GREENHOUSE GAS ASSESSMENT

PAPUA NEW GUINEA LIQUEFIED NATURAL GAS PROJECT

PREPARED FOR:

COFFEY NATURAL SYSTEMS PTY LTD

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KEWAN BOND PTY LTD

ENVIRONMENTAL ACCOUNTING
AND CONSULTING SERVICES

Executive Summary

The Papua New Guinea Liquefied Natural Gas Project (PNG LNG Project) involves the development of gas resources located in the Central Highlands of Papua New Guinea, the production of gas and its transportation to an LNG facility at Portion 152 on the coast of the Gulf of Papua, north west of Port Moresby at Caution Bay. The gas is to be liquefied at the LNG facility and the LNG product transported by ship to international gas markets.

The LNG plant is proposed to have two 50% LNG liquefaction trains, processing 1,131 kSm3/hr of feed gas and will be capable of producing a peak capacity of 6.3 MTPA LNG. The development will also produce 30,000 ML of condensate over the thirty-year production period.

The calculation of greenhouse gas emissions from project construction and operation includes emissions of three main greenhouse gases – carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). These gases each have a different capacity to contribute to global warming, which is known as its global warming potential (GWP). Total emissions are expressed as carbon dioxide equivalents (CO_2-e), which considers the quantity of each gas and its GWP. The PNG LNG Project is expected to generate greenhouse gas emissions to a maximum of 3.1 million tonnes CO_2-e per annum. Over the thirty year life of the project total emissions are estimated to range between 77.4 million and 89.1 million tonnes CO_2-e, depending on the technology chosen for the gas turbines at the LNG plant (i.e. Frame or Aero-Derivative).

Figure 1 and **Table 1** present the emissions estimated from each major source throughout the project.

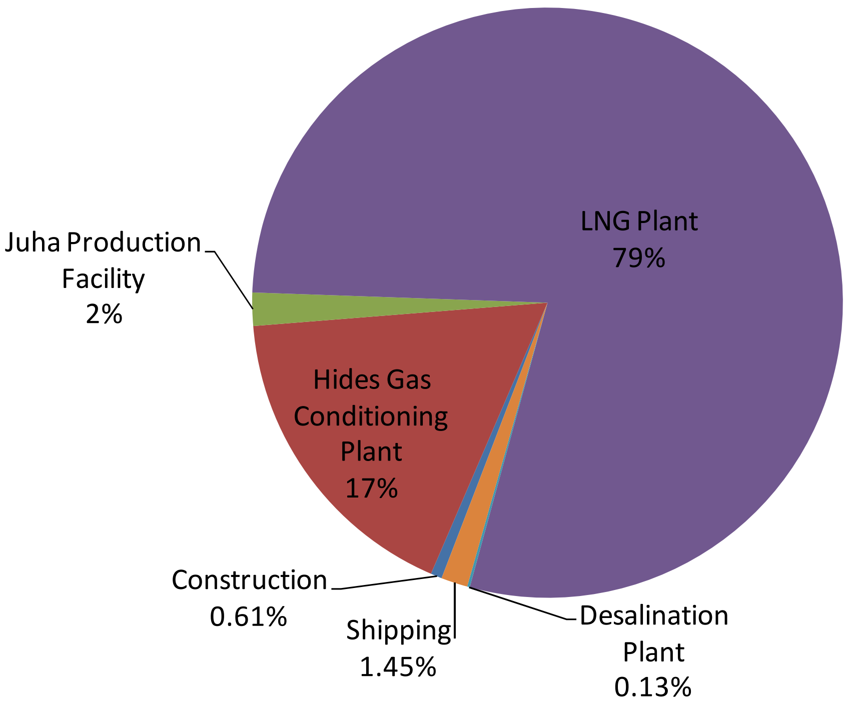

Figure 1 PNG LNG Project GHG Emissions

The PNG LNG Project is likely to be a large contributor to PNG's total emissions. However, PNG LNG will have a low emissions intensity when compared to other fossil fuels commonly used for electricity generation. The eventual consumption of LNG produced by the PNG LNG Project by customers will result in significantly less greenhouse gas emissions compared to sourcing the same quantity of energy from coal, fuel oil or diesel. Emissions associated with the PNG LNG Project also compare favourably against other LNG facilities worldwide, due largely to the low CO_2 content of the gas and the adoption of energy efficient technology such as waste heat recovery.

At a time when there is considerable pressure globally to reduce emissions of greenhouse gases in an effort to curb the impacts of global warming, the adoption of low emission fuels such as natural gas is encouraged. The PNG LNG Project represents a significant source of natural gas with a low greenhouse gas intensity.

Activity	Maximum Annual Emissions ($t\ CO_2$-e)	Total Emissions Frame Option ($t\ CO_2$-e)	Total Emissions Aero-derivative Option ($t\ CO_2$-e)
Upstream construction (incl. pipeline)	165,299	330,599	330,599
LNG facility construction (incl. pipeline)	54,222	216,890	216,890
Total Construction	**219,522**[1]	**547,488**	**547,488**
Pipeline compressors	299,951	7,604,776	7,604,776
Booster compressors	212,668	4,930,246	4,930,246
Turbo generator package	64,225	1,890,667	1,890,667
MEG vent gas incinerator	9,775	287,755	287,755
HP/LP flare	15,085	386,900	386,900
Essential diesel generator	20	585	585
Hot oil fired heater	0.002	0.06	0.06
Diesel fire water pump	3	88	88
Industrial area incinerator	10,923	325,378	325,378
Total Hides Gas Conditioning Plant	**609,989**[1]	**15,426,395**	**15,426,395**
Rich gas compressor	111,597	1,194,928	1,194,928
Turbine generator package	20,860	271,182	271,182
TEG Regeneration Package	5,054	65,705	65,705
HP/LP Flare	309	4,012	4,012
Essential diesel generator	6,290	81,764	81,764
Total Juha Production Facility	**144,110**	**1,617,590**	**1,617,590**
Power Generation (GTG's)	417,246	12,517,392	10,246,671
Propane refrigerant compressors (C3R)	640,502	19,215,072	14,185,704
Mixed refrigerant compressors (MR)	857,964	25,738,935	21,278,557
Acid gas incinerator	210,000	6,300,000	6,300,000
Heaters/boilers	188,697	5,660,916	5,660,916
Desalination plant	3,296	116,892	116,892
Miscellaneous[2]	24,605	738,142	738,142
Total LNG Plant	**2,342,311**	**70,287,348**	**58,526,881**
Total Shipping	**43,184**	**1,295,512**	**1,295,512**
TOTAL PREDICTED EMISSIONS	**3,139,593**[1]	**89,174,334**	**77,413,867**

Table 1 PNG LNG Project GHG Emissions

[1] The maximum annual emissions for various components of the project can occur during different years, so the sum of maximum annual emissions for each component is not equal to the maximum annual emissions for the project.
[2] Low pressure fuel gas for flare header purging, flare pilots and incinerators.

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1. Project Overview

The Papua New Guinea Liquefied Natural Gas (PNG LNG) Project involves the development of a number of gas fields and facilities in a series of development phases to produce liquefied natural gas (LNG) for export. The development will also produce condensate. The development of the Hides, Angore, and Juha gas fields and blowdown of the gas caps at the existing Kutubu, Agogo and Gobe oil fields will supply the gas resources. An extensive onshore and offshore pipeline network will enable transportation of the gas to a new LNG Plant near Port Moresby and stabilised condensate to the existing oil processing and storage, and offloading facilities at the Kutubu Central Processing Facility and Kumul Marine Terminal respectively. Small amounts of condensate are also produced at the LNG Facilities site.

Esso Highlands Limited (Esso), a Papua New Guinea subsidiary of the Exxon Mobil Corporation (ExxonMobil), is the operator of the PNG LNG Project. The PNG LNG Project will be developed in five phases over a period of 10 years to ensure reliability and consistent quality of supply of LNG for over the 30 year life of the project.

A list of the proposed developments is provided below, and **Figure 2** shows a schematic of facilities and pipelines:

Upstream Development Components:

- Hides gas field development:
    - Seven wellpads with a total of eight new wells and re-completion of two existing wells.
    - Hides gathering system including gas flowlines from new and re-completed Hides wells.
    - Hides spineline and mono-ethylene glycol (MEG) Pipeline in the same right of way (ROW).
    - Hides Gas Conditioning Plant.
    - Hides–Kutubu Condensate Pipeline in the same ROW as the LNG Project Gas Pipeline.
- Juha gas field development:
    - Three new wellpads with four new wells.
    - Juha gathering system including gas flowlines from new Juha wells.
    - Juha spinelines and MEG Pipeline in the same ROWs.
    - Juha Production Facility.
    - Juha-Hides pipelines right of way (ROW) containing three pipelines including Juha–Hides Rich Gas Pipeline, Juha–Hides Liquids Pipeline and Hides–Juha MEG Pipeline.
- Angore gas field development:

  - o Two new wellpads with two new wells.
  - o Angore gathering system including gas flowlines from new Angore wells.
  - o Angore spineline and Angore MEG Pipeline to Hides Gas Conditioning Plant, both in the same ROW.

- Gas from existing fields:
  - o Gas treatment at the Agogo Production Facility and a new Agogo Gas Pipeline from the Agogo Production Facility to LNG Project Gas Pipeline.
  - o Gas treatment at the Gobe Production Facility and a new Gobe Gas Pipeline from the Gobe Production Facility to LNG Project Gas Pipeline.
  - o Gas treatment at the Kutubu Central Processing Facility and a new Kutubu Gas Pipeline from the Kutubu Central Processing Facility to the LNG Project Gas Pipeline.
  - o South East Hedinia gas field development: one new wellpad and two new wells; new gathering system including gas flow lines from the South East Hedinia new wells to the Kutubu Central Processing Facility in the same ROW as the Kutubu Gas Pipeline.
- Kopi scraper station.
- LNG Project Gas Pipeline:
  - o Onshore: from Hides Gas Conditioning Plant to Omati River Landfall.
  - o Offshore: Omati River Landfall to Caution Bay Landfall.

LNG Facilities Development Components:

- Onshore LNG Plant including gas processing and liquefaction trains, storage tanks, flare system and utilities.
- Marine facilities including jetty, LNG and condensate export berths, materials offloading facility and tug moorage.

The LNG plant will be capable of producing a peak capacity of 6.3 million tonnes LNG/annum at a target specification of 42.5 MJ/m3 (1140 Btu/scf). The development will also produce 30,000 ML (188 Mbbls) of condensate over the thirty-year production period.

Supporting Facilities and Infrastructure:

In addition to the principal gas production, processing and transport, and LNG production and export facilities, the project will involve the following permanent infrastructure and facilities:

- New roads and upgrade of existing roads.
- New bridges and upgrade of existing bridges.
- Upgrade of two existing airfields (upstream at Komo and Tari).

- New helipads (multiple).
- New wharf and an upgrade of the existing Kopi roll-on, roll-off facility.
- Water supply systems and pipelines, wastewater and waste management facilities.
- Operations Camps (at Hides, Juha and Tari).

A series of temporary works and access roads will also be required during the construction phase, including:

- Construction camps (multiple).
- Material/pipe laydown areas.

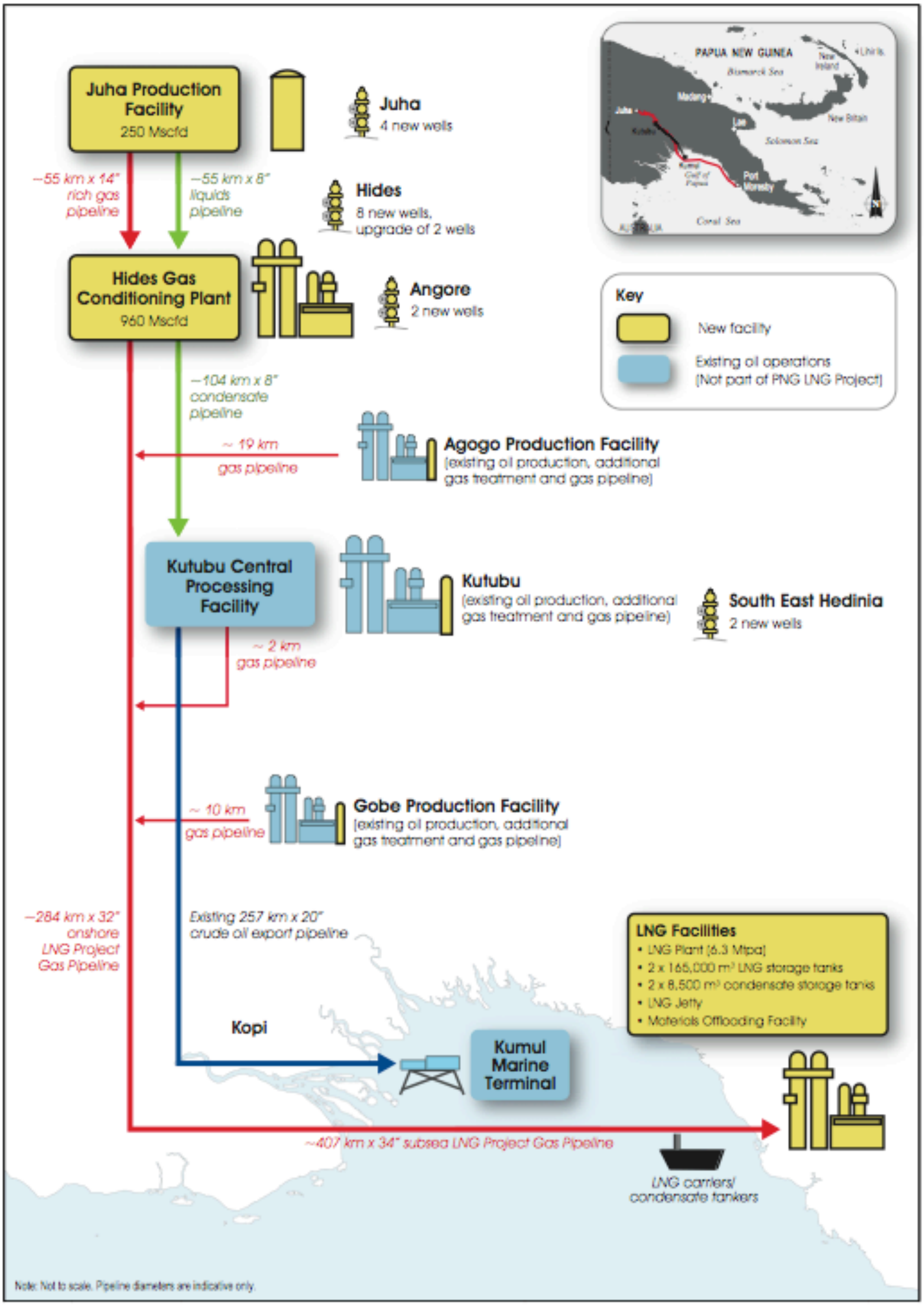


Figure 2 Facilities Schematic

2. The Greenhouse Effect

Greenhouses gases occur naturally in the atmosphere - trapping the sun's warmth and maintaining the Earth's surface temperature at a level necessary to support life. However, human activities such as burning fossil fuels and land clearing are increasing the concentrations of these gases, trapping more heat and changing the climate. This is the enhanced greenhouse effect. It is generally accepted amongst most of the world's scientists that the existing and predicted levels of greenhouse gas emissions have the potential to have a significant adverse impact on the world's climate.

The main greenhouse gases generated by human activities are:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFC's)
- Perfluorocarbons (PFC's)
- Sulphur hexafluoride (SF_6)
- Non-methane volatile organic compounds (NMVOC's)
- Carbon monoxide (CO)
- Nitrogen oxides (NO_x).

These gases differ in their capacity to trap heat and contribute to the greenhouse effect. The capacity of each gas to contribute to global warming is referred to as it's 'global warming potential' (GWP) and is measured relative to that of carbon dioxide i.e. carbon dioxide has a GWP of 1, whereas methane has a GWP of 21 because one tonne of methane has the same capacity to contribute to global warming as 21 tonnes of carbon dioxide. The greenhouse gases applicable to fossil fuel combustion and their respective GWP's are provided in **Table 2**.

Gas	Global Warming Potential
Carbon Dioxide	**1**
Methane	**21**
Nitrous Oxide	**310**

Table 2 Global warming potential of greenhouse gases[3]

Because of the variation in GWP between different gases, the emission factors used to calculate greenhouse gas emissions from the construction and operation of the PNG LNG Project are stated in terms of carbon dioxide equivalents (CO_2-e) and consider the various GWP's of the different greenhouse gases.

[3] Greenhouse gases Perfluorocarbons, Hydrofluorocarbons, Sulphurhexafluoride are usually not applicable to energy generation. (Source – Australian Greenhouse Office, 2006)

3. Global and National Strategies

3.1. Global

The Intergovernmental Panel on Climate Change (IPCC) is the international body responsible for assessing the state of knowledge about climate change. The IPCC provides guidance to the international community on issues related to climate change response. The IPCC's findings provide the rationale for international action on climate change.

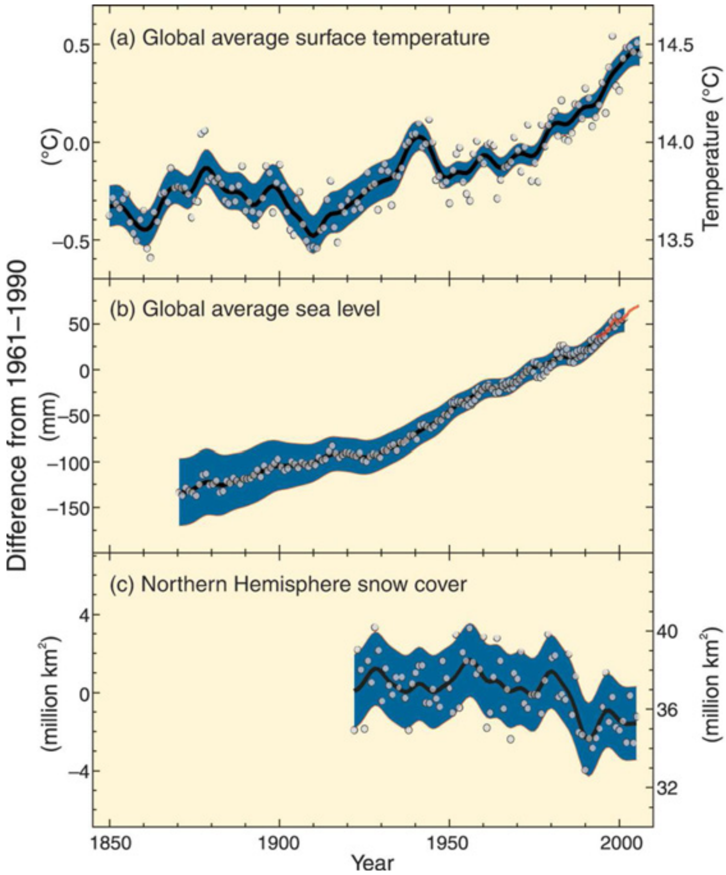
According to the Fourth Assessment Report of the IPCC (IPCC 2007):

- Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level – as indicated in **Figure 3**.
- Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.
- Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004.
- There is high agreement and much evidence that with current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades.
- Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century.

The 2007 IPCC report also projected the following changes due to climate change by the end of this century:

- Sea level increases of up to 59cm
- Global temperature increases of up to 4.0°C
- Increasingly acidic oceans impacting on fish stocks and marine life
- Shrinking snow cover and glaciers affecting water supplies
- More frequent droughts and heat waves
- More intense tropical cyclones, heavier rains and more natural disasters
- Changes in wind, rain, and temperature patterns affecting agriculture and livestock production and access to water in tropical and subtropical regions

Figure 3 Changes in temperature, sea level and Northern Hemisphere snow cover



Source – IPCC, 2007

The United Nations Framework Convention on Climate Change (UNFCCC), to which PNG is a signatory, is the basis for developing an international response to climate change.

The Kyoto Protocol to the Convention on Climate Change was developed through the UNFCCC negotiating process. It is an international treaty designed to limit global greenhouse gas emissions by setting legally-binding emissions targets for developed countries. Under the Kyoto Protocol, industrialised countries are required to reduce the emissions of six greenhouse gases (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) on average by 5.2 % below the 1990 levels during the first "commitment period" from 2008 to 2012. There are no emission targets for developing countries such as PNG, however the Protocol's Clean Development Mechanism allows a country with an emission reduction commitment under the Kyoto Protocol to implement an emission reduction project in developing countries and earn saleable certified emission reduction credits.

To date, 180 countries have ratified the Kyoto Protocol (UNFCCC website, 2008).

The Kyoto Protocol came into force in early 2005, as did a number of emissions trading schemes to support the Protocol. The emissions trading scheme with the greatest coverage is the European Union Emissions Trading Scheme (EUETS), which commenced in January 2005. Australia has recently announced plans to implement an emissions trading scheme in 2010, after ratifying the Kyoto Protocol in December 2007.

3.2. National

The Fourth Assessment Report of the IPCC made the following predictions for the Asia Region:

- By the 2050s, freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease.
- Coastal areas, especially heavily populated megadelta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers.
- Climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanisation, industrialisation and economic development.
- Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle.

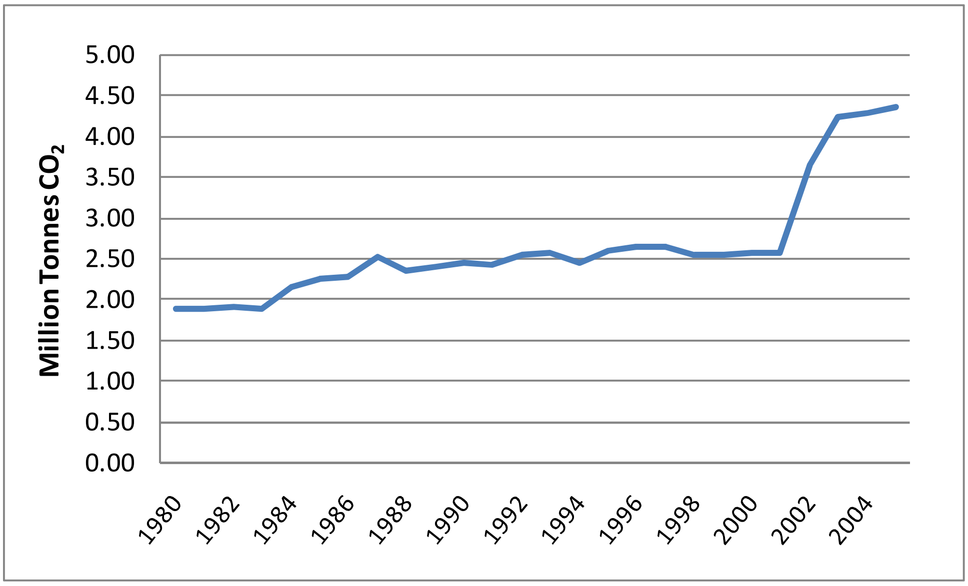
PNG ratified the UN Convention on Climate Change in 1993 and the Kyoto Protocol in 2002. According to a presentation by the PNG Department of National Planning & Monitoring (2007), a draft Carbon Trade Policy has been developed and, as of May 2007, is awaiting endorsement by PNG's National Executive Council (NEC). Also awaiting NEC endorsement is a proposal to develop a National Clean Development Mechanism (CDM) Authority.

Through the Kyoto Protocol's clean development mechanism, PNG is actively pursuing projects that result in carbon reductions, such as the Lihir Geothermal Power Project, which involves the development of a 30 MW geothermal power plant (UNFCCC, 2005).

In March 2008, PNG entered into a cooperative agreement with Australia to reduce greenhouse gas emissions from deforestation and forest degradation – the 'Papua New Guinea – Australia Forest Carbon Partnership'. Nearly two thirds of PNG's land area is forested (more than 29 million hectares), hosting some of the richest flora and fauna in the world and more than seven percent of the planet's biodiversity. (PNG-Australia Forest Carbon Partnership, 2008).

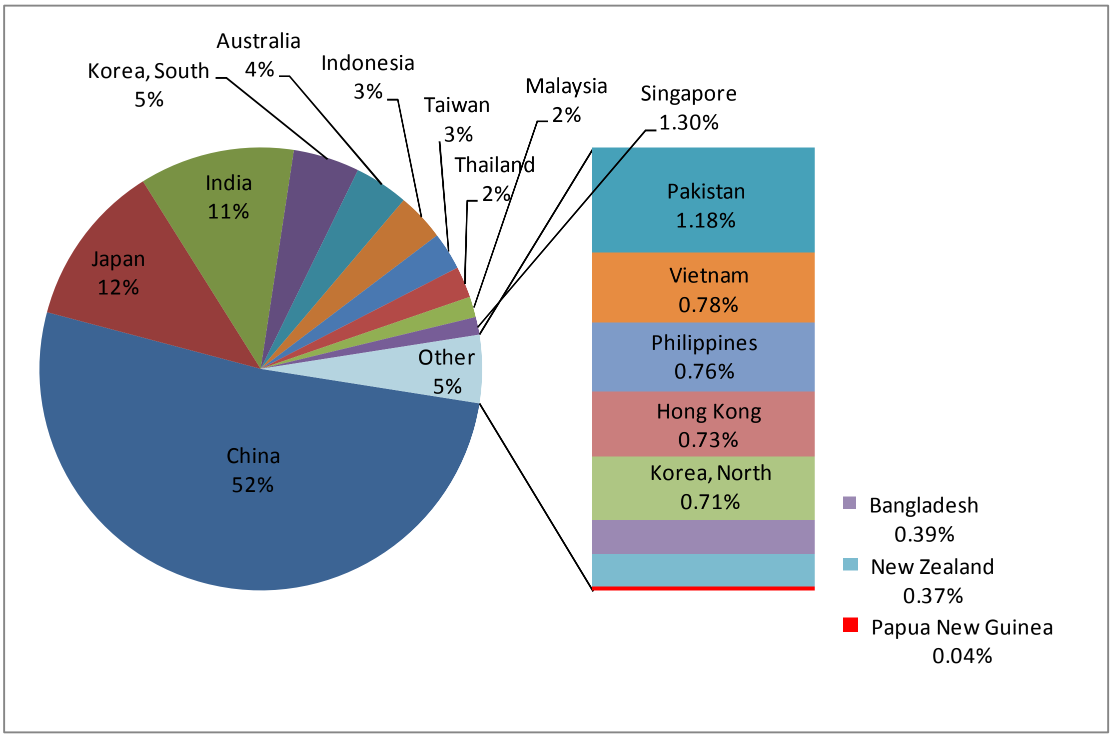
Emissions of CO_2 in PNG from fossil fuel combustion are presented in **Figure 4**. Emissions have increased significantly from 2.58 million tonnes in 2001 to 4.35 million tonnes in 2005. As a comparison, Australia's CO_2 emissions from fossil fuel combustion increased from 366.8 million tonnes in 2001 to 406.6 million tonnes in 2005. **Figure 5** shows that PNG contributes a very small proportion of greenhouse gas emissions from fossil fuel combustion – 0.04% of emissions from the Asia/Oceania region and 0.02% of global emissions.

Figure 4 PNG CO_2 Emissions from Fossil Fuel Combustion (1980 to 2005)



Source – Energy Information Administration, 2007

Figure 5 2005 CO_2 Emissions from Fossil Fuel Combustion - Asia and Oceania



Source - Energy Information Administration, 2007

4. Greenhouse Assessment Methods

An assessment of the greenhouse gas emissions associated with the construction and operation of the PNG LNG Project was conducted by Kewan Bond Pty Ltd. The assessment involved:

- Identification of the likely sources of greenhouse gas emissions from the construction and operation.
- Calculation of the likely quantities of greenhouse gases from these sources.
- Interpretation of expected greenhouse gas emissions and comparison against total PNG emissions, emission intensities at other LNG plants and other energy sources.
- Identification of emission abatement measures currently planned.

Emissions of greenhouse gases were calculated in accordance with methods provided by the Australian Greenhouse Office (AGO) and Australian Department of Climate Change, which are generally in accordance with the WBCSD / WRI Greenhouse Gas Protocol.

4.1. Greenhouse Gases Included

Consistent with the Kyoto Protocol (Refer Section 3.1), efforts by industrialised countries to minimise greenhouse gas emissions have concentrated on six key greenhouse gases. Of these, only CO_2, CH_4 and N_2O are usually applicable to natural gas production and combustion (AGO, 2006).

HFC emissions are associated mainly with refrigeration and air conditioning, while PFC emissions are associated mainly with Aluminium production. SF_6 emissions are related to gas insulated switchgear, circuit breaker applications, and in the production of magnesium (AGO, 2008)

Although predicted emissions of greenhouse gases from the PNG LNG Project are reported in terms of carbon dioxide equivalents, the assessment considers emissions of CO_2, CH_4 and N_2O, for which the global warming potential for each is presented in **Table 2**. The great majority of the total CO_2-e emissions (99.65%) are CO_2. CH_4 and N_2O represent only 0.3% and 0.05% respectively of the CO_2-e emissions factor, as indicated in **Table 3**.

Gas Specification	CO_2 Emission Factor (kg CO_2^{-e}/kg fuel)	CH_4 Emission Factor (kg CO_2^{-e}/ kg fuel)	N_2O Emission Factor (kg CO_2^{-e}/ kg fuel)	Emission Factor (kg CO_2^{-e}/ kg fuel)
Hides Case 10 (Yr 1-10, 21-30)	2.72	0.0081	0.0015	**2.73**
Hides Case 7 (Yr 11-20)	2.66	0.0078	0.0014	**2.67**
Juha Case 4 (Yr 10-23)	2.54	0.0074	0.0014	**2.55**
LNG Plant Fuel (Yr 1-30)	2.56	0.008	0.0015	**2.57**

Table 3 Gas Combustion Emission Factors

The Australian Generator Efficiency Standards (AGO 2006) advise that '*there is no significant production of methane from combustion of natural gas in a boiler or gas turbine as methane emissions result from incomplete combustion, which, if persistent, is both inefficient and uneconomic. Whereas the quantity of carbon dioxide emitted can be calculated based on the quantity of natural gas consumed, assuming stoichiometric combustion, it is not possible to similarly calculate the quantity of methane emitted. Methane emissions must either be measured using a program of regular sampling and analysis, or estimated.*'

Similarly '*Nitrous oxide is generally formed under low temperature and reducing conditions, and as a consequence there is no significant production of nitrous oxide from natural gas fired power plant. Whereas the quantity of carbon dioxide emitted can be calculated based on the quantity of natural gas consumed, assuming stoichiometric combustion, it is not possible to similarly calculate the quantity of nitrous oxide emitted. Nitrous oxide emissions must either be measured using a program of regular sampling and analysis, or estimated.*'

Although representing only a small proportion of total greenhouse gas emissions, emissions of CH_4 and N_2O have been estimated using the latest emission factors provided by the Australian Greenhouse Office for natural gas combustion by gas turbines, combined with the specific gross calorific value and density of the various fuel gases expected for the PNG LNG Project.

Estimated greenhouse gas emissions include only Scope 1 emissions, which are direct emissions that occur from sources that are owned or controlled by the company (WBCSD/WRI). For example, emissions from combustion of natural gas in the production of LNG, combustion of diesel by vehicles and equipment during the construction and operation of the PNG LNG project.

Scope 2 emissions include those resulting from the generation of purchased electricity that is consumed by the company (WBCSD/WRI). There are no Scope 2 emissions associated with the PNG LNG Project as there will be no consumption of purchased electricity that is generated elsewhere.

Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company (WBCSD/WRI). Scope 3 emissions are excluded from the emission calculations used to determine compliance with Kyoto Protocol commitments and are generally excluded from a country's national emissions inventory. This avoids double-counting of emissions as Scope 3 emissions for one facility can be either Scope 1 or Scope 2 emissions from another facility. For these reasons, Scope 3 emissions have not been estimated as part of this greenhouse gas assessment of the PNG LNG Project.

4.2. Fuel Gas Emission Factors

Gas compositions are expected to vary during the life of the project and between different stages of the gas processing. Concentrations of methane, ethane, propane, butane, pentane, nitrogen and carbon dioxide, as well as the energy content are the main variables considered. Four gas compositions have been provided by the proponent as being representative of the gas compositions expected to be experienced during the life of the project. These compositions were used to calculate variations in emission factors during the thirty year project, as shown in **Table 3**. The methods for calculating the gas-specific emission factor from the gas composition data are in accordance with the AGO's Generator Efficiency Standards Technical Guidelines 2006.

According to the proponent, the fuel gas to the Hides Gas Conditioning Plant is expected to most closely reflect the 'Hides Case 10' gas composition for years 1-10 and years 21-30. The composition of gas for years 11-20 is expected to reflect 'Hides Case 7'. Emissions of greenhouse gases were calculated for each year of operation based on the consumption of a particular gas composition at quantities provided by the proponent.

Juha Production Facility is expected to receive 'Juha Case 4' gas for its entire operational life between years 10-23.

The 'LNG Plant Fuel' composition and emission factors have been used for the entire life of the LNG plant.

4.3. Emission Sources

Sources of greenhouse gas emissions associated with the construction and operation of the PNG LNG Project and included in this assessment are listed below.

a) Hides Gas Conditioning Plant:

- Diesel used during construction of plant and pipelines
- Gas used in pipeline compressors, booster compressors and turbo generators
- Vent gas incineration/flaring
- Diesel used in essentials generator, fire water pump and industrial area incinerator
- Gas used for hot oil fired heater

b) Juha Production Facility:

- Diesel used during construction of plant and pipelines
- Gas used by rich gas compressor, turbine generators, and TEG regeneration
- Flaring
- Diesel used by essentials generator

c) LNG Plant

- Diesel used during construction of plant and pipelines
- Gas used by gas turbines for power generation and refrigerant compressors (frame technology or aero-derivative technology)
- Gas used by heaters/boilers
- Flaring, mainly from the acid gas removal unit
- Gas used to generate electricity to power the desalination plant

d) Shipping

- Heavy Fuel Oil and Marine Diesel Oil used by ships and tugs for transport of the LNG and condensate product. Only those shipping activities between the pilot station and the LNG facility are included. Emissions associated with shipping on the high seas to international markets would constitute a Scope 3 emission and are excluded.

Clearing of vegetation for the pipelines and facilities (which result in emissions from decomposing vegetative matter) have not been calculated and are excluded from this assessment. Methods for measuring and calculating emissions from deforestation in PNG are yet to be developed. PNG and Australia have recently entered into a cooperative agreement to address this and other issues relating to greenhouse gas emissions from deforestation – the Papua New Guinea – Australia Forest Carbon Partnership (March 2008).

Leaks and accidental releases of gas from gas pipelines are considered to only occur under rare abnormal conditions and would represent a very low proportion of total greenhouse gas emissions. This view is supported by the AGO in their guidelines, which assume emissions from these sources to be zero due to the following facts (which are also expected to apply to the PNG LNG Project):

- The gas transmission system is very new and is built and maintained to high quality standards – evidenced by the extreme rarity of accidental releases.
- Most lines are built with isolating valves at regular intervals along the line, limiting the quantity of gas released in the event of a line rupture.
- Routine monitoring of methane concentrations in compressor stations have consistently recorded extremely low concentrations.

(Australian Greenhouse Office, 2005 – Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2003: Energy, Fugitive Fuel Emissions –pg 20-21)

4.4. Sensitivity and Accuracy of Results

The calculation of predicted greenhouse gas emissions is subject to various error factors and causes for potential variations in results. These include:

- Factors of error within standard emission factors adopted (e.g. rounding)
- Factors of error within standard calculation and modelling methods adopted
- Variations from assumed gas specifications and flow rates
- Variations from assumed efficiency of plant and equipment

The accuracy of the emission estimates within this study have been greatly increased through the calculation of gas-specific emission factors based on the likely composition of the gas and the application of the latest emission calculation and modelling methods.

5. Greenhouse Gas Emissions

5.1. Emissions from Project Construction

It is anticipated that construction of the PNG LNG Project will be conducted over four years. Greenhouse gas emissions associated with construction arise through the combustion of diesel by plant and equipment. An estimated 203,204 kL of diesel is expected to be consumed during the construction of the project. Although the actual equipment and fuel use may vary from these estimates, it is important to note that diesel consumption will comprise only a very small proportion of total greenhouse emissions for the project. The emission factor for diesel provided by the Australian Department of Climate Change is 2.7 t CO_2-e/kL and was used to calculate greenhouse gas emissions from these activities.

Table 4 shows the resulting emissions expected during the construction of the upstream facilities and LNG facility.

	Annual Emissions (t CO_2-e)				Total
Stage	Year 1	Year 2	Year 3	Year 4	
Upstream (diesel)	82,650	118,071	82,650	47,228	330,599
LNG facility (diesel)	54,222	54,222	54,222	54,222	216,890
TOTAL	**136,872**	**172,293**	**136,872**	**101,451**	**547,488**

Table 4 Emissions Summary – Construction

5.2. Emissions from Upstream Facilities

Emissions associated with the upstream facilities include the operation of the Hides, Angore and Juha gas fields, the Hides Gas Conditioning Plant and the Juha Production Facility.

Emissions from the operation of the Hides, Angore and Juha well fields are expected to be minor and will generally only occur during maintenance or when a hydrate plug forms and requires clearing. The anticipated emission sources from the well fields include:

- Pig Launcher - Residual vapours released upon opening the depressurised launcher trap door after pigging. This event is expected to occur infrequently (perhaps quarterly) and is expected to result in only trace emissions of uncombusted hydrocarbons (0.5kg per event).

- Vent KO Drum - Minor emissions from depressuring launcher / wellpad piping (maintenance/hydrates). This event is similarly expected to occur infrequently (perhaps 1 hr/yr or 1 day/30 yrs). Major spineline relief would be extremely rare.

- Vent KO Pot - Minor emissions from depressuring wellpad piping if valves need maintenance or hydrate plug forms. The volume of the pipework would be released in tis event, which is only expected for 1hr/yr.

Emissions from these sources are considered insignificant relative to emissions from the Hides Gas Conditioning Plant and Juha Production Facility and have therefore not been included in this assessment.

Although annual consumption of fuel gas at the Hides Gas Conditioning Plant and Juha Production Facility is assumed to be constant, emissions of greenhouse gases vary due to changes in the gas composition. **Table 5** shows the total project emissions for each of the upstream emission sources identified in **Section 4.3**.

	Maximum Annual Emissions (tCO_2-e)	Total Upstream Emissions (tCO_2-e)
Hides Gas Conditioning Plant	**609,989**	**15,426,395**
Pipeline compressors	299,951	7,604,776
Booster compressors	212,668	4,930,246
Turbo generator package	64,225	1,890,667
MEG vent gas incinerator	9,775	287,755
HP/LP flare	15,085	386,900
Essential diesel generator	20	585
Hot oil fired heater	0.002	0.06
Diesel fire water pump	3	88
Industrial area incinerator	10,923	325,378
Juha Production Facility	**144,110**	**1,617,590**
Rich gas compressor	111,597	1,194,928
Turbine generator package	20,860	271,182
TEG Regeneration Package	5,054	65,705
HP/LP Flare	309	4,012
Essential diesel generator	6,290	81,764
TOTAL	**754,098**	**17,043,985**

Table 5 Emissions Summary – Upstream

The majority (90%) of total upstream emissions will be generated from the Hides Gas Conditioning Plant. It is currently anticipated that the Juha Production Facility will only be operating for thirteen years from years 10-22. Annual emissions from the Hides Gas Conditioning Plant range from 375,211 tonnes CO_2-e to 598,173 tonnes CO_2-e, with the majority being generated through the consumption of gas by pipeline and booster compressors, as indicated in **Figure 6**.

Emissions from the Juha Production Facility range from 116,137 tonnes to 144,110 tonnes CO_2-e per annum, with the rich gas compressor contributing the majority of these, as indicated in **Figure 7**.

A full inventory of upstream emissions over the life of the project is presented in **Appendix A**.

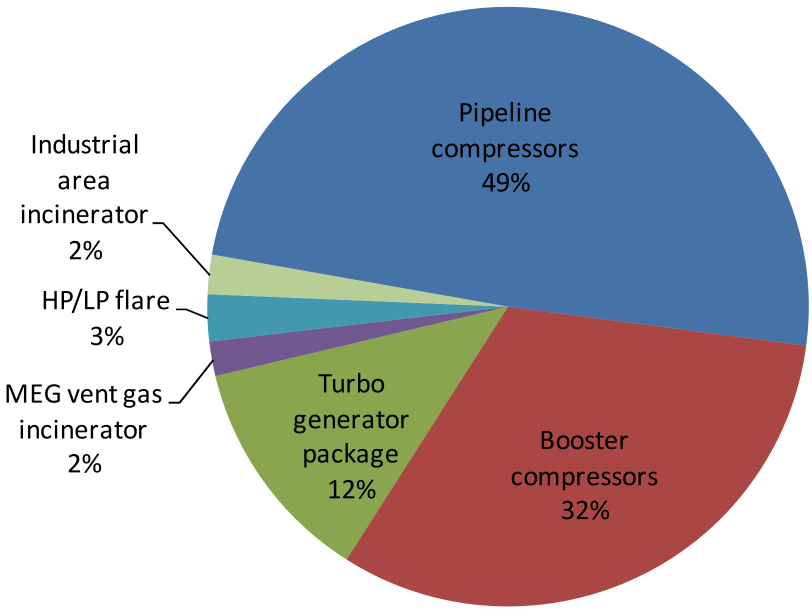


Figure 6 Hides Gas Conditioning Plant Emissions

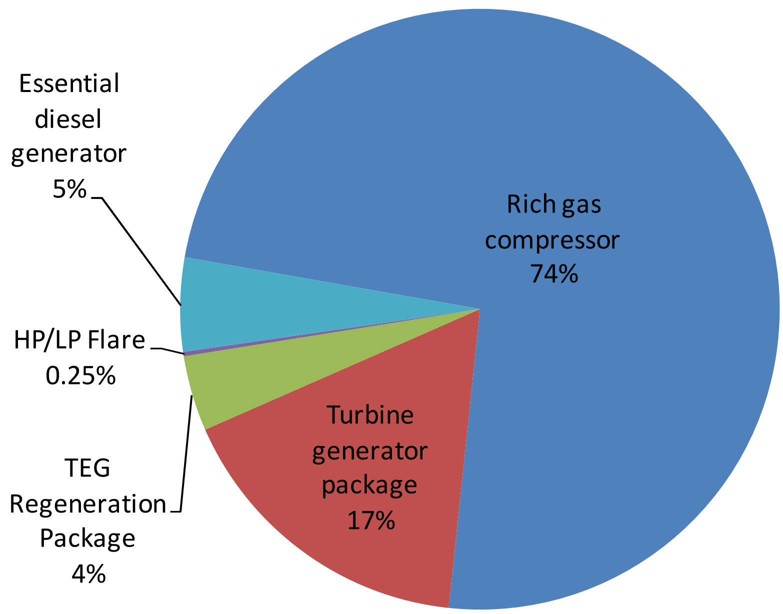


Figure 7 Juha Production Facility Emissions

5.3. Emissions from LNG Facility

The two LNG liquefaction trains will process 1,131 kSm3/hr (960 Mscfd) of feed gas. For each LNG train there will two (2) Refrigerant Compressors driven by gas turbines – namely the Mixed Refrigerant (MR) and the Propane Refrigerant (C3R) Compressors. The LNG plant power requirements are met by the Gas Turbine Generators (GTGs). Currently there are two options being considered for the selection of turbines – the industrial type Frame turbines and the Aero-derivative turbines. The Aero-derivative turbines offer superior fuel efficiency (and therefore reduced emissions) over the Frames due to the design of the machines. Meanwhile, the reliability of the Frame machines is expected to be superior over the Aero-derivative turbines. The final selection between the two turbine technologies will depend on a detailed cost-benefit, risk and RAM analyses.

Emission estimates have been conducted for both turbine technologies and are presented in **Table 6** for Frame turbines and for Aero-derivative turbines. A full inventory of LNG facility emissions over the life of the project is presented in **Appendix A**.

	Max. Annual Emissions (t CO_2-e)	Total LNG Facility Emissions (t CO_2-e)	Total LNG Facility Emissions (t CO_2-e)
Turbine technology	Frame	Frame	Aero-derivative
Power Generation (GTG's)	417,246	12,517,392	10,246,671
Propane refrigerant compressors (C3R)	640,502	19,215,072	14,185,704
Mixed refrigerant compressors (MR)	857,964	25,738,935	21,278,557
Acid gas incinerator	210,000	6,300,000	6,300,000
Heaters/boilers	188,697	5,660,916	5,660,916
Desalination plant	3,296	116,892	116,892
Miscellaneous[4]	24,605	738,142	738,142
TOTAL	2,342,311	70,287,348	58,526,881

Table 6 LNG Facility Emissions

Acid gas from the acid gas removal units will be incinerated, which will also result in greenhouse gas emissions. The quantity of acid gas to be incinerated is largely determined by the CO_2 content of the feed gas. The CO_2 content of the feed gas ranges between 0.7% – 2% and is relatively low compared to other LNG projects around the world (refer **Section 6**).

Emissions from heaters and boilers are minimized through the adoption of waste heat recovery. Waste heat from the exhausts of the propane refrigerant compressors

[4] Low pressure fuel gas for flare header purging, flare pilots and incinerators.

Fresh water requirements during construction and operation of the LNG facility will be met by desalinating sea water via a desalination plant. It is estimated that up to 900 ML of fresh water per annum will be required during the construction phase and approximately 548 ML/annum during the operation phase.

The small quantities of 'Miscellaneous' emissions result from the consumption of LP fuel gas for flare header purging, flare pilots and incinerators. Flares will only be operating during times of emergency or during start-up and shutdown. The plant design basis does not consider any continuous flaring of hydrocarbons during normal operations. It is not possible to calculate the annual gas throughput through the flares as it depends on a number of parameters such as number of emergency shutdowns, planned shutdowns and the depressurizing philosophy of the plant. The only continuous emissions from the flares will be due to flaring of the flare header purge gas and pilot gas for each flare. These quantities are minimal, but have been included in calculation of project greenhouse gas emissions.

LNG and condensate will be shipped to customers worldwide from the port facilities to be constructed at Portion 152. Greenhouse gas emissions from these shipping activities to the boundary of the pilot station have been estimated based on the predicted fuel consumption by ships and tugs and the estimated number of visits and are presented in **Table 7**.

	Maximum Annual Emissions (t CO_2-e)	Total Project Emissions (t CO_2-e)
Shipping (LNG Carriers)	16,632	498,948
Tugs (for LNG Carriers)	23,295	698,840
Shipping (Condensate Tankers)	223	6,686
Tugs (for Condensate Tankers)	3,035	91,039
TOTAL	**43,185**	**1,295,512**

Table 7 Shipping Emissions

When an LNG carrier or Condensate tanker calls at the port facility, tugs will also be required for:

- Escorting the carrier or tanker from the pilot station to the jetty;
- Assisting the carrier or tanker with mooring;
- Standing by while loading;
- Assisting with unmooring; and
- Escorting the carrier or tanker back out to the pilot station.

Although yet to be confirmed, for the purposes of impact assessment, it is assumed that the tugs will be homeported at Motukea rather than at the port at Portion 152. This represents the worst case for greenhouse gas emissions as it is the furthest that tugs would need to transit for the project. It is planned that LNG carriers will make 95 port calls per annum, while the Condensate tankers will make 17 port calls per annum.

Emissions associated with shipping represent approximately 2% of total emissions from the LNG Facility, as shown in **Figure 8**. The proportions of emissions associated with each aspect of the LNG Facility shown in **Figure 8** are essentially the same for both turbine options (i.e. frame and aero-derivative).

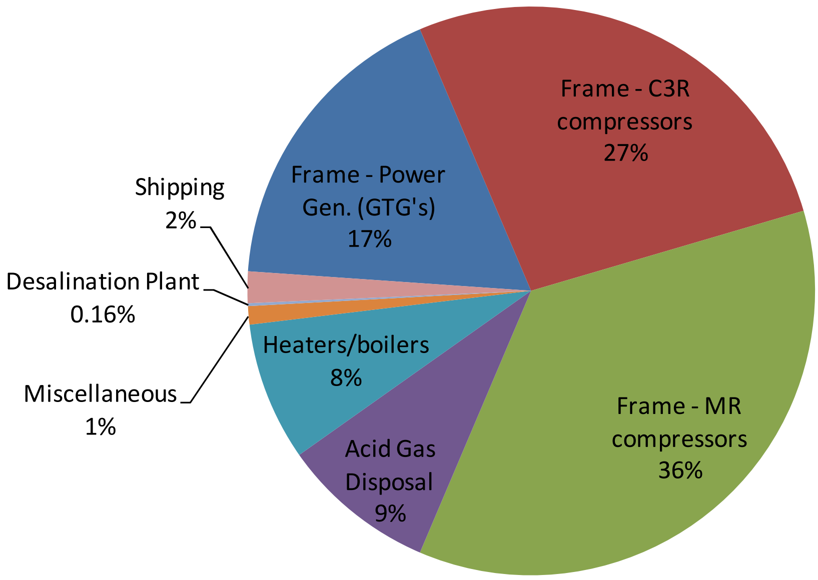


Figure 8 LNG Facility Emissions

5.4. Total Project Lifecycle Emissions

The total emissions over the expected thirty year life of the PNG LNG Project are presented in **Table 8** and **Figure 9**. The LNG plant itself is expected to contribute 79% of total project emissions.

Activity	Maximum Annual Emissions (t CO_2-e)	Total Emissions Frame Option (t CO_2-e)	Total Emissions Aero-derivative Option (t CO_2-e)
Construction	-	547,488	547,488
Hides Gas Conditioning Plant	609,989	15,426,395	15,426,395
Juha Production Facility	144,110	1,617,590	1,617,590
LNG Plant	2,339,015	70,287,348	58,526,881
Shipping	43,184	1,295,512	1,295,512
TOTAL EMISSIONS	**3,136,297**	**89,174,334**	**77,413,867**

Table 8 Project Lifecycle Emissions

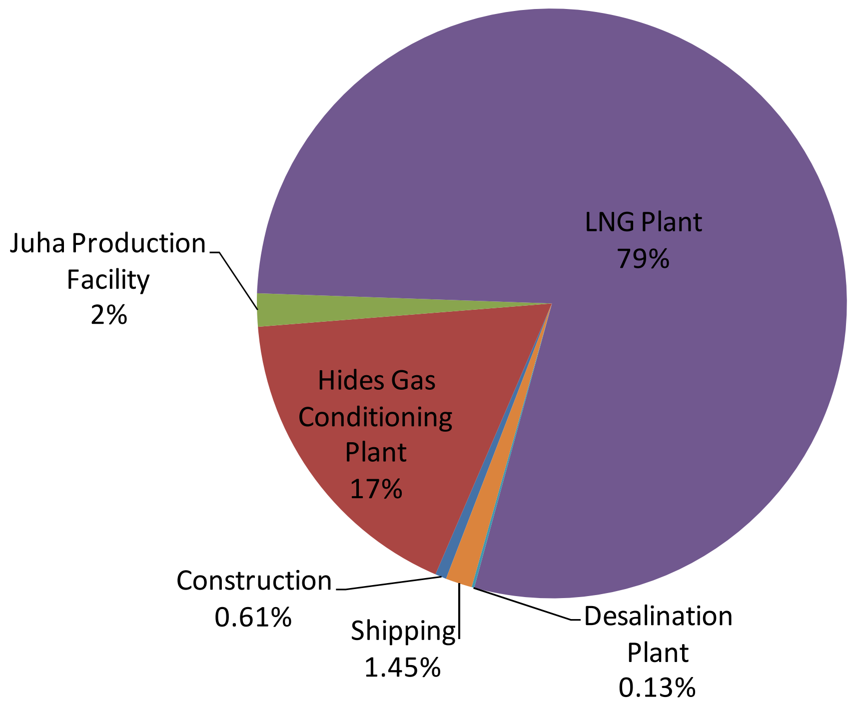


Figure 9 Total Project Emissions

Figure 10 presents the predicted emissions over the thirty year life of the project, for both the frame and aero-derivative turbine options. The full greenhouse gas inventory for the PNG LNG Project is presented in **Appendix A.**

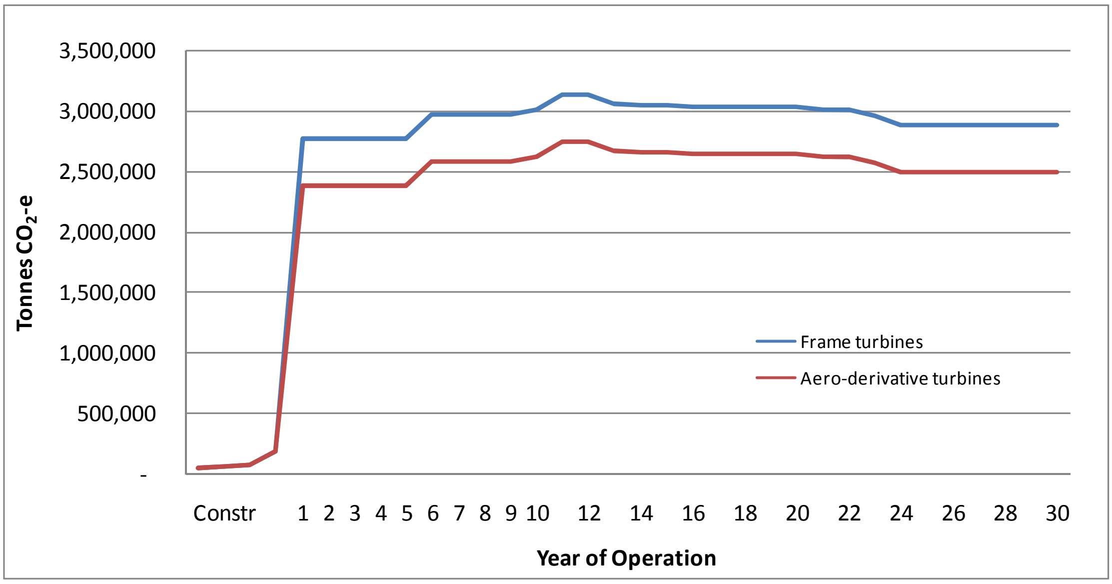


Figure 10 PNG LNG Estimated Annual Emissions

The greenhouse gas emissions associated with the PNG LNG Project are large when compared with the total GHG emissions from fossil fuel combustion in Papua New Guinea from 2005 (presented in **Section 3.2**). The maximum annual greenhouse gas emissions from the project (3.1 million tonnes CO_2-e) would represent 42% of total PNG emissions, if added to national emissions calculated for 2005, as indicated in **Figure 11**.

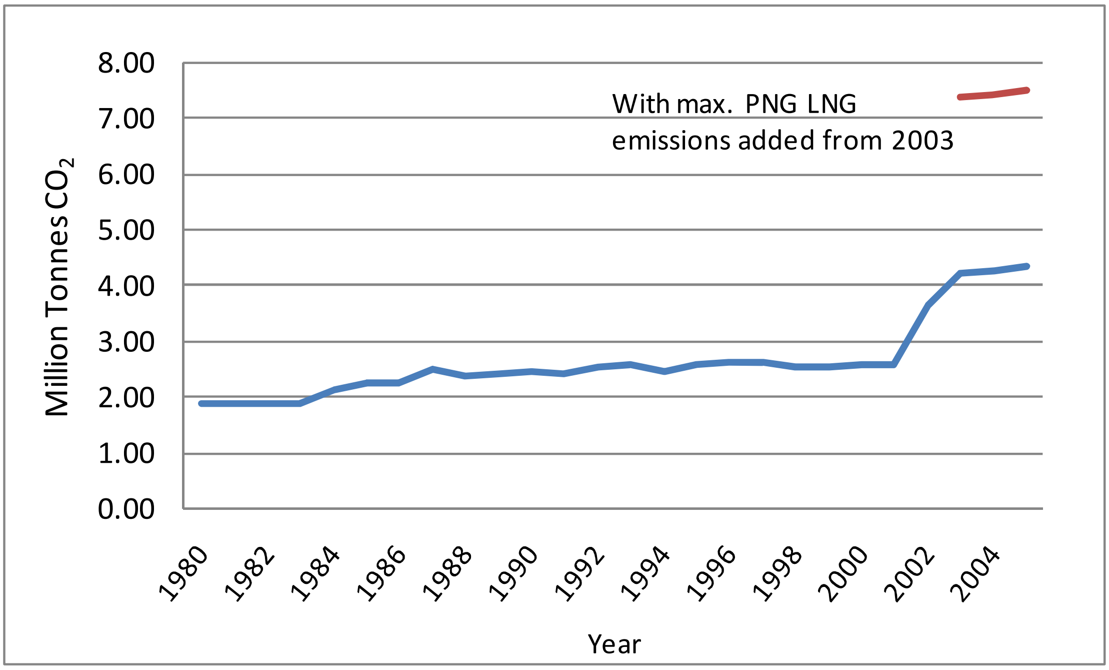


Figure 11 PNG CO_2 Emissions from Fossil Fuel Combustion - with PNG LNG Project

6. Benchmarking of Greenhouse Gas Emissions

The emission factor for the eventual use of LNG from the PNG LNG Project has been calculated at 53.87 kg CO_2-e per GJ, based on the specific gas composition data. This compares favourably to the emission intensity of other fossil fuels commonly used for stationary energy, as listed below (Source – Australian Department of Climate Change NGA Factors, 2008):

- Brown coal – 93.2 kg CO2-e per GJ
- Black coal – in the order of 91.2 kg CO2-e per GJ
- Fuel oil - 73.1 kg CO2-e per GJ
- Diesel – 69.5 kg CO_2-e per GJ

These emission factors represent the Scope 1 emissions as defined within the GHG Protocol (i.e. the direct emissions from the combustion of the fuel on site). However, when comparing the greenhouse gas intensities of different fuels, it is important to also consider the emissions associated with extracting, refining and transporting those fuels – Scope 3 emissions under the GHG Protocol.

The PNG LNG Project is expected to produce 8,610 PJ of LNG over its 30 year life. When compared against the estimated greenhouse gas emissions of 88.1 million tonnes CO_2-e, this equates to 10.23 kg CO_2-e per GJ of LNG. Therefore the full-fuel emissions factor for customers of the PNG LNG Project will involve Scope 1 emissions of 53.87 kg CO_2-e per GJ, plus Scope 3 emissions of 10.23 kg CO_2-e per GJ – a total of 64.1 kg CO_2-e per GJ. **Figure 12** presents this against the full-fuel emission factors for other stationary energy sources as presented in the Australian Department of Climate Change NGA Factors (2008). Although the Scope 3 emissions for LNG are higher than for most other fuels due to the energy associated with the liquefaction of the natural gas, the overall full-fuel cycle emissions per GJ are still lower than other common energy sources.

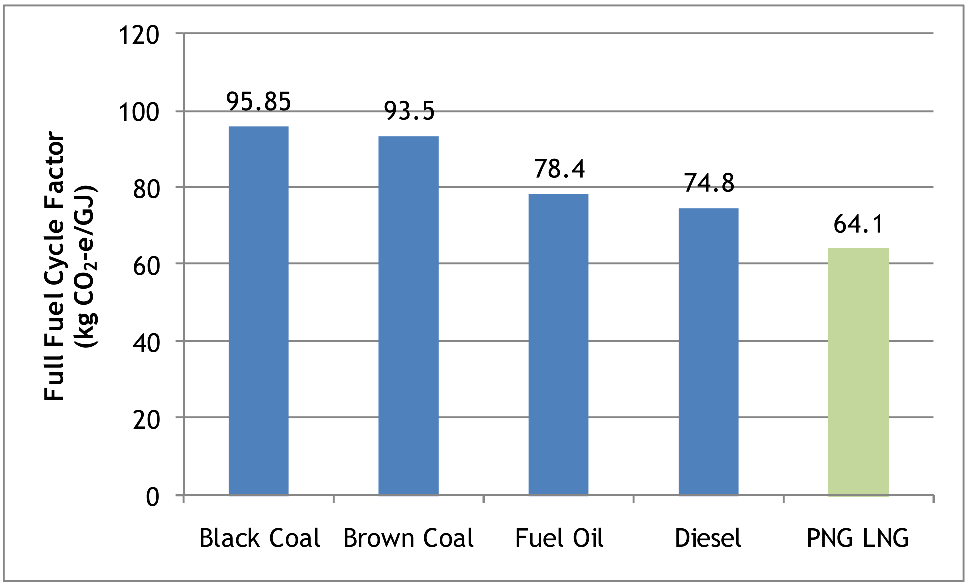


Figure 12 Emissions Benchmarking of Fossil Fuels

Figure 13 and **Table 9** present the greenhouse intensities of recent LNG developments. This benchmarking information was sourced from Woodside's Greenhouse Gas Abatement Program prepared for their Pluto Project (2007). All of the benchmarked LNG developments have been constructed within the last six years with the exception of the Gorgon reference case and Karratha Gas Plant.

This data compares emissions from just the LNG plant and does not include emissions from gas extraction or processing prior to reaching the LNG plant (i.e. does not include emissions from the Hides Gas Conditioning Plant or Juha Production Facility).

The greenhouse intensity of the facilities is influenced by a range of internal (technology) factors and external (environmental/geographic) factors. The main environmental factors that have a significant impact on greenhouse efficiency are the reservoir CO_2 content (higher CO_2 content equates to more CO_2 removal prior to liquefaction) and ambient temperature (compressor efficiency is favoured by cooler temperatures).

Technological and process factors that influence greenhouse intensity include:

- Choice of liquefaction technology
- Power generation – choice of energy source, technology and configuration
- Waste heat recovery
- Acid gas removal process

Information on some of these influencing factors is presented in **Table 9** to allow a more informed comparison between the benchmarked facilities.

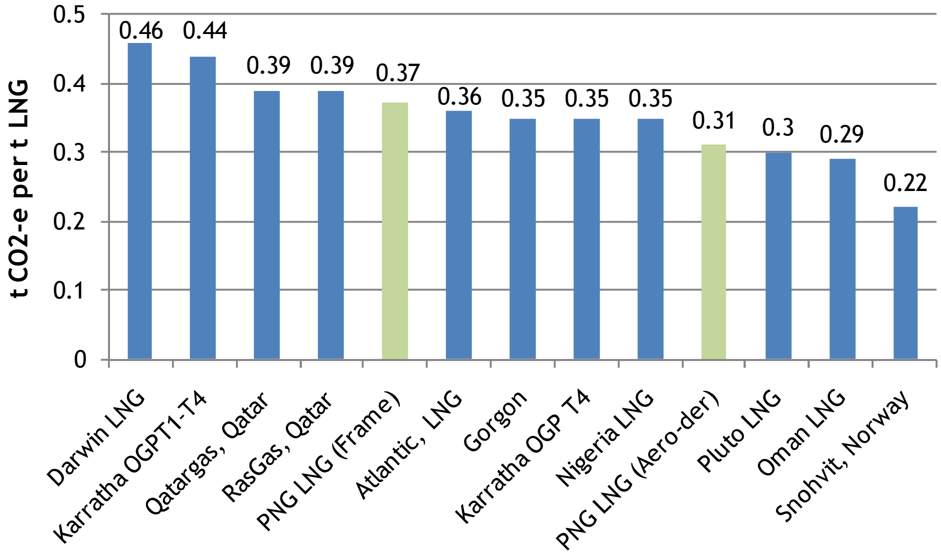


Figure 13 Emissions Benchmarking of LNG Facilities

(Source – Woodside 2007)

Project	Capacity (MTPA)	Aero-Derivative turbines		Geosequestration	Waste Heat Recovery		MDEA[5]	Reservoir CO2
		Process	Power		Process	Power		
Darwin LNG	3.7	Y	N	N	Y	N	Y	6.0 mol%
Karratha OGPT1-T4	7.5-8	N	N	N	Y	N	Y	2.5 mol%
Qatargas, Qatar	4.8	N	N	N	N	N	N	2.1 mol%
RasGas, Qatar	6.4	N	N	N	N	N	N	2.3 mol%
Atlantic, LNG	15.1	N	N	N	Y	N	N	0.8 mol%
Gorgon	8	N	N	Y[6]	Y	N	Y	14 mol%
Karratha OGP T4	4.5	N	Y	N	Y	N	Y	2.5 mol%
Nigeria LNG	6.1	N	N	N	N	N	Y	1.8 mol%
PNG LNG	6.3	TBA[7]	N	N	Y	N	Y	0.7 – 2.0 mol%
Pluto LNG	4.8	N	N	N	Y	N	Y	2.0 mol%
Oman LNG	6.9	N	N	N	N	N	N	1.0 mol%
Snohvit, Norway	4.2	N	Y	Y[6]	Y	N	Y	8.0 mol%

Table 9 Benchmarking Global LNG Facilities

(Source – Woodside 2007)

[5] Methyldiethanolamine – used in acid gas/CO_2 treatment and removal
[6] Proposed
[7] Decision yet to be made between Frame turbines and Aero-Derivative turbines

7. Greenhouse Gas Emission Management

The proposed PNG LNG Project includes a number of design features and good industry practice initiatives that will ensure energy efficiency is maximised and greenhouse gas emissions are minimised.

7.1 ExxonMobil Standards

ExxonMobil has developed standards relating to flaring and venting that stipulate the requirements to be applied to all projects that have the potential to flare or vent produced gases. In general terms, these require that projects:

- Comply with applicable regulatory requirements,
- Where practical, design the facility to avoid routine flaring and venting of associated gas, and avoid venting of CO_2 separated from natural gas production,
- Obtain management endorsement for facility designs that include routine flaring or venting of associated gas, or venting of CO_2 separated from natural gas production prior to the finalisation of the early project design.

7.2 Waste Heat Recovery

Waste heat will be recovered and used as an energy source at the Hides Gas Conditioning Plant and the LNG Plant, which will reduce fuel gas consumption and greenhouse gas emissions that would otherwise be associated with providing a heat source (e.g. via a gas-fired heater or boiler).

At the Hides Gas Conditioning Plant, it is proposed to use waste heat from the exhaust of the pipeline compressor gas turbines to provide heat to the thermal fluid based hot oil system.

Similarly at the LNG plant, waste heat recovery units will utilize heat from the exhaust from the Frame 7 gas turbines driving the two propane refrigeration compressors and provide the main source of heat to the hot oil system

7.3 Consideration of Geosequestration

Geosequestration of carbon dioxide involves the capture, transport, injection and storage of CO_2 in underground formations for the primary purpose of mitigating greenhouse gas emissions. The following options for geosequestration of CO_2 from the PNG LNG Project were investigated:

- Disposal subsurface near the LNG plant at Portion 152 from project start up
- Disposal into Juha reservoir after Juha start up in year 10

- Disposal into Hides reservoir after Juha start up in year 10
- Disposal into the Gobe reservoir after Gobe blowdown in year 10

After investigating each option, none were considered viable. Reasons included lack of suitable reservoirs for injection (at Portion 152), potential losses of gas reserves, limited CO_2 removal (at Juha), and prohibitive operational and capital costs. Also, the provision of power to inject CO_2 would result in an additional 2 million tonnes CO_2 being emitted. The decision was therefore made to vent the CO_2 at the acid gas flare.

ExxonMobil concluded that potential energy efficiency improvements offered greater opportunities for reducing greenhouse gas emissions than the sequestering of vent gas.

8. Conclusions

The PNG LNG Project is expected to generate greenhouse gas emissions to a maximum of 3.1 million tonnes CO_2-e per annum. Over the thirty year life of the project total emissions are estimated to range between 77 million and 89 million tonnes CO_2-e, depending on the technology chosen for the gas turbines at the LNG plant.

The PNG LNG Project is likely to be a significant contributor to PNG's total emissions. However the production and export of LNG will represent a reduction in global greenhouse gas emissions compared to if global customers were to use other fossil fuel sources for their energy requirements (e.g. coal, fuel oil or diesel). The LNG from this project is also likely to have a lower greenhouse gas intensity than most other LNG projects around the world when the emissions associated with LNG production are considered.

At a time when there is considerable pressure globally to reduce emissions of greenhouse gases in an effort to curb the impacts of global warming, the adoption of low emission fuels such as natural gas is encouraged. The PNG LNG project represents a significant source of natural gas with a low greenhouse gas intensity.

9. Acronyms and Abbreviations

AGO – Australian Greenhouse Office

Btu/scf – British thermal units per standard cubic feet

C3R – propane refrigerant

CDM – Clean Development Project

CO – carbon monoxide

CO_2 – carbon dioxide

CO_2-e – carbon dioxide equivalent

CH_4 – methane

EUETS – European Union Emissions Trading Scheme

GHG – Greenhouse gas

GJ - Gigajoule

GTG's – gas turbine generator

GWP – global warming potential

HFC's – Hydrofluorocarbons

HHV – Higher Heating Value (also known as Gross Calorific Value)

HP - high pressure

IPCC - Intergovernmental Panel on Climate Change

kL – kilolitre

KO – knock-out

kSm^3/hr – thousand standard cubic metres per hour

LNG – Liquefied natural gas

LP – low pressure

Mbbls – million barrels

MDEA - Monodiethanolamine

MEG – Mono-ethylene Glycol

MJ/m^3 – megajoules per cubic metre

ML - mealitre

MR – mixed refrigerant

Mscfd – million standard cubic feet per day

MTPA – million tonnes per annum

MW – megawatt

N_2O – Nitrous oxide

NEC - National Executive Council

NGA – National Greenhouse Accounts

NMVOC's – Non-Methane Volatile Organic Compound(s)

NOx – oxides of nitrogen

PFC's – Perfluorocarbons

PJ - petajoule

RAM Analysis – Reliability and maintainability analysis

Scope 1 emissions - cover direct emissions from sources within the boundary of an organisation such as fuel combustion and manufacturing processes.

Scope 2 emissions - cover indirect emissions from the consumption of purchased electricity, steam or heat produced by another organisation. Scope 2 emissions result from the combustion of fuel to generate the electricity, steam or heat and do not include emissions associated with the production of fuel. Scopes 1 and 2 are carefully defined to ensure that two or more organisations do not report the same emissions in the same scope.

Scope 3 emissions - include all other indirect emissions that are a consequence of an organisation's activities but are not from sources owned or controlled by the organisation.

SF_6 – Sulphur hexafluoride

t CO_2-e – tonnes of carbon dioxide equivalent

TEG - Tri-ethylene Glycol

UNFCCC - United Nations Framework Convention on Climate Change

WBCSD / WRI - World Business Council for Sustainable Development / World Resources Institute

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Appendix 1 PNG LNG Project Greenhouse Gas Inventory

Activity	Units	Yr1	Yr2	Yr3	Yr4	Yr5	Yr6	Yr7	Yr8	Yr9	Yr10	Yr11	Yr12	Yr13	Yr14	Yr15	Yr16	Yr17	Yr18	Yr19	Yr20	Yr21	Yr22	Yr23	Yr24	Yr25	Yr26	Yr27	Yr28	Yr29	Yr30	Total
UPSTREAM																																
Construction	kt CO_2-e																															**331**
Hides Gas Conditioning Plant																																
Pipeline compressors	kt CO_2-e	292	292	292	292	292	292	292	292	292	292	300	300	255	255	255	255	255	255	255	255	248	248	194	194	194	194	194	194	194	194	**7,605**
Booster compressors	kt CO_2-e	-	-	-	-	-	207	207	207	207	207	213	213	181	181	181	181	181	181	181	181	176	176	209	209	209	209	209	209	209	209	**4,930**
Turbo generator package	kt CO_2-e	62	62	62	62	62	62	62	62	62	62	64	64	64	64	64	64	64	64	64	64	62	62	62	62	62	62	62	62	62	62	**1,891**
MEG vent gas incinerator	kt CO_2-e	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	**288**
HP/LP flare	kt CO_2-e	12	12	12	12	15	12	12	12	12	15	13	13	13	13	15	13	13	13	13	15	12	12	12	12	15	12	12	12	12	15	**387**
Essential diesel generator	kt CO_2-e	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	**0.59**
Hot oil fired heater	kt CO_2-e	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Diesel fire water pump	kt CO_2-e	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.09**
Industrial area incinerator	kt CO_2-e	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	**325**
Juha Production Facility																																
Rich gas compressor	kt CO_2-e	-	-	-	-	-	-	-	-	-	-	112	112	112	96	96	84	84	84	84	84	84	84	84	-	-	-	-	-	-	-	**1,195**
Turbine generator package	kt CO_2-e	-	-	-	-	-	-	-	-	-	21	21	21	21	21	21	21	21	21	21	21	21	21	-	-	-	-	-	-	-	-	**271**
TEG Regeneration Package	kt CO_2-e	-	-	-	-	-	-	-	-	-	5	5	5	5	5	5	5	5	5	5	5	5	5	-	-	-	-	-	-	-	-	**66**
HP/LP Flare	kt CO_2-e	-	-	-	-	-	-	-	-	-	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	-	-	-	-	-	-	-	-	**4**
Essential diesel generator	kt CO_2-e	-	-	-	-	-	-	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	-	-	-	-	-	-	-	-	**82**
TOTAL UPSTREAM GHG EMISSIONS	**kt CO_2-e**	**387**	**387**	**387**	**387**	**389**	**593**	**593**	**593**	**593**	**628**	**754**	**754**	**677**	**661**	**664**	**649**	**649**	**649**	**649**	**652**	**635**	**635**	**582**	**499**	**501**	**499**	**499**	**499**	**499**	**501**	**17,375**
DOWNSTREAM																																
Construction	kt CO_2-e																															**217**
Frame - Power Gen. (GTG's)	kt CO_2-e	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	**12,517**
Frame - C3R compressors	kt CO_2-e	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	**19,215**
Frame - MR compressors	kt CO_2-e	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	858	**25,739**
Aero - Power Generation (GTG's)	kt CO_2-e	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	**10,247**
Aero - C3R compressors	kt CO_2-e	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	473	**14,186**
Aero - MR compressors	kt CO_2-e	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	709	**21,279**
Acid gas incinerator	kt CO_2-e	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	**6,300**
Heaters/boilers	kt CO_2-e	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	**5,661**
Desalination Plant	kt CO_2-e	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	**117**
Miscellaneous	kt CO_2-e	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	**738**
Shipping (LNG Carriers)	kt CO_2-e	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	**499**
Tugs (for LNG Carriers)	kt CO_2-e	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	**699**
Shipping (Condensate Carriers)	kt CO_2-e	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	**6.7**
Tugs (for Condensate Carriers)	kt CO_2-e	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	**91**
TOTAL DOWNSTREAM - Frame	**kt CO_2-e**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**2,385**	**71,800**
TOTAL DOWNSTREAM - Aero-derivative	**kt CO_2-e**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**60,039**
PROJECT GHG EMISSIONS - Frame	**MT CO_2-e**	**2.77**	**2.77**	**2.77**	**2.77**	**2.77**	**2.98**	**2.98**	**2.98**	**2.98**	**3.01**	**3.14**	**3.14**	**3.06**	**3.05**	**3.05**	**3.03**	**3.03**	**3.03**	**3.03**	**3.04**	**3.02**	**3.02**	**2.97**	**2.88**	**2.89**	**2.88**	**2.88**	**2.88**	**2.88**	**2.89**	**89.17**
PROJECT GHG EMISSIONS - Aero	**MT CO_2-e**	**2.38**	**2.38**	**2.38**	**2.38**	**2.38**	**2.59**	**2.59**	**2.59**	**2.59**	**2.62**	**2.75**	**2.75**	**2.67**	**2.65**	**2.66**	**2.64**	**2.64**	**2.64**	**2.64**	**2.65**	**2.63**	**2.63**	**2.58**	**2.49**	**2.49**	**2.49**	**2.49**	**2.49**	**2.49**	**2.49**	**77.41**