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October 2021

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IEEFA.org

# How To Save the Barossa Project From Itself

## *Carbon Capture and Storage Will Not Help as Barossa Gas Is High-CO2 Gas*

## Overview

There are implications surrounding Santos' recent announcement of the Bayu-Undan carbon capture and storage (CCS) plan[1] to save its Barossa offshore development project in the Timor Sea offshore Australia.

The carbon dioxide (CO2) content of Barossa gas is extremely high - about twice that of the next highest gas resources currently being converted to liquefied natural gas (LNG) in Australia.[2] It is also much higher again than the gas feeding LNG plants in competitor LNG exporting countries – in a market growing increasingly sensitive to emissions arising from its purchases. Perhaps that is why Santos is trying to reduce the Barossa project's emissions: to stop it being an emissions factory with an LNG by-product.

The average emissions intensity of Australian-made LNG is approximately 0.70 tonne CO2 per tonne of LNG produced, whereas LNG from the Barossa project would have an emissions intensity of 1.47 tCO2/tLNG before it is transported and burnt in North Asian markets. That makes both the product and the project itself in need of being saved or abandoned, as the majority (57%) of emissions are from combustion, and *capture of that is not practical*.

Unlike Chevron at its Gorgon CCS project[3], this time around Santos should be obliged to be as good as its word and be required to *implement* the CCS scheme as part of the Barossa development and *to demonstrate its satisfactory operation* before reaching full LNG output at Darwin and commencing exports of Barossa gas as LNG.

This paper explores available scenarios open to Santos at its Barossa development as it heads towards its net zero emissions target by 2040[4], and finds each scenario falls short.

The following table summarises the results for each Scenario.

[1] Santos. Bayu-Undan Joint Venture and Timor-Leste's ANPM sign MOU on Bayu-Undan Carbon Capture and Storage. 14 September 2021.
[2] IEEFA. Should Santos' Proposed Barossa Gas 'Backfill' for the Darwin LNG Facility Proceed to Development? March 2021.
[3] Financial Times. Monster problem: Gorgon project is a test case for carbon capture. 26 July 2021.
[4] Santos. Santos to be net-zero emissions by 2040. 1 December 2020.

**Table 1: Barossa Project Emissions – Summary of Scenarios and Emissions**

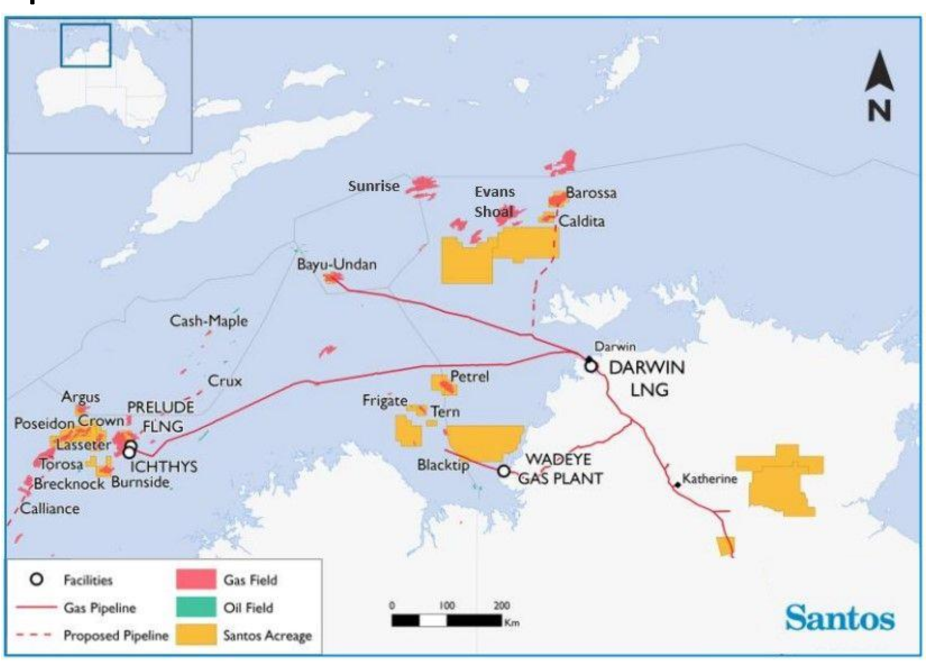
| | Offshore at Barossa MtCO2pa | | Onshore at DLNG MtCO2pa | | Total MtCO2pa | Emissions Intensity |
|---|---|---|---|---|---|---|
| Scenario | Vent | Combustion | Vent | Combustion | | tCO2/tLNG |
| A | 1.8 | 1.6 | 0.5 | 1.5 | 5.4 | **1.47** |
| B | 0 | 1.9 | 0.5 | 1.5 | 3.9 | **1.06** |
| C | 0 | 0 | 0.5 | 0 | 0.5 | **0.14** |
| | | | | Australian Average | | **0.7** |

## Scenario A: Background - Barossa Gas Is High Emission Gas

As the Bayu-Undan gasfield is near fully depleted, gas from Barossa is planned to ‘backfill’ the Darwin LNG plant to keep it operating beyond 2023. This date may be extended further if Santos’ current drilling program around Bayu-Undan is successful in identifying additional gas supplies. In that case, the Darwin LNG plant would continue to operate until gas supply from Barossa was available.

Figure 1 shows the location of the Barossa field (~300km north of Darwin) with a dotted line showing the planned new pipeline to the currently active pipeline carrying gas from Bayu-Undan (~500km west of Darwin) to the LNG plant on Darwin Harbour.

**Figure 1: Location of the Barossa Field with Current and Planned Pipelines**




*Source: Santos.*

To explore what CCS might mean in practice for the Barossa development, Table 2 shows the four main sources of emissions described in the Offshore Project Proposal (OPP) by the original Barossa development proponent and operator, ConocoPhillips. The OPP was the basis for the approval of the project given by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) in March 2018.

### Table 2: Four Main Sources of Emission from the Barossa Offshore Development Project – Scenario A (OPP Case)

| Million tonnes CO2 pa | Vent | Combustion | Total |
|---|---|---|---|
| Offshore (FPSO) | 1.82 | 1.56 | 3.38 |
| Onshore (Darwin LNG) | 0.51e | 1.54e | 2.05 |
| Total | 2.33 | 3.1 | 5.43 |

*Source: OPP, e: estimated split of DLNG emissions between combustion and vent.*

Venting almost pure CO2 (reported incorrectly as 'fugitive CO2') is unavoidable in making LNG as complete removal of CO2 is necessary before gas can become liquefied natural gas (LNG) product. The Santos operated Darwin LNG plant is only capable of removing the last 6 volume percent (v%) of CO2.

Because of the unusually high 18v% CO2 content of gas found in the Barossa field, there are two gas processing sites, both venting CO2 and also combusting gas for energy to run their processes (and thus both also emitting CO2).

The first stage of CO2 removal occurs offshore near the gas field on the floating production storage and offloading vessel (FPSO), reducing the CO2 content from 18v% to 6v% before the gas is sent by pipeline to Darwin. The second stage of CO2 separation takes place at the onshore Darwin LNG plant - from 6v% to almost zero.

Combustion emissions arise from burning some of the raw gas arriving at the FPSO, and again at the Darwin LNG plant as fuel to power the purification, liquefaction, storage, product loading and all other needs of the two operating sites of the project.

It should be noted that CO2 emissions from gas turbines burning 18v% or 6v%CO2 fuel gas will have much higher emissions per unit of power generated compared to similar units burning normal pipeline gas from the gas grid. (Gas grid specifications require CO2 content to be *not* higher than 2v% in effect.)

The total emissions from the Barossa to Darwin LNG development of 5.43 MtCO2pa, when compared to its production of 3.7 MtLNGpa means that the Barossa project's specific emissions in production (SEP) or emissions intensity is 1.47 tonnes of CO2 for every tonne of LNG produced. This is about twice the average for Australian LNG plants and probably much higher again than for LNG produced in competing LNG exporting countries.

## Scenario B: High Hopes of Capture and Storage of CO2 from Barossa Project Increases Costs

The capture and storage of CO2 from the Barossa project would add substantially to the project's costs, lengthen its schedule, and diminish its viability because of a number of considerations.

First, modification of the gas processing capabilities on Barossa's yet-to-be-built FPSO would be required to include extra compression, needed to boost the 1.82 million tonnes per year (Mt/yr) of reservoir CO2 (currently planned to be captured and vented to the atmosphere) to about 200 times atmospheric pressure to send it by pipeline to Bayu-Undan.

The extra processing space for this compression might require a major redesign to the layout, or even to the FPSO vessel itself. As this vessel may already be in the detailed design phase, rework would be expensive.

Further, the extra compression required would use more gas reserves and emit more CO2 than the current anticipated 1.56 Mt/yr arising from energy production on the FPSO - perhaps 20% more or 0.31 Mt/yr.

Even if such modifications were made to the FPSO, capturing the 1.56 (+ 20%) Mt/yr CO2 emissions from power generation or compression is unlikely to be feasible as the exhaust stream from a gas turbine is quite dilute in CO2 and suitable capture processes are not currently economically feasible onshore, let alone offshore. The higher than usual emissions arising from the use of a fuel gas that is nine (or three) times the usual gas grid CO2 content would not alter the infeasibility of capturing CO2 post-combustion.

**Capturing CO2 emissions from power generation or compression is unlikely to be feasible.**

The reservoir gas captured on the FPSO would need to be transferred by an additional yet-to-be-built (or approved) ~430 km pipeline from Barossa to Bayu-Undan.[5]

On arrival at Bayu-Undan, the CO2 - after losing pressure through pipeline friction - would require recompression for injection into suitable depleted gas reservoirs that have already been 'proven' good for long-term CO2 storage.

[5] This route was surveyed by Conoco/Santos before 2010 – perhaps anticipating this might be the correct thing to do if they were to commercialise the Barossa resource.

The existing compressors on the Bayu-Undan platforms would be unsuitable for $CO_2$ recompression however, and different types would be required. Extra $CO_2$ emissions will occur in generating the power for this compression via gas turbines.

As recompressing the $CO_2$ requires power and therefore availability of fuel gas at Bayu-Undan, some Bayu-Undan gas production would need to continue to provide power for the life of the project. Alternatively, if gas production at Bayu-Undan has completely ceased by this time, the compression gas requirements might be supplied from the existing gas export line from Bayu-Undan to Darwin, with backflow occurring from the junction with the new Barossa line.

Combustion emissions are the major part of the 2.05 $MtCO_2$/yr released into the atmosphere at the Darwin LNG plant and it would not be feasible to capture this, for the same reason as it not being feasible on the FPSO.

The reservoir gas component of approximately 0.5 $MtCO_2$/yr captured from the LNG plant feed gas would be hard to justify a 500km pipeline to Bayu-Undan for re-injection and storage.

All of the above might result in a net reduction in emissions of 1.82 - 0.31 = 1.51 $MtCO_2$/yr from the OPP base of 5.43 $MtCO_2$/yr, that is a ~28% reduction to 3.92 $MtCO_2$/yr.

The emissions situation would then look like Table 3.

## Table 3: Barossa Emissions – Scenario B (CCS Case)

| Million tonnes CO2/year | Vent | Combustion | Total |
|---|---|---|---|
| Offshore (FPSO) | 1.82 to B-U CCS | 1.56 + 0.31 = 1.87 | 1.87 |
| Onshore (D LNG) | 0.51e | 1.54e | 2.05 |
| Total | 0.51 | 3.41 | 3.92 |

*Source: Author's calculations.*

For production of 3.7 MtLNG/yr, using CCS would still make the Barossa project the 'dirtiest' in Australia and possibly in the world with a SEP or emissions intensity of 1.06 $tCO_2$/tLNG.

The substantial change of adding CCS would cause the project to be both delayed and made more expensive.

This may compromise the viability of the project, and also calls into question the original 2018 approval. The final investment decision (FID) would need to be reviewed by all owners. Necessary approvals by authorities (NOPSEMA and others) would likely add further costs and delays.

**Using CCS would still make the Barossa project the 'dirtiest' in Australia and possibly in the world.**

This all demonstrates that trying to make LNG from high CO2 gas, even with CCS, is a fool's errand.

## Scenario C: CCS Plus Electrification Still Means Emissions

Another option is to use renewable electricity to drive electric motors instead of burning gas in gas turbine drivers for all the compression and other power needs of the project at both the Barossa and Darwin locations, and perhaps also extended to power the storage operation at Bayu-Undan. This option could reduce emissions, but not completely eliminate them.

A long-term power purchase agreement with a renewable energy supplier near Darwin would need to be established. Due to the geographically advantaged location for solar generation in northern Australia, there is at least one proposed project which intends to generate 15+GW of power for export to Singapore. An agreement for supply to a continuous load of about 250 megawatts (MW) may be attractive to a domestic renewable power supplier and should be able to provide an economic price for the LNG producer.

**This option could reduce emissions, but not eliminate them.**

Electrification would require high voltage direct current (HVDC) supply cables to be laid from Darwin to the Barossa FPSO and to the Bayu-Undan platforms. The Darwin LNG plant would also need to be converted to all electric drives.

A pipeline for the remaining reservoir gas component of approximately 0.5 MtCO2/yr captured from the LNG plant feed gas in Darwin would again in this case be too small to justify a 500km 3999pipeline to Bayu-Undan for re-injection and storage (CS).

In this case the emissions situation would then look like Table 4.

### Table 4: Barossa Emissions – Scenario C (CCS plus Electrification Case)

| Million tonnes CO2/yr | Vent | Combustion | Total |
|---|---|---|---|
| Offshore (FPSO) | 1.82 to B-U CCS | 0 | 0 |
| Onshore (D LNG) | 0.51e | 0 | 0.5 |
| Total | 0.51 | 0 | 0.5 |

With combustion and reservoir gas emissions offshore on the FPSO eliminated, and combustion emissions onshore at the Darwin LNG plant eliminated, the emissions in this scenario would reduce from 5.43 to 0.5 MtCO2/yr - a 91% reduction. The emissions intensity of Barossa LNG would be much lower (0.14 tCO2/tLNG) however the project would still be producing LNG with emissions, which is some way from Santos' zero emissions ambition.

Another alternative scenario would be electrification as for Scenario C, but without the costs and risks of CCS. With electrification only, emissions would be reduced to 2.33 $MtCO_2/yr$ for a SEP or emissions intensity of 0.63 $tCO_2/tLNG$. This is below the Australian industry average of 0.7 t/t and would eliminate the risks of CCS failure. However, extra investment and operating costs would be required.

# Conclusion

In every scenario considered here, the Barossa offshore gas project releases emissions. Table 5 summarises the results for each scenario.

### Table 5: Barossa Project Emissions – Summary of Scenarios and Emissions

| | Offshore at Barossa MtCO2pa | | Onshore at DLNG MtCO2pa | | Total MtCO2pa | Emissions Intensity |
|---|---|---|---|---|---|---|
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| A | 1.8 | 1.6 | 0.5 | 1.5 | 5.4 | **1.47** |
| B | 0 | 1.9 | 0.5 | 1.5 | 3.9 | **1.06** |
| C | 0 | 0 | 0.5 | 0 | 0.5 | **0.14** |
| | | | | Australian Average | | **0.7** |

The partner companies involved in the Barossa project must go back to the drawing board and rethink their strategic objectives in a world facing more extreme weather events due to the increasing levels of emissions from the burning of fossil fuels, including gas and LNG.

The International Energy Agency's (IEA) Net Zero by 2050 Roadmap states decisively that there must be no new gas if the world is to get anywhere close to staying under 1.5 degrees C.[6]

Before it gets off the ground, the emissions-intensive Barossa project is a lemon, or to quote Australia's second richest person, Dr Andrew Forrest, Barossa is 'an atrocious project'.[7]

[6] IEA. Net Zero by 2050. May 2021.
[7] Crikey. Twiggy hits the mark: Santos' new Barossa gas field is a 'carbon emissions factory with an LNG by-product. 16 June 2021.

# About IEEFA

The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

# About the Author

## John Robert

John Robert is a Chemical Engineer and Industrial Economist with more than 40 years of experience, including directly developing and/or managing estimates for capital and operating costs for LNG plants, along with benchmark comparisons for export competitiveness and reviewing the potential impact of emissions trading schemes such as Australia's proposed Carbon Pollution Reduction Scheme (CPRS) on LNG and chemicals projects. He spent almost eight years at Exxon in the Australian petrochemicals industry, followed by a similar period as an Australian Government Trade Commissioner in Europe and the Middle East. John was a business development manager and technical / economic consultant with Davy McKee (later Aker Kvaerner) for some twenty years, and then engineering manager with MEO Australia Limited, covering all aspects of innovative offshore methanol and LNG projects in the Timor Sea. He was responsible for the engineering development of the Timor Sea LNG Project (TSLNGP) since its inception in early 2002.

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