Santos | PETRONAS

GLNG: Supplementary EIS

Greenhouse Gas Management

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1 Objective for greenhouse gas emissions management

The principal GLNG Project sustainability objective for greenhouse gas emissions management is to apply energy efficient production and processing methods to produce a low carbon intensity energy product (EIS Section 16).

2 Scope of greenhouse gas emissions assessment

The scope of this emissions assessment includes construction and operation of the GLNG Project, which includes the natural gas fields, the natural gas transmission pipeline and the LNG facility.

The emission forecasts presented in this report have been updated from the EIS to reflect corrections and improved data resulting from further analysis and progression of project design and engineering teams. Scope 1 and Scope 2 greenhouse gas emissions calculated for the project are unaffected by these changes, as they were transcription errors in the EIS tables, the correct factors were applied in the data calculations. Scope 3 emissions have been amended to reflect the correct combustion factor.

Specific data amendments included:

Scope 1 and Scope 2 emissions:

- **Section 3.1** - Reference to global warming potential (GWP) factor of nitrous oxide of 210 has been corrected to 310 (EIS, Page 6.9.2).

- **Table 1** - Emission factor for consumption of natural gas Queensland, corrected from 51.3 **tonnes** CO_2e per GJ to 51.3 **kilograms** CO_2e per GJ (EIS, Table 6.9.1).

- **Table 3** – Emissions factors detailed for 10 mtpa case (EIS, Table 6.9.3).

Scope 3 emissions:

- **Figure 1** - Combustion factors adjusted from 20,205,000 to 3mtpa * 2.845 = 8,535,000 (EIS, Table 6.9.8) to reflect schedule 1 of the *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (Cth) (Measurement Determination). The adjusted combustion factors posted in the EIS in tabular form have been presented in this supplement (Figure 1) graphically to aid comparison.

- **Figure 1** - Combustion factors for LNG, oil and coal have been corrected in Figure 1 in this report (EIS, Table 6.9.9). The adjusted combustion factors posted in the EIS in tabular form have been presented in this supplement (Figure 1) graphically to aid comparison.

- **Figure 2** - Benchmarking assessment updated to assess LNG facility emissions for all cases (EIS, Figure 6.9.1).

This report reviews the greenhouse gas emissions from sources within the boundary of the GLNG Project and from GLNG Project activities; details the approach to energy efficiency and mitigation; provides a benchmarking assessment; and outlines GLNG Project commitments to ongoing monitoring and management.

3 Emission calculation methodology

The greenhouse gas emission calculation methodology outlined in this section applies to all aspects of the GLNG Project, including the CSG fields, the gas transmission pipeline and the LNG facility.

3.1 Greenhouse gas emission accounting methodology

Greenhouse gas emissions associated with the GLNG Project and included in the emissions inventory are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

In accordance with the Greenhouse Gas Protocol (Protocol)[1], emission volumes were estimated and expressed in values of carbon dioxide equivalent (CO_2-e) (IPCC, 1997)[2]. These values are derived by applying a GWP factor to each type of greenhouse gas as follows: CO_2 GWP of 1, CH_4 GWP of 21 and N_2O GWP of 310. GWP is a measure of the amount of infrared radiation captured by a gas in comparison to an equivalent mass of CO_2 over a fixed lifetime.

Greenhouse gas emission inventories in this report were estimated based on the methods outlined in the following documents:

- The Protocol which provides an international standard for accounting and reporting greenhouse gas emissions.
- The Measurement Determination made under section 10(3) of the *National Greenhouse and Energy Reporting Act 2007* (Cth) (NGER Act). The Measurement Determination provides for the measurement of greenhouse gas emissions from the operation of facilities.
- The Australia National Greenhouse Accounts (NGA) Factors[3].
- National Carbon Accounting Toolbox FullCAM model[4].

[1] WRI and WBCSD, 2005, The Greenhouse Gas Protocol, The Greenhouse gas Protocol for Project Account. November. Prepared by World Resources Institute and World Business Council for Sustainable Development. USA

[2] 1997, Revised 1996, IPCC Guidelines for National Greenhouse Gas Inventories, Volumes 1, 2 and 3. Prepared by J.T. Houghton, L.G. Meira Filho, B. Lim, K. Tranton, I. Mamaty, Y. Bonduki, D.J. Griggs, B.A. Callander from the Intergovernmental Panel on Climate Change, Meteorological Office. Bracknell, United Kingdom

[3] November 2008, National Greenhouse Accounts (NGA) Factors Department of Climate Change, Australian Government. Canberra

[4] DCC, National Carbon Accounting Toolbox - FullCAM Carbon Accounting Model

Within the Protocol, there are three scopes of greenhouse gas emissions that have been defined for accounting and reporting purposes. These are:

- Scope 1: Direct greenhouse gas emissions from sources owned or controlled by the reporting entity (e.g. fuel use, venting and flaring).
- Scope 2: Indirect greenhouse gas emissions from the generation of purchased energy products (e.g. purchase of electricity).
- Scope 3: Indirect greenhouse gas emissions that are a consequence of the activities of the entity but arise from sources not controlled by the reporting entity (e.g. extraction and production of purchased materials, transportation, combustion of LNG).

Table 1: Measurement (Determination) Schedule 1: emission factors

Emissions (kg CO_2-e/GJ)	Energy content	CO_2	CH_4	N_2O
Combustion of coal seam methane	$3.77 * 10^{-3}$ GJ/m^3	51.1	0.2	0.03
Diesel oil – stationary sources	38.6 GJ/kL	69.2	0.1	0.2
Diesel oil – transport	38.6 GJ/kL	69.2	0.2	0.5
Gasoline – transport	34.2 GJ/kL	66.7	0.6	2.3

4 Emission sources

Emission sources for construction and operation of the GLNG Project are outlined in the following table.

Table 2: Greenhouse gas emission sources

Scope	Construction	Operations
1	▪ Drilling emissions are not included in the overall construction emissions – construction of wells will be ongoing throughout the life of the GLNG Project and therefore these emissions have been incorporated into the emissions during operations. ▪ GLNG facility and pipeline construction equipment ▪ Accommodation ▪ Land clearing ▪ Passenger ferry ▪ Barge transport ▪ Bridge construction equipment ▪ Transport, bridge material	▪ Fuel consumption in process equipment ▪ Power generation ▪ Fugitive emissions[5] ▪ Flaring and venting ▪ Fuel consumption in vehicles ▪ Land clearing ▪ Drilling
2	▪ Scope 2 emissions are not included for the construction as they are immaterial in the context of total emissions.	▪ Scope 2 emissions are not included for the operations as they are immaterial in the context of total emissions. ▪ Field operations will be primarily gas or diesel powered and self generated and are therefore included as Scope 1.
3	▪ Construction emissions ▪ Transport	▪ Transport ▪ Transport of LNG to end customer ▪ Combustion of LNG by end customer – assumed to be used for power generation.

An estimate of greenhouse gas emissions from land clearing has been based on a conservative (i.e. high emission) scenario. However, Santos will avoid land clearing to the extent practicable by preferentially selecting drilling locations that have already been cleared and minimising disturbance where clearing is required.

The estimates of emissions from land clearing are based on a cleared area of four hectares per well lease. This footprint includes construction laydown areas, road construction and other activities that will not be required at all locations. Cleared areas will typically be much smaller than four hectares and operational wells are typically no more than one hectare.

Carbon sequestration from revegetation of the exploration well lease and final decommissioning of the site has not been included in the greenhouse gas emissions inventory.

[5] An estimate of 0.1% gas lost has been made, based on industry accepted practices.

5 Emissions profile

A detailed assessment of greenhouse gas emissions for each aspect of the GLNG Project has been conducted to determine annual emissions and total emissions for construction and 25 years of operation.

5.1 Scope 1 greenhouse gas emissions

An emission profile has been calculated for both the 3 mtpa case and the 10 mtpa case. A conservative factor has been applied to calculate emissions for the 10 mtpa case, namely a factor of 2.5 upstream and 3 downstream.

Table 3: Operations: Scope 1 average annual greenhouse gas emissions[6]

Project section	Activity type	3 mtpa (tonnes CO_2-e /yr)	10 mtpa (tonnes CO_2-e/yr)
Facility	Fuel consumption in process equipment	825,764	2,471,724
	Power generation	102,735	319,196
	Fugitive emissions	653	1,959
	Flaring and venting	233,570	679,642
CSG fields and pipelines	Fuel consumption in process equipment	1,401,047	3,502,618
	Fuel consumption in vehicles	3,549	8,873
	Fugitive emissions	1,486	3,715
	Flaring and venting	23,994	59,985
	Land clearing	57,902	144,755
Total		**2,650,700**	**7,192,467**

Emissions from construction are relatively low, less than 10% of average annual operating emissions for the 3 mtpa case. Two development scenarios are presented in Table 4, the base case of building an access bridge to Curtis Island and the option of not building the bridge. Greenhouse gas emissions do not vary significantly between the two options.

Construction of the pipeline also involves two options, with an option of replacing some truck movements for delivery of construction materials with rail movements. Only emissions for Scope 1 and Scope 2 are reported here, as both the delivery trucks and the rail are Scope 3 emissions (refer Table 7).

[6] (refer EIS: Table 4.5.2).

Table 4: Construction - Scope 1 greenhouse gas emissions[7]

Construction scenario	Emissions source	Scope 1 (tonnes CO_2-e)	Scope 2 (tonnes CO_2-e)
Pipeline	Construction equipment	2,962	-
	Land clearing	171,588	-
	Accommodation	-	4,095
	Subtotal	**174,550**	**4,095**
Facility - bridge (base case)	Facility construction equipment	38,000	-
	Accommodation	13,738	-
	Land clearing	30,184	-
	Passenger ferry	11,621	-
	Barge transport, facility materials	16,140	-
	Bridge construction equipment	8,133	-
	Transport, bridge material	8,076	-
	Subtotal	**125,892**	**-**
Facility - barge option	Facility construction equipment	38,000	-
	Accommodation	13,738	-
	Land clearing	30,184	-
	Passenger ferry	11,621	-
	Barge transport, facility materials	16,140	-
	Subtotal	**109,683**	**-**

5.2 Project life emissions

Greenhouse gas emissions were also calculated as a cumulative total over the 25 year life of the GLNG Project.

The estimates assume that drilling activities continue for 25 years in Roma, 12 years in Arcadia Valley and 16 years in Fairview. All field compressor stations have been assumed to operate for the 25 year life span of the GLNG Project.

LNG facility construction emissions are reported for both the base case, which includes construction of a bridge to Curtis Island, and the no bridge option.

Table 5: Operations - Scope 1 greenhouse gas emissions[8]

	3 mtpa case (tonnes CO_2-e / 25 yrs)
Base case – bridge	66,449,911
No bridge option	66,433,702

[7] (refer EIS: Table 6.9.4).

[8] (refer EIS: Table 6.9.6).

5.3 Scope 3 greenhouse gas emissions

The majority of Scope 3 emissions from the GLNG Project result from the end use of the LNG, typically for electricity generation or retail use by consumers.

It is highly probable that the LNG from the GLNG Project will be exported to Asia, possibly Japan, China or Korea. Therefore for the purposes of determining a reasonable estimation of Scope 3 emissions the distance of transport to Japan (~5,950 km) and combustion emission factors in accordance with Schedule 1 of the Measure Determination were applied.

Table 6: Operations - Scope 3 greenhouse gas emissions[9]

Scope 3 Activity	3 mtpa Case (tonnes CO_2-e / year)	10 mtpa Case (tonnes CO_2-e / year)
Transport	312,182	936,545
Combustion for power generation	8,535,000	28,450,000

Scope 3 construction and transport emissions are negligible, less than 1% of annual operation emissions. Construction emissions have been estimated for four scenarios and based on a 25 year project lifespan and are shown below in Table 7.

Table 7: Construction - Scope 3 greenhouse gas emissions[10]

Scenario	3 mtpa LNG Case (tonnes CO_2-e / 25 yr)	10 mtpa LNG Case (tonnes CO_2-e / 25 yr)
Bridge, no rail	24,612	37,390
Bridge with rail	23,047	35,825
No bridge, no rail	19,415	19,415
No bridge with rail	17,850	17,850

[9] (refer EIS: Table 6.9.8).

[10] (refer EIS: Table 6.9.7).

6 Mitigation initiatives

To achieve the GLNG Project's greenhouse gas management objective of applying energy efficient production and processing methods to produce a low carbon intensity energy product, a number of mitigation initiatives have been introduced.

Some of the opportunities identified and incorporated into the GLNG Project design include:

- Gas liquefaction processes that are highly efficient and minimise flaring of gas.
- High-efficiency compressor and power generation turbines at the LNG facility running on CSG, reducing energy consumption and reliance on coal-based electricity from the grid.
- Use of boil-off gas in the LNG facility as fuel to improve overall plant energy efficiency rather than venting or flaring.
- Selection of appropriate solvent for the CO_2 removal process in order to minimise the co-release of CH_4.
- Use of aeroderivative turbines for the LNG facility with higher thermal efficiency and improved fuel efficiency compared to frame-type turbines traditionally used.
- Minimising flaring and venting where feasible and where possible flaring methane, converting the greenhouse gas content of the released gas from CH_4 to CO_2 reducing emissions by 21 times.
- Gas-fired in-field pipeline compressor station engines (in place of diesel fuel) with the possibility of electrically powered compressor engines using power generated by Santos' own gas-powered generators.
- Field operation protocols designed to minimise flaring, venting and other emissions sources.

The GLNG Project will almost exclusively be generating its own electricity from natural gas. This will not only ensure a lower footprint but will complement the Queensland Government's objective of increasing gas-fired generation to 18 % by 2020.

7 Monitoring and management

Climate change is a long-term issue and Santos as a stakeholder in the energy business recognises that one of its key social and environmental responsibilities is to pursue strategies that address the issue of climate change. Santos is committed to working with Government, industry and the community to address climate change with specific focus on addressing energy efficiency, adaptation strategies, development of good policy, the transition to lower emission technologies and reporting transparency.

7.1 Climate Change Policy

A clean energy strategy is the cornerstone of Santos' Climate Change Policy. The policy is based on Santos' vision to lower the carbon intensity of its products. It will guide moves to increase energy efficiency, embed a carbon price and continue public emissions reporting.

To achieve these commitments, Santos will:

- Continue to reduce the carbon intensity of Santos' products by focusing on energy efficiency, technology development and by embedding a carbon price in all activities.
- Use energy more efficiently by identifying opportunities to implement energy efficiency projects and report their progress.
- Examine the commercial development of low emission technologies, including storage solutions which will contribute towards long-term emission reduction targets.
- Pursue no flaring or venting of associated gas, unless there are no feasible alternatives.
- Continue to publicly disclose Santos' emissions profile and carefully examine forecast emissions.
- Understand, manage and monitor climate change risk and develop appropriate adaptation strategies for our business.
- Assist Governments and engage with other stakeholders on the design of effective and equitable climate change regulations and policy.

Santos will inform employees about its commitment to climate change and will ensure that climate change initiatives continue to be implemented. The Santos Board will review progress against this Climate Change Policy quarterly.

7.2 Energy efficiency and emissions reduction

In accordance with Santos' Climate Change Policy, the GLNG Project is committed to actively pursuing energy efficiency.

Compliance with the *Energy Efficiency Opportunities Act 2006* (Cth) (EEO Act) is part of Santos' ongoing energy efficiency strategy to look at ways to run operations more efficiently, preserve sales gas reserves, increase revenue and reduce Santos' carbon footprint.

Santos has registered an energy efficiency assessment and reporting schedule with the Government which exceeds its obligations under the EEO Act. As part of this program Santos will conduct detailed energy assessments across its operations within a five year program cycle and report annually on progress.

Santos' energy efficiency reporting will document energy use and accuracy of measurement on a site by site basis, identify energy efficiency projects and document whether these projects have been implemented. As part of this commitment to reporting, Santos publishes an energy efficiency opportunities report in its annual Sustainability Report.

Santos' energy initiatives include:

- An annually reviewed energy/loss reduction project seriatim.
- Development of energy efficiency plans with site specific targets.
- Development of site utility management programs aimed at reducing fuel utilisation for utilities and minimising wastage.
- Transport reduction.
- Preparation and maintenance of Standard Operating Procedures for reducing energy utilisation and loss.
- Incorporation of energy awareness in competency training modules.
- Incentive programs for the reduction of fuel utilisation and loss.
- Incorporation of energy utilisation and evaluation component in purchasing procedures for new plant and equipment and for new acquisitions.

Santos has programs in place to service and maintain plant and equipment as appropriate in order to ensure that equipment utilises fuel as efficiently as possible.

7.3 Greenhouse gas reporting

Under the NGER Act, Santos is required to report annually on greenhouse gas emissions, energy production and energy consumption.

As the operator of the GLNG Project, Santos is committed to disclosing its climate change performance and meets numerous reporting commitments including:

- Quarterly reports to the Santos Environment, Health, Safety and Sustainability Committee of the Board;
- Publication of the emissions profile on the Santos' website and in its Annual Report and Sustainability Report;
- Independent assurance of emissions inventory;
- EEO Act program;
- NGER Act system;
- Carbon Disclosure Project; and
- Annual reporting of air emissions to the National Pollution Inventory.

Santos prepares and maintains appropriate databases in order to meet these reporting requirements.

7.4 Assurance, risk & audit

Santos recognises the value of independent verification of its greenhouse gas emissions inventory. As such, external auditors have been engaged over a number of years to conduct independent reviews of the systems and methodologies used in calculating Santos' emissions.

These audits provide Santos with feedback on its reporting process; assurance that the published emissions inventory provides a true and reasonable representation of its emissions; and improved transparency of Santos' reporting processes.

As part of the Santos Internal Audit Plan, an external review of Santos' preparedness for the business impacts of climate change is commissioned on a regular basis.

The scope of this review includes:

- Identifying developments in the area of climate change.

- Assessing how Santos is positioned and the company's readiness to comply with and deliver against its Climate Change Policy.
- Identifying how Santos is responding or preparing to respond to relevant legislation.

Santos has a risk management framework that enables it to make informed decisions and to assist functions to undertake risk management processes. The function of the framework is to:

- Develop and maintain consistent, relevant and effective risk processes that lead to consistent risk based decision making as part of operational and strategic management
- Assist all functions throughout Santos to adopt a common, holistic framework for the management of risks
- Assist all functions to embed risk management into their critical processes so that it becomes integral with normal business practice and becomes part of the way things are done, and
- Provide information on the major risks that Santos faces, the effectiveness of control strategies and the progress with risk management plans. This assists the board and management to discharge their corporate governance duties

Santos will continue to monitor climate science developments to incorporate into engineering designs. In the instance of an extreme weather event, Santos has emergency procedures in place.

7.5 Carbon Pollution Reduction Scheme

The Government has taken steps towards implementing a national greenhouse gas emissions trading scheme to be known as the Carbon Pollution Reduction Scheme (CPRS). The Government has announced that it intends for the CPRS to commence on 1 July 2011. Legislation is required for the implementation of the CPRS. The Government has drafted legislation, but it has not been passed by Parliament and there is uncertainty regarding final design elements. If the CPRS or a similar greenhouse gas regulatory scheme commences, Santos will have a carbon permit liability in respect of the GLNG Project.

8 Benchmarking and assessment context

8.1 Market demand for energy

The provision of adequate, reliable and affordable energy is essential to meeting the needs of people in developed and developing countries.

Global energy demand expressed in millions of oil equivalent barrels per day is expected to increase, on average, by 1.3% per year from 2005 to 2030, even with significant efficiency gains. 80% of this increase in demand is likely to come from developing countries such as China and India, where economies are growing most rapidly.

8.2 LNG a clean global contributor

In the transition to a lower-carbon world, LNG offers a unique opportunity for Australia – both for growing the domestic economy and to global emission reductions.

The scale of prospective investment in Australian LNG development is already significant but is embryonic compared to its potential. Achieving this potential will bring with it economic growth as well as export, employment and Government revenue benefits, while providing diversity to Australia's energy economy with increased penetration of gas in the domestic manufacturing industry and a major boost to remote regional economies in Queensland.

The Australian Petroleum Production and Exploration Association's submission on the Government's Green Paper on the design of the CPRS noted that natural gas is the lowest greenhouse gas emitting fossil fuel. When used for power generation, it generates less than 50% of the emissions associated with coal-fired power and in comparison uses only a small fraction of water. It is an abundant and affordable resource, available today and to future generations of Australians.

There is a clear global requirement for the development of low carbon resources which are able to assist existing Australian energy producers in the country's transition to sustainable energy development and use.

As a global stakeholder in the energy business, Santos recognises its responsibility to pursue energy strategies which contribute to a reduction or offset of global emissions through displacement of coal-fired energy sources. Accordingly, the provision of increased LNG supply will assist Australia to move towards a cleaner energy portfolio.

The emissions from the combustion of LNG are approximately 40% less when compared to the combustion of black coal of equivalent energy content. These calculations were estimated by applying the emission factors in the Schedule 1 of the Measurement Determination and the results[11] are shown in Figure 1.

[11] These comparisons do not take into consideration the varying efficiencies of power generators.

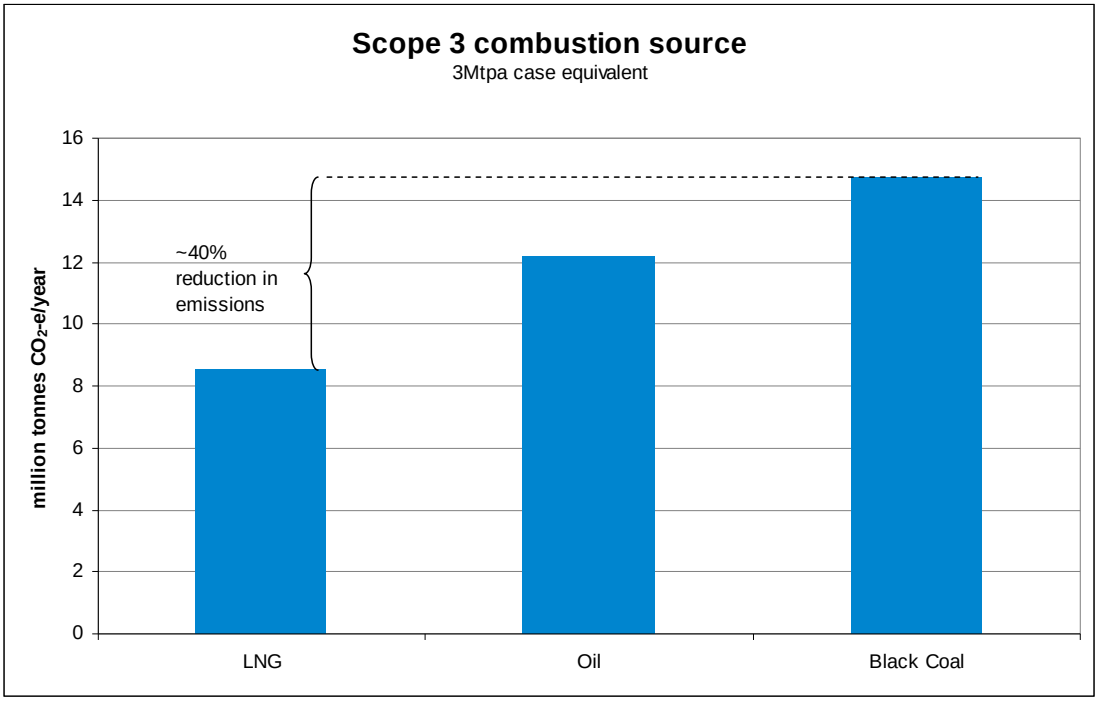

Figure 1: Comparative Scope 3 emissions[12]

8.3 Australian and Queensland context

Australia's net greenhouse gas emissions across all sectors totalled 576.0 Mt CO_2-e in 2006, with the energy sector contributing 400.9 Mt CO_2-e. Emissions from LNG facilities are captured under the energy category in accordance with the IPCC Guidelines for National Greenhouse Gas Inventories.

Queensland total emissions were 170.9 Mt CO_2-e and energy sector emissions were 94.9 Mt CO_2-e.

The following table shows average annual emissions from the GLNG Project as a percentage of Australian and Queensland emissions. The GLNG Project will constitute less than 0.5% to Australia's annual emissions total in the 3 mtpa case and 1.25% in the 10 mtpa case.

Table 8: Percentage of Australian and QLD emissions [13]

	Total emissions $MtCO_2e$	**GLNG 3 Mtpa (2.65 $MtCO_2$-e)**	**GLNG 10 Mtpa (7.19 $MtCO_2$-e)**
Queensland energy sector emissions	94.9	2.79 %	7.58 %
Total Queensland emissions	170.9	1.55 %	4.21 %
Australian energy sector emissions	400.9	0.66 %	1.79 %
Total Australian emissions	576.0	0.46 %	1.25 %

[12] (refer: EIS Table 4.2.2).

[13] (refer EIS: amended Table 6.9.10 and Table 6.9.11).

The GLNG Project has been compared with published data from a number of Australian and international LNG projects (refer Figure 2). This figure demonstrates that the GLNG Project compares favourably with other LNG facilities. Note that the Snohvit facility is significantly advantaged due to a cooler operating environment in the North Sea.

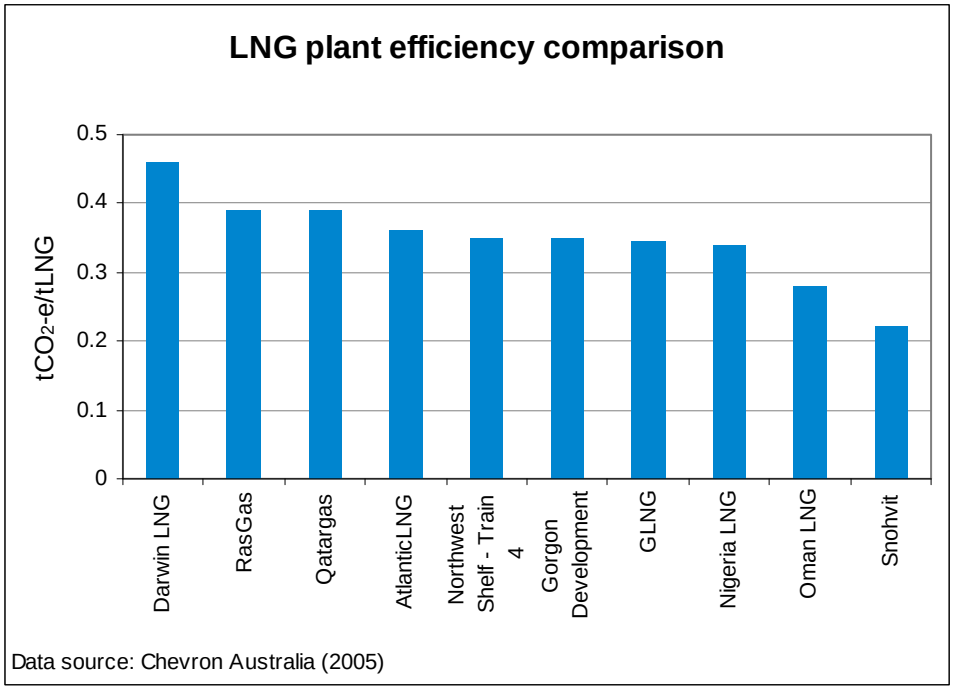

Figure 2: LNG plant efficiency comparison

Conclusion

The GLNG Project is applying energy efficient production and processing design to produce a low carbon intensity energy product to supply growing Asia-Pacific economies.

There are typically four significant factors influencing the emissions intensity of LNG projects:

- Reservoir composition (i.e. CO_2% in the gas).
- Reservoir pressure (this will determine the amount of compression required to convert natural gas to LNG).
- Distance of the gas fields to practicable port location/facilities, and
- Energy efficiency of the LNG facility design.

The GLNG Project has very low reservoir CO_2 composition and is adopting energy efficient plant design. The gas fields, located 435km from Gladstone, have very low reservoir pressure and the compression required for the GLNG Project is a major source of greenhouse gas emissions.

Based on the 3 mtpa case, forecast Scope 1 (direct) emissions from the GLNG Project are 2.65 $MtCO_2$ per annum. This equates to an emissions intensity of 0.88 tCO_2-e/tLNG. This efficiency will improve as the project ramps up to the 10 mtpa processing facility to an intensity of approximately 0.72 tCo_2-e/tLNG (~ 7.192 $MtCO_2$ per annum).

This GLNG Project compares favourably with other LNG facilities (refer Figure 2: LNG plant efficiency comparison) and will deliver an energy product that is greater than 40% more efficient than coal.