supply includes:
  - Perdaman urea project on the Burrup peninsula to take 125 TJ/day
  - H2Perth project is to use initially 40 TJ/day of fossil gas to produce hydrogen from natural gas from around 2023/4, which is to be expanded to 60 TJ/day of fossil gas
- Intrinsically linked to the H2Perth project is a 250 MW H2 electrolyser drawing power from the South West Interconnected System (SWIS).

Estimates of the total greenhouse gas implications of the Scarborough-Pluto expansion project are spread across several different reports and documents. Whilst much of the focus has been on the LNG implications, the project would add effectively 20% to the gas supply in WA, well above the projected demand throughout the next decade. These additional fossil gas resources the effectively lock-in large demand centres for natural gas which do not presently exist, and could alternatively use green hydrogen.

It is clear from Woodside's documentation that the massive interconnector it is constructing is to "provide potential to accelerate future developments of other offshore Pluto gas reserves, as well as third-party resources"[8].

It is important for the purpose of analysing the project to begin with its initial approval scale, which was 12 Mtpa LNG, and was estimated then in 2006 to emit, at full operation, around 4.1 $MtCO_2e$/yr.

8 See Woodside PLUTO LNG EXPANSION Overview of November 2021 https://files.woodside/docs/default-source/our-business---documents-and-files/pluto---documents-and-files/pluto-lng-expansion-overview.pdf?sfvrsn=81e1de87_24

Scale of the Pluto LNG project

The subsequent scale of the Pluto project has been reduced to approximately 10.2 Mtpa LNG, 15% lower than originally planned. The reduction in scale should have substantially reduced the allowed emissions from the project, between 10 to 16% depending upon the assumptions made for offshore emissions. In round terms one would have expected that the 4.1 $MtCO_2e$/yr of emissions allowed under the original permit should have been reduced by about 15% to approximately 3.5 $MtCO_2e$/yr. This fact will be highly relevant when we turn to evaluate Woodside's claimed emission reductions under the GGAP.

Table 3 Changing scale of Pluto LNG development from 2006 to 2021

Pluto LNG Development	**2006 Public Environmental Report[9]**		**2021 GGAP Reported**	
	Years 1-5	Years 6-20	Actual Average Annual Values Pluto Train 1	Average projected GGAP Pluto Train 1 and 2
LNG Production (MtLNG/yr)	5.90	12.00	4.90	10.2
Estimated Annual Onshore Greenhouse Gas Emissions ($MtCO_2e$/yr)	1.84	3.75	1.94	3.40
Average Annual GHG Emissions – Offshore Facilities ($MtCO_2e$/yr)	0.00	0.30	N.R.[10]	0.25[11]
Total emissions ($MtCO_2e$/yr)	1.85	4.04	1.94	3.65
LNG GHG intensity (tCO_2e/tLNG)	0.31	0.34	0.40	0.36

Pluto Domestic Gas Expansion

While there has been much attention on the emissions from the LNG plant expansion, what is of particular interest here is that the expanded domestic gas (DomGas) supply is massive, and if used would add at least 20% to the country's projected 2030 demand for gas[12]. The additional DomGas coming online under this expansion would add emissions of about 4.2 $MtCO_2$/yr from the mid 20's (2025/2026), equivalent to an increase in WA's emissions of 4.9% above 2005 levels on its own.

In other words, it is highly relevant to an evaluation of the additional state-wide greenhouse gas emissions from this project to understand what the additional demand could be for this gas, and consequently what the total carbon lock-in for Western Australia would be from this amount of gas coming online, with facilities expecting to recover investment costs.

9 Woodside, 2006. Pluto LNG Development. Draft Public Environmental Report/Public Environmental Review, Available at: http://www.epa.wa.gov.au/proposals/pluto-lng-development-site-b-option-burrup-peninsula.

10 This was not reported in the GGAP and is assumed here to be zero for Pluto Train 1. The GHG intensity in the 2006 PER can be estimated at 0.00058 tCO_2/tLNG for this phase of the project as it was originally proposed. See Woodside (2006) Table 5-3 Average Annual GHG Emissions – Offshore Facilities

11 The greenhouse gas intensity of offshore activities, deriving from the need for the compression of gas for transfer to the onshore processing facilities is taken from the 2006 PER where it can be estimated at 0.025 tCO_2/tLNG. No information is provided in the GGAP however it appears unsafe to assume this is zero given the extensive offshore development and need for long-range transport of the gas. See Woodside (2006) Table 5-3 Average Annual GHG Emissions – Offshore Facilities

12 See figure 1 in AEMO (2020) at https://aemo.com.au/-/media/files/gas/national_planning_and_forecasting/wa_gsoo/2020/2020-wa-gsoo-report.pdf?la=en

Table 4: Domestic Gas Assumptions for Pluto expansion

	TJ/day	PJ/yr	$MtCO_2$/yr	% of 2005 emissions (including land sector)	% of 2019 State emissions (including land sector)
Existing Pluto 1 2021 DomGas supply maximum	25	9.1	0.47	0.6%	0.5%
Maximum DomGas after Pluto Train 1 and 2 expansion[13]	250	91.3	4.70	5.6%	4.6%
Additional DomGas from Pluto Train 2 and Train 1 expansion	225	82.1	4.23	4.9%	4.1%
Additional known demand for DomGas					
Perdaman Urea Plant - understood to be linked to FID	125	45.6	2.35	3.1%	2.6%
Woodside H2Perth Project - may be linked to FID, uncertain	40	14.6	0.75	1.0%	0.8%
Subtotal additional DomGas	165	60.2	3.10	4.1%	3.4%
Unallocated additional DomGas from Pluto Train 2 and Train 1 expansion	60	21.9	1.13	0.9%	0.7%

Demand for additional 225 TJ/day domestic gas

The Perdaman Urea plant is understood to have an agreement to take 125 TJ/day from Woodside. This agreement is understood to be relevant to financial closure on the Pluto project expansion. This would add about 3% above 2005 levels to the State's emissions.

The Woodside H2Perth project has indicated it would take initially 40 TJ/day to produce 200 tH2/day, with the other 100 tH2/day based around a 240 MW electrolyser, drawing power from the South-West Interconnected Network (SWIS). Given this project is also meant to draw power from the SWIS grid, to produce approximately 200 tH2/day, the additional emissions caused by this also need to be considered.

Taking into account the shutdown of two coal units at Muja[14], and assuming they are replaced fully by renewables, and that the additional power demand on the SWIS (about 10%) is sourced from renewables only, then the minimum additional emissions would be close to 1$MtCO_2e$/year or about 1.2% from 2005. All up, from 2023/4, the H2Perth project would add about 2.1% to the States emissions above 2005 emissions levels.

13 Assumes maximum potential of domestic gas.

14 Muja C unit 5 (195 MW) in 2022 and Muja C unit 6 (193 MW) in 2024

Green Hydrogen overlooked in favour of fossil gas

It is important to note the Perdaman Project and H2 Perth Project plans could be decarbonised. It is possible to transition the plans for the Perdaman Urea project and H2Perth project into zero carbon projects by replacing natural gas with green hydrogen, and sourcing electricity from renewable energy.

There are already at least four renewable hydrogen projects in WA at an advanced development stage (CSIRO 2021). For example, Yara Pilbara and ENGIE are building a renewable hydrogen plant on the Burrup Peninsula of Western Australia (and neighbouring the Woodside Pluto LNG train) (Yara Australia 2021). The hydrogen can be used to produce ammonia which can be used for green urea production.

After a 10 MW solar add-on demonstration project by 2023, the Yarra Pilbara project is intended to expand to 150-500MW of solar and wind by 2026, build a renewable ammonia plant with 800 ktpa by 2028, and add an additional 500MW of renewables by 2030 (Milne 2021). The project plans for nearly 100% emissions free renewable feedstock for the new ammonia plant by 2030.

Another urea project in Western Australia plans to use renewable hydrogen for urea production at Project Haber, near Geraldton. Infinite Blue Energy (IBE) and Strike Energy signed a memorandum of understanding for IBE’s Arrowsmith Hydrogen Plant to supply renewable hydrogen (solar and wind) to the Project Haber (Infinite Blue Energy 2021).

The Arrowsmith project will produce 265 tonnes per day of green hydrogen for domestic and export markets, including Project Haber. This is equivalent to 96,000 tonnes of green hydrogen per year, require 1.3 GW of solar, 1 GW of wind and 0.1 GW of battery energy. Arrowsmith will displace 1.3 $MtCO_2$ based on natural gas emission rates (Infinite Blue Energy 2021). Project Haber will phase out natural gas for green hydrogen from 2025.

In the following sections we will step through Woodside's Scope 1 emissions, as well as the domestic and international components of scope 3 emissions. We will focus on estimating the total emissions from the project, not split up by equity or other metrics.

SCOPE 1 GREENHOUSE GAS EMISSIONS FROM SCARBOROUGH AND PLUTO EXPANSION PROJECT

Under corporate standards for emissions accounting, GHG emissions are classified under three scopes:

- The scope 1 category encompasses direct emissions from assets owned or operated by the company.
- Scope 2 emissions are indirect emissions resulting from the conversion of energy, e.g., for power generation, purchased by the company.
- Scope 3 emissions are indirect emissions which occur in the company's value chain (e.g., as a result of upstream and downstream activities) and which are not included under the scope 2 category (WRI & WBCSD, 2011).

Pluto LNG Project: Scope 1 emissions

In 2006, Woodside was granted approval to build a two-train LNG processing facility with a production capacity of 12 MtLNG p.a. and at an emissions level of 4.1 $MtCO_2e$ p.a. (Woodside, 2006). The Pluto LNG Facility currently produces around 4.9 Mt LNG p.a., utilising one train, from natural gas sourced from the Pluto and Xena fields[15].

The company is proposing to develop a second train to process natural gas from the Scarborough field, and increase the production capacity to 10.2 Mtpa LNG, ~15% below the original scale.[16]

To comply with Western Australia's Greenhouse Gas Emissions Policy for Major Projects, the company is claiming to gradually "reduce or abate" the Pluto LNG Facility's Scope 1 emissions, to achieve what it claims will be a 30% reduction of scope 1 emissions by 2030, and a 100% reduction by 2050. (Woodside, 2021c).

The Western Australian government has recently approved the Greenhouse Gas Abatement Program (GGAP) for the Pluto LNG facility, which comprises Pluto's Train 1 and the proposed Train 2 (Sanderson, 2021).

Table 5 shows the Scope 1 emissions, emissions intensities, and emissions reductions for Pluto's Trains 1 and 2. The proposed Scope 1 emissions reductions targets put forth in the Pluto LNG Facility GGAP are based on the originally approved 12 MtLNG p.a. capacity and its associated 4.1 $MtCO_2e$ p.a. emissions.

As can be seen in Table 5, the company claims 12% reductions in 2026, 30% in 2030, 40% in 2040, 65% in 2045 and 100% in 2050. However when the reduced scale of the project is factored in, the real additional reductions are nowhere near these levels. We find that in 2026, this could instead amount to a 4% increase in emissions, an 18% reduction by 2030, 29% by 2040, 59% by 2045 and 100% in 2050.

15 The Pluto LNG facility also currently produces 25 TJ/day of domestic gas, as reported in (Woodside, 2021c). Note that this reported amount is inconsistent with the 250 TJ/day reported to investors in (Woodside, 2021d).

16 Note that the Pluto LNG Facility capacity given in the GHG Abatement Program document released in June 2021, i.e., 10.2 MtLNG p.a. (Woodside, 2021c), is inconsistent with that reported to investors in August 2021, 8 Mt LNG p.a. (Woodside, 2021d).

The magnitude of Woodside's proposed emissions reductions, even if achieved in practice, are substantially lower than claimed, as they are based on a counterfactual baseline that no longer exists. The company has reduced the scale of production, and the resulting real emissions reductions are much lower than Woodside's targets imply.

Table 5: Scope 1 emissions and emissions intensities for Pluto LNG project

	2026	2030	2035	2040	2045	2050
Emissions approved in 2006 $MtCO_2e$/yr	4.1	4.1	4.1	4.1	4.1	4.1
Emissions intensity at 2006 approved emissions levels tCO_2e/tLNG	0.34	0.34	0.34	0.34	0.34	0.34
Woodside claimed %- Reduction from 2006 approved emissions level	-12%	-30%	-35%	-40%	-65%	-100%
% of Woodside's claimed reductions due to reduced scale	125%	50%	43%	38%	23%	15%
Real reductions % need by GGAP after accounting for scale reduction	4%	-18%	-24%	-29%	-59%	-100%
Woodside's allowed emissions from GGAP ($MtCO_2e$)	3.61	2.87	2.67	2.46	1.44	0.00
Emissions at 2021 reduced scale (using 2006 approved emissions levels GHG intensity)	3.49	3.49	3.49	3.49	3.49	3.49
Real reductions needed by GGAP after accounting for scale reduction	0.12	-0.62	-0.82	-1.03	-2.05	-3.49
Projected emissions in 2026 after all actions and changes ($MtCO_2e$)	3.78	3.78	3.78	3.78	3.78	3.78
2026 intensity (tCO_2/tLNG)	0.37					
Offsets or reductions needed to meet GGAP targets $MtCO_2e$ p.a.	(0.17)	(0.91)	(1.11)	(1.32)	(2.34)	(3.78)

It is important to note that Woodside has only committed to the 2030 and 2050 emissions reductions targets, stating that subsequent interim targets will be "established in future revisions" of the Pluto LNG Facility GGAP (Woodside, 2021c). Given that a gradual emissions reduction is uncertain, the actual "reduction and abatement" could be significantly less (Milne, 2021a).

Even taking the interim targets suggested in the GGAP as a given, however, the bulk of the emissions reductions occur after 2045. This will allow the company to produce LNG from Scarborough, largely unencumbered by emissions reductions restrictions, for most of the field's 30-year expected life[17]. Moreover, by pushing back the bulk of the emissions reductions work to the end of the project's life, time-adjusted costs arising from these efforts will appear lower on the company's balance sheets, allowing Woodside to present the project to investors as having a higher net-present value.

It is unclear how exactly Woodside plans to achieve this large drop in emissions levels past 2045, outside of possible carbon offsets. The technological "no regrets" emission reductions listed in the Pluto LNG Facility GGAP appear to have already been implemented.

For Train 1, the company lists a total of 0.23 tCO_2e/t LNG scope 1 GHG intensity savings implemented. However these technological emissions reductions measures appear to be the same

17 For details on the Scarborough field's expected life, see (Woodside, 2020b).

as those listed in the company's 2006 Public Environmental Review (PER) for the Pluto LNG development (Woodside, 2006). In that report, the company reported that efficiency improvements implemented into the design of the Pluto LNG Development reduced the projects emissions intensity from 0.56 tCO_2/tLNG (plus 0.06 "contingency") to 0.35 tCO_2/tLNG (plus 0.04 "contingency"). The difference of 0.23 tCO_2/tLNG is the same as that reported in the GGAP (Woodside, 2021c).

In other words, the specific technological "no regrets" emission reductions claimed in the GGAP were already embedded in the 2006 PER and related approvals and were already with respect to a counterfactual baseline of unknown quality.

Similarly, the 560 $ktCO_2e$ emissions savings planned for the design of Train 2 seem to be accounted for in the projected annual scope 1 emissions, as shown in Table 5.

Beyond this, the company states it will "voluntarily offset" emission if its reduction targets cannot be sufficiently met onsite.

We will return to the question of abatement through carbon offsets below.

Greenhouse gas intensity of Pluto LNG

The total greenhouse gas intensity of Pluto LNG was estimated in the 2006 PER as about 0.34 tCO_2/tLNG and is here estimated to be about 0.37 tCO_2/tLNG when both Pluto 1 and 2 are fully operational from 2026. This estimate assumes the 5% greenhouse gas intensity improvement to Train 1 is realised as promised in the GGAP by 2025 and that gas is sourced from the Scarborough basin, with its relatively low reservoir CO_2 content. This GHG intensity estimates includes emissions from both onshore and offshore production facilities, which is essential to get the total picture of the greenhouse gas intensity of LNG manufacture from the Pluto project as a whole. These results are shown in Table 6 below.

The conclusion here is that GHG intensity of Pluto LNG is likely to be 10% greater than can be inferred directly from the GGAP, with a large part of the difference due to the need to include the offshore emissions in the total GHG intensity

Table 6 Greenhouse Gas intensity of Scarborough-Pluto LNG production

GHG intensity of LNG Production $tCO_2e/tLNG$	2006 Public Environmental review (PER) (1)	Pluto Train 1 - Actual Average Annual Values (2)	Pluto Train 1 in 2026 - 5% onshore GHG intensity improvement (3)	Predicted Annual Values Pluto Train 2 from 2026 (4)	Pluto Train 1 and 2 -predicted 2026 average (5)
Liquefaction Gas Turbines	0.146	0.168	0.175	0.228	0.202
Power Generation Turbines	0.101	0.089	0.093	0.018	0.054
Venting from CO_2 Removal	0.055	0.067	0.032 (6)	0.005	0.018
Flaring	0.006	0.070	0.074	0.008	0.038
Fugitives	0.004	0.002	0.002	0.019	0.012
Onshore GHG intensity	0.312	0.396	0.376	0.276	0.324
Offshore production	0.025	0.001	0.032	0.059	0.046
Total GHG intensity	0.337	0.396	0.408	0.335	0.370

Notes

(1) Derived from (Woodside 2006). Onshore emissions are from Table 5-2 'Estimated Annual Onshore Greenhouse Gas Emissions Averaged Over First 20 years' and Offshore emissions Table 5-3 'Average Annual GHG Emissions – Offshore Facilities' using the Post Offshore Compression data.

(2) Onshore GHG intensity derived from data in Greenhouse Gas Abatement Plan (GGAP) (Woodside 2021) from actual Pluto Train 1 production to 2020. Offshore emissions intensity is from (Woodside 2006) Table 5-3 'Average Annual GHG Emissions – Offshore Facilities' using the Pre Offshore Compression data as no offshore data are provided in GGAP.

(3) Pluto Train 1 on shore emission factors are inferred from the 5% greenhouse gas onshore improvement cited in the greenhouse gas action plan from 2020 levels for Pluto Train 1. The 5% improvement by 2026 from average levels in 2020 includes changes in the reservoir CO2 content which have been inferred separately based upon the GGAP and the proportion of Scarborough gas expected to supply Pluto Train 1. Offshore emission factor is calculated from By assuming that the Scarborough fraction of gas supply for Pluto Train 1 is about 55 percent, equivalent to about 2.7 MtLNG p.a., after allocation in the first 5.3 MtLNG p.a. of gas sufficient to manufacture 8 MtLNG p.a. from Scarborough to Train 2. The remainder of the gas supply to Pluto Train 1 is assumed to have a very low production intensity, consistent with the levels in the 2006 PER for the Pre Offshore Compression phase of the project, hence could be an underestimate. The offshore GHG production intensity for Scarborough gas is derived from Table 7-15 of Scarborough – Offshore Project Proposal, Revision 5 of February 2020 (Woodside 2020). A similar approach is taken to calculating the reservoir CO2 intensity of Pluto Train 1 with gas assumed to come from both Scarborough and the existing resource and weighted average derived from data in the GGAP for present Pluto Train 1 reservoir CO2 and the fraction assumed to come from Scarborough as above. Whilst Reservoir CO2 data estimates were published in the 2006 PER, in the Scarborough – Offshore Project Proposal, Revision 5 of February 2020 (Woodside 2020) it has been assumed that the GGAP is authoritative.

(4) Pluto Train 2 on shore emission factors are inferred from the 2021 GGAP, including the reservoir CO2 content-based Scarborough gas which is expected to supply all of Pluto Train 2. The GGAP reservoir CO2 content emission factor is higher than that in of Scarborough – Offshore Project Proposal, Revision 5 of February 2020 (Woodside 2020) and is used here as it is a more recent estimate.

(5) Pluto Train 1 and 2 average is the weighted arithmetic mean of Pluto 1 and 2 factors assuming Pluto Train 1 capacity is 4.9 MtLNG p.a. and Pluto 2 is 5.3 MtLNG p.a., for a total project scale of 10.2 MtLNG p.a. capacity

Implications of Scope 1 emissions and the GGAP for WA emissions

The Pluto LNG Facility GGAP suffers from a fundamental issue in that it permits ongoing increases in greenhouse gas emissions at a time when Western Australia needs to be setting 2030 emission reduction goals consistent with the Paris Agreement, and ensuring the state is placed on a trajectory consistent with reaching net-zero emissions by 2050.

Whilst the GGAP gives the impression that great efforts are being made to reduce emissions, emissions are in fact permitted to increase in absolute terms. Even if Woodside's targets were fully implemented, emissions would not reduce below recent levels until the 2040s. The Pluto project Scope 1 emissions accounted for about 2.7% of 2005 state emissions in 2020, and would rise to about 5% from 2026, an increase in emissions equivalent to around 2.3% of 2005 WA emissions.

In 2030, if unabated, the Pluto project Scope 1 emissions would be 89% above 2020 levels. Even if Woodside's reductions were achieved in practice, emissions would still be 45% above 2020 levels.

The WA government has stated that the GGAP "aligns the Pluto LNG project with the McGowan Government's commitment to net zero emissions by 2050" (Sanderson, 2021) . In reality, the Pluto-to-Scarborough development will significantly increase Western Australia's emissions.

The State government, however, does not have a strategy to get to net zero emissions, nor does it have interim targets for 2030 beyond a general reference to the federal government's 26 to 28% reductions below 2005 emission levels by this time. From any measure, such a substantial increase in emissions as has been mandated under the GGAP does not appear consistent with a pathway to net zero emissions.

Options to reduce Scope 1 emissions

The company does have Scope 1 emissions reductions measures available to it.

Manufacturing processes in LNG plants are highly energy intensive. Renewable electrification of the manufacturing processes would remove these corresponding emissions from gas turbines.

The company has power generation accounting for 22.5% of the emissions due to Pluto Train 1, and liquefaction is another 42% of emissions and these processes could be run with renewable energy. Woodside dismisses the possibility of utilising renewable energy for power generation (including renewables coupled with battery storage), as it assesses these to be inadequate to meet its demand requirements.

However, other Australian LNG producers are already replacing gas turbines with batteries for spinning reserve capacity and industry consultants have noted that using renewable energy at LNG plants could add value to these projects, particularly when carbon pricing is considered (Wood Mackenzie, 2020b).

There are clear examples of large power users in Western Australia replacing gas with renewables. Rio Tinto has spent USD 1.5bn on wind and solar energy to replace gas at its mining processing facility in the Pilbara (Milne, 2021c). The plan is for 1 GW of renewable energy to meet 80% of the site's power needs.

CO_2 emissions could be substantially reduced by effectively capturing the CO_2 in the gas stream into the gas reservoir. This CO_2 must be extracted to process the raw natural gas into LNG, and hence could be transported and stored in secure geological reservoirs (CCS).

Fugitive emissions also account for a high portion of emissions and would need to be a focus for decarbonisation.

Scope 1 Carbon offsets and carbon liability

Carbon "offsets" are used to greenwash fossil fuels, diverting the focus from the critical need to rapidly phase out fossil fuels. To comply with regulation, Woodside plans to rely heavily on the use of carbon offsets to meet its Scope 1 emissions reduction targets. Whereas a credible plan to reduce emissions has been neglected. Below we outline how offsets do not effectively reduce emissions yet are used to justify emissions released.

The Pluto LNG Facility Greenhouse Gas Abatement Program (GGAP) was developed to comply with Ministerial Statement 757 conditions 12-1 and 12-2 (EPA, 2007). Condition 12-1 requires a Greenhouse Gas Abatement Program and Condition 12-2 requires a GHG offset package to offsets the reservoir CO_2 released into the atmosphere, for the duration of the project.

Evidence suggests using carbon storage on land such as tree planting to offset CO_2 of burning fossil fuels is scientifically flawed and creates social and economic risks:

1) Ecosystems can only store a limited amount of CO_2 and the potential for sequestration reflects the depletion of past land use change (Mackey et al. 2013).
2) Replenishing land carbon stock reduces CO_2, but this is a small amount compared to the potential of fossil fuels emissions (Mackey et al. 2013).
3) The land use, land use change and forestry (LULUCF) sector is highly uncertain and the reliability of offsets is facing growing concerns. Woodside proposes to utilise Australian Carbon Credit Units (ACCUs) in reaching its emissions reductions targets for the Pluto LNG facility.
    - These particular offset units have been criticised for a lack of integrity in the associated accounting method (ACF & The Australia Institute, 2021). The ACF and Australia Institute finds a fifth of ACCUs are not real abatements, as the "avoided" deforestation projects are found to be non-additional abatement. Similarly, the CSIRO found climate driven changes such as increased rainfall can increase carbon storage with implications for the issue of additionality (Roxburgh et al. 2020).
    - The CSIRO assessed the physical risks to carbon sequestration under Australia's Emissions Reduction Fund land sector methodologies, finding that primary risks include ecological disturbances, for instance drought, fire, pests and disease. These findings suggest the effectiveness of offsets are not guaranteed (Roxburgh et al. 2020).
4) There are difficulties in measuring the effectiveness of nature based solutions, due to the challenging nature of measuring social-ecological systems, such as changing political support or ecosystems (Seddon et al. 2020).
5) Nature based solutions can result in low biodiversity value, for instance with non-native monocultures or afforestation, which can lead to maladaptation (Seddon et al. 2020). Rather, focus should be on protecting the existing ecosystems and rapid fossil fuel phase out (Seddon et al. 2021).

6) There are is a high level of risk associated with carbon offsets, including expropriation of indigenous peoples territories, displacement of people and local economies, and food insecurity (Forest Peoples Programme 2021; AbibiNsroma Foundation et al. 2021).
7) Nature based solutions such as tree planting are not always cost effective when compared to alternatives, and engineered approaches to decarbonisation should be part of the solution (Seddon et al. 2020). Studies into the cost effectiveness of nature based solutions underestimate the long term economic benefits of working with nature due to difficulty in placing a valuation or the uncertainty in non-market value (Seddon et al. 2020). Different stakeholder value costs and benefits differently (Seddon et al. 2020).

Woodside has assumed that the cost of offsetting will be low however this is an unsafe assumption, particularly if one is concerned about emission units that are guaranteed to have the properties mentioned above, including being real, additional, and verifiable emission reductions.

Woodside underestimates costs of Scope 1 offsets and carbon liability

We have calculated the cost of carbon offsetting for Scope 1 emissions from the Pluto LNG facility at a range of different international carbon price levels consistent with emissions reductions compatible with the Paris Agreement.

Woodside proposes to utilise Australian Carbon Credit Units (ACCUs) in reaching its emissions reductions targets for the Pluto LNG facility. But these particular offset units have been criticised for their lack of integrity in the associated accounting method (ACF & The Australia Institute, 2021).

In September of this year, the price of ACCUs have reached upwards of AUD 26/tonne (around USD 19/tonne) (Yin & Goliya, 2021). This represents around a 53% increase since the start of 2021. This appears being driven in part by investor pressure on companies to reduce carbon emissions. There is increased price uncertainty as negotiations on Article 6 of the Paris Agreement that concluded during COP26 will very likely result in stricter regulations in global offset markets beyond what is currently found under the Clean Development Mechanism. CERs are available at a fraction of the price of ACCUs and make up around 95% of voluntary cancellations in the Australian carbon market.

Internationally EU-ETS prices have risen from around USD 40/tonne to almost USD 80/tonne since January 2021 driven by the increasing pace of climate policy implementation in the EU-27 and the enhanced 55% reduction for 2030.

The carbon offset prices assumed by Woodside are not consistent with the implementation of the Paris agreement, either internationally or within Australia over the next 30 years. The company assumes that a long-term carbon price for Australia is US$80/ tonne, in other words that the Australian market will not have to reduce emissions consistent with the Paris Agreement.

In terms of exposure to future carbon prices the most robust approach would be to look at the projected likely range of prices under the Paris agreement implementation pathways. Given the range of modelling approaches, assumptions, and uncertainty there is a significant range of such prices in the literature, but they are all much higher and rise much faster than Woodside assumes. In a world that implements the Paris agreement, including in Australia, companies and actors will increasingly be exposed to these kinds of prices.

At the low end is the IEA's NZE scenario for major emerging economies where carbon prices reach 90 USD/tonne in 2030 and increase to 200 USD/tonne by 2050. The mid-range is based on the IEA's

NZE scenario for advanced economies which has carbon prices at 130 and 250 USD/tonne in 2030 and 2050 respectively (IEA, 2021f).

The upper bound uses projections from the Network for Greening the Financial System (NGFS) climate scenarios used by Central Banks and Supervisors. Their 1.5°C scenario has carbon prices reaching 190 USD/tonne in 2030 and up to 680 USD/tonne in 2050 (NGFS, 2021).

Table 7: Carbon pricing (USD_{2020}/tCO_2) under 1.5°C compatible scenarios

	2025	2030	2035	2040	2045	2050
NGFS 1.5C model average	142	190	261	356	475	677
IEA NZE Advanced economies	65	130	168	205	228	250
IEA NZE Major emerging economies	45	90	125	160	180	200

Carbon prices from IEA NZE scenario for advanced and emerging economies and from NGFS – Network for Greening the Financial System 1.5°C pathway (IEA, 2021f; NGFS, 2021).

Here we have calculated the cost of carbon offsetting for Scope 1 emissions from the Pluto LNG facility at these different carbon price levels following three trajectories[18].

By 2050, the cost of acquiring offsets could range from 21% to 71% of Woodside's export revenue (Figure 8). The costs could range from USD about 700 million to 2.4 billion by 2050.

The time series of offset requirement is a linear trajectory based on the proposed emissions reduction targets set out in the Pluto GGAP. Here we assume that the entirety of the emissions reductions needed to meet the proposed targets is due to offsets purchased at the range of carbon prices shown in Table 7.

18 All carbon prices here are given in terms of 2020 USD.

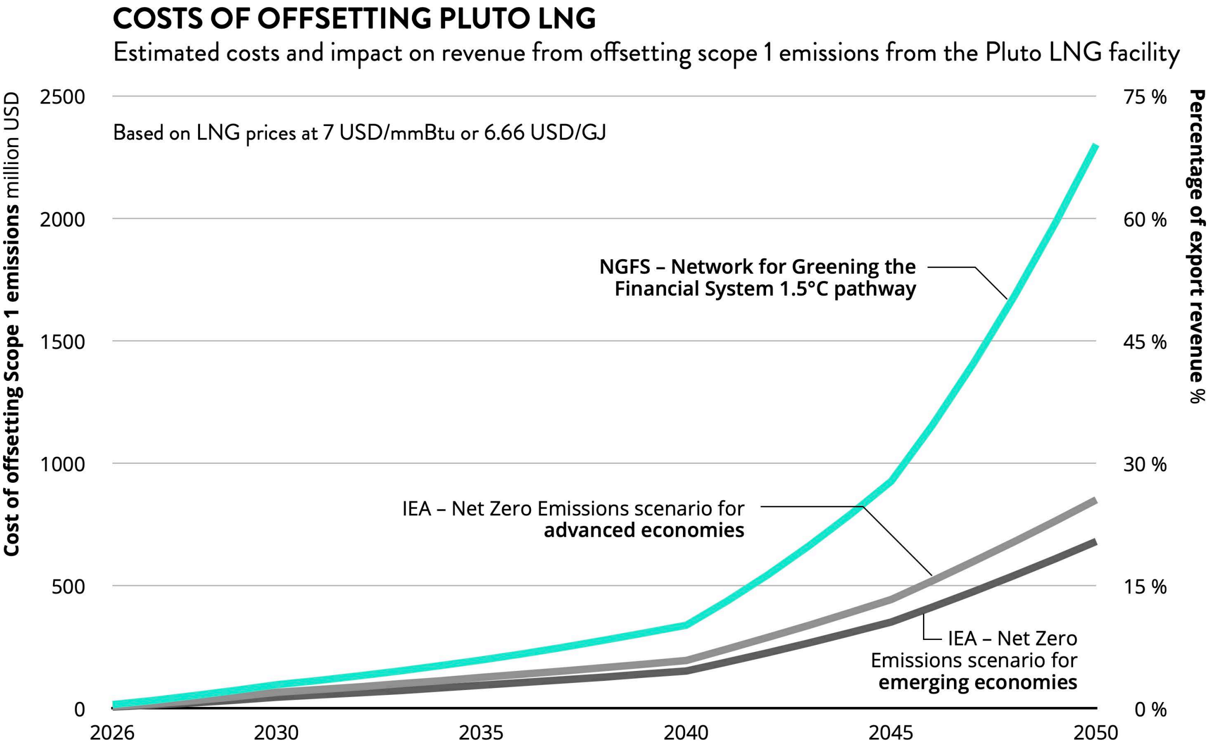

Figure 8: Cost of offsetting Scope 1 emissions from Pluto LNG plant

Carbon prices from IEA NZE scenario for advanced and emerging economies and from NGFS – Network for Greening the Financial System 1.5°C pathway

To estimate the effect on Woodside's export revenue we assume an LNG export price of 7 USD/mmBtu (6.66 USD/GJ) and that the Pluto LNG Facility operates at the full nominal capacity of 10.2 MtLNG p.a. This would result in annual export sales revenue of USD 3,313 million. The company's sales revenue in 2020 for the Pluto LNG Facility was USD 1,445 million (Woodside, 2021a) and, given the scale increase from the addition of the second train, our revenue estimates here seems reasonable. Further, unit production costs for Pluto LNG were 4.2 USD/boe.

The offsetting costs shown here could have a major impact on the project's bottom line, particularly after the mid-2030s.

SCOPE 3 GREENHOUSE GAS EMISSIONS FROM SCARBOROUGH AND PLUTO EXPANSION PROJECT

Woodside's latest sustainability reporting includes data on the company's greenhouse gas emissions. These emissions are categorised by scope and by ownership, i.e., what is emitted by assets under Woodside's operation and what is emitted by the company's equity share in those and other assets[19].

Looking at this data, visualised in Figure 9, it is immediately obvious that Scope 3 emissions are far larger than scope 1 and 2 and that Woodside's operations are responsible for far more emissions than what the company has equity in. Note that here we have provided a simple estimation of scope 3 emissions for years not reported by the company. This estimate is based on hydrocarbon production in those years and uses an average hydrocarbon emissions intensity value calculated from reported data.

Woodside and Scope 3 emissions

Woodside reports both hydrocarbon production and scope 3 emissions for years 2019 and 2020 (Woodside, 2021b). This data is given for both assets under operation and equity share. We have used this to calculate four values of scope 3 hydrocarbon emissions intensity, with an average of 2.7 tCO_2e/tonne hydrocarbon and a standard deviation of 0.16 kt CO_2e/kt hydrocarbon. Woodside reports that LNG accounted for around 75% of their 2020 production and domestic gas another 5% (Woodside, 2021a). BHP reports scope 3 emissions intensity from natural gas production in 2019 of around 2.76 tCO_2e/tonne produced (BHP, 2019). Given this, our estimate here seems fairly well fit for purpose.

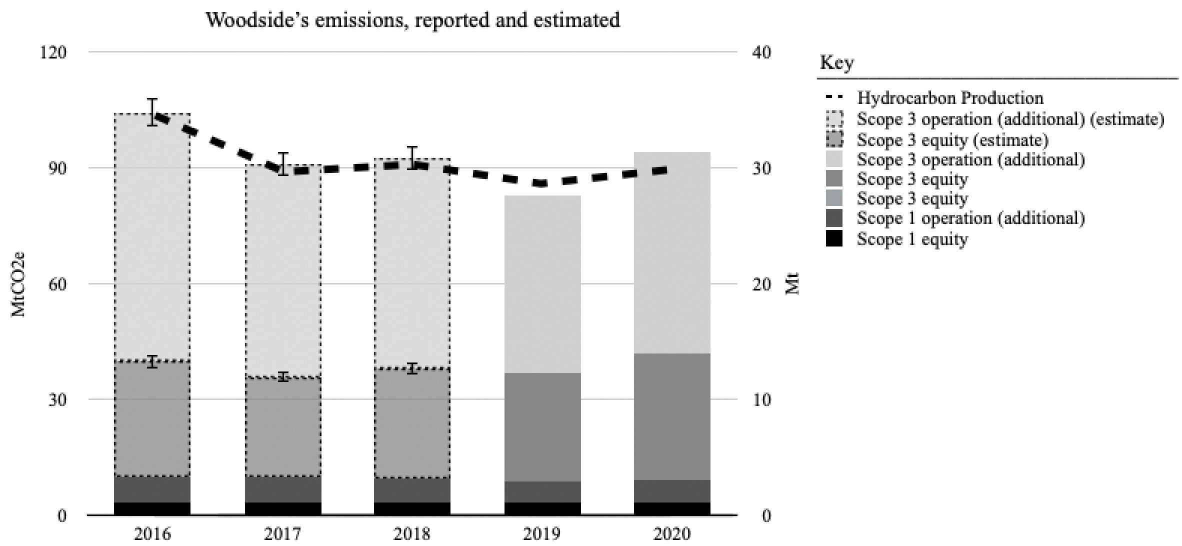

Figure 9: Scope 1 and Scope 3 Emissions reported by Woodside

See (Woodside, 2021b). Emissions from assets under operation are given as additional to those falling under the "equity" category. Scope 3 emissions for years not reported by Woodside have been estimated based on reported hydrocarbon production in those years. Associated error bars are displayed. Hydrocarbon production, in Mt, is shown on the right-hand side axis.

19 Woodside states that their equity portion of emissions includes emissions from assets not operated by the company (Woodside, 2021b).

Estimated Scope 3 emissions for Scarborough-Pluto project

The total Scope 3 emissions of the project are huge. They include emissions from domestic gas, LNG emissions, condensate sales, and are set to approximately double from close to 18 $MtCO_2e$/yr year in 2020 to over 38 $MtCO_2e$/yr from the mid-2020s. Scope 3 emissions averaged seven times more than Scope 1 emissions in the five years to 2020 and in the five years between 2026 and 2030 can be expected to be nearly nine times higher than the corresponding Scope 1 emissions.

The largest fraction of these emissions would occur internationally, in the markets where LNG and condensates are sold, with about 15% occurring in Western Australia.

TOTAL SCOPE 1 AND SCOPE 3 EMISSIONS FROM THE SCARBOROUGH-PLUTO PROJECT

Total Scope 1 and 3 emissions from the Pluto project are set to rise from about 19.7 $MtCO_2e$/yr in 2020 close to 41 $MtCO_2e$/yr by 2030 (Figure 10).

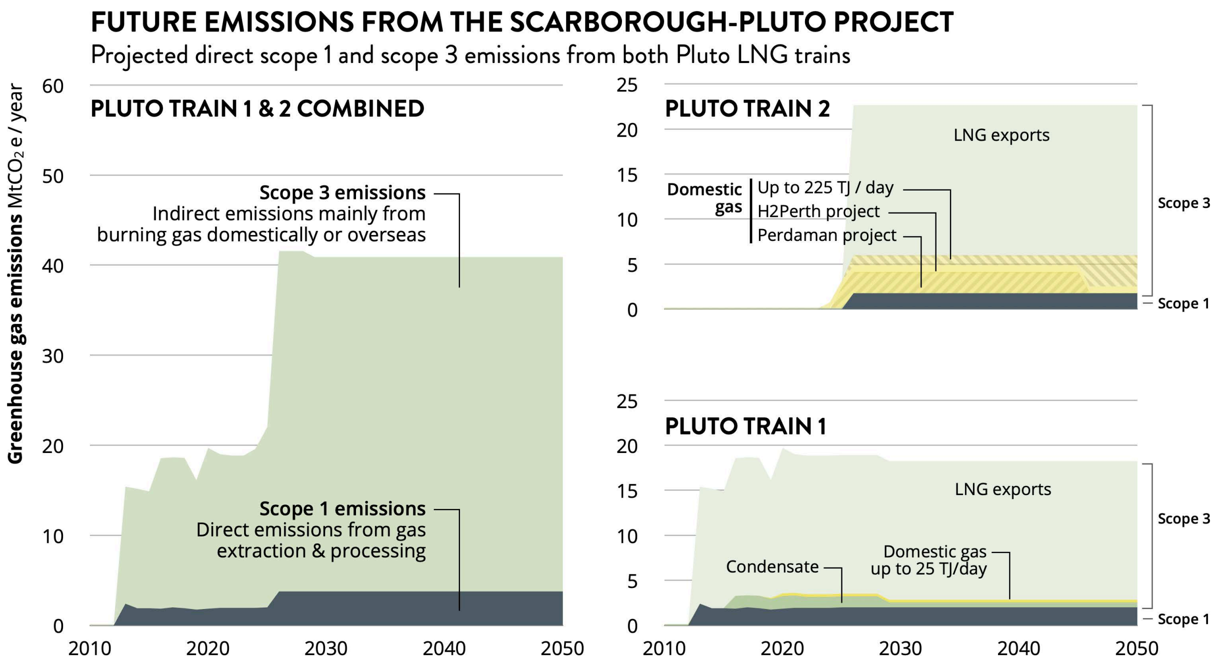

Figure 10: Scope 1 and Scope 3 state and international emissions from Pluto LNG project

Cumulative Scope 1 and Scope 3 emissions 60% larger than Woodside has reported

The Scarborough-Pluto project is projected to extend until 2055. In this section we give an estimation of the total Scope 1 and 3 cumulative emissions from 2021 to 2055.

A critical parameter in making these estimations is the emission intensity of exported LNG when it is used in a power plant or applied in process manufacturing. In its 2020 Scarborough offshore permit application Woodside used a factor of 3.14 tCO_2e/tLNG and we would use this as a central estimate. Note however that there are higher and lower investments in the literature and the table below documents arrange, focused around different assumptions on methane releases during transport, degasification and delivery to final end-user. This is quite an important factor is over 80% of the cumulative Scope 1 and 3 emissions will come from LNG combustion at point of final use. Table 8 outlines the cumulative emissions estimates of this report for Pluto train 1 and 2.

With this emission factor the total cumulative emissions from the project are estimated to be around 1.37 billion tonnes of GHG emissions from 2021-2055. Of this close to 20% is project to be emitted in Western Australia or close to 0.27 billion tonnes of GHG emissions.

Woodside has publicly reported substantially lower emissions from the Scarborough project of around 878 $MtCO_2e$ although it has used very similar emission factors to those used in this study. The reason for this is that Woodside has used only the Scarborough part of the larger Pluto project and has omitted to include the emissions from Pluto Train 1 that do not derive from the Scarborough gas field. This means that the real cumulative Scope 1 and 3 emissions over the same period for the Pluto LNG project is nearly 60% larger than Woodside has reported.

Table 8: Total Cumulative Scope 1 and 3 emissions estimates of Pluto Train 1 and Train 2 emissions

CH4 loss	$tCO_2e/tLNG$	Period	Pluto Train 1 Scope 1 emissions	Pluto Train 1 Scope 3	Train 2 Scope 1 emissions	Pluto Train 2 Scope 3	Total Scope 1 and 3
0.5%	**2.92**	**2021- 2056**	**72**	**551**	**55**	**615**	**1,293**
1.0%	**3.05**	**2021- 2056**	**72**	**574**	**55**	**636**	**1,337**
1.4%	**3.14**	**2021- 2056**	**72**	**590**	**55**	**651**	**1,368**
1.5%	3.18	2021- 2056	72	597	55	657	1,381
2.0%	3.31	2021- 2056	72	619	55	678	1,424
3.0%	3.56	2021- 2056	72	664	55	720	1,512
4.0%	3.82	2021- 2056	72	710	55	763	1,599
5.0%	4.08	2021- 2056	72	755	55	805	1,686

For completeness here Table 9 outlines Woodside's cumulative emissions estimates for the Scarborough Project.

Table 9: Woodside's emissions summary estimate for Scope 1 and Scope 3 emissions for Scarborough (Woodside, 2020b).

	Average year ($MtCO_2e$)	Total expected field life ($MtCO_2e$)
Scope 1 Emissions	0.47	11.52
Scope 3 Emissions - Downstream Processing and Reservoir CO_2 Venting	2.84	87.97
Scope 3 Emissions - Transport and Combustion	25.11	778.53
Total	**28.42**	**878.02**

Note: Source is Table 7-20 (Woodside, 2020b). This table "looks" at the emissions from the point of view of the Scarborough gas field development, hence the classification of Scope 1 and 3 are different from other elements of both Woodside's reporting and the analysis used in this report. As a consequence, the table does not show the emissions that derived from Pluto Train 1 that does not consume Scarborough gas resources, and that accounts for most the difference between what the company has reported and what the cumulative emissions actually are for the entire project.

Increasing LNG and gas market risks from Scope 3 emissions

Perhaps more pertinent from an investment risk perspective is that the company does not appear to account for the effect of such a large amount of scope 3 emissions on demand for their fossil fuel products, specifically exported LNG. It is these emissions that will translate into direct costs for Woodside's customers, given the likely strengthening of climate related legislation, and particularly carbon pricing, over the proposed lifetime of the Scarborough development.

Despite the company's inaction, investors seem to be attuned to this fact. At Woodside's most recent annual general meeting, Blackrock, the company's largest investor, voted against the re-election of the company's longest serving director specifically because Woodside has not introduced scope 3 emissions reduction targets.

As Blackrock notes, "it is particularly important for investors to understand the complete emissions profile of carbon-intensive companies as the world transitions to a low carbon economy" (BlackRock, 2021).

From both a climate perspective and an investment perspective, Woodside's scope 3 emissions are of greater concern than scope 1 and 2 emissions. To be sure, the company does assume a USD 80/tonne carbon price in the valuation of their assets (Woodside, 2021a)[20].

Using the estimated scope 3 emissions intensity of Woodside's production (2.7 tCO_2e/tonne), and assuming this applies to exported LNG, the carbon price translates to around USD 218/tonne LNG, or, in units commonly used for LNG prices, USD 4.24/mmBTU[21].

For Scarborough, Woodside assumes a cost of supply below USD 6.8/mmBtu would make LNG from this project globally competitive. (Woodside, 2019b, 2021f)[22]. But the additional abatement costs estimated above would represent a 62% increase in the globally competitive LNG price.

Although Woodside has yet to adequately address its scope 3 emissions, the company does appear to understand that this represents a financial risk. In its latest annual report, Woodside claims its recently-appointed Senior Vice President on Climate "initiated a dialogue" with the company's major customers on the topic of scope 3 emissions (Woodside, 2021a).

Elsewhere, the company claims it is targeting an offsets portfolio carbon cost of USD 15/tonne or less, but does not indicate how this price level would be achieved, nor how many offsets it will be able to offer at this price (Woodside, 2021e).

Should Woodside achieve this feat, abatement using these offsets would raise LNG prices by as much as 12%.

20 Note that recent analysis of the EU-ETS shows that carbon prices could reach to EUR 90/tonne (over USD 100/tonne) by 2030 (Simon, 2021).

21 Here we have used the conversion factor 1 tonne LNG = 51.56 million btu (mmBTU) taken from (Australian Government, 2021a). Other sources have a lower conversion rate of 1 tonne LNG = 46.405 mmBTU (BP, 2021). This would result in a higher LNG price.

22 This is based on an integrated cost of supply "delivered ex-ship" to Northeast Asian ports. There is no indication that these prices include the cost of abatement by CCS or other means.

IMPLICATIONS OF SCOPE 1 AND 3 EMISSIONS FOR WESTERN AUSTRALIA

Of relevance to Western Australia is that Scope 1 and 3 emissions from the project are set to increase from about 3.1 % of 2005 emissions to 10.9% from 2026 onwards (Figure 11). Most these emissions will be locked in by the Pluto Train 2 and expansion project, not just by the Scope 1 emissions of the LNG plant expansion, but also by the related commitments to projects that would rely on the additional domestic gas supplied by Woodside's project for 20 years or more. In other words, the scope of the carbon lock-in from the Pluto project extends far beyond the Scope 1 emissions themselves.

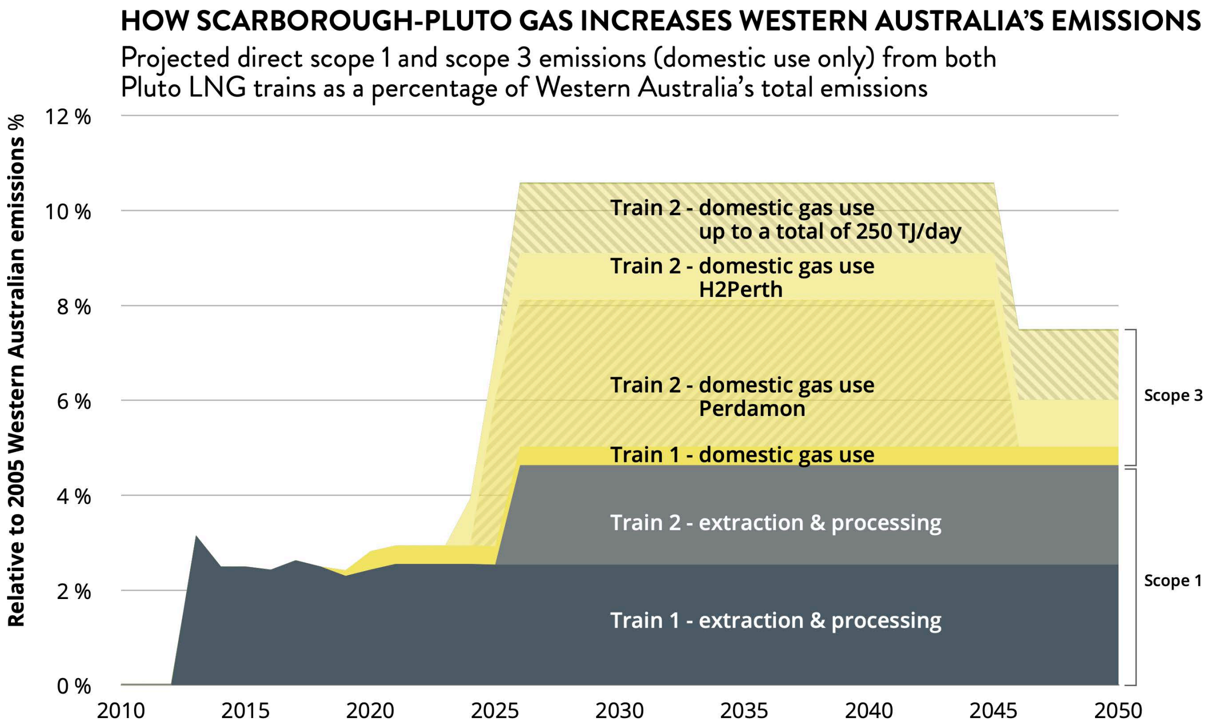

Figure 11 Total Pluto Scope 1 and 3 emissions occurring in Western Australia

Table 10 below summarises the estimated emissions from the full-scale Pluto project in Western Australia.

The Pluto LNG plant at full-scale will likely emit Scope 1 emissions of about 3.8 $MtCO_2e$/year, equivalent to around 5% of 2005 WA emissions. This is an increase from the present of around 2 $MtCO_2e$/year.

In terms of scope 3 emissions, currently emissions from combustion of domestic gas from Pluto train 1 are about 0.3 MtCO2e/year. The additional domestic gas from the Scarborough-Pluto would add Scope 3 emissions of about 4.2 $MtCO_2e$/year, equivalent to around 5.6% of 2005 WA emissions.

At least 73% of this is already earmarked for two projects for which the sale or use of the gas appears to be linked to the financial viability of the Pluto expansion. The Perdaman urea project on the Burrup peninsula, which would result in emissions of 2.4 $MtCO_2e$/year, equivalent to around 3.1% of 2005 WA emissions. The H2Perth project would result in emissions from gas use of at least 0.8 $MtCO_2e$/year, equivalent to around 1% of 2005 WA emissions. Additionally unallocated additional domestic gas from Pluto train 1 expansion and Pluto train 2 would result in another 1.1 $MtCO_2e$/yr, equivalent to 1.5% of 2005 emissions.

The Scarborough-Pluto project Scope 1 and Scope 3 emissions within WA will amount to 8.3 $MtCO_2e$, equivalent to around 10.9% of WA emissions in 2005.

Beyond Scope 3 emissions, but intrinsically linked to the H2Perth project is a 250 MW H2 electrolyser drawing power from the southwest interconnected electricity system (SWIS). With generous assumptions this would add about 0.9 $MtCO_2e$/year, equivalent to around 1.2% of 2005 WA emissions.

When including the co-related H2 Perth project, emissions are higher, at 9.2 $MtCO_2e$/year, equivalent to around 12.1% of 2005 WA emissions.

The GGAP reductions, even if fully effective - which is doubtful - will reduce this by only 1.2%.

Table 10. Summary of estimated emissions in Western Australia from the full scale Pluto Project.

	Pluto Train 1 Scope 1 emissions (1)	Pluto Train 1 Scope 3 emissions (domestic gas) (2)	Pluto Train 2 Scope 1 emissions (1)	Pluto Train 2 expansion Scope 3 (domestic gas emissions) Perdaman (3)	Pluto Train 2 expansion Scope 3 (domestic gas emissions) H2Perth (4)	Pluto Train 2 Dom Gas up to 250TJ/day (5)	Pluto Scope 1 and Scope 3 in WA (6)	H2Perth power from South West Power grid SWIS (7)	Pluto and all locked in emissions (8)
2020 Emissions $MtCO_2e$	2.04	0.29	NA	NA	NA	NA	2.33	NA	2.33
% of 2005 emissions	2.7%	0.4%	0.0%	0.0%	0.0%	0.0%	3.1%	0.0%	3.1%
% of 2019 emissions	2.2%	0.3%	0.0%	0.0%	0.0%	0.0%	2.5%	0.0%	2.5%
2026 Emissions $MtCO_2e$	2.00	0.29	1.78	2.35	0.75	1.13	8.30	0.88	9.18
% of 2005 emissions	2.6%	0.4%	2.3%	3.1%	1.0%	1.5%	10.9%	1.2%	12.1%
% of 2019 emissions	2.2%	0.3%	1.9%	2.6%	0.8%	1.2%	9.0%	1.0%	10.0%

Notes:

1. *Pluto train one emissions also include an estimate of the energy used in offshore activities, which in particular add emissions after the mid 20s*
2. *These emissions are from the estimated DomGas sales in 2020 at about 16 TJ/day rather than the maximum 25 TJ/day from Pluto Train 1*
3. *Assumes 125 TJ per day to Perdaman Urea plant. Perdaman urea project on the Burrup peninsula to take 125 TJ/day, which would result in emissions of 2.4 MtCO2e/year equivalent to around 3.1% of 2005 WA emissions.*
4. *Assumes 40 TJ/day for the H2Perth, but does not include the proposed increase to 60 TJ/day. H2Perth project is to use 40 TJ/day to produce hydrogen from natural gas, and would result in emissions from gas use of at least 0.8 MtCO2e/year equivalent to around 1% of 2005 WA emissions*
5. *The proposed Pluto Project expansion includes expansion of DomGas supply from 25 TJ/day to 250 TJ/day an increase of 225 TJ/day. The values in this column are the difference between the maximum increase and the allocation to Perdaman Urea and H2Perth Come on which collectively would use about 73% of the additional DomGas Supply*
6. *All scope 1 and 3 emissions that occur in WA*
7. *The H2 Perth project. Intrinsically linked to the H2Perth project is a 240 MW H2 electrolyser drawing power from the SWIS and with generous assumptions would add about 0.8 MtCO2e/year equivalent to around 1% of 2005 WA emissions. Taking into account the shutdown of two coal units at Muja, and assuming they are replaced fully by renewables, and that the additional power demand on the SWIS from the electrolyser (about 10%) is sourced from additional renewables only, then the minimum additional emissions would be close to 0.84 MtCO2e/year or about 1.1% from 2005. All up, from 2023/4, the H2Perth project would add about 2.1% to the States emissions above 2005 emissions levels.*
8. *What is locked in is defined as Scope 1 and Scope 3 emissions that occur in WA, mainly the additional DomGas supply, plus the emissions from the SWIS due to the H2Perth project.*

The adverse impact of Scarborough-Pluto Project on 2030 emission targets for WA

Scope 1 and 3 emissions from the Scarborough-Pluto project will make it much harder for the WA economy to reduce emissions by 2030,

Two examples illustrate how much more difficult it will be to reach a greenhouse gas target for Western Australia consider the implications of the Scarborough-Pluto project for reaching 28% reduction, the high end of the federal government's 2030 target, and the Business Council of Australia's 45% reduction by 2030 proposal for Australia. Neither of these are Paris compatible 2030 reductions for Australia as a whole.

- A 28% reduction from 2005 levels by 2030 for Western Australia means that emissions would need to be reduced to 55 $MtCO_2$/year by that year. With a total estimated locked-in emissions in Western Australia of around 9.2 $MtCO_2$, this would mean that the rest of the economy would need to reduce emissions to around 45.6 $MtCO_2$, a reduction of 40% from 2005 state emission levels.
- A 45% reduction from 2005 levels by 2030 for Western Australia means that emissions would need to be reduced to 39.4 $MtCO_2$/year by that year. With a total estimated locked-in emissions in Western Australia of around 9.2 $MtCO_2$, this would mean that the rest of the economy would need to reduce emissions to around 30.2 $MtCO_2$, a reduction of 60% from 2005 state emission levels.

Figure ES 4 provides a visual representation of the scale of emissions reductions required by Western Australia to meet a (hypothetical) 45% reduction target by 2030 and the state's aspirational target of net zero by 2050. The Pluto scope 1 and 3 emissions and H2Perth project will further lock WA into emissions, that will need to be reduced elsewhere in the economy, placing the burden on other economic sectors.

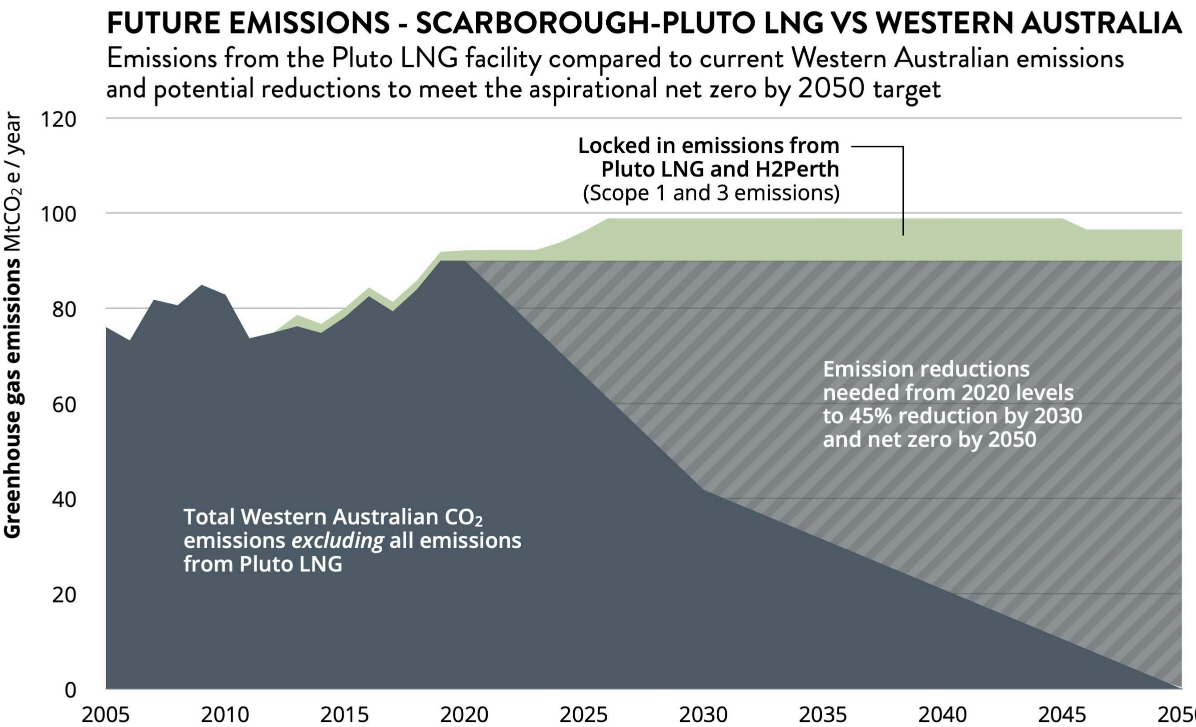

Figure 12: Emission's reductions needed in Western Australia from 2020 levels to meet a (hypothetical) 45% reduction target by 2030 and the state's aspirational target of net zero by 2050.

PARIS AGREEMENT COMPATIBLE SCENARIOS AND NATURAL GAS

IEA Sustainable Development Scenarios are not Paris compatible

The IEA states that its SDS is "fully aligned with the Paris Agreement to hold the rise in global average temperature to 'well below 2°C … and pursuing efforts to limit [it] to 1.5 °C'" (IEA, 2020c).

Due to the way the IEA has characterised its SDS, major fossil fuel industries have tended to use this as a reference point for Paris Agreement compatibility in relation to their business plans and activities, notably in the natural gas area. Woodside, for example, argues the International Energy Agency (IEA) Sustainable Development Scenario "aligns with the Paris Agreement ambition to hold global temperature rises below 2 degrees Celsius this century" (McConnell & Grant, 2019; Woodside, 2019a).

The IEA has previously explained that under its SDS, global energy-related emissions would fall to 10 $GtCO_2$ in 2050 and reach net zero in 2070. In the SDS net emissions would need to turn negative and around 300 $GtCO_2$ would need to be sequestered by 2100 to provide a 50% chance of limiting temperature rise to below 1.5°C (IEA, 2019). The IEA reiterates this analysis in 2020 (IEA, 2020c).

Recent analysis of the SDS has found this scenario has a high probability of exceeding the 1.5°C temperature limit, above 75% around mid-century and falling to just below 60% by 2100. The scenario is projected to result in a median warming level of 1.78°C above pre-industrial in 2056.

As such, the SDS is classified as a "Lower 2°C" pathway that is inconsistent with the Paris Agreement's long-term temperature goal. In contrast, the IEA's NZE is found to have a lower probability of exceeding the 1.5°C temperature limit, just below 60% by mid-century and dropping to around 20% by 2100. The NZE scenario is projected to rise slightly above the 1.5°C limit between 2035 and 2060 but remain under 1.6°C at its peak warming level. It is therefore classified as a '1.5°C low overshoot' scenario (Brecha et al., 2021).

Indeed, the IEA makes clear that the emissions reductions of the SDS, i.e., net zero by 2070, would require "*an energy sector transformation of unparalleled magnitude and scope that would rely on the active and continuous support of countries and citizens across the world*" and that the significantly more ambitious goal of reaching net zero by 2050 would *"require far-reaching changes in consumer behaviour, and would push technology innovation and deployment to their limits."*

IEA Net Zero Scenario and Natural gas

This more ambitious goal forms the basis of the IEA's NZE, a scenario that provides a 50% chance of limiting temperature rise to 1.5°C without relying on a large level of negative emissions (IEA, 2020c).

As mentioned above, Woodside has justified the Scarborough development using the natural gas supply and demand curves from the IEA SDS (IEA, 2020b) to argue that there is a significant supply gap to meet natural gas demand projections which it has argued are consistent with the Paris Agreement (see the SDS demand curve in Figure 13 below).

However, when this is unpacked, quite a different picture emerges.

Below, we recreate the forecast supply and SDS demand curve used by Woodside but with two additions. First, the SDS demand is compared with an NZE compatible demand curve. Second, the supply curve is updated based on the most recent information from the IEA (IEA, 2021e).[23]

It is important to note that the IEA NZE report differentiates between unabated natural gas and that with CCS. It shows an increasing share of the latter deployed for fossil fuels in Total Primary Energy Supply (TPES) out to 2050 Figure 13. It also differentiates between these two categories and illustrates the role CCS is expected to play, already within the next decade, and increasingly out past 2040.

When one applies the IEA NZE natural gas demand curve for both unabated (without CCS) and abated natural gas (with CCS), the available supply of natural gas is close to equal the projected demand. Demand drops further and substantially when taking just the unabated natural gas under the NZE, indicating that there would be significant gas resources unused in this scenario.

It also includes a demand scenario for unabated natural gas based on the median of 1.5°C compatible pathways[24]. One can see that there is a much more rapid reduction in natural gas demand compared even to the IEA NZE, leaving an even larger amount of natural gas unexploited.

23 SDS and supply data are taken from (IEA, 2020a). NZE time series is based on the data underlying Figure 3.3 in (IEA, 2021d). Data from 2020 is given in 5-year intervals. A growth function has been applied to intervening years.

NZE unabated is based on data found in Table A.1 of (IEA, 2021d). The data in the table is given in 10-year intervals from 2020. We have thus assumed that CCS is only deployed after 2025. From 2026, a linear trend, based on the "Natural gas with CCUS" values from the IEA table, is subtracted from the NZE time series and the result is labelled here "NZE unabated."

Historic production values have been updated and taken from (IEA, 2021e). Forecast production values have also been updated to reflect new information. For years 2021 to 2024, this is based on the short-term outlook (IEA, 2021a) which states that "Demand recovery in 2021 and further growth in emerging markets in the coming years are accompanied by gas supply expansion, as output grows by 9% between 2020 and 2024 in this forecast. It is worth mentioning, however, that this additional output comes at a slower rate than before 2020 and is almost exclusively from projects already under development." From 2025, the rate of decrease in supply from the IEA's earlier forecast, about 3% decline per year, is applied.

Finally, the data is converted from billion cubic meters (bcm) of natural gas, as it appears in the various IEA sources, to exajoules of natural gas (EJ) using the conversion factor of 1 bcm = 0.036 EJ taken from (BP, 2021).

24 The pathways are derived from global least cost pathways taken from the IPCC's special report on the impacts of global warming of 1.5°C above pre-industrial levels (IPCC, 2018). See section "Paris agreement and major LNG importing countries - demand side risk" below for further details.

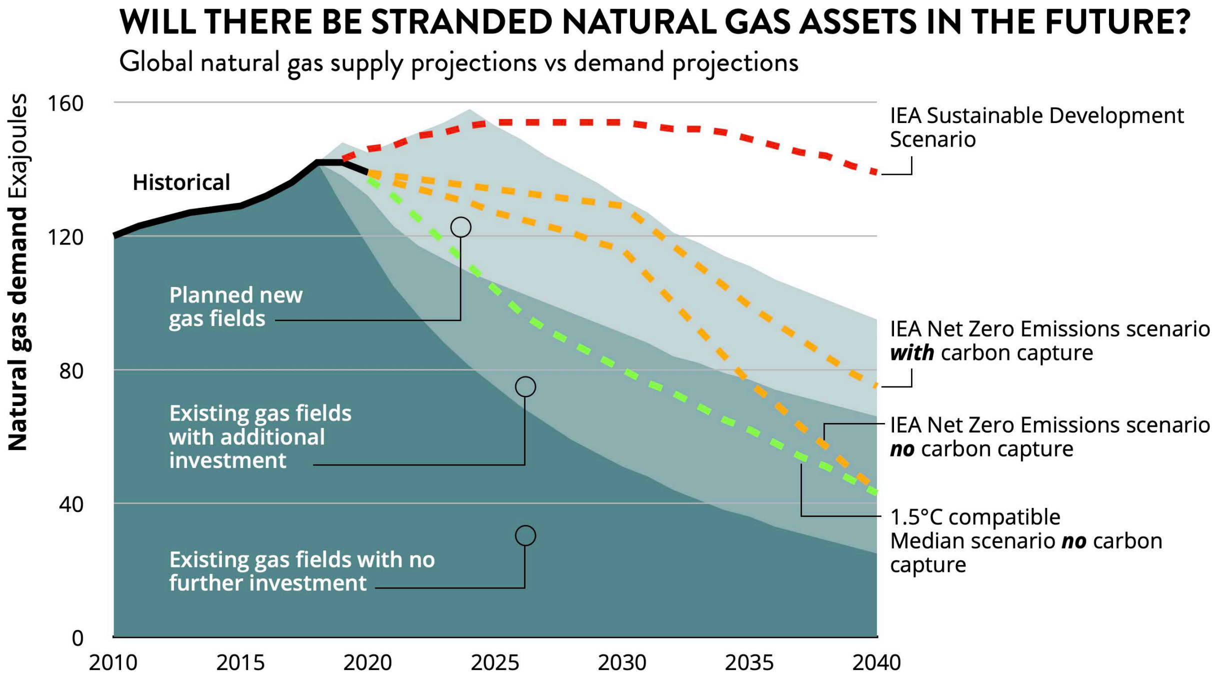

Figure 13: Gas demand vs supply under 1.5°C compatible scenarios and the IEA's NZE and SDS scenarios.

This makes clear a few points.

First, total demand between 2025 (when the two demand curves, from the NZE and SDS, diverge), to 2040 is cut by more than half compared to what Woodside estimates.

Second the natural gas supply is much greater under current projections than was the case in 2020, when the IEA initially published this graph.

Accounting for this increased production potential reinforces, in the specific case of gas, the clear statement in the NZE (IEA, 2021d) that "*the rapid drop in oil and natural gas demand in the NZE means that no fossil fuel exploration is required and no new oil and natural gas fields are required beyond those that have already been approved for development*."

The increasingly important role of CCS in emissions reduction implies that the need for natural gas is much lower if CCS is excluded. This means there is a gap between the IEA's estimated availability of gas in the period before 2035 and the demand curve for unabated natural gas. The median of 1.5°C pathways is significantly lower in the period through to the mid 2030s then the IEA NZE scenario, indicating there may be other opportunities to meet energy needs without resorting to natural gas**.**

Table 11: Gas demand for median of 1.5°C compatible pathways compared to IEA NZE scenario

	2019	2020	2030	2040	2050
NZE Unabated (EJ)	139	136	116	44	17
NZE w/CCS (EJ)		1	13	31	43
NZE all gas (EJ)	**139**	**137**	**129**	**75**	**60**
1.5°C Unabated (EJ)	126	128	89	43	31
1.5°C w/CCS (EJ)	0	0	5	14	22
1.5°C all gas (EJ)	**126**	**128**	**94**	**57**	**53**

Supply of unabated, sequestered (w/ CCS), and total gas (EJ) in TPES under the IEA's NZE (IEA, 2021d) *and under the median of a range of 1.5°C compatible global energy system pathways.*

LNG demand and 1.5C compatible pathways

One of the key developments in natural gas use in the energy system in the last decade has been the rise of liquefied natural gas (LNG), which has been touted as a cleaner alternative to coal, and for which there are substantial expansion plans globally.

Emissions from LNG supply and end use had reached an estimated 1.25 GtCO_2e/yr (~17% of emissions from natural gas) by 2020, and LNG accounted for about 12% of total gas use globally in 2020, with growth under present policies being close to 16% of gas demand globally by 2035.

LNG is a very carbon-intensive fuel source and considering emissions in production, manufacture distribution and gasification, including methane leakages, may have a greater GHG footprint than coal-fired generation when used for power production.

Because of its carbon intensity and cost, the IEA NZE Pathway projects a rapid collapse of the LNG trade at the global level, which will be felt differently in different regions.

This report presents an important case example of the likely impacts of a declining global demand for natural gas under Paris Agreement, that of the world's largest LNG exporter, Australia, whose LNG trade can, under the IEA NZE pathway, be expected to collapse faster than the global average to close to 25% below 2020 levels by 2030 and to halve by 2040.

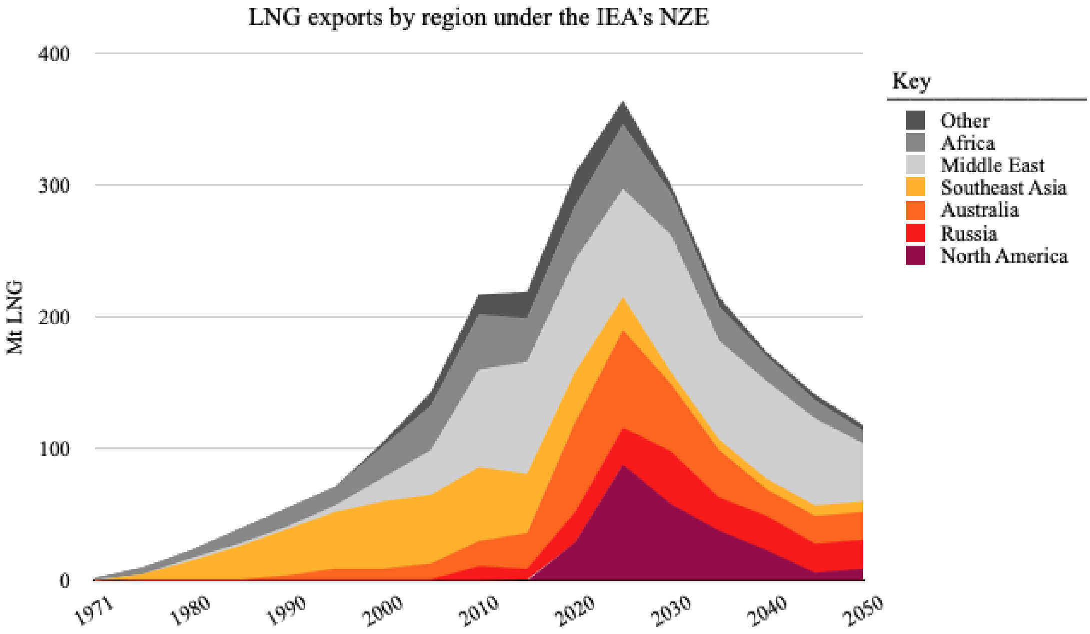

Figure 14: LNG exports by region under the IEA's NZE

Source: (IEA, 2021d).

Being formulated on the premise of a net zero emissions world in 2050, the outlook for natural gas demand in the NZE differs significantly from that in the SDS. As shown in Figure 14 under the NZE, Australia's LNG exports will decrease from a peak of around 74.3 Mt LNG (101 bcm) in 2025 to around 20.3 Mt LNG (27.6 bcm) by 2040 (IEA, 2021d).

PLUTO-SCARBOROUGH GREENHOUSE GAS INTENSITY AND THE PARIS AGREEMENT

One of the key arguments that is made by Woodside is that displacing coal in power grids in Asia assists in reducing emissions and thereby assist and reaching the goals of the Paris agreement. Much of this argument hinges on the greenhouse gas intensity of LNG when used to generate power compared to coal, however what is overlooked by Woodside is the rapidly changing and reducing emission intensity of electricity required under the Paris agreement.

In this section we unpack a number of the arguments.

Woodside draws upon commissioned work from the consultancy ERM. In its Comparative Life Cycle Assessment of the Browse and Scarborough gas fields, ERM attempts to show the positive climate impacts for likely LNG importing countries of generating power from gas sourced from Scarborough and Browse gas basins (McConnell and Grant 2019). ERM calculates emissions intensities for power generated from Scarborough and Browse LNG and compares this with that of a baseline grid. This baseline is the "fossil" grid emissions intensity taken from three scenarios reported in the IEA's 2019 World Energy Outlook (WEO): Current Policy (CPS), Stated Policy (STEPS), and Sustainable Development (SDS).

As has been previously pointed out none of these scenarios are consistent with the Paris agreement and in particular the comparison between the SDS scenario and others is not a valid way of looking at the role of LNG in reducing emissions to levels consistent with the Paris agreement.

Analytically the use of a purely fossil-fuel based grid as a baseline for emissions intensity obfuscates the reality of the emissions picture for the LNG importing countries.

Japan, for instance, generated 23% of its electricity from renewables in 2020, and another 5% from nuclear energy (Climate Transparency 2021b). Its new renewables target for 2030 is 36-38% (Climate Action Tracker 2021). Likewise, China generated 29% of power from renewables, and 5% from nuclear in that year (Climate Transparency 2021a).

The IEA NZE scenario envisages a very rapid decarbonisation in which renewables and other zero carbon technologies are ramped up very quickly whilst coal and gas are substantially reduced rapidly. The IEA STEPS scenario is consistent with present current policies globally which has a median warming of around 2.7°C above preindustrial. The IEA SDS scenario is closer to 2°C pathway and hence not Paris Agreement compatible.

It is inappropriate in this context for ERM to argue that using a fossil-fuel based grid for baseline comparison reflects "most realistically how gas will compete in the target markets" and that "gas-on-renewables competition" is limited (McConnell and Grant 2019).

ERM does acknowledge that the "average" grid in these countries has a significantly lower emissions intensity than their baseline comparator. However, even when discussing the "average" grid, the numbers presented by ERM do not appear to align with IEA estimates (IEA 2019).

ERM presents its calculated emissions intensities in units of tCO_2e/MWh, indicating that it is accounting for all GHG emissions and estimates grid emissions intensity values averaged over the years 2026-40. Nonetheless, we can compare the grid intensities ERM provide with our own assessment of the WEO scenarios[25].

Table 12: Grid emissions intensities: IEA scenarios vs LNG sources from Scarborough-Pluto

	ERM[26] calculated country or region intensity (tCO_2e/MWh)		WEO 2019 (tCO_2/MWh) (1)		WEO 2021 (tCO_2/MWh) (1)			ERM calculated LNG (tCO_2e/MWh)		CA calculated LNG intensity (tCO_2e/MWh)
	STEPS Av.	SDS Av.	STEPS Av.	SDS Av.	STEPS Av.	SDS Av.	NZE Av. (2)	Browse	Scarborough	Pluto Train 1 and 2 average
China	0.59	0.42	0.50	0.31	0.46	0.32	0.18	0.56	0.49	0.63
Japan	0.44	0.3	0.31	0.16	0.26	0.19	0.11	0.5	0.44	0.46
ASEAN	0.61	0.36	0.52	0.27	0.50	0.30	0.17	0.57	0.49	0.54
India	0.63	0.35	0.53	0.29	0.46	0.25	0.14	0.57	0.49	0.56
Global	0.48	0.33	0.39	0.22	0.35	0.21	0.12	0.61	0.52	0.56

Grid emissions intensities for different markets under IEA scenarios compared with emissions intensity of power generated by LNG sourced from Browse and Scarborough gas fields (IEA, 2019, 2021f; McConnell & Grant, 2019).

Notes (1) IEA estimates are for CO2 only, for CO2 equivalent approximately 2% would need to be added. This does not make a significant difference to the comparison with the CO2 equivalent intensities

(2) these intensities illustrative only as they are scaled to the global change between SDS and NZE

As can be seen from Table 12, the grid emissions intensities for the LNG importing markets are likely to be lower than what has been calculated by ERM using the data from (IEA 2019). Moreover, as can be seen in the Table, the IEA has revised its grid intensity estimates in the most recent edition of the WEO, (IEA 2021b). As it stands, the STEPS scenario in the importing countries results in generally lower grid emissions intensities than what can be delivered by Scarborough-sourced LNG, with the exception of the ASEAN region, even though this scenario would warm the world by 2.7°C above preindustrial.

The emissions intensities under the SDS are lower still – 30% in the case of China, but the NZE with more realistic greenhouse gas intensity reductions for electricity generation consistent with the Paris agreement is at least another 40% or more lower.

In Table 12 we have given IEA reported grid emissions intensities averaged over the period 2026-40. This aggregate does not reflect the fact that these emissions intensities are set to significantly decrease over the given time period as can be seen in Figure 15. These intensity reductions are due to a move away from coal and oil in power production. While the STEPS scenario does see gas replacing other fossil fuels, most of the shift is to renewable generation. Under the SDS, renewables account for an even greater share[27]. The IEA has not published country and regional breakdowns for the NZE, however at the global level this trend continues NZE having higher again renewable penetration, some 15% higher than in the SDS, with more corresponding displacement of fossil fuels. This trend can be expected to apply also at the national and regional level.

25 The WEO grid emissions intensities in Table 12 are calculated from the IEA reported total TWh of power generated and total MtCO2 emissions from the electricity and heat sectors. For this reason, they represent a maximum value for grid intensity.

26 ERM report by McConnell & Grant, 2019).

27 As an example, in Japan gas currently accounts for 37% of power generation. This decreases to 17% and 7% in 2040 under the STEPS and SDS respectively. At the same time, renewables share increases from the current 23% to 42% and 53% under the STEPS and SDS respectively. Similar transformations occur for the other target countries/regions.

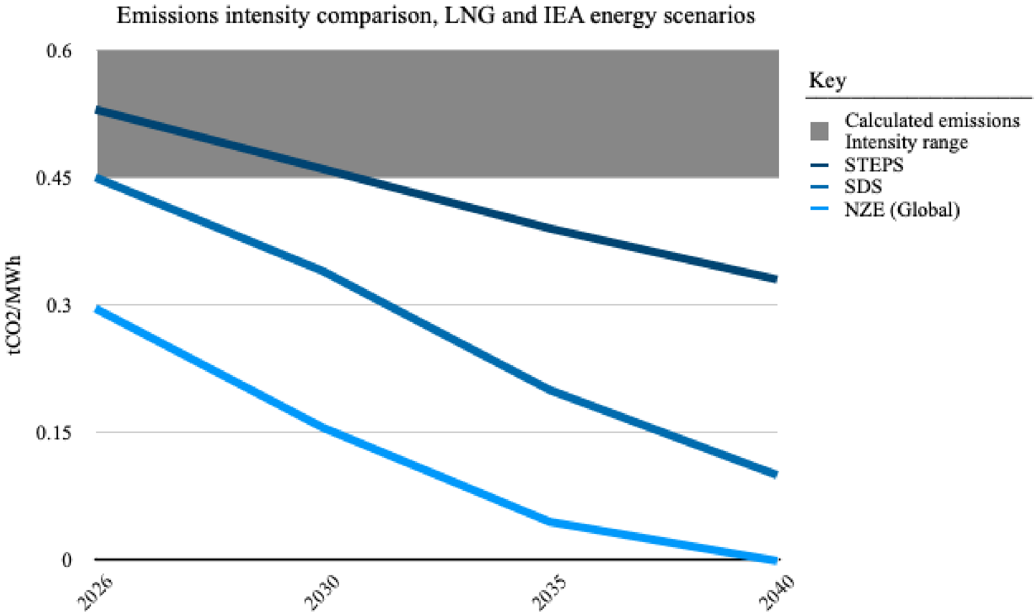

Figure 15: Decrease in power generation emissions intensity required under IEA STEPS, SDS, and NZE
Notes: To compare like with like, here we have assumed that CO_2 accounts for 98% of the total in the GHG emissions intensity values from Another question is how exactly ERM arrived at the LNG-generated power emissions intensity values. Below, we estimate this value using ranges for the key inputs. Using the assumptions outlined in the ***Table 13*** *below we arrive at an LNG-generated power emissions intensity of between 0.46-0.62 tCO2e/MWh which is in general higher than those estimated by ERM. In* ***Table 13*** *below we have estimated the emission intensity of LNG power in major Asia markets based on standard GHG emission factor for LNG sourced from the Scarborough-Pluto Project and compared these with ERM results from 2019 for gas sourced from Scarborough.*
Table 13. The STEPS and SDS series are weighted averages of the China, Japan, ASEAN, and India emissions intensity values using as weights the assumed distribution of Browse and Scarborough gas taken from (McConnell & Grant, 2019). *The NZE series is the global aggregate.* (IEA, 2021f).

Another question is how exactly ERM arrived at the LNG-generated power emissions intensity values. Below, we estimate this value using ranges for the key inputs. Using the assumptions outlined in the Table 13 below we arrive at an LNG-generated power emissions intensity of between 0.46-0.62 tCO_2e/MWh which is in general higher than those estimated by ERM. In Table 13 below we have estimated the emission intensity of LNG power in major Asia markets based on standard GHG emission factor for LNG sourced from the Scarborough-Pluto Project and compared these with ERM results from 2019 for gas sourced from Scarborough.

Table 13: Emissions intensity for LNG-generated power

Country/Region	Gas to power conversion efficiency 2020s (1)	Pluto Train 1 and 2 average (2)	ERM study - Scarborough	
	%	tCO_2e/MWh	tCO_2e/MWh	
China	40%	0.6252	0.4900	28%
Japan	55%	0.4576	0.4400	4%
ASEAN	46%	0.5402	0.4900	10%
India	45%	0.5566	0.4900	14%
Global	50%	0.5600	0.5200	8%

Notes

(1). The average of conversion efficiency from gas primary energy content to electrical power based upon data in IEA WEO 2021 for 2020 and 2030 under the SDS scenario.

(2) Assuming

- LNG energy content of 54.5 MJ/kgLNG

- Carbon content of LNG from North West Shelf gas of 2.79 tCO2/tLNG based on Edwards, J. H. et al. (1996) and Table 1 of American Petroleum Institute (2015) https://www.api.org/-/media/Files/EHS/climate-change/api-lng-ghg-emissions-guidelines-05-2015.pdf,

- GHG intensity of production of LNG from Pluto project from 2016 estimated in this report of 0.37 tCO2e/tLNG

- Market specific shipping losses based on loss rates per 1000 km of transport from range of technologies reviewed by Pace Global (2015) (see Exhibit 7-1: Summary of GHG Emissions and Relevant Inputs for LNG Shipping). LNG market weighted average of 0.095 tCO2e/tLNG feed.

- Average regasification and final distribution losses as fraction of carbon content of NWS LNG as specified above from ERM (2019) estimated as 0.19 tCO2e/tLNG

The ERM study makes the case that the LNG importing countries can reduce emissions from power generation by utilising Scarborough-sourced LNG. To show this, the report analyses a scenario in which these countries (India, China, Japan, ASEAN) cumulatively import a total volume of LNG equating to approximately 656 TWh over the period 2026-40[28]. This scenario indicates that replacing this amount of generation from the "fossil grid" with Scarborough LNG generated power results in a savings of 259 and 165 $MtCO_2e$ for electricity generation under the IEA's STEPS and SDS respectively[29].

In Table 14 we have recreated this analysis using the updated STEPS and SDS data from (IEA 2021b) and our calculated scope 3 emissions intensity values. As can be seen, while the general result holds, the savings have decreased to 180 and 85 $MtCO_2e$ for the STEPS and SDS fossil grids respectively.

28 This TWh value has been calculated using the ERM reported average scope 3 emissions intensity (tCO2e/MWh) for each country, the distribution of gas volume delivered, and the total emissions (MtCO2e) from LNG generated power over the period 2026-40.

29 Note that ERM are referring to (IEA 2019)

Table 14: Total emissions from power generation which may be replaced by Scarborough-sourced LNG in importing regions.

	STEPS (1)		SDS (1)		NZE (2)		Scarborough (3)
	Fossil grid	**Whole grid**	**Fossil grid**	**Whole grid**	**Fossil grid**	**Whole grid**	
Calculated ($MtCO_2e$)	544	284	450	176	339	96	364
ERM ($MTCO_2e$)	576		482				317

Notes

(1) *These emissions over the period 2026-40 have been calculated by first determining emissions intensities for the LNG importing countries (China, Japan, ASEAN, India). This is done using TWh generation and $MtCO_2$ emissions data for the STEPS and SDS from* (IEA 2021b). *As the IEA reports aggregate emissions for the electricity and heat sectors, the emissions levels represent an upper bound. Using the data, we calculate tCO_2/MWh emissions intensity values for each country. This is done for both the fossil fuel portion of the grid and the whole grid. As the IEA only provides data for interval years, we have here used linear interpolation for the intervening years so as to cover the entire time period 2026-40. The emissions intensity is then multiplied by the assumed amount of generation from Scarborough-sourced LNG, 656 TWh. As this amount is for the entire time period, we assume that it is distributed equally over the time period, i.e., 43.8 TWh p.a. This annual amount of LNG is delivered to the target countries according to the distribution factors in* (McConnell and Grant 2019)*: China (31%), Japan (24%), ASEAN (27%), India (19%). Using these factors, we calculate a weighted sum of the $MtCO_2$ emissions resulting from 43.8 TWh p.a. of grid generation (fossil or whole accordingly) under STEPS or SDS over the period 2026-40. To calculate GHG emissions, we assume that non-CO_2 gases contribute a further 2%.*

(2) *For the NZE emissions, calculations are done as stated above. However, as the IEA does not provide country-specific NZE data, the tCO_2/MWh emissions intensity is based on a scaling from the global NZE data. Specifically, we have used the global share of TWh generation and $MtCO_2$ emissions for each country under the SDS as scaling factors. Once calculated separately, these derived NZE generation and emissions values are in turn used to calculate the emissions intensity values.*

(3) *To compare the grid generation emissions under the IEA scenarios we calculate the emissions due to the same amount of generation using Scarborough-sourced LNG in the importing countries. Our calculated Scarborough LNG emissions value is calculated using the country-specific "Pluto Train 1 and 2 average" intensities in Another question is how exactly ERM arrived at the LNG-generated power emissions intensity values. Below, we estimate this value using ranges for the key inputs. Using the assumptions outlined in the **Table 13** below we arrive at an LNG-generated power emissions intensity of between 0.46-0.62 tCO2e/MWh which is in general higher than those estimated by ERM. In **Table 13** below we have estimated the emission intensity of LNG power in major Asia markets based on standard GHG emission factor for LNG sourced from the Scarborough-Pluto Project and compared these with ERM results from 2019 for gas sourced from Scarborough.*

(4) *Table 13 above. As opposed to the IEA scenarios, the emissions intensity from Scarborough-sourced LNG generated power is not assumed to be subject to dynamic reduction effects, as illustrated in Figure 15. Therefore, the calculation here is an aggregate over the entire period 2026-40. The LNG distribution factors used in the IEA scenario calculations is the same as is the total amount of generation due to Scarborough LNG.*

The results of our analysis, which follows ERM, are not surprising. Carbon emissions from LNG-generated electricity are lower than that from coal and oil. This is well established. So, replacing the latter two fuels with the former will obviously result in lower CO_2 emissions from power generation. However, the underlying assumption that the "fossil grid" is the "appropriate comparator" for LNG sourced power is not justified, as we have explained above and further shown in our recent reporting (Climate Analytics 2021)

If we instead base our comparative analysis on the whole grid (including generation from non-fossil fuels) as opposed to only the fossil fuel portion, the results tell a wholly different, and we would argue, more accurate description of the real emission effects of an attempt to substitute LNG into rapidly decarbonizing grids. As shown in Table 14, replacing generation from the grid with Scarborough-sourced LNG does not reduce emissions but rather increases them by 81 to 189 $MtCO_2e$, for the STEPS and SDS respectively, over the period 2026-40.

As we have explained above, neither the STEPS nor the SDS are Paris Agreement compatible. Therefore, we extend our analysis here to include the NZE. For this scenario, unlike the others, introducing Scarborough LNG into the fossil grid would raise emissions, by 25 $MtCO_2e$ over the period 2026-40. For the whole grid, Scarborough LNG would raise emissions by 268 $MtCO_2e$ over this period.

The IEA scenarios call for a dynamic process in which grid emissions intensities are reduced both through a shift to renewables and through efficiency improvements. This means that both whole-of-grid and fossil grid emissions intensities decline. Therefore, what is critical here, and what ERM ignores in their analysis, is the carbon lock-in from bringing new LNG projects, such as Scarborough-to-Pluto online. Indeed, this is why the IEA states that "*no fossil fuel exploration is required and no new oil and natural gas fields are required beyond those that have already been approved for development*" (IEA, 2021d)

WOODSIDE, NATURAL GAS AND THE PARIS AGREEMENT

Woodside Petroleum Ltd, the company behind the Burrup Hub development, continues to advocate a substantial and multi-decade role for natural gas in transitioning the world to a low emissions economy and in reaching zero emissions globally by around mid-century. It argues that demand for natural gas will increase as countries seek to meet their Paris Agreement commitments, that fossil gas and in particular LNG is needed to meet the Paris Agreements long term goals.

Woodside argues that the Burrup Hub development, and specifically Scarborough and the Pluto Train 2 expansion[30] are important for the world's aims to reduce emissions to net zero by 2050.

Woodside's 2020 Sustainability Report exemplifies the company's line of argument with regards to LNG's role in a future "sustainable" energy system:

"LNG is relatively lower carbon than other fossil fuels on a lifecycle basis, so enables countries to take immediate action on emissions reduction whilst delivering energy supplies. It has other benefits too: it is lower in local air-quality pollutants than other fossil fuels; it can be diverted between destinations to match fluctuating demand; and it can provide "firming" capacity with renewables to accelerate their roll-out. Gas is used in many sectors – such as industrial, commercial, residential and transport applications – where emissions can be hard to abate through electrification." (Woodside, 2021b).

Woodside has used the IEA's SDS scenario to justify its development of the Scarborough field, claiming that it would go to fulfilling demand not met, under the SDS, by supply from current and expected investments in existing fields (IEA, 2020b; Woodside, 2020b). In this section, we find that it is highly problematic that the IEA SDS scenario is used to justify Paris Compatibility of gas when the scenario has a high probability of exceeding the 1.5°C temperature limit.

Woodside in its Scarborough Offshore Project Proposal, claims that under the IEA's SDS scenario, for the company's key exporting markets (China, Japan, India, and SE Asia) "*gas and zero carbon energy (mostly nuclear, solar and wind) fill the gap left by decreased coal and oil demand*."

30 https://www.woodside.com.au/what-we-do/australian-growth-projects/pluto-train-2

It further states that "*in the absence of projects such as Scarborough to meet this demand, the alternatives are other gas sources, coal and oil*" and that these alternatives will lead to higher emissions than that of the Scarborough development. Woodside makes reference to IEA SDS estimates that have Chinese gas demand reaching over 300 Mtoe in 2040 (around 12.5 EJ) (Woodside, 2020b).

Woodside claims there will be an increasing global LNG demand even under Paris Agreement "compliant" pathways and that there is a gap between available gas resource and this demand, thereby providing a justification for resource expansion, including additional LNG export capacity (Woodside, 2020a). In making this claim Woodside deploys the International Energy Agency's (IEA) Stated Policy (STEPS), Sustainable Development (SDS), and Net Zero Emissions by 2050 (NZE) scenarios.

Based on the increasing, and unmet, future gas demand shown in the SDS and NZE scenarios, the company argues that "*there is significant demand for investment in gas supply to meet global energy demand in 2030".*

The STEPS scenario is clearly not compatible with the Paris Agreement, as it leads to global mean warming of about 2.7 degrees. Woodside claims that IEA's SDS scenario is compatible with the Paris Agreement's long term (1.5˚C) temperature goal, but this is incorrect, and hence the claim that increased global demand for natural gas under this scenario is Paris Agreement compatible is also incorrect (Brecha et al., 2021).

Indeed, this fact led the IEA to develop its Net Zero Emissions by 2050 scenario. The NZE scenario has characteristics in line with the Paris Agreement, it overestimates unabated gas consumption over the next decade, and has conservative assumptions on the availability of low carbon alternatives for non-electricity applications of natural gas[31].

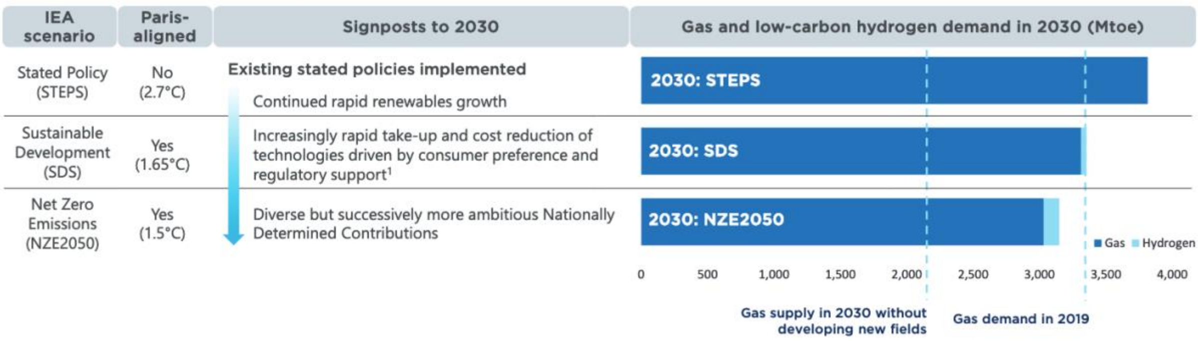

Figure 16: Gas demand (Mtoe) in 2030 under the IEA's STEPS, SDS, and NZE as appears in (Woodside, 2020a). Average global temperature increase (above pre-industrial) for each scenario is shown.

Figure 16 from Woodside purports to show that there is a gap between the available supply of natural gas globally and gas demand projected by 2030, in what is claimed by Woodside to be Paris Agreement compatible scenarios (SDS, NZE).

This conclusion is questionable, given the median of the 1.5° pathways published by the IPCC SR1.5 indicate the likely demand is towards 2000 Mtoe close to or below the available supply from existing

31 See "Gas is the New Coal" report for details: https://climateanalytics.org/media/gas_is_new_coal_nov_2021_1_1.pdf

gas fields, along with the evidence that the NZE is likely to overestimate the likely natural gas demand under Paris Agreement implementation.

It bears emphasising that in justifying the Scarborough-Pluto development based on future projections of increased natural gas demand, Woodside does not differentiate between unabated and abated natural gas.

At most, the role of Carbon, Capture, and Storage (CCS) is mentioned in passing, as a “potential opportunity,” in Woodside’s latest sustainability reporting (Woodside, 2021b). This critical point which will be addressed later in this report as the company is essentially asking policy makers to support very large scale, rapid deployment of carbon capture and storage technologies applied to natural gas combustion. Such deployment is nowhere visible in global energy markets and is judged here to be incompatible with present technological trends and likely future developments.

In relation to its operations in WA, Woodside is also arguing its recent initiatives put the company on track towards net zero by 2050 and reducing overall greenhouse gas emissions accordingly. In this it is referring to its equity share of direct, or Scope 1 and 2, emissions (Woodside, 2020a, 2021d). The company cites its decarbonisation efforts on offshore sites, carbon offset business, and investments in blue and green hydrogen development, as “levers” which facilitate the achievement of Paris compatible emission reductions in Western Australia and Australia at large (Woodside, 2020a).

Expected LNG demand and decarbonisation efforts under its net zero aspiration for 2050 are critical arguments the company is using to justify its Scarborough development and the development of a second train for its Pluto project.

To be clear, here Woodside is following a narrative commonly used by gas proponents that claims:

- Switching from coal to gas will lower power sector emissions ensuring system reliability
- Gas allows for a greater integration of renewables in the power sector
- Gas is necessary to reduce emissions in hard to abate sectors such as industry, particularly due to its use in the production of hydrogen

Each of these arguments turns out to be limited in applicability or incorrect, given recent developments in the technology area. These issues are unpacked in another report “Why gas is the new coal” and will not be explored in detail here[32]. However, in summary:

- Natural gas emissions over the entire lifecycle are critically underestimated, and lower emissions are not a solution when there is a lower cost alternative to both coal and gas. Renewable energy, solar and wind, have falling costs and are among the cheapest options for new generation.
- Renewable energy and storage technology ensure system reliability, and storage technology allows for greater integration of renewables, particularly in light of technological learning, manufacturer experience and lower costs.
- Green hydrogen (produced from renewable energy) can reduce emissions in hard to abate sectors while keeping in step with the Paris Agreement.

The IEA estimates green hydrogen (with solar PV) could be produced in the lowest cost renewable regions for less than USD 1.5/kg by 2030, comparable to cost of blue hydrogen (IEA, 2021b).

32 https://climateanalytics.org/publications/2021/why-gas-is-the-new-coal/

Bloomberg New Energy Finance (BNEF) expects green hydrogen to outcompete blue hydrogen in all major markets by 2030 (BNEF, 2021).

In Australia, hydrogen derived from solar PV could have one of the lowest estimated delivered green hydrogen costs to large-scale industrial users in 2030 globally, at USD 1.48/kg and USD 0.84/kg by 2050, due to the renewable energy resources and storage resources available (Hydrogen Economy Outlook, 2020).

CSIRO estimates Australian renewable hydrogen for industrial fuel will be cost competitive with natural gas hydrogen for feedstock *before 2025* (CSIRO, 2018). Blue hydrogen is highly emissions intensive, and further investing in this technology will lock in carbon intensive infrastructure and could crowd out the rapid scale-up of green hydrogen (Climate Analytics, 2021).

A critical part of Woodside's argument for why natural gas fits within a Paris Agreement world is a reliance on the rollout a massive scale of carbon capture and storage.

Paris Agreement compatible energy transition pathways show a rapidly declining use of unabated natural gas in the power sector. The IPCC 1.5°C compatible pathways show around 10% of power sector use of gas being subject to CCS by 2030 (Figure 17). There is absolutely no sign of this scale of CCS capacity in the global CCS pipeline.

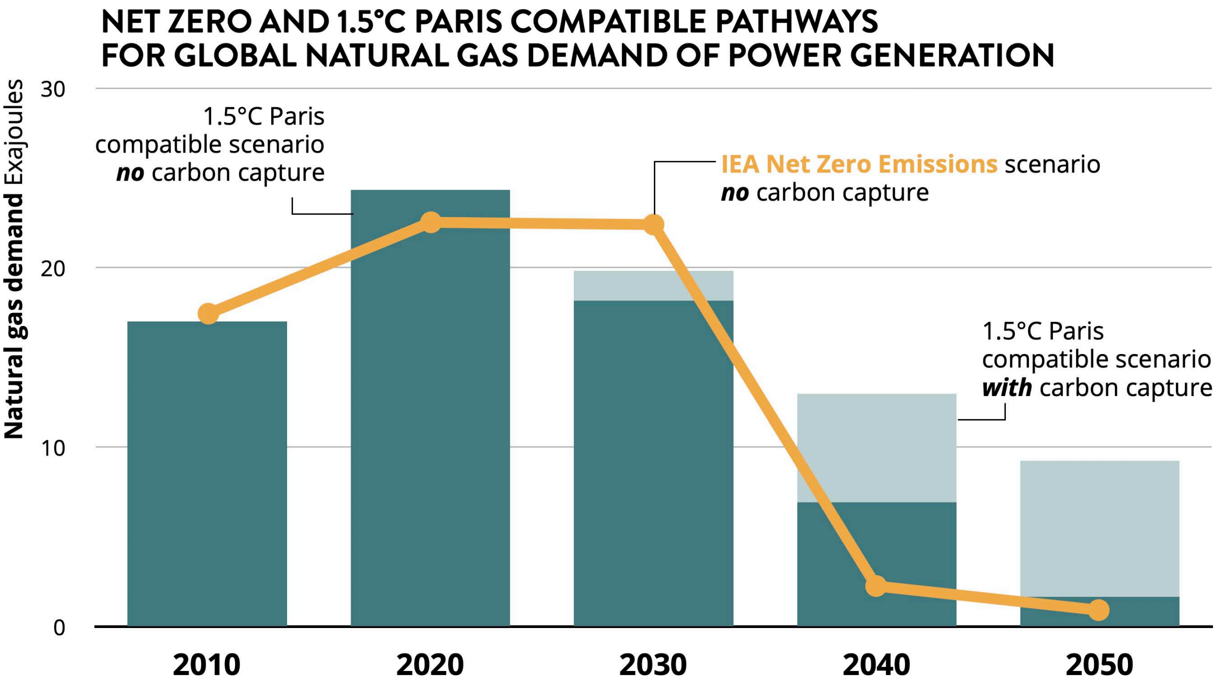

Figure 17: Gas powered generation under Paris compatible pathways with and without CCS. The indicated NZE pathway is for unabated natural gas generation.

There are still many barriers towards the very large-scale rollout of CCS implied by the IEA scenarios, with cost being the most significant. This stands in sharp contrast to solar energy, wind energy and electric storage, which have all witnessed dramatic cost reductions over the past decade, and which produce little to no emissions. The cost of renewables is now well below the cost of fossil fuel power, including with CCS.

Relying on carbon capture and storage is unsafe, very expensive and unlikely to work

THE IMPACT OF CONSULTING FIRMS ON VIEWS ABOUT GAS AND THE PARIS AGREEMENT

An important influence on policy that has been observed is that several consulting firms who are engaged by government and the oil and gas sector in general, have views about the role of natural gas in Paris Agreement implementation that are inconsistent with the available science. It is therefore important to provide some insight into these perspectives as part of this report.

Consulting companies, such as McKinsey & Company and Wood Mackenzie, contribute to the narrative that natural gas has an important and increasing role to play in future energy systems over the next several decades, by projecting significant increases in gas demand while generally avoiding discussion on climate and emissions reductions. An example of this, is Figure 18 below, taken from a 2019 McKinsey report (McKinsey & Company, 2019).

Figures such as these have a very important and adverse impacts on the understanding of governments and policy makers about the role of natural gas in the Paris Agreement transition. Uncritical acceptance of these projections is, in our experience, commonplace in many places, including in government and political circles in Western Australia (Figure 18).

The McKinsey company example shows a substantial gap between projected demand for LNG and available supply, which, if correct, would give comfort to those considering investing in, or permitting developments such as Scarborough, to go ahead.

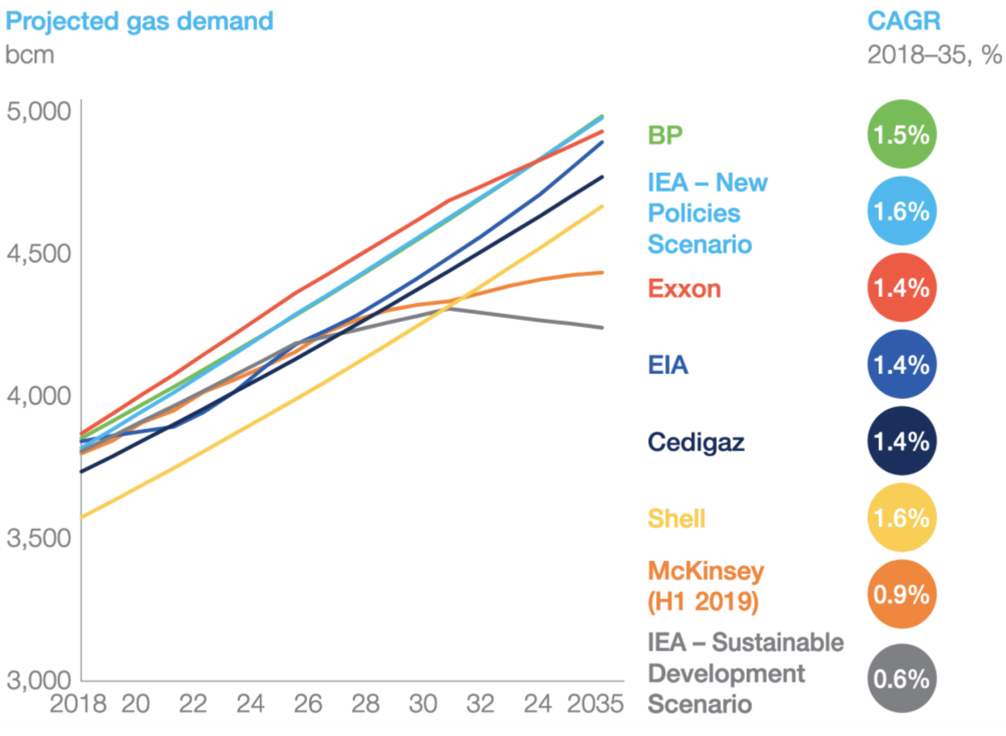

Figure 18: Chart from (McKinsey & Company, 2019) showing an expected increase in natural gas demand under various institutional scenarios.

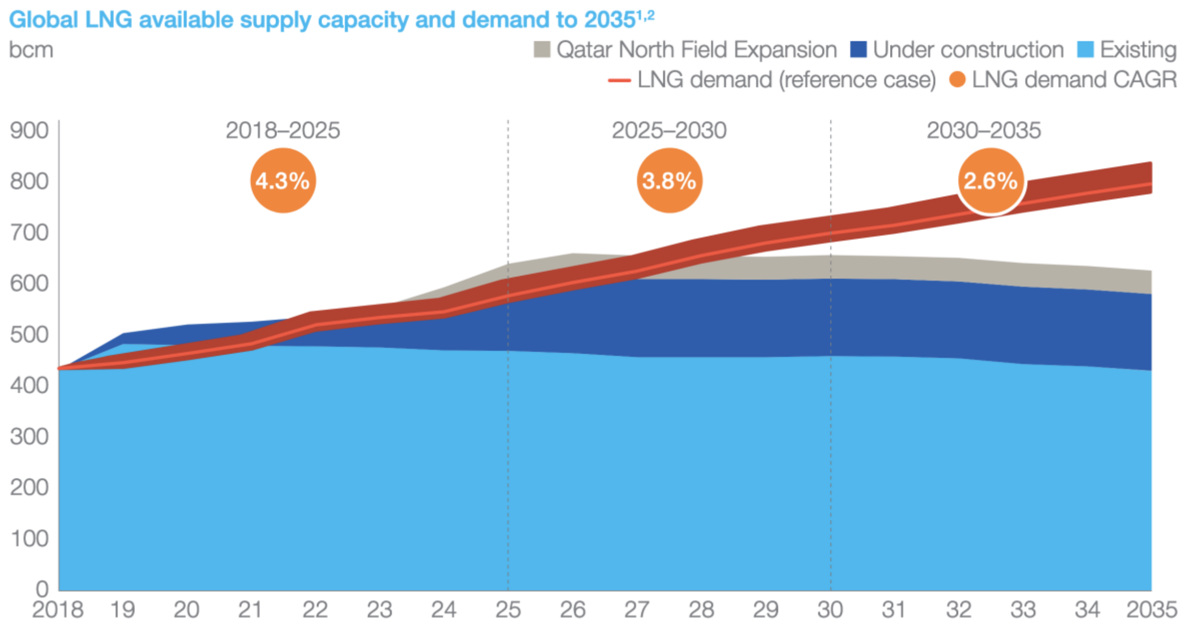

Figure 19: Chart from McKinsey showing an expected gap between future natural gas supply and demand beginning in the late 2020s.

Source: (McKinsey & Company, 2019)

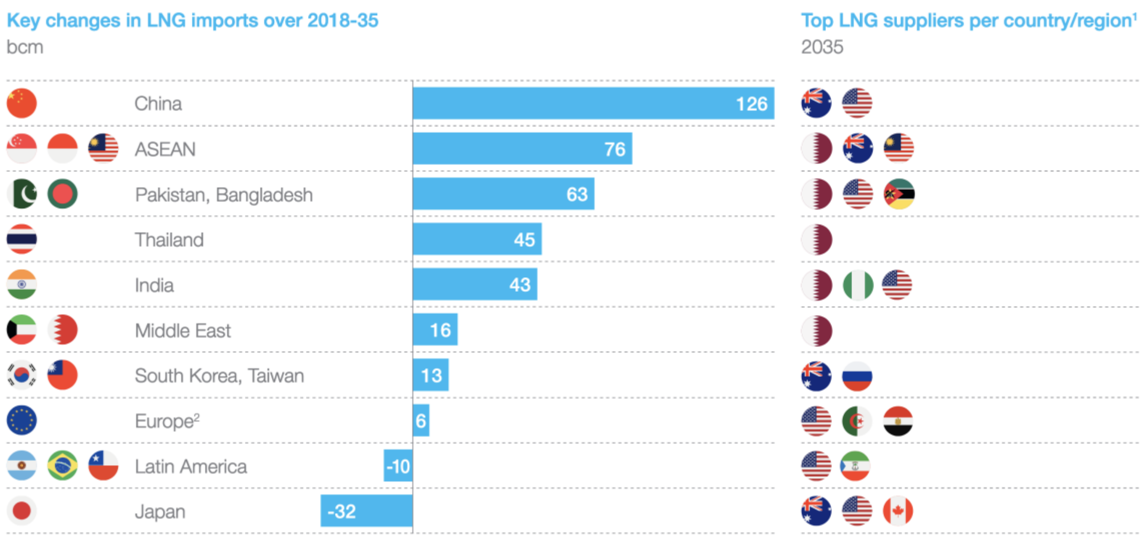

Figure 20: Chart from McKinsey showing an expected increase in natural gas demand in most regions.

Note that this chart suggests that gas demand will be greatest in those regions for which Australia is a top supplier. Source: (McKinsey & Company, 2019)

In its most recent global gas outlook, McKinsey does recognise that the emissions intensity of LNG will be a critical factor in determining future demand and costs, noting that "*global emissions regulations are set to grow in geography and scope*" and that this could potentially restrict opportunities to supply LNG for higher emission projects. Nonetheless, it forecasts that more than 200 Mt LNG/yr (272 bcm) of new capacity will be needed by 2050 to meet projected demand[33]. (McKinsey & Company, 2021). This is in line with its earlier projection that a supply gap of 200-220 bcm will open by 2035 (McKinsey & Company, 2019).

33 Using conversion factor of 1 million tonnes of LNG (Mt LNG) = 1.36 billion cubic metres of natural gas (bcm) taken from (BP, 2021).

This is in stark contrast to the LNG projections contained in the IEA's NZE scenario[34], which projects close to a 65 reduction in LNG capacity needs by 2050 rather than a growth.

A more recent McKinsey article on the impact of decarbonisation on the gas and LNG industry is more circumspect and acknowledges that these projections, which reflect current trends in policy and technology, would lead to a temperature rise of 3.5°C above pre-industrial levels by 2100 (Agosta et al., 2021).

Moreover, in a report specifically on pathways limiting warming to 1.5°C, the consulting firm has natural gas demand decreasing by 20-35% by 2030, in contrast to the aforementioned reference case which has gas demand peaking in 2037 and LNG demand peaking in 2046 (Henderson et al., 2020; McKinsey & Company, 2021).

Another example is energy consulting firm Wood Mackenzie which has begun to recognise the effect of emissions regulations on the global LNG outlook noting that "75% of today's LNG demand are covered by countries with carbon neutral goals." However, it frames this as an opportunity for coal-to-gas switching and the use of CCS and gas-based hydrogen production (Wood Mackenzie, 2021). Moreover, it continues to make the case for increased gas demand in Asia, particularly China, as can be seen in a 2020 report Figure 21 (Thompson, 2020).

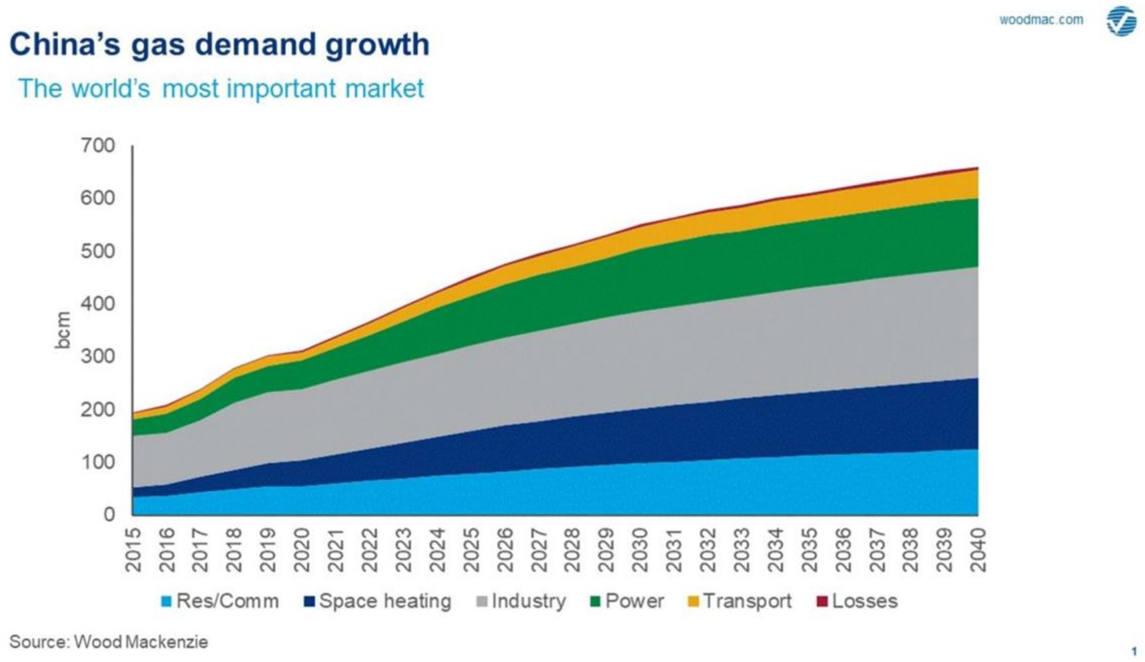

Figure 21: Wood Mackenzie gas demand outlook for China.

Source: (Thompson, 2020).

In another report, Wood Mackenzie introduces a decarbonisation scenario which "considers a possible pathway to limiting global warming to under 2°C by 2050." (Filippenko & Mezentseva, 2020). This temperature goal examined is not consistent with the Paris Agreement and whil3 this "Accelerated Energy Transition" scenario shows a marked decrease in natural gas use compared to baseline projections; it is still higher than levels consistent with the Paris Agreement. Elsewhere, the

34 See Figure 4.17 in IEA NZE report.

consulting firm obfuscates the issue of natural gas' role in the energy transition by categorising LNG contracts which include the purchase of carbon offset credits as "green" (Thompson, 2021). By referring to LNG as "green," Wood Mackenzie dangerously brushes aside the real risks of carbon lock-in and crowding out investment in actually "green" renewables and battery storage.

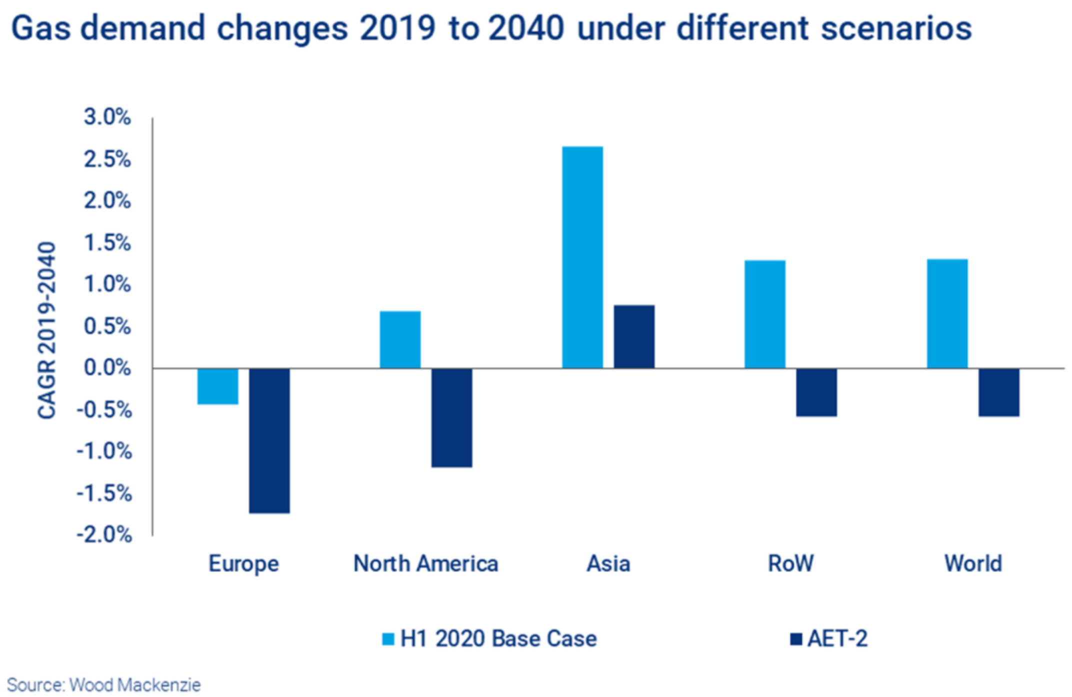

Figure 22: Gas demand changes in 2040 from 2019 levels under Wood Mackenzie's Base Case and Accelerated Energy Transition Scenario-2 (AET-2)

Source: (Filippenko & Mezentseva, 2020).

WA'S LNG EXPORT MARKET UNDER PARIS AGREEMENT IMPLEMENTATION

Having unpacked the claims put forth by Woodside and other proponents of natural as to how this fossil fuel fits into Paris Agreement compatible pathways, we now turn to the question of markets: what is the outlook for demand and supply in the Asia Pacific region, where Woodside sells much of its LNG?

To get an overall sense of the outlook for the region's largest LNG supplier under a Paris Agreement compatible pathway, we examine the IEA's recent projection under its NZE. Extracting Australia's projected exports of LNG from the IEA's net zero pathways study, one sees immediately that exports peak by the mid 2020s and drop substantially to be at or below 2018 levels by 2030, and below 2015 levels by the late 2030s.

Figure 23 maps the history of West Australian and Australian LNG exports against IEA NZE historical and projected demand for the country, and clearly shows that under the IEA's NZE pathway, LNG exports could peak in the mid 2020s and begin a rapid decline, almost as fast as the growth since 2010-2015, to levels not seen since that time. This contrasts with the LNG production capacity projected to be operational in Australia from 2025, which shows an increasing gap. At the least this signals a very difficult market environment for LNG exporters and could signal the collapse of quite a number.

In other words, what Figure 23 shows is that if one assumes that the Paris Agreement is implemented, according to the IEA's energy modelling approach, there is likely a collapse in demand for Australian LNG just over the horizon.

Put another way, it could be argued that Woodside is essentially betting that the world will not implement the Paris agreement, and, will simultaneously roll out carbon capture and storage technology at a scale and rate that is nowhere visible in the present deployment pathways for this technology.

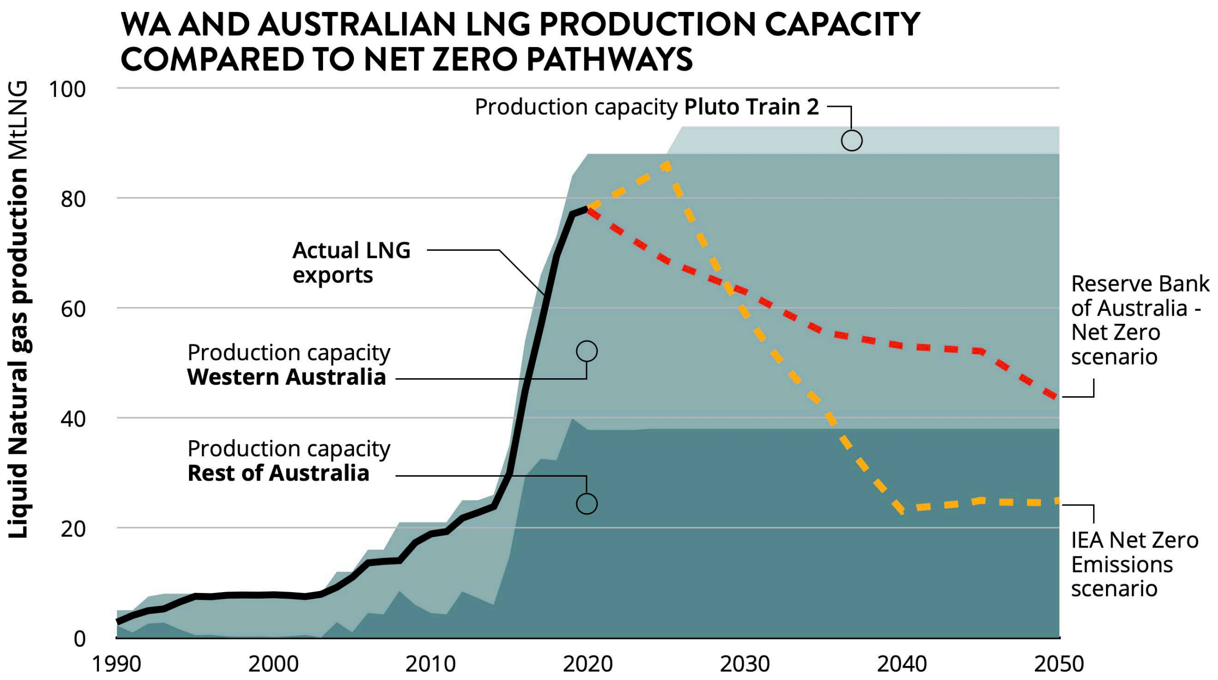

Figure 23: Australian and western Australia's LNG production capacity vs IEA and RBA LNG export Net Zero demand scenarios

Notes: This figure shows Australia and western Australia's LNG exports actual until around 2020 and then production at capacity levels of 90% beyond that time common compared to the IEA Net Zero and RBA projections for Australian LNG exports.

Paris agreement and major LNG importing countries - demand side risk

In order to better understand how a 1.5°C global pathway will affect Woodside's Scarborough project, and its natural gas activities generally, it is important to examine country-level 1.5°C pathways for the company's largest export markets: China, India, South Korea, and Japan. Demand for natural gas will largely decline for Japan and South Korea immediately in most scenarios, whereas in China demand drops within the next decade.

In Figure 24, Figure 25, Figure 26, and Figure 27 we show the gas demand these four key Asian markets under four different Paris Agreement compatible pathways. These country pathways are derived from global least cost pathways taken from the IPCC's special report on the impacts of global warming of 1.5°C above pre-industrial levels (IPCC, 2018).[35] For each of the countries included in Figure 24, from the full set of 1.5°C pathways, we highlight a number of 'illustrative' pathways to assess the level of gas demand (or rather, its contribution to total primary energy supply) that enable reaching this climate goal.[36]

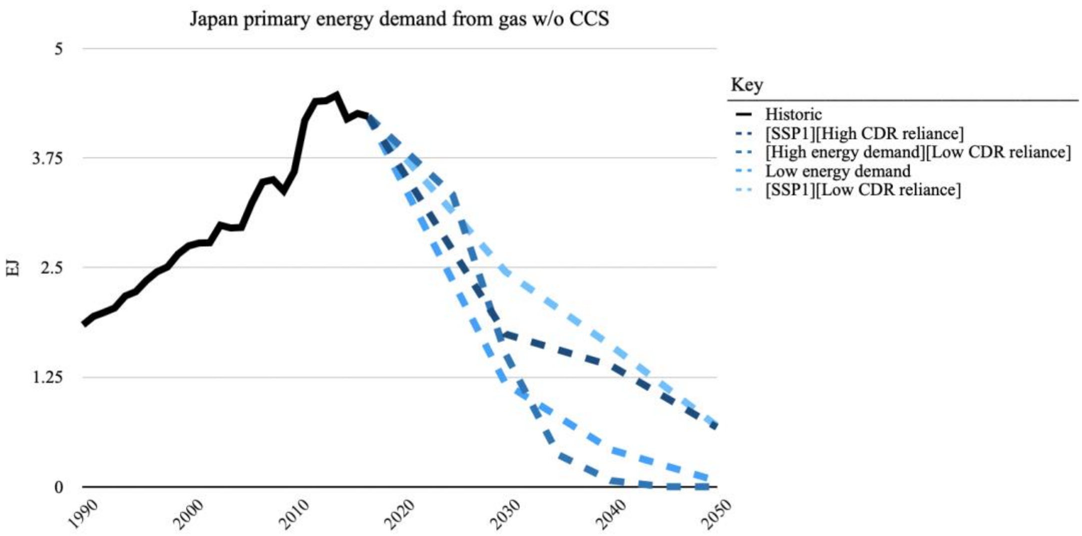

Figure 24: Gas demand in Japan historic and projected under 1.5°C compatible pathways.

Japan saw a sharp increase in natural gas use in the power sector after the Fukushima accident in 2011, but consumption has been declining since 2016. This is due to both the country restarting nuclear power plants and also the increasing cost competitiveness of renewable energy, the latter resulting in plans to build 10 GW of offshore wind capacity by 2030.

This is in line with the Ministry of Economy, Trade, and Industry's proposed revised 2030 electricity mix which sees natural gas' share at 20% (previously projected to be 27%) and renewable energy at 36-38% (previously 22-24%). (Climate Action Tracker, 2021). While the country would likely need to reduce its natural gas consumption even further to be on 1.5°C compatible pathway, these current policies already indicate that gas will play an increasingly smaller role in the country's energy mix.

35 These global pathways are defined as those that limit warming to 1.5°C with no or limited overshoot (<0.1°C). In these pathways, the increase of global average temperature above its pre-industrial level is limited to below 1.6°C for the whole twenty-first century and below 1.5°C by 2100 (typically 1.3°C). (Welder et al., 2021).

36 These 'illustrative' pathways are selected from the range of global least cost pathways included in (IPCC, 2018) as they meet sustainability criteria around the use of carbon dioxide removal (CDR) options. Namely, that the use of bioenergy with carbon capture and sequestration (BECCS) is limited to below 5 $GtCO_2$ p.a., and that the use of afforestation and reforestation is limited to below 3.6 $GtCO_2$ p.a., by 2050. The three pathways thus selected model a future energy demand under a) low CDR relance, b) high CDR reliance, and c) both low CDR reliance and high energy demand. In addition to the 'illustrative' pathways taken from (IPCC, 2018), a fourth pathway, modelling a future low energy demand, is taken from (Grubler et al., 2018). See (Welder et al., 2021) for further details.

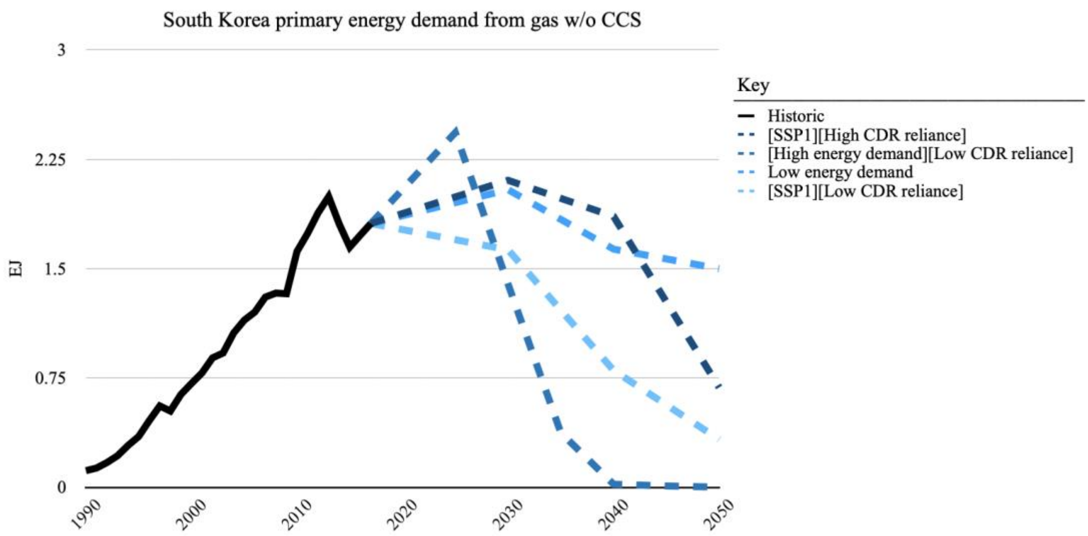

Figure 25: Gas demand in South Korea historic and projected under 1.5°C compatible pathways.

South Korea has seen a similar trajectory in natural gas use as Japan, albeit starting at a lower level. Between 2013 and 2015, natural gas consumption fell by around 17% due, in part to the cost competitiveness of domestic coal over imported gas. Note that the country's self-sufficiency in natural gas is 0.6% meaning that it relies almost entirely on LNG imports to meet demand for this fuel.

The government has recently released a roadmap for carbon neutrality by 2050. The document features two scenarios which achieve this goal. Both scenarios show a reduction in coal and LNG-fired power generation from 2018 levels by 2030, from 41.9% to 21.8% for the former and from 26.8% to 19.5% for the latter.

The first scenario would see the gradual elimination of all thermal power generation by 2050 while the second retains some LNG capacity (5% of total generation in 2050)[37]. However, the second scenario explicitly relies on a significant increase in CCS and direct air carbon capture. (Republic of Korea, 2021; Woo-ri, 2021).

Under a Paris Agreement compatible trajectory, South Korean gas demand stays more or less at around current levels over the next decade before declining, in some cases to zero by 2040. Pathways with a high level of gas demand past 2030 assume a heavy reliance on carbon dioxide removal (CDR) options.

The forecast for Chinese gas demand under 1.5°C compatible pathways is very much dependent on the underlying assumptions regarding energy demand and the use of carbon dioxide removal (CDR), like CCS. Indeed, under a pathway that assumes high CDR reliance, gas consumption increases rapidly to over three times the current level, peaking shortly after 2030, before declining at a somewhat slower but still rapid place and returning to current levels around 2050[38].

37 Scenario B of the 2050 Carbon Neutral Scenarios has LNG generating 61 TWh of power in 2050 (Republic of Korea, 2021). This would equate to 0.22 EJ which is in line with the lower range of the 1.5°C scenarios shown in Figure 25.

38 Note the ordinate scale in Figure 26 compared with that in Figure 24 and Figure 25.

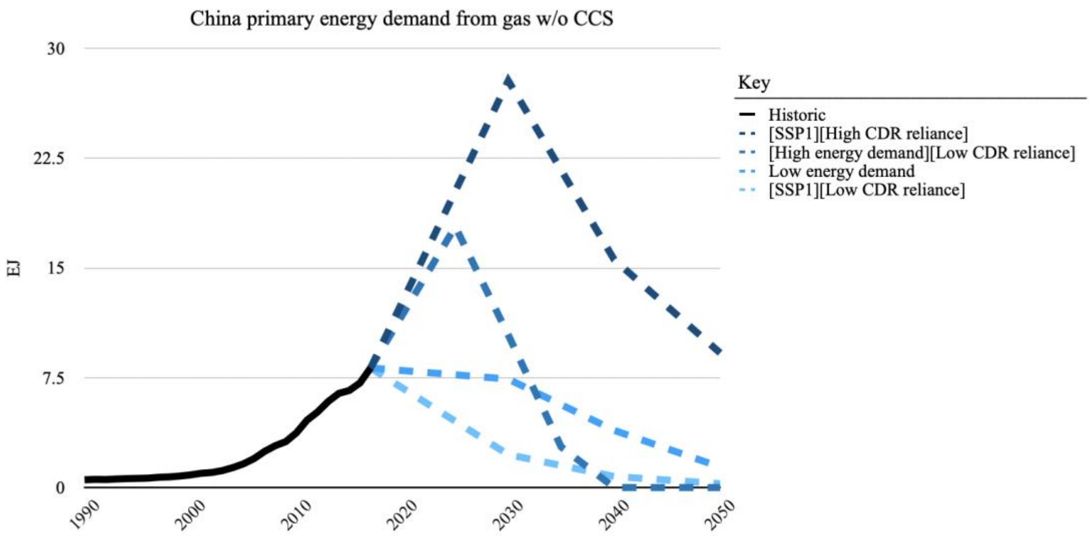

Figure 26: Gas demand in China historic and projected under 1.5°C compatible pathways.

As can be seen in Figure 26, under 1.5°C compatible pathways, Chinese gas demand in 2040 falls very much short of Woodside's expectation, except in cases of high energy demand and/or high CDR reliance. The latter would necessitate both rapid deployment of CCS and substantial carbon removal through other means.

In its latest World Energy Outlook, the IEA has China's natural gas primary energy supply, under an announced pledges scenario, peaking at around 15.5 EJ in 2035 before declining to 11 EJ in 2050. This equates to about 460 bcm on natural gas in 2035, declining to 314 bcm in 2050. (IEA, 2021f). This looks quite different from the demand projected by consultancy firms (Figure 26).

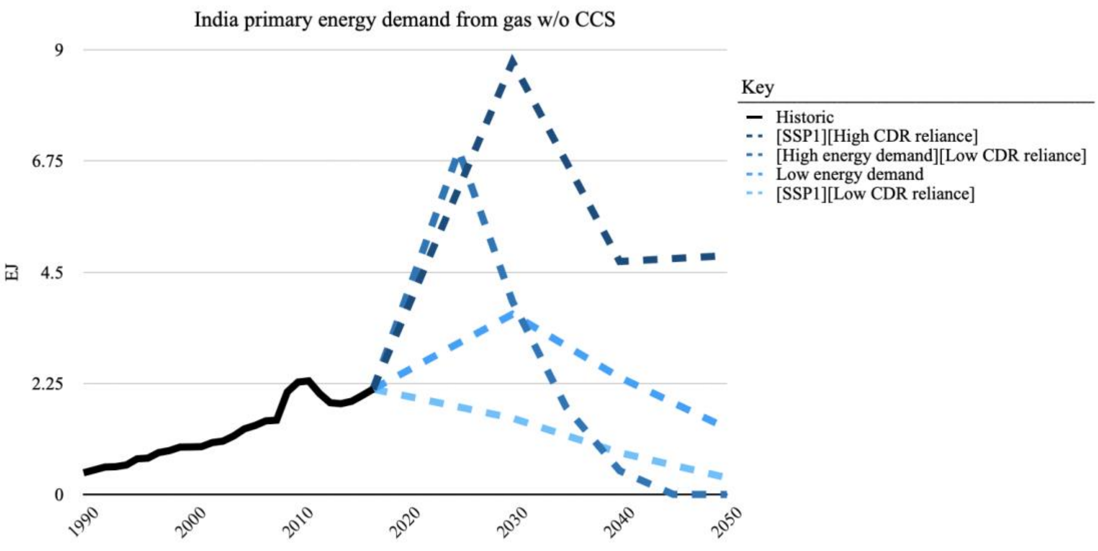

Figure 27: Gas demand in India historic and projected under 1.5°C compatible pathways

The role of gas in India's future energy system is likely to be as a replacement for coal and oil, as opposed to as a means for meeting new growth in energy demand. While natural gas does play a role in India's energy transition, care must be taken to minimise methane leaks along the gas value chain, and careful consideration must be placed on infrastructure investment so as to avoid stranded asset risk as the country eventually realizes net zero emissions. (IEA, 2021c). Note that under its SDS, the IEA has India's gas demand peaking at about 8.2 EJ in 2040 and dropping to around 5 EJ in 2050. This is very similar to the high CDR 1.5°C pathway presented here.

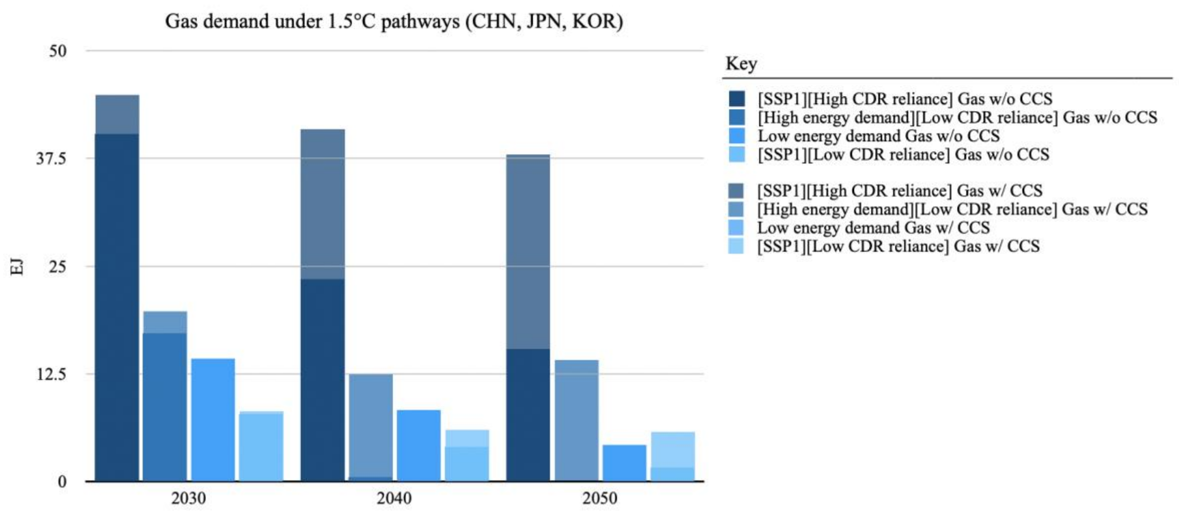

Figure 28: Aggregate gas demand, both with and without CCS, in Japan, China, and South Korea under four 'illustrative' 1.5°C pathways.

In Figure 28 we look at the aggregate gas demand of the four countries and now include gas with CCS. As shown, unabated gas demand falls rapidly from 2030. The largest levels of gas consumption occur under scenarios with either high CDR reliance or high energy demand and are largely due to China. Taking the median of the four 'illustrative' pathways, the change in total gas demand for these four countries from the last historic year used in our analysis, 2017, to 2040 translates to a -2% compound annual growth rate (CAGR). Unabated gas demand has a corresponding CAGR of -4%[39]. This can be compared with the around 0.8% CAGR in Asian gas consumption, put forth by Wood Mackenzie in its "under 2°C by 2050" scenario (Filippenko & Mezentseva, 2020).

Recently, South Korea and Japan have signaled urgency in transitioning their energy systems away from LNG, with preference for hydrogen and renewable energy. An official from Japan's Ministry of Economy, Trade and Industry has indicated hydrogen could replace gas as soon as 2025, to avoid stranded asset risks in LNG (van Leeuwen, 2021).

Similarly, a Foreign Ministry official from South Korea indicated that investment will move beyond LNG as soon as possible (van Leeuwen, 2021). Asia's gas demand could decline as a result, and Australia's LNG exports would likely correspond.

Risks to LNG demand from Carbon Border Adjustment Mechanism (CBAM)

The Carbon Border Adjustment Mechanism (CBAM) recently proposed by the EU under its "Fit for 55" plan also presents a critical risk to the viability of Woodside's LNG project as it will likely affect the demand for LNG from importing countries. China, Japan, South Korea, and India are all in the top 10 of the EU's largest trading partners.

39 Around 0.16% CAGR for total demand, and -2.5% for unabated gas, using the average of the 'illustrative' pathway values.

Western Australian LNG in the global market - supply side risk

As we have seen, a key argument that Woodside uses to justify the Scarborough gas development is the assumed future demand for LNG in major Asia-Pacific markets. It goes without saying that neither Woodside, nor Australia more generally, have a monopoly on LNG supply in this region. It is therefore instructive to examine the Scarborough project in relation to other major projects which seek to serve the Asia-Pacific LNG market.

As we can see in Figure 29, LNG exports from major exporting countries, primarily Australia and Qatar, have been increasing in line with rising LNG imports in the Asia Pacific region. As of 2020, close to 100% of Australian LNG exports flow to Asia Pacific (see Table 15 below for further details). China, Japan, and South Korea made up 73% of total Asia Pacific LNG imports in 2020 (BP, 2021).

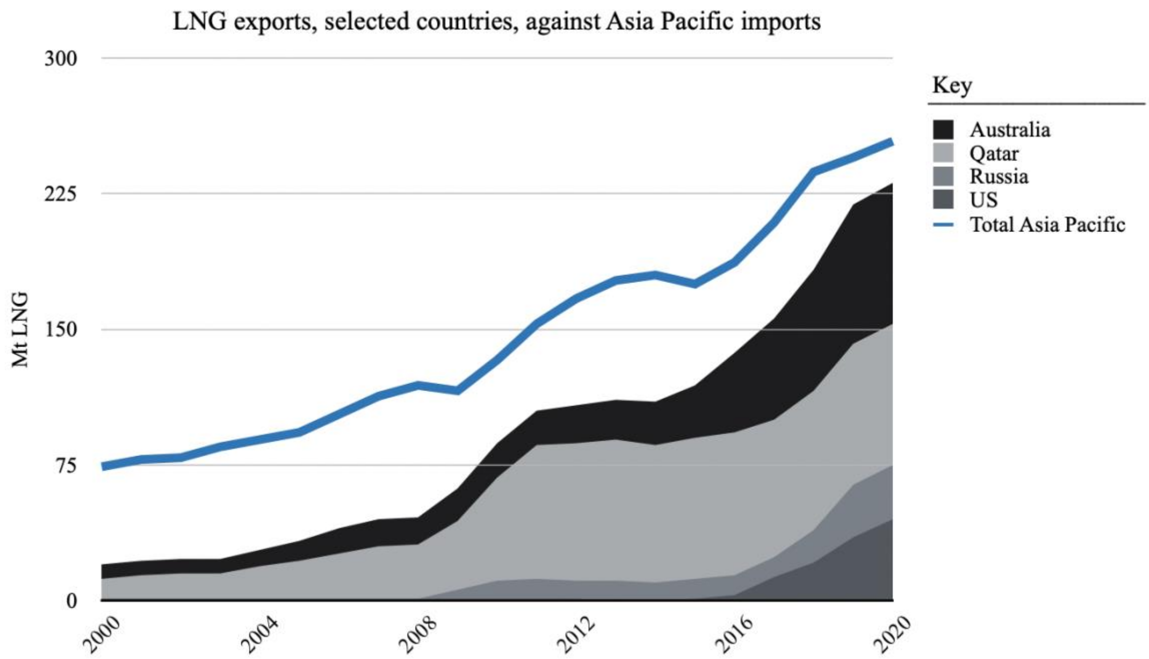

Figure 29: LNG exports from selected countries whose primary markets are Asia Pacific countries compared with total LNG imports from Asia Pacific countries.

Notes: China, Japan, and South Korea made up 73% of total Asia Pacific LNG imports in 2020. Source: (BP, 2021)

Australia's production of conventional and coal seam gas has increased significantly since 2015, with Western Australia accounting for almost the entire increase in the former. This ramping up of production has been motivated in large part by increased LNG exports, particularly to China, Japan, and South Korea. This has, in turn, led to an increase in the market price of LNG at Australia's Short Term Trading Market (STTM) hubs, as can be seen in Figure 30.

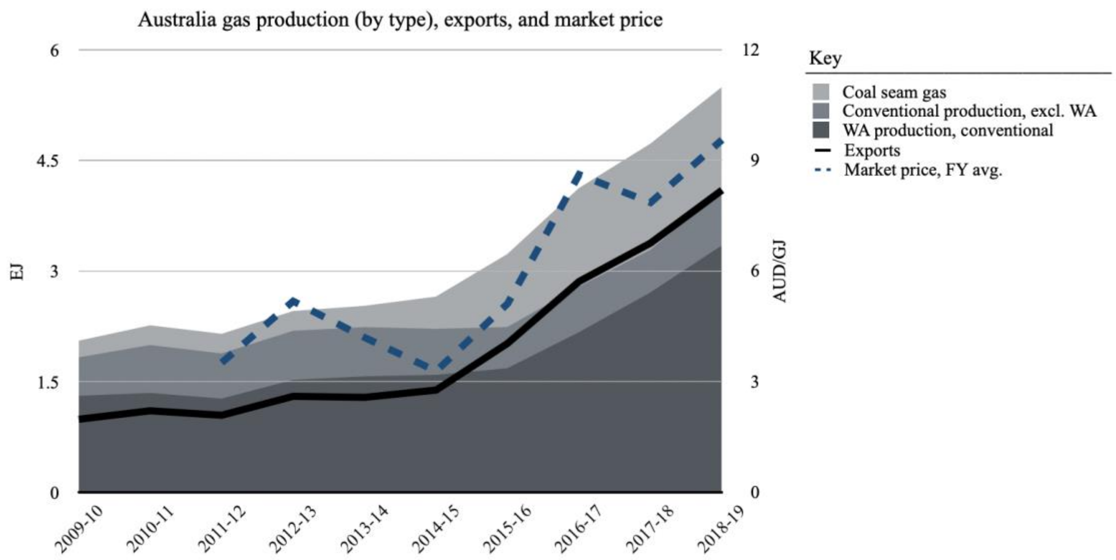

Figure 30: Australian gas production and exports 2009-2019 vs gas market price

Source: Tables R and J, respectively, of (Department of Industry Science Energy and Resources, 2020). Gas market price taken from (Australian Energy Regulator, 2021).

The Australian Competition & Consumer Commission publishes data on LNG "netback prices" defined as a "measure of an export parity price that a gas supplier can expect to receive for exporting its gas." Recent data to October 2023 has the gas price settling to a low of around 12.3 AUD/GJ from May 2023 after coming down from a high of over 40 AUD/GJ expected over the next few months (ACCC, 2021). These prices are based on futures contracts spanning the next two years. Of course, recent futures prices have fluctuated with the recent increase in spot LNG price observed since May 2021. This recent increase has been caused by an earlier slowdown in production due to lower demand in 2020 and a subsequent increase in demand as importing nations recovered from the effects of the pandemic (Jaganathan, 2021).

Short term fluctuations in supply and demand aside, we may examine the distribution of LNG prices, both historic and for futures contracts, to get a better sense of where an equilibrium price may settle. As shown in Figure 31, historic prices average around 6.8 AUD/GJ, while recent futures prices (for contracts since May 2021), average at around 9.8 AUD/GJ. The difference between the peaks of the historic and futures price distributions suggest that the market foresees a systemic change in the supply and demand profiles for LNG globally which results in a higher equilibrium price.

This futures equilibrium price can be compared to a recent McKinsey report which states that, given an assumed LNG supply gap of around 100-140 million tonnes by 2035, to stay competitive LNG projects will need to be priced at 7 USD/million BTU (Chong et al., 2019). This translates to about 9.2 AUD/GJ at current exchange rates. Many factors affect gas export prices and thus we are not attempting here to forecast the cost competitiveness of LNG from the Scarborough development. Instead, we wish to draw attention to the difference in LNG demand forecast by McKinsey and that put forth by the IEA in its NZE scenario.

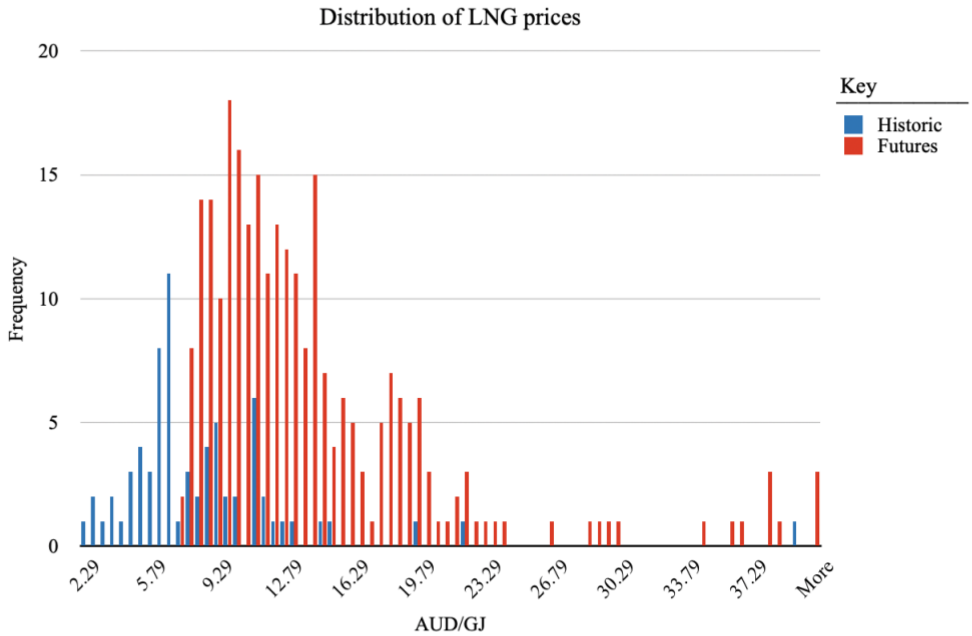

Figure 31: Distribution of LNG netback prices, historical and for recent futures contracts (ACCC, 2021).

In Figure 32 we have plotted the McKinsey LNG demand curve from 2019 along with the IEA's forecast under the NZE. These are both compared to recent demand and supply data (historic and forecast) from Shell. Note that the earlier McKinsey forecast fits into the demand range now projected by Shell.

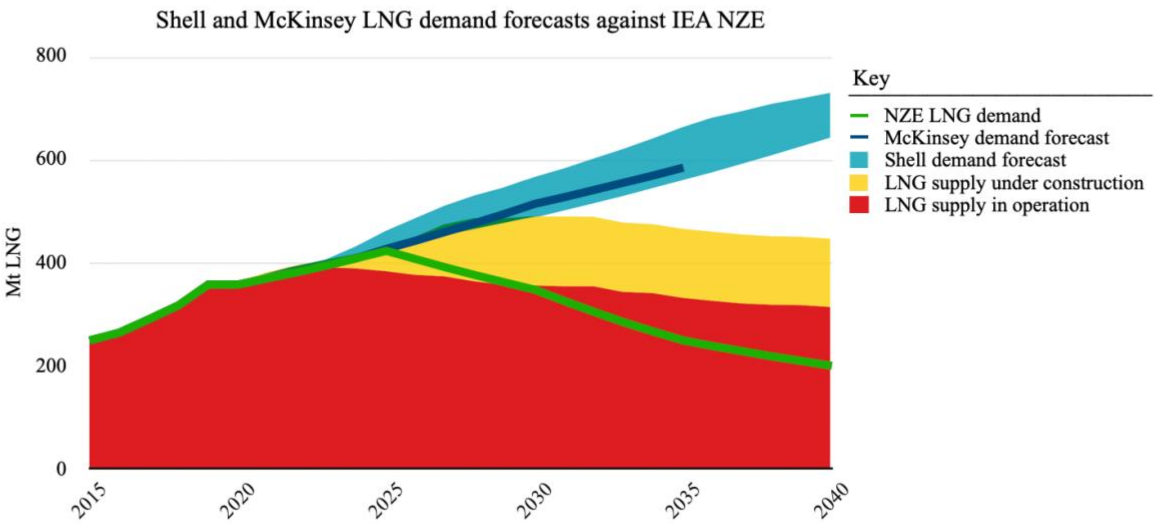

Figure 32: LNG demand and supply forecast from Shell, McKinsey compared IEA NZE LNG projection

Notes: LNG supply and Shell demand forecast taken from (Shell, 2021). McKinsey demand forecast follows the CAGR given in Figure 19. NZE demand from (IEA, 2021d). Note that growth rates from the NZE projection have been applied to historic LNG trade volumes taken from (BP, 2021)

Figure 32 shows a sharp divergence in the demand forecasts from McKinsey and Shell and that of the NZE, from around 2025. This is important as McKinsey's assessment of cost competitiveness is based on the assumption of unmet demand totalling to 100-140 Mt LNG in 2035. The less demand there is, the more cost competitive projects must become reaching a level of around 3 USD/million BTU for 30 Mt LNG unmet demand or less (this being the cost of LNG produced in Qatar's North Field). As shown in Figure 32, the demand forecast under the NZE is even below this.

The NZE forecast implies that while there is some need for LNG capacity under construction in the short term, this newer capacity, and even some existing capacity, will likely face stranded asset risk past 2030.

Australian LNG exports surpassed Qatar's in 2019 and, as of 2020, both countries have about a 22% share of the total(BP, 2021). However, up to fairly recently, Qatar had been the world's largest exporter of LNG. Between 2012-2017 the country's exports accounted for about 30% of the total each year. In May 2021, a 12-year moratorium on LNG development in Qatar's North Field was lifted. Currently, Qatar Petroleum (QP) seeks to implement the North Field Expansion project in two phases, the first of which is underway and set to increase output from current levels of 77 million tonnes p.a. to 110 million tonnes p.a.

A second phase, which has yet to undergo final investment decision, would increase Qatari capacity to 126 million tonnes p.a. so that production would increase by 64% on current levels by 2027. At the same time QP have launched a Sustainability Strategy which seeks to reduce emissions by 2030 and includes a target to deploy CCS with an aim of capturing at least 7 $MtCO_2$ p.a., a volume not achieved by any CCS project to date (Qatar Petroleum, 2021a, 2021b).

Table 15: In 2020, Asia Pacific LNG imports from the countries listed accounted for 78% of the total.

Exporting Country	Australia	Qatar	Russia	US	Malaysia	Indonesia	Sum	Total net imports
Asia Pacific Imports (Mt LNG)	77.63	52.29	11.25	19.34	23.85	14.74	199.10	254.43
Share of Imports	30.5%	20.6%	4.4%	7.6%	9.4%	5.8%	78.3%	
Global net imports (Mt LNG)	77.77	77.13	29.6	44.76	23.85	14.99	249.75	356.12
Share of Imports to Asia Pacific	99.8%	67.8%	38%	43.2%	100%	98.3%	55.9%	

On the supply side, most of the countries listed served Asia Pacific countries exclusively, or almost. However, Qatar and the U.S. exports were more diversified. Note that Asia Pacific imports from the selected countries made up 56% of global total imports. Source (GIIGNL, 2021)

U.S. LNG exports have been steadily increasing since 2015 and have seen a 50% growth between 2009-19, the highest rate of any exporting country over that period, whereas Australia's LNG exports have grown by 15.3% over the same period. (BP, 2021). Asia Pacific was the main export destination for U.S. LNG in 2020 (Zaretskaya, 2021). Asia Pacific imports are likely to be a key focus of U.S. exporters as European demand falters under government climate targets and the falling cost of renewables. However, much uncertainty remains around the cost competitiveness of U.S. LNG in Asia Pacific, where prices have been low and subject to high levels of volatility. (Reynolds et al., 2021).

Russia, another major LNG exporter, has announced a target to increase its share in the global market to 20% by 2035, up from around 8% in 2020. To do so, the country intends to open up both LNG production and transportation capabilities in the Artic. This will in turn allow the country to increase exports to Asia Pacific. (Sukhankin, 2021).

The bottom line from this overview is that several major competitors are also expanding their production, also without apparent consideration of Paris Agreement compatibility, meaning that there is a significant likelihood, if the world implements the Paris Agreement, that the Scarborough project would be exporting LNG into a market flooded with surplus LNG capacity. Given the current outlook on supply, price, and the prospects for CCS deployment, it is not certain that Woodside will be among the low-cost producers that would survive a rapidly declining market.

LNG infrastructure - investment risk

The economic viability of the Scarborough and Pluto Train 2 development revolve around achieving a 12% internal rate of return (IRR) over a maximum 8-year payback period. This payback period would commence upon the Ready for Start-up (RFSU) phase of the project and assumes a Brent oil price of USD 65 per billion barrels. Woodside further assumes a cost of supply of USD 6.8 per million Btu would make LNG from this project globally competitive (Woodside, 2019b, 2021f).

Woodside is reportedly pitching the Scarborough-to-Pluto LNG project as an infrastructure investment (Macdonald & Redrup, 2021; Milne, 2021b). Infrastructure is typically a low-risk, low return long-term investment. The high IRR and short payback period suggest that Scarborough-to-Pluto is not a suitable candidate for investors interested in infrastructure projects. As part of its pitch to investors, Woodside makes claims of long-term market demand for LNG and that the project has below average emissions intensity. As we have shown here, on both counts, the claims are false or, at best, dubious.

Moreover, Woodside’s push to sell-down its equity share, and the lack of appetite for this project from other oil and gas majors, speaks to the inherent riskiness of this development. The company acquired an initial 25% equity stake in the Scarborough field from BHP Billiton in 2016 and in 2018 purchased an additional 50% stake from ExxonMobil. With regards to Pluto, Woodside holds a 90% interest overall but 100% of Train 2.

Before his company sold off its stake, in 2013 ExxonMobil executive Mark Nolan stated that the Scarborough project will be “very challenged from a cost point of view” due to the dry composition of the gas resource and the need for expensive horizontal deep-water drilling (Forster, 2013; Robertson, 2021).

Mr Nolan is not alone in this assessment. In 2020, Wood Mackenzie estimated the cost of Scarborough-sourced LNG at around USD 9/mmBtu. It noted that the need for a dedicated pipeline to the deep-water basin, the “lean nature” of the gas (meaning that the gas is dry with no associated liquids), and the relatively high cost of labour in Western Australia were key factors influencing the high LNG cost estimate. (Robertson, 2021; Wood Mackenzie, 2020a).

Critical to the financial stability of the Scarborough-to-Pluto project is the ability of Woodside to enter into long-term contracts with LNG customers. The company has stated it will need to have at least 50% of its equity share in the project’s production capacity (around 2.5 MtLNG p.a.) covered by long term contracts in order to proceed with the final investment decision (FID) (Woodside, 2021e)[40]. It is therefore instructive to examine some proposed contracts.

In December 2019, Woodside signed a sale and purchase agreement with the German electric utility Uniper to deliver 0.5 MtLNG p.a. beginning in 2021 and increasing 1 Mt p.a. from 2026-33. This

40 The company states that this consists of 2.5 Mtpa of LNG and 125 TJ/day of domestic gas and assumes their current Scarborough upstream equity interest of 73.5% (Woodside, 2021e).

agreement was amended in January 2021 to double the annual LNG delivery amounts and is contingent on the Scarborough FID (Uniper, 2021). Importantly, the contract would represent around 80% of the coverage the company is seeking.

Occurring almost in parallel with the negotiations with Woodside, Uniper was also undergoing plans to develop the Wilhelmshaven LNG import terminal in Germany's Lower Saxony region. However due to difficulties receiving the necessary legal clearances, concern from environmental groups, and insufficient demand for the imported LNG, the company cancelled the project in April 2021. The company has since announced plans to develop the site as a green hydrogen hub (Elliott, 2020; ICIS, 2021). Although it does not appear that Uniper has backed out of its end of the sale and purchase agreement, the German utility's dropping of its LNG terminal project certainly does not bode well for Woodside.

CONCLUSION: THE SCARBOROUGH AND PLUTO DEVELOPMENT UNDERMINE THE PARIS AGREEMENT AND BLOCK CLEAN ENERGY TRANSITION IN WA

Woodside and other proponents of natural gas promote a narrative that places natural gas, perhaps better termed as fossil gas, as a key component of a zero-emissions future. Specifically, this narrative has seven key points:

- Paris agreement aligned pathways allow for an ongoing and sustained use of natural gas at higher than present levels for some decades
- There is a gap between the available supply of fossil gas and Paris Agreement compatible global and regional demand, which Scarborough would help fill
- A switch from coal to fossil gas will lower emissions,
- Fossil gas allows for renewable energy integration
- Fossil gas is necessary for emissions reductions in hard to abate sectors.
- Blue hydrogen is a transition fuel towards fully green hydrogen
- Carbon capture and storage will be rolled out at massive scale for natural gas applications

On all counts we have shown that this narrative is false or dubious at best.

Claims that natural gas has lower carbon emissions than coal disregard the critical point that emissions of methane, by far a more potent greenhouse gas than carbon, from the production of natural gas are widely underreported and likely quite high.

It also does not account for the life-cycle costs of LNG, which result in quite high greenhouse gas emissions per unit of energy, and substantially narrow the benefits that might otherwise accrue from natural gas displacing coal in the absence of methane fugitive emissions.

Recent empirical evidence on the energy transition in Asian countries show that natural gas is impeding investment in, and development of, renewable energy technologies and their associated infrastructure, and this is in line with studies on carbon lock-in and the crowding out effect.

Current technologies, energy efficiency measures and a rollout of green hydrogen would, together, make it possible to decarbonise hard to abate sectors (and at the same time create major opportunities for WA). If the viability of using natural gas, including the required uptake of CCS technology to offset carbon emissions and the issue of methane emissions, are measured against that of renewable-based hydrogen and other actually low emissions technologies, the cost competitiveness and emissions reduction arguments favouring the former increasingly appear to be a house of cards.

Blue hydrogen is not carbon free, would involve the need to deploy massive carbon capture and storage infrastructure, provide for long term security of storage, which in Australia is typically given to taxpayers and governments to cover, does not achieve net zero missions and it is likely to create substantial reputational problems for the country's hydrogen exports.

To justify its case for a surprisingly large and extended role for natural gas in meeting the Paris agreement's goals globally and regionally, Woodside has relied on scenarios that are well known not to be Paris agreement compatible.

The International Energy Agency had been under pressure for a number of years due to the inability of its SDS scenarios to make the Paris agreement long term temperature goal and has finally responded this year with its ground-breaking net zero pathway (NZE). Woodside coupled this inappropriate natural gas demand pathway with estimates from the IEA of available gas supply, but since the publication of the IEA NZE report has chosen to ignore the Agency's invocation that no additional fossil fuel resource development is needed.

Implicitly, Woodside is essentially asking policy makers, the finance sector, and governments to bet on a massive rollout of an essentially unproven technology with a history of failures, cost overruns and major deployment delays, carbon capture and storage.

In arguing for the Burrup Hub development, and that of the Scarborough gas field specifically, Woodside has assumed that natural gas demand, particularly in its key LNG export markets in Asia, will increase throughout the bulk of the project's 30-year lifetime.

Furthermore, the company claims that this projected demand is not met by currently forecast supply and that therefore gas sourced from Scarborough will go to filling a demand gap. At the same time, Woodside wrongly claims that this assumption of increased natural gas demand is in line with the Paris Agreement, and thus with efforts to limit global average temperature increase to well below 2°C above pre-industrial levels and pursue best efforts to limit the temperature increase to 1.5°C.

Woodside is erroneously drawing directly from projections made by the IEA in its sustainable development scenario (SDS), labelling these as Paris aligned when they're not.

As we have shown, the SDS is inconsistent with the Paris Agreement's long term temperature goal (LTTG). Moreover, taking gas demand from the IEA's NZE scenario, which is consistent with the Paris Agreement's LTTG, one sees that the supposed demand gap disappears and so, as the IEA states, no new development of gas fields is needed, and this, of course, applies to Scarborough.

Considering an actual Paris Agreement compatible world, the Burrup Hub development will face an increasingly tight LNG market.

On the demand side, the main markets for Scarborough gas - China, Japan, and South Korea - would need to drastically reduce their natural gas consumption under pathways which limit warming to 1.5°C, in some cases immediately, but in all rapidly, after 2030.

On the supply side, Woodside faces competition from LNG suppliers with lower costs and who, anticipating likely environmental regulations from importing countries with net zero emissions targets, are already investing in CCS technology and other emissions reductions measures. Of course, we are not advocating here for the use of CCS as a means of emissions reduction, because of its inherent problems.

Indeed, in line with the Paris Agreement's LTTG, we are instead advocating for a rapid, albeit just, transition away from natural gas. We are drawing attention to the fact that Woodside, despite its claims of sustainability and Paris Agreement compatibility, does not have a competitive advantage among LNG exporters in terms of its emissions profile.

As we have seen, development of the Scarborough gas field and other components of the Burrup Hub "vision" come with great risks as governments around the world embrace stronger emissions reductions targets, implement associated legislation, and transition their energy systems.

This analysis finds the Scarborough to Pluto gas project is inconsistent with the Paris Agreement's goal to limit global mean warming to 1.5°C above pre-industrial levels

In taking on those risks, Woodside is asking its investors to bet against the successful implementation of the Paris Agreement. This, in turn, is a bet against the climate.

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