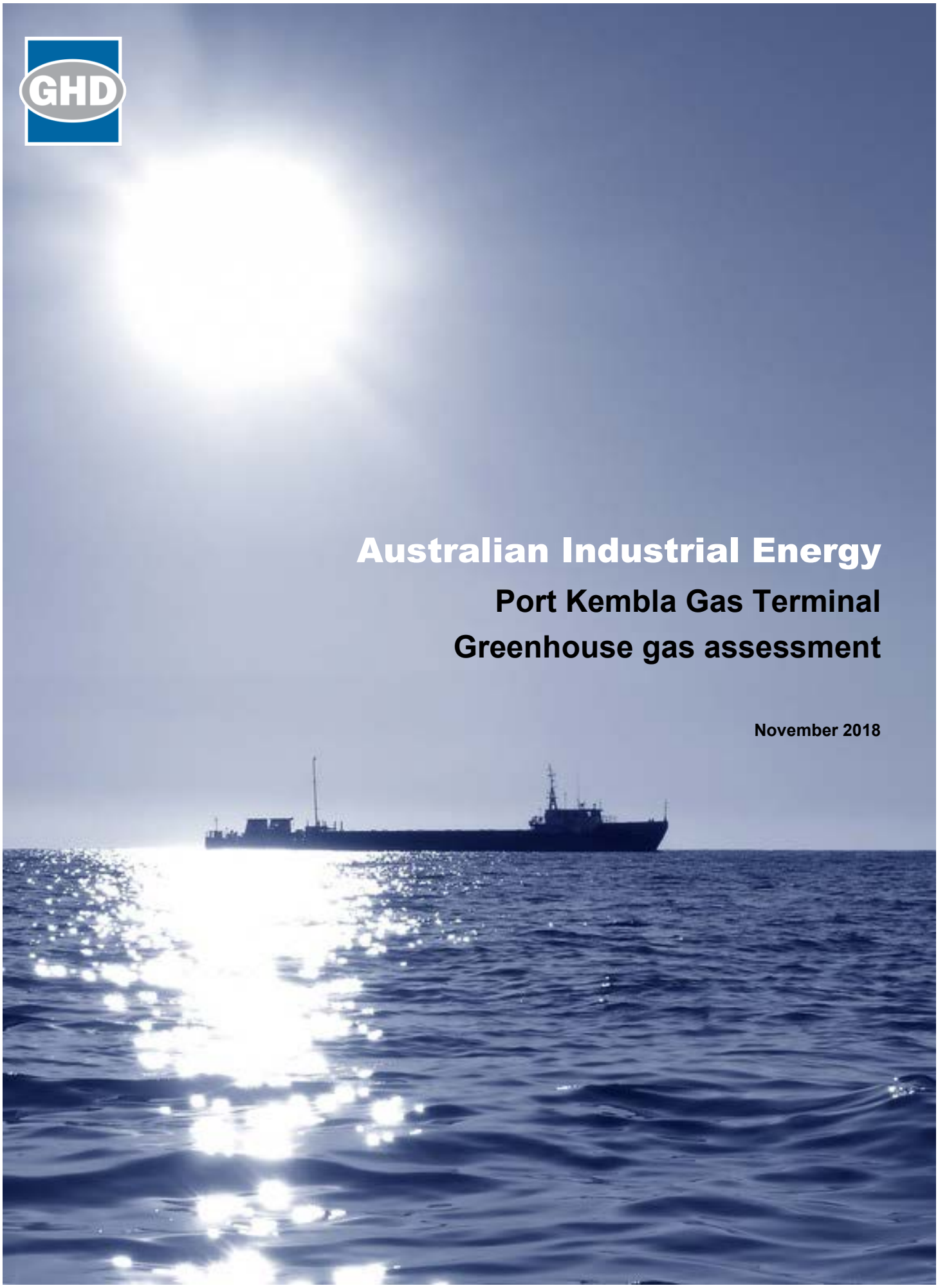
Appendix P
Greenhouse gas



Australian Industrial Energy

Port Kembla Gas Terminal

Greenhouse gas assessment

November 2018

Glossary

Term	Meaning
The Project	The Port Kembla Gas Terminal. The Project is the development of a Liquefied Natural Gas (LNG) import terminal at Port Kembla, south of Wollongong in NSW. The project will have the capacity to deliver 100 petajoules of natural gas per annum.
Liquefied Natural Gas (LNG)	Liquified natural gas is natural gas which has turned into a liquid by cooling it to -161 degrees Celsius for ease and safety of non-pressurised storage and/or transport. It is a composition of mostly methane and some mixture of ethane. LNG is odourless,colourless, non-toxic and non-flammable in liquid form.
Berth 101 (B101)	Part of the project and is located between B102 and 'The Cut' shipping channel providing access to the Inner Harbour at Port Kembla, NSW.
Wharf Facilities	Offloading arms or hoses which transfer gas from the FSRU into the pipeline
Mooring	A place where a boat or ship is moored. Any permanent structure to which a vessel may be secured
Dredging	An excavation activity or operation usually carried out at least partly underwater, in shallow seas or fresh water areas with the purpose of gathering up bottom sediments and disposing of them at a different location. This technique is often used to keep waterways navigable.
Pipeline	A short underground gas pipeline connection will be constructed from Berth 101 to the existing east coast gas transmission network at Cringila.
Floating Storage and Regasification Unit (FSRU)	A vessel which will be moored at berth 101 on the eastern side of the Inner Harbor at Port Kembla, NSW.
LNG carrier vessel	Liquid natural gas carrier vessel

Abbreviations

Abbreviation	Definition
AIE	Australian Industrial Energy - consortium of Australian and international companies with extensive expertise and experience in the global energy sector
API	American Petroleum Institute
BOG	Boil Off Gas
CH_4	Methane
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
EGP	Eastern Gas Pipeline
FSRU	Floating Storage and Regasification Unit
GCU	Gas Combustion Unit
GHG	Greenhouse gas
GWP	Global Warming Potential
kWh	Kilowatt hour
IPCC	Intergovernmental Panel on Climate Change
LNG	Liquefied Natural Gas
MARPOL	International Maritime Organisation International Convention for the Prevention of Pollution from Ships
MDO	Marine Diesel Oil
NG	Natural gas
NGER	National Greenhouse and Energy Reporting
NSW	New South Wales
N_2O	Nitrous oxide
PKCT	Port Kembla Coal Terminal
PJ	Petajoule - an SI unit of energy

Table of Contents

1. Introduction

1.1 Background

Australian Industrial Energy (AIE) proposes to develop the Port Kembla Gas Terminal (the project). The project involves the development of a liquefied natural gas (LNG) import terminal at Port Kembla, south of Wollongong in NSW. The project will be the first of its kind in NSW and provide a simple, flexible solution to the state's gas supply challenges.

NSW currently imports more than 95% of the natural gas it uses, with the majority of supplies coming as interstate supplies from Victoria and South Australia. In recent years, gas supplies to the Australia east coast market have tightened, resulting in increased prices for both industrial and domestic users. Several recent economic studies, including from the Australian Energy Market Operator (AEMO) and EnergyQuest have predicted significant future gas shortfalls for NSW by 2022.

The project provides an immediate solution to address predicted shortages and is predicted to result in considerable economic benefits for both the Illawarra region and NSW.

The project will have capacity to deliver 100 petajoules of natural gas, equivalent to more than 70% of NSW's gas needs and provide between 10 to 12 days of natural gas storage in case of interstate supply disruption. LNG will be sourced from worldwide suppliers and transported by LNG carriers to the Port Kembla Gas Terminal. The LNG will then be re-gasified for input into the NSW gas transmission network.

Key objectives of the project are to:

- Introduce a new source of competitively priced gas to meet predicted supply shortfalls and help put downward pressure on prices
- Provide gas security to NSW with ability to supply more than 70% of the State's gas needs
- Provide long term contracts to industrial users and ability to meet 100% of the State's industrial demand (manufacturers, power stations, hospitals, small businesses etc.)
- Help support the 300,000 jobs across NSW, and the 15,000 jobs in the Illawarra region, which rely on the competitive, reliable supply of natural gas
- Support the diversification and future growth of Port Kembla consistent with the NSW Ports 30 Year Master Plan.

1.2 Project overview

The project incorporates four key components proposed to be located within industrial land declared under the State Environmental Planning Policy (Three Ports), which include:

- LNG carriers (LNGCs) — of the hundreds currently in operation transporting LNG from production facilities to demand centres globally.
- Floating storage and regasification unit (FSRU) — a vessel which will be moored at berth 101 on the eastern side of the inner harbour at Port Kembla. There are around 30 of these currently in operation worldwide with a further 75 ordered or in feasibility planning. The FSRU contains all of the equipment necessary to safely store, regasify, and dispatch

the gas into the NSW distribution network. Once no longer required the vessel can be relocated and reused.

- Wharf and berth facilities — such as offloading arms which transfer gas from the FSRU into the pipeline.
- Gas pipeline — a short underground gas pipeline connection from Berth 101 to the existing east coast gas transmission network at Cringila.

At present it is envisaged that an LNG shipment will be required every 2 to 3 weeks to provide for an annual supply of up to 100 PJ of gas. Supply could be increased further to around 140 to 150 PJ per annum through a slight increase in LNG delivery schedules and pipeline upgrades.

It is expected to take about 10 to 12 months to complete construction and other works in order commence operations, it is possible to have first gas by the end of Quarter 1 in 2020.

The estimated capital investment for the development is between $200 and $250 million.

1.3 Purpose of this report

The purpose of this report is to quantify greenhouse gas (GHG) emissions from the proposed LNG facility and to identify the potential greenhouse gas emissions impact of the Project.

1.4 Scope and limitations

This report has been prepared by GHD for AIE and may only be used and relied on by AIE. The emissions inventory has been prepared in accordance with applicable guidelines.

The method used was as follows:

- Defined an appropriate boundary for the greenhouse gas inventory, and identified the greenhouse gases to be covered including carbon dioxide, nitrous oxide, methane and sulphur hexafluoride
- Identified relevant sources of GHG emissions from construction and operations
- Identified and applied appropriate emissions estimation methodologies for each source
- Determined the carbon dioxide equivalent emissions from each source and the total greenhouse gas emissions for the project
- Compared totals with State and national emissions totals.

2. Methodology

2.1 Overview

The SEARS does not mandate a specific standard, protocol, or methodology for the greenhouse gas assessment. This assessment has been undertaken in accordance with the principles of ISO 14064-2 and National Greenhouse and Energy Reporting (NGER) (Measurement) Determination 2008 for measuring emissions. Relevant sections of the following documents were used for the purposes of defining appropriate methods for quantification of emissions from individual sources:

- NGER (Measurement) Determination 2008 (as amended) and NGER Act 2007, Commonwealth Department of Environment and Energy
- American Petroleum Institute (API) Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry (2009).

These guidelines are considered representative of good practice GHG accounting in Australia and are applicable to the project.

2.2 Greenhouse gases and global warming potentials

The greenhouse gases considered in this assessment and the corresponding global warming potential (GWP) for each gas are listed Table 2-1. GWP is a metric used to quantify and communicate the relative contributions of different substances to climate change over a given time horizon. GWP accounts for the radiative efficiencies of various gases and their lifetimes in the atmosphere, allowing for the impacts of individual gases on global climate change to be compared relative to those for the reference gas carbon dioxide. In this assessment, the GWPs from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment report and s2.02 of the National Greenhouse and Energy Reporting (NGER) Regulations 2008 were used. These are reflective of radiative forcing over a 100 year time horizon.

Table 2-1 Greenhouse gases and 100 year global warming potentials

Greenhouse gas	Global Warming potential
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298

2.3 Assessment boundary

The following GHG emissions have been considered:

- Scope 1 emissions from direct energy use during construction and operation.
- Scope 2 emissions from indirect energy use from imports and exports of electricity, heat or steam

The following emission sources were included in the assessment boundary:

1. Fuel consumption during construction activities (including electricity generation, gas pipeline, civil works, and onshore related infrastructure)

2. Construction personnel commuting
3. Energy (fuel/ electricity) consumption during operation of facility including:
   - Grid electricity use (such as for onshore buildings, ancillary equipment)
   - Fuel used for stationary purposes including electricity generation and operation of the FSRU
   - Fugitive emissions from the FSRU and pipeline
   - Employee commuting

2.4 Exclusions

This assessment considers only greenhouse gas emissions sources within the boundary of the project, and excludes upstream and downstream emissions.

Exclusions from this GHG assessment include:

- Upstream emissions associated with transport of the LNG to the project site.
- Downstream emissions associated with the use of the natural gas product.
- Emissions which are likely to be negligible compared with other emissions from the project were excluded from the assessment, including:
  - Emissions associated with combustion of fuels used in minor quantities such as LPG, acetylene, solvents, oils and greases.
  - Emissions associated with minor electricity use at the wharf.
  - Emissions associated with the leakage of hydrofluorocarbons. The project may use negligible quantities of hydrofluorocarbons for refrigeration and air conditioning during operation of the FSRU.
  - Emissions associated with removal of any vegetation during construction. The pipeline route is mostly through an established industrial corridor and would require limited vegetation removal.
  - Emissions from the FSRU wastewater holding tanks/treatment system prior to wastewater being discharged to shore.
- Emissions from sulphur hexafluoride or perfluorocarbons – these substances are not used or stored as part of the project.
- Emissions from venting on the FSRU. There are four low pressure emergency vent masts (one at the top of each LNG tank) and one high pressure emergency vent mast (located at the regasification module). Venting does not occur during normal operations, only in the case of emergencies.
- Emissions from the Gas Combustion Unit (GCU). The GCU is part of the Gas Management System and is used to control cargo tank pressure. Boil Off Gas (BOG) vaporises and increases the tank pressure on board the FSRU. BOG will be managed to avoid using the GCU.
- Emissions from leaks at the LNG carriers. LNG carriers are constructed to stringent global standards. LNG is shipped in double-hulled tankers specifically designed and constructed to prevent leakage or rupture.

- Scope 3 emissions such as those associated with embodied energy of construction materials, transportation of materials and equipment during construction, or management of waste materials.

2.5 Calculation procedures

Emissions were calculated as follows:

- For emissions during the construction phase:
  - Relevant activity data for vehicles, dredging equipment and construction plant use was identified, and emissions factors were selected and applied;
- For emissions during the operations phase:
  - Activity assumptions for vehicle use during employee commuting were made, and emissions factors were selected and applied;
  - Emissions from fuel combustion and electricity use, and fugitive emissions from FSRU and pipeline operations were estimated using Method 1 from the NGER (Measurement) Determination.

2.6 Assumptions

Assumptions used in estimating GHG emissions for the construction and operation of the project are listed in Table 2-2. The assessment was based on emission factors available at the time of the assessment and future changes in emission factors were not considered.

Activity data used for the GHG assessment was provided by AIE. All Emission Factors (EF) used were as per the NGER (Measurement) Determination.

Table 2-2 Greenhouse gas assessment assumptions by source

Parameter	Assumptions
Construction	
Diesel combustion – transport purposes	Estimated 150 construction personnel at peak manning/ activity. For the purpose of this assessment construction personnel are assumed to commute from the Wollongong/ Port Kembla area on a daily basis, with all vehicles diesel. Estimated fuel consumption is 0.4 kL.
Diesel combustion – stationary energy purposes	Estimated diesel use for the construction of the new berth, mooring facilities, onshore receiving facility and ancillary infrastructure (roads, fencing, communications) is 1,500 kL. Estimated diesel use for mobile electricity generators is 200 kL. Estimated diesel use for dredging and placement of dredged material is 1,178 kL.
Electricity use	No grid electricity is anticipated to be used during construction. Electricity will be produced via diesel generators and emissions are accounted for in diesel combustion for stationary energy purposes above.
Operations	

Parameter	Assumptions
Diesel combustion – transport purposes	Estimated 50 operational personnel. Approximately 28 members of crew will be based on the FSRU. For the purpose of this assessment operation personnel are assumed to commute from the Wollongong/ Port Kembla area on a daily basis. Estimated fuel consumption is 0.1 kL/a.
Diesel combustion – stationary energy purposes	Estimated diesel use for the emergency electricity generator is 42 kL/a (based on 1 MW engine operating approximately 170 hours per annum and a fuel use of 244L/h).
MDO combustion	A small quantity of Marine Diesel Oil (MDO) is used in the FSRU generators, estimated by the FSRU operator as 0.46 t/d, equivalent to 187 kL/a.
LNG/NG combustion – electricity generators/ compressors	LNG is vaporized to natural gas (NG) and used in generators on board the FSRU to generate electricity. Electricity generator fuel use includes all requirements for regasification, compression of gas to transmission pipeline pressure, and recondensing Boil Off Gas (BOG). Fuel used was estimated based on engine performance data at a send out rate of 250 mmscfd, equivalent to 100 PJ/a. Performance data from two FSRU were evaluated, and the most conservative used. Fuel usage of 34.3 t/d was used, equivalent to 728 TJ/a.
LNG/NG combustion – LNG transfer	LNG/NG is combusted to generate power during the transfer from the LNG carrier to the FSRU. This was estimated as 0.06 PJ/a based on the number of expected transfers (up to 24 transfers per annum, with 2 engines running for 24 h).
LNG/NG combustion – auxiliary boiler	A small quantity of fuel was estimated as used in the auxiliary boiler estimated as approximately 250 kL/a. The auxiliary boiler provides steam for heating of auxiliary systems like fuel vaporizers, accommodation heating etc. The auxiliary boilers do not normally operate as recovered heat from the main engines will cover the need. Fuel use was based on manufacturers data and operation for approximately 6 days per year.
Fugitive emissions - FSRU	Fugitive emissions were estimated from the FSRU as per the NGER (Measurement) Determination, section 3.72, based on total throughput of 100 PJ/a. This method applies a set leak factor to equipment based on the total gas throughput.
Fugitive emissions - pipeline	Fugitive emissions were estimated from the gas transmission pipeline as per the NGER (Measurement) Determination, section 3.76, based on pipeline length of 6.3 km. This method applies a set leak factor based on pipeline length.
Electricity use	No grid electricity is anticipated to be used during operation. Electricity will be produced via generators on the FSRU using Boil Off Gas (vaporized LNG) as fuel. Excess electricity may be sent to the grid, however, this has not been factored into this assessment.

3. Impact assessment

3.1 Construction emissions

A summary of estimated scope 1 GHG emissions occurring as a result of construction activities for the Project is presented in Table 3-1 below. This represents emissions across the entire construction period. There are no Scope 2 emissions anticipated.

Table 3-1 Construction emissions

Activity	Scope 1 Emissions (t CO_2-e)
Diesel combustion (stationary): - Construction	4,065
- Dredging	3,707
- Generators	542
Diesel combustion (transport)	1
Total	8,314

3.2 Operational emissions

A summary of estimated annual greenhouse gas emissions from operation of the Project is available in Table 3-2 below. There are no Scope 2 emissions anticipated.

Table 3-2 Annual operational emissions

Activity	Scope 1 Emissions (t CO_2-e)	Percentage of emissions
Diesel - commuting	0.3	0.0%
Diesel - emergency generator	113	0.3%
MDO - electricity generation	558	1.3%
LNG/NG - electricity generation	37,541	85.0%
LNG/NG - LNG transfer	3,263	7.4%
LNG/NG - auxiliary boiler	336	0.8%
LNG/NG - fugitives	2,239	5.1%
Natural gas transmission - operations	66	0.1%
Total	**44,145**	100%

3.3 Impact of Emissions

The quantity of emissions estimated to occur during construction are estimated as approximately 8,300 tCO_2-e during the entire construction period. Construction emissions are estimated as approximately 19% of operational emissions. Construction emissions will be of limited duration.

The quantity of emissions estimated to occur during operations are estimated as approximately 44,100 tCO_2-e per annum.

Scope 1 emissions associated with FSRU and pipeline operations are above the threshold for facility level reporting under the National Greenhouse and Energy Reporting (NGER) Act of 25,000 t CO_2-e so will require annual reporting under the NGER scheme. Scope 1 emissions are estimated to be below the Emissions Reduction Fund Safeguard Mechanism benchmark threshold of 100,000 t CO_2-e, so will not have to apply for a baseline.

Australia's national greenhouse gas emissions, by sector, for the year to December 2017 are presented in Table 3.4 below. Total annual emissions are 533.7 Mt CO_2-e. Annual emissions from the project would account for approximately 0.01% of Australia's annual emissions, which is negligible.

The most recently published state-based emissions inventory is for 2016. NSW greenhouse gas emissions, by sector, for the 2016 year are also presented in Table 3.4 below. Total annual emissions are 131.6 Mt CO_2-e. Annual emissions from the project would account for approximately 0.03% of NSW's annual emissions, which is also insignificant.

Table 3-3 Impact of project emissions on national totals

Emissions Source	2017 Australian Emissions (Mt CO_2-e) [1]	2016 NSW Emissions (Mt CO_2-e) [2]
Energy – Electricity	184.5	51.8
Energy – Stationary Energy excluding electricity	96.9	15.3
Energy – Transport	100.0	27.4
Energy – Fugitive Emissions	55.4	15.6
Industrial processes and product use	35.8	13.2
Agriculture	71.2	17.5
Waste	12.6	3.2
Land Use, Land Use Change and Forestry	-22.7	-12.5
Overall Total	533.7	131.6

Source:

1. Table 3, Department of the Environment and Energy "*Quarterly Update of Australia's National Greenhouse Gas Inventory: December 2017*" 18 May 2018
2. Table 12, Department of the Environment and Energy "*State and Territory Greenhouse Gas Inventories 2016*" February 2018

4. Greenhouse gas reduction measures

The Paris Agreement is a non-binding international agreement between parties to the United Nations Framework Convention on Climate Change prepared in December 2015. Article 4 of the agreement describes its aim as:

> *"to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty"*

Australia ratified the Paris Agreement on the 9th of November 2016, however it is noted that there is considerable policy uncertainty regarding how Australia's nationally determined contribution will be met. Notwithstanding this, AIE recognises that the intent of the Paris Agreement is to achieve a balance between anthropogenic greenhouse gas emissions and greenhouse gas sinks in the second half of this century.

4.1 Construction

The following measures will be undertaken to minimise/ reduce greenhouse gas emissions and energy use during construction:

- All plant and equipment used during the construction works shall be regularly maintained to comply with the relevant exhaust emission guidelines
- Sustainable procurement practices will be adopted where feasible.
- The following measures will be considered by contractor(s):
  - Construction materials sourced locally where possible
  - Construction materials that have minimal embodied energy be selected
  - Use of PVC plastic minimised
  - Construction materials that are low maintenance and durable
  - Plant and equipment will be switched off when not in constant use and not left idling
  - Plant and equipment brought onsite will be regularly serviced and energy efficient vehicles or equipment will be selected where available
  - Any plant and equipment that is not working efficiently (i.e. emitting excessive smoke) will be removed from site and replaced as soon as possible
  - Construction works will be planned to ensure minimal movement of plant and equipment, including barges

4.2 Operations

The FSRU to be purchased/ leased has not yet been decided. However, the following measures will be undertaken to minimise/ reduce greenhouse gas emissions and energy use during operations:

- The FSRU is a marine vessel and is subject to the International Maritime Organisation International Convention for the Prevention of Pollution from Ships (MARPOL). Australia implements MARPOL through the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and the *Navigation Act 2012*. MARPOL Annex VI has two mandatory energy efficiency requirements for ships, with the main objective of reducing international shipping's GHG emissions via improved ship design and operations:

  - Ship Energy Efficiency Management Plan, for all ships, and
  - Energy Efficiency Design Index, for new ships only. The Index is expressed as carbon dioxide generated per tonne cargo per nautical mile transported (g CO_2-e/t.mile). This index does not apply to the FSRU in operation at Port Kembla as it is stationary.
- The FSRU will obtain and maintain an International Energy Efficiency Certificate, and implement a Ship Energy Efficiency Management Plan in accordance with MARPOL.
- The engine types on the proposed FSRU are designed to use dual fuels, with LNG/NG as the main fuel, which is inherently less polluting than diesel or other fuels for power generation. The engines are designed for high efficiency and reliability, and low emissions.
- Boil Off Gas (BOG) will be managed to avoid using the Gas Combustion Unit (GCU).
- The equipment will be maintained appropriately to minimise the risk of unintended leaks and unnecessary venting, for the FSRU and pipeline.
- The operations will comply with the general principles of the Green Port Guidelines (Sydney Ports Corporation, 2006)

In addition to the above measures, greenhouse gases, energy production and energy consumption will be measured and reported annually. Data management, records and reporting of fuel and electricity consumption and quantities of any fugitive emissions will be established and maintained as required under National Greenhouse and Energy Reporting legislation.

5. Conclusions

The quantity of emissions estimated to occur during construction are estimated as approximately 8,300 tCO_2-e during the entire construction period.

The quantity of emissions estimated to occur during operations are estimated as approximately 44,100 tCO_2-e per annum. Annual emissions from the project would account for approximately 0.01% of Australia's annual emissions and 0.03% of NSW's annual emissions, which is insignificant.

Measures will be implemented to minimise and reduce greenhouse gas emissions and energy.

6. References

Commonwealth of Australia “National greenhouse and Energy Reporting (Measurement) Determination 2008”, Compilation No. 10, July 2018

Department of the Environment and Energy “Quarterly Update of Australia’s National Greenhouse Gas Inventory: December 2017, Incorporating NEM electricity emissions up to March 2018” 18 May 2018

Department of the Environment and Energy “State and Territory Greenhouse Gas Inventories 2016” February 2018