Technical Report C

Greenhouse gas impact assessment

Viva Energy Gas Terminal Project

Prepared for
Viva Energy Gas Australia Pty Ltd
ABN: N/A

AECOM

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25-Feb-2022
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Client: Viva Energy Gas Australia Pty Ltd

ABN: N/A

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Executive summary

This technical report provides a greenhouse gas impact assessment conducted to support the Environment Effects Statement (EES) for the Viva Energy Gas Terminal Project (the project).

In December 2020, the Victorian Minister for Planning determined that the project requires assessment through an EES under the *Environment Effects Act 1978* (Vic). The reasons for the decision were primarily related to the potential for significant adverse effects on the marine environment of Corio Bay and the potential for contributing to greenhouse gas emissions. Secondarily, the EES was required to assess the effects of the project on air quality, noise, land use, Aboriginal and historic heritage, native vegetation, groundwater, traffic, and transport as well as visual amenity.

In January 2021, the project was also determined to require assessment and approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* ('EPBC Act') due to the potential for the project to have a significant impact on wetlands of international importance, listed threatened species and communities, and listed migratory species. The EES process is the accredited environmental assessment process for the controlled action decision under the EPBC Act in accordance with the bilateral agreement between the Commonwealth and Victorian governments.

Overview

Viva Energy Gas Australia Pty Ltd (Viva Energy) is planning to develop a floating gas terminal using a ship known as a floating storage and regasification unit (FSRU) which would be continuously moored at Refinery Pier in Corio Bay, Geelong. The key objective of the project is to facilitate supply of a new source of gas for the South-East Australian gas market where there is a projected supply shortfall in coming years.

The FSRU would store liquefied natural gas (LNG) received from visiting LNG carriers (that would moor directly adjacent to the FSRU), and regasify the LNG as required to meet industrial, commercial, and residential customer demand. For the project the usual FSRU operating mode is open loop regasification which would use seawater to heat the LNG with some modification such that the FSRU seawater discharge would be transferred to the adjacent refinery for reuse within the cooling water process. The FSRU would also be able to operate in closed loop mode using gas-fired boilers to generate steam to heat the LNG and this operating mode would only be used in in very limited instances where discharge water may not be able to be transferred to the refinery A combined loop regasification process involving a combination of modes to heat the seawater could also potentially be used if the ambient seawater temperature is too low for open loop regasification to operate effectively.

A 7-kilometre gas pipeline would transfer the gas from the FSRU to the Victorian Transmission System (VTS) at Lara.

The gas terminal would be located adjacent to, and on, Viva Energy's Geelong Refinery in a heavily industrialised setting and would benefit from Viva Energy's experience and capability as an existing Major Hazard Facility (MHF) operator and potential synergies between the two facilities such as reuse of the FSRU seawater discharge within the refinery operations.

Methodology

The greenhouse gas impact assessment methodology followed the principles set out in the following documents:

- *National Greenhouse and Energy Reporting Act 2007* (Cth) ('NGER Act'*) and National Greenhouse and Energy Reporting (Measurement) Determination 2008* (as amended), Commonwealth Department of Environment and Energy
- *The Greenhouse Gas Protocol (GHG Protocol),* the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI)
- *American Petroleum Institute (API) Compendium of GHG Emissions Methodologies for the Oil and Natural Gas Industry,* August 2009
- *ISO 14064-1:2018 Greenhouse gases – Part 1: Specification with guidance at the organisation level for quantification and reporting of greenhouse gas emissions and removals*

- *ISO 14040:2006 Environmental management – Lifecycle assessment – Principles and framework* and *ISO 14044:2006 Environmental management – Lifecycle assessment – Requirements and guidelines*. These standards are applicable to the calculation of materials lifecycle impacts using the Infrastructure Sustainability (IS) Materials Calculator.

Greenhouse gas (GHG) emissions were estimated in accordance with the principles of the internationally accepted GHG Protocol. According to the GHG Protocol, greenhouse gas emissions are split into three categories, known as 'Scopes'. Scope 1, Scope 2, and Scope 3 are defined by the GHG Protocol as:

- Scope 1 – Direct emissions of greenhouse gas from sources that are owned or operated by a reporting organisation (examples include combustion of diesel in company-owned vehicles or used in on-site plant and equipment)
- Scope 2 – Indirect emissions associated with the import of energy from another source (examples include import of electricity from the grid, or heat)
- Scope 3 – Other indirect emissions, other than energy imports (above) which are a direct result of the operations of the organisation, but from sources not owned or operated by them and due to upstream or downstream activities (examples include indirect upstream emissions associated with the extraction, production, and transport of purchased construction materials; and business travel (by ship, air or rail)).

The study, in accordance with the EES scoping requirements, has considered both direct and indirect greenhouse gas emissions that would result from the project. Direct Scope 1 emissions, and indirect Scope 2 and Scope 3 emissions identified as material for the project (in accordance with GHG Protocol criteria) and within the proponent's ability to control, were considered for construction and operation scenarios.

Existing conditions

The context of the existing conditions for the greenhouse gas impact assessment is the current Victorian emissions profile. In the *State and Territory Greenhouse Gas Inventories 2019* report, Victoria's total emissions were 91.33 million-tonnes of carbon dioxide equivalent (Mt CO_2-e). Energy industries (i.e., direct combustion) accounted for 51 per cent of Victoria's total emissions or 46.88 Mt CO_2-e.

Construction impact assessment

The total construction emissions (Scope 1, 2, and relevant Scope 3) for the project are estimated to be 62,168 t CO2-e.

Operation impact assessment

The open and closed loop scenarios assumed the supply of natural gas at 250 terajoules per day (TJ/day) during summer (90 days per year), 350 TJ/day during spring and autumn (183 days per year), 500 TJ/day during the winter (86 days per year) and 620 TJ/day during peak demand days in winter (6 days per year), delivering a total of up to 45 cargos of LNG into the VTS. This equates to approximately 160 petajoules (PJ) of natural gas delivery per annum.

The usual operating mode for the FSRU is open loop however closed loop has also been assessed on the basis that it represents the 'worst case' operating scenario.

The combined loop regasification process would potentially be used if the seawater falls below a specified temperature. This has been assumed to be 30 days a year.

The total annual operational emissions (Scope 1, 2 and relevant Scope 3) for the project would be as follows:

- Open loop operating mode (using seawater to heat the LNG) – 47,906 t CO_2-e
- Closed loop operating mode (using gas fired boilers to heat the LNG) – 178,985 t CO_2-e
- Combined loop operating mode – 65,280 t CO_2-e.

The closed loop operational mode would trigger requirements under the *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*.

Summary of impacts on Victoria's Scope 1 and Scope 2 emissions

The total Scope 1 and 2 emissions during the construction period equates to 0.01 per cent of Victoria's annual greenhouse gas emissions.

Table 1-1 presents a comparison of the project's annual Scope 1 and 2 operational emissions to Victoria's annual Scope 1 and 2 greenhouse gas emissions. The most significant opportunity to minimise emissions would be, as proposed, to adopt open loop as the usual mode of FSRU regasification operation, as this would emit four times less greenhouse gas emissions than closed loop.

Table 1-1 Comparison of the project's annual operational greenhouse gas emissions to Victoria's annual emissions

Emissions source	Total annual Scope 1 and 2 greenhouse gas emissions (kt CO_2-e)	% of Victoria's annual total greenhouse gas emissions
Victoria 2019	**91,330**	**100**
Project during operation - Open loop operating mode	47	0.05
Project during operation - Closed loop operating mode	179	0.20
Project during operation - Combined loop operating mode	65	0.07

Summary of recommended mitigation measures

This report details recommended mitigation measures that, if adopted, would reduce the emissions impact of the project both during construction and operation. It is anticipated that the project would adopt mitigation measures utilising the mitigation hierarchy in order to first avoid then minimise emissions produced during construction and operation, before considering offsets. All efforts to reduce emissions should be considered given the ongoing impact of climate change on society.

Table 1-2 Project mitigation measures for greenhouse gas emissions

MM ID	Mitigation measure	Project phase
MM-GG01	**Minimise embodied and transport emissions of materials** Low embodied energy and locally sourced materials should be considered and used where practicable to minimise embodied and transport emissions. The proponent could develop criteria for a minimum proportion of supplementary cementitious material content in concrete, recycled steel, and recycled aggregates. The criteria should consider the location materials are being sourced from to minimise associated transport emissions.	Design and construction
MM-GG02	**Managing quality of materials** Materials that are low maintenance and durable should be selected to avoid unnecessary replacement. The quality of key materials (i.e., pipe and mooring infrastructure) should be inspected before supplying	Construction

MM ID	Mitigation measure	Project phase
	to site to avoid additional transport and handling of materials.	
MM-GG03	**Source local plant and equipment** Locally sourced plant and equipment (i.e., within Victoria) should be considered and used where practicable to reduce emissions associated with transport. Sourcing local plant and equipment where practicable should be included in the selection criteria for tendering of works associated with plant and equipment.	Construction
MM-GG04	**Coordination of construction activities** Construction activities should be coordinated to reduce unnecessarily extending the construction period and to avoid inefficient use of equipment.	Construction
MM-GG05	**Sustainable procurement and resource management practices** Sustainable procurement and resource management practices should be adopted to avoid the inefficient use of materials, fossil fuels, and electricity. The proponent should refer to ISO 20400:2017 Sustainable procurement which provides guidance on integrating sustainability within procurement.	Construction and operation
MM-GG06	**Local workforce** Local workforce should be engaged where possible. Interstate and international travel should be minimised and where appropriate replaced by virtual engagement. The proponent could complete a transport plan to detail how fuel emissions from employee transport would be minimised.	Construction and operation
MM-GG07	**Plant and equipment fuel efficiency** Selection of plant and equipment should incorporate consideration of fuel efficiency to reduce the consumption of fossil fuels.	Construction and operation
MM-GG08	**Waste – avoid, reduce, reuse** Design should reduce the total quantum of materials required through design refinement and incorporate reuse materials during construction and operation of the project. The proponent could develop a waste management plan that considers waste reduction, segregation of waste, and disposal of waste to ensure that waste is correctly separated and diverted from landfill where appropriate.	Design, construction, and operation

MM ID	Mitigation measure	Project phase
MM-GG09	**Implementation of Energy Management Systems** An energy management system will be implemented in accordance with the International Organisation for Standardisation (ISO) 50001 *Energy Management Systems* (ISO 50001) for the operation of the FSRU. The ISO 50001 provides a framework for organisations to take a systematic approach to achieve continual improvement of energy performance and efficiency and reductions in greenhouse gas emissions. This framework is considered global best practice, and involves: • developing energy use baselines • developing energy management plans • identifying performance indicators • setting targets for improvement. Progress will be regularly monitored, reported, and reviewed. Implementation of this system will also involve external certification by ISO-accredited auditors (typically on a three year cycle) in which both compliance with the ISO standard and performance improvement will need to be demonstrated to maintain certification.	Operation
MM-GG10	**Emergency management procedures** Safety controls and emergency management practices should be put in place in the case of unplanned activities, incidents, and emergencies (i.e., unplanned maintenance or venting) to minimise the release of fugitive greenhouse gas emissions.	Operation
MM-GG11	**Certified carbon offsets** The project could consider purchasing certified carbon offset to compensate for emissions produced during construction and annual emissions produced during operation. A strategy to offset certain emissions could be implemented (e.g., offsetting all Scope 1 and 2 emissions). Note that offsets would only be considered for project emissions after measures that aim to avoid or minimise emissions have been adopted.	Construction and operation

Abbreviations and glossary of terms

Abbreviation/Term	Definition
API	American Petroleum Institute
CO_2	Carbon Dioxide
CH_4	Methane
EES	Environment Effects Statement
EMF	Environmental Management Framework
EPA	Environmental Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ERF	Emissions Reduction Fund
FSRU	Floating Storage and Regasification Unit
GHG	Greenhouse Gas Emissions
HDD	Horizontal Directional Drilling
IS	Infrastructure Sustainability
ISO	International Organisation for Standardisation
LGA	Local Government Area
LNG	Liquefied Natural Gas
MDO	Marine Diesel Oil
MHF	Major Hazard Facility
MM	Mitigation Measure
NGAF	National Greenhouse Account Factors
NGER	National Greenhouse and Energy Reporting
N_2O	Nitrous Oxide
Operational boundary	Operational boundary is the terminology used to describe the scope of activities (during both construction and operation) that are within the proponent's ability to control.
PJ	Petajoules
ROW	Right of Way
SWP	South West Pipeline
TJ	Terajoules
T	Tonnes
TRG	Technical Reference Group
VTS	Victorian Transmission System

1.0 Introduction

This technical report provides a greenhouse gas impact assessment conducted to support the Environment Effects Statement (EES) for the Viva Energy Gas Terminal Project (the project).

Viva Energy Gas Australia Pty Ltd (Viva Energy) is planning to develop a gas terminal using a ship known as a floating storage and regasification unit (FSRU), which would be continuously moored at Refinery Pier in Corio Bay, Geelong. The key objective of the project is to facilitate supply of a new source of gas for the south-east Australian gas market where there is a projected supply shortfall in coming years.

The FSRU would store liquefied natural gas (LNG) received from visiting LNG carriers (that would moor directly adjacent to the FSRU) and would convert LNG back into a gaseous state by heating the LNG using seawater (a process known as regasification) as required to meet industrial, commercial, and residential customer demand. A 7-kilometre gas transmission pipeline would transfer the gas from the FSRU to the Victorian Transmission System (VTS) at Lara.

The project would be situated adjacent to, and on, Viva Energy's Geelong Refinery, within a heavily developed port and industrial area on the western shores of Corio Bay between the Geelong suburbs of Corio and North Shore. Co-locating the project with the existing Geelong Refinery and within the Port of Geelong offers significant opportunity to minimise potential environmental effects and utilise a number of attributes that come with the port and industrial setting.

In December 2020, the Victorian Minister for Planning determined that the project requires assessment through an EES under the *Environment Effects Act 1978* (Vic). The reasons for the decision were primarily related to the potential for significant adverse effects on the marine environment of Corio Bay and the potential for contributing to greenhouse gas emissions. Secondarily, the EES was required to assess the effects of the project on air quality, noise, land use, Aboriginal and historic heritage, native vegetation, groundwater, traffic, and transport as well as visual amenity.

In January 2021 the project was also determined to require assessment and approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* ('EPBC Act') due to the potential for the project to have a significant impact on the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site (a wetland of international importance), listed threatened species and communities, and listed migratory species. The EES process is the accredited environmental assessment process for the controlled action decision under the EPBC Act in accordance with the bilateral agreement between the Commonwealth and Victorian governments.

1.1 Purpose

This greenhouse gas impact assessment identifies, assesses, and characterises the potential environmental impacts of greenhouse gas emissions associated with the construction and operation of the project to inform the preparation of the EES required for the project.

The report identifies and recommends mitigation measures to avoid, minimise and manage potential impacts which will inform the development of an Environmental Management Framework (EMF) for the project. The mitigation measures listed in the EMF would be implemented in the approvals and management plans for the project.

1.2 Why understanding greenhouse gas emissions is important

Australia's climate is changing, and greenhouse gas emissions are a key contributor to climate change. More intense and frequent storms, heatwaves, droughts, sea level rise, bushfires and other extreme weather events are impacting our natural and built environments. Climate impacts are already observable and there is broad scientific consensus that further changes will occur and that impacts are likely to increase. Australia's 2015 Paris Agreement target is to reduce greenhouse gas emissions by 26-28 per cent below 2005 levels by 2030. The *Climate Change Act 2017 (Vic)* sets the legislative foundation to manage climate change risks and drive Victoria's transition to net zero emissions by 2050. The Victorian government has set interim targets to reduce emissions by 28 – 33 per cent below 2005 levels by 2025, and 45 – 50 per cent by 2030. The Victorian government has also committed to 50 per cent of Victoria's electricity to be from renewable sources by 2030. The energy industries sector accounted for approximately 51 per cent of Victoria's overall greenhouse gas emissions in 2019 (Commonwealth of Australia, 2021).

Greenhouse gases are generally measured as tonnes (t) or kilo tonnes (kt) of carbon dioxide equivalent (CO_2-e). This represents the amount of greenhouse gases emitted as an equivalent amount of CO_2 which has a global warming potential of one. For example, one tonne of CH_4 released into the atmosphere will cause the same amount of global warming as 25 tonnes of CO_2. Therefore, one tonne of CH_4 is expressed as 25 t CO_2-e (Department of the Environment, 2018).

Direct project activities that would cause the release of greenhouse gases into the atmosphere include:

- burning fossil fuels in vehicles, plant, and equipment
- consumption of electricity produced by burning fossil fuels (such as coal or natural gas)
- consumption of materials where the manufacturing processes involve greenhouse gas emissions (for example manufacturing steel or cement)
- disposal of construction and operational waste
- dredging of seabed sediment
- clearance of vegetation.

1.3 Project area

The project would be located adjacent to, and on, the Geelong Refinery and Refinery Pier in the City of Greater Geelong, 75 kilometres (km) south-west of Melbourne. The project area is within a heavily developed port and industrial area on the western shores of Corio Bay between the Geelong suburbs of Corio and North Shore. The Geelong central business district is located approximately 7km south of the project.

Corio Bay is the largest internal bay in the south-west corner of Port Phillip Bay and is a sheltered, shallow basin at the western end of the Geelong Arm with an area of 43 square kilometres (km^2). The Point Wilson/Limeburners Bay section of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site is located along the northern shoreline of Corio Bay approximately one kilometre to the north-east of the project.

The Port of Geelong has been in operation for over 150 years and is the largest industrial bulk cargo port in Victoria attracting over 600 ship visits and handling more than 14 million tonnes of product annually. Geelong's shipping channels extend 18 nautical miles through Corio Bay from Point Richards through to Refinery Pier. Ports Victoria (formerly Victorian Regional Channels Authority) manages commercial navigation in the port waters in and around Geelong and is responsible for the safe and efficient movement of shipping, and for maintaining shipping channels and navigation aids. The channels are man-made having been deepened and widened through periodic dredging to support port trade development.

Refinery Pier is the primary location within the Port of Geelong for movement of bulk liquids. Vessels up to 265 metres in length currently utilise the four berths at Refinery Pier which service Viva Energy refinery operations. The majority of ship visits to the port are to Refinery Pier, with Viva Energy accounting for over half of the trade through the Port of Geelong.

The Geelong Refinery has been operating since 1954 with both the refinery and the co-located LyondellBasell plant being licensed Major Hazard Facilities (MHFs). A range of industrial activities are situated in the Port environs including wood fibre processing and chemical, fertiliser and cement manufacture.

To the north of the Geelong Refinery along the proposed underground pipeline corridor, the area is predominantly rural. There are several other existing Viva Energy-owned underground pipelines running between the refinery and the connection point to the South West Pipeline (SWP) at Lara. The proposed pipeline route follows already disturbed pipeline corridors, where possible, through a mix of land uses.

The project area is shown in Figure 1-1.

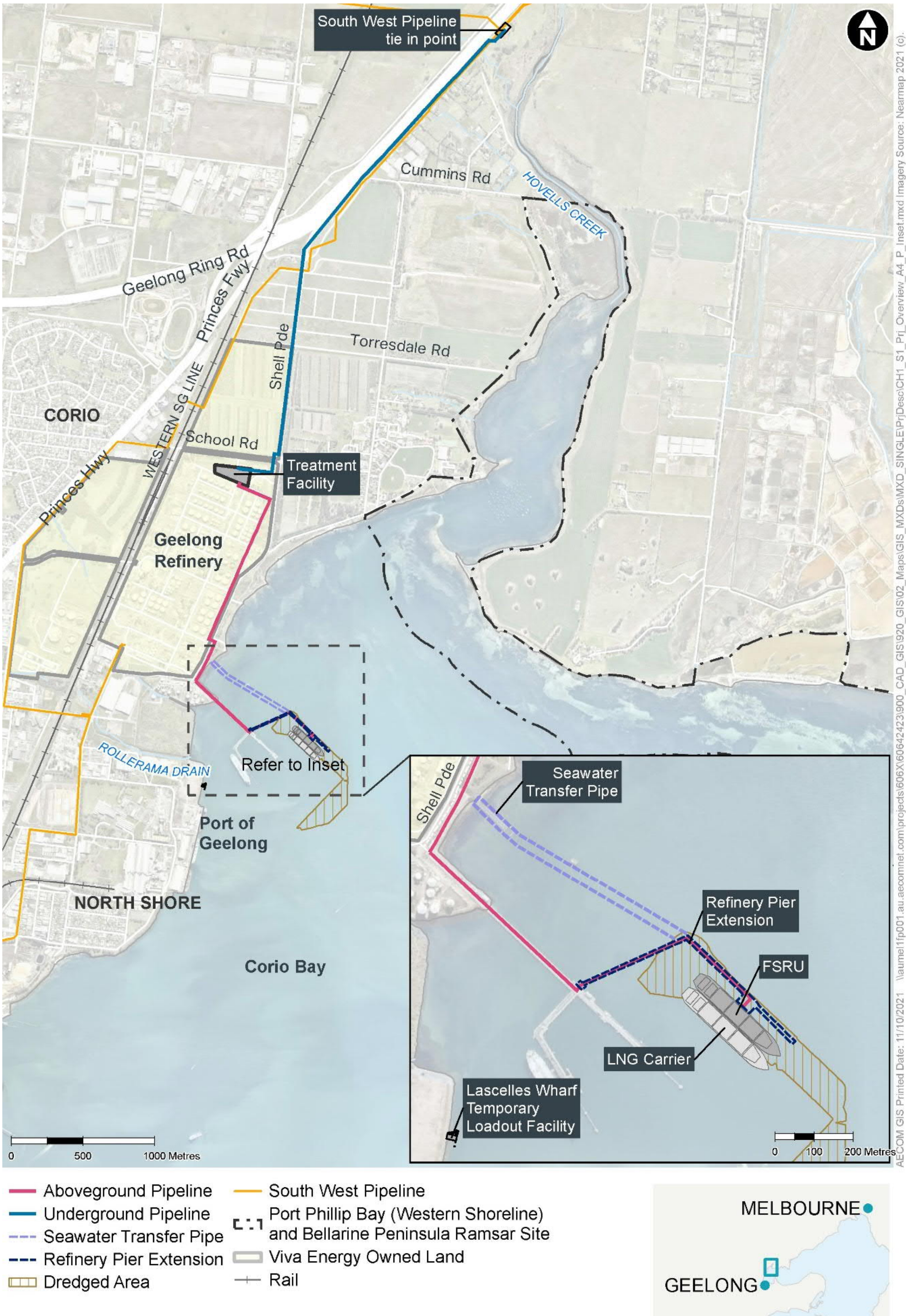

Figure 1-1: Project overview

1.4 Project description

This section summarises the project as described in Chapter 4: *Project description*. Key components of the project include:

- extension of the existing Refinery Pier with an approximately 570 metre (m) long angled pier arm, new berth and ancillary pier infrastructure including high pressure gas marine loading arms (MLAs) and a transfer line connecting the seawater discharge points on the FSRU to the refinery seawater intake
- continuous mooring of an FSRU at the new Refinery Pier berth to store and convert LNG into natural gas. LNG carriers would moor alongside the FSRU and unload the LNG.
- construction and operation of approximately 3 km of aboveground gas pipeline on the pier and within the refinery site connecting the FSRU to the new treatment facility
- construction and operation of a treatment facility on refinery premises including injection of nitrogen and odorant (if required)
- construction and operation of an underground gas transmission pipeline, approximately 4 km in length, connecting to the SWP at Lara.

The Refinery Pier extension would be located to the north-east of Refinery Pier No. 1. The new pier arm would be positioned to allow for sufficient clearance between an LNG carrier berthed alongside the FSRU and a vessel berthed at the existing Refinery Pier berth No. 1. Dredging of approximately 490,000 cubic metres of seabed sediment would be required to allow for the new berth pocket and swing basin.

The FSRU vessel would be up to 300m in length and 50m in breadth, with the capacity to store approximately 170 000 cubic metres (m^3) of LNG. The FSRU would receive LNG from visiting LNG carriers and store it on board in cryogenic storage tanks at about – 160 °C.

The FSRU would receive up to 160 PJ per annum (approximately 45 LNG carriers) depending on demand. The number of LNG carriers would also depend on their storage capacity, which could vary from 140,000 to 170,000 m^3.

When gas is needed, the FSRU would convert the LNG back into a gaseous state by heating the LNG using seawater (a process known as regasification). The natural gas would then be transferred through the aboveground pipeline from the FSRU to the treatment facility where odorant and nitrogen would be added, where required, to meet Victorian Transmission System (VTS) gas quality specifications. Nitrogen injection would occur when any given gas cargo needs to be adjusted (diluted) to meet local specifications. Odorant is added as a safety requirement so that the normally odourless gas can be smelt when in use. From the treatment facility, the underground section of the pipeline would transfer the natural gas to the tie-in point to the SWP at Lara.

1.4.1 Key construction activities

Construction of the project would occur over a period of up to 18 months. The key construction activities relate to:

- localised dredging of seabed sediments to enable the FSRU and LNG carriers to berth at Refinery Pier and excavation of a shallow trench for the seawater transfer pipe
- construction of a temporary loadout facility at Lascelles Wharf
- construction of the new pier arm and berthing infrastructure, and aboveground pipeline along Refinery Pier and through the refinery
- construction of the treatment facility on a laydown area at the northern boundary of the refinery site
- construction of the buried pipeline
- construction at the tie-in point to the SWP at Lara.

There are no construction activities required for the FSRU component of the project. The vessel would be built, commissioned and all production and safety systems verified prior to being brought to site.

An estimated 490,000 cubic metres (m^3) of dredging would be required, over an area of approximately 12 hectares (ha), adjacent to the existing shipping channel to provide sufficient water depth at the new berth and within the swing basin for visiting LNG carriers to turn. Dredging within the new berth would be undertaken to a depth of 13.1 metres and the swing basin would be dredged to a depth of 12.7 metres. The dredging physical footprint is shown in Figure 1-1. It is planned to deposit the dredged material within the existing dredged material ground in Port Phillip to the east of Point Wilson, approximately 26 km from Refinery Pier.

The temporary loadout facility at Lascelles Wharf would be the first construction activity to take place in order to facilitate the Refinery Pier extension. This would involve the installation of 10 piles using hydraulic hammers.

Construction of the pier arm would be carried out once dredging was complete, primarily from the water using barge-mounted cranes. Steel piles would be driven into the seabed by barge-mounted cranes and pre-cast concrete and pre-fabricated steel components would be transported to site by barge and lifted into position. The installation of pier infrastructure such as the marine loading arms (MLAs), piping from the FSRU to the existing refinery seawater intake (SWI) and aboveground pipeline would also be undertaken from the water using barge-mounted cranes and construction support boats.

Installation of the 3 km above ground pipeline along the pier and through the refinery is anticipated to take 3.5 months to complete. The above ground pipeline would run along the pier to the existing pipe track east of Shell Parade within the pier foreshore compound. It would then pass through a road under-crossing to the existing refinery pipe track. The pipeline would then run north along the existing refinery pipe track to an existing laydown area where the treatment facility would be located.

The treatment facility would be located within an existing laydown area in the refinery site and cover an area of approximately 80 m x 120 m. Construction of the treatment facility would take up to 18 months and would be undertaken by specialist crews across distinct phases of work. These would include initial earthworks and civil construction, mechanical installation and electrical and instrumentation works.

The 4 km underground pipeline would be installed in stages over a 4 month period within a corridor which has been selected so as to avoid watercourses or other environmental sensitivities, where possible. Firstly, a construction right of way (ROW) would be established, clearly identified and fenced off where required. Typically, this would be between 15 and 20 m wide, and minimised where possible to reduce disturbance. Once the construction ROW is established, vegetation would be removed, and a trench excavated to a maximum depth of 2 m and a maximum width of 1 m for the pipeline to be placed. Following the placement of the pipeline, the construction ROW would be rehabilitated to its pre-existing condition as far as practicable for the purposes for which it was used immediately before the construction of that part of the pipeline.

Trenchless construction (including thrust boring or horizontal directional drilling (HDD)) would be used to install the underground pipeline in areas that are not suited to open trenching techniques, such as at intersections with major roads. Trenchless construction would involve boring or drilling a hole beneath the ground surface at a shallow angle and then pushing or pulling a welded length of pipe through the hole without disturbing the surface. It is anticipated that the maximum depth of the trenchless section would be 25 m.

The anticipated trenching, HDD and thrust bore locations are presented in Figure 1-2. It is possible that along the northern section of Macgregor Court the pipeline would also be constructed using HDD, however, this would be confirmed during detailed design. Therefore, for the purpose of this assessment it has been assumed that trenching would be used along the northern section of Macgregor Court as per Figure 1-2 noting that this would not have a material impact on the calculated emissions.

Construction at the tie-in point to the SWP at Lara would be undertaken by specialist crews across the distinct phases of works, as with the treatment facility.

Figure 1-2: Proposed location of trenching construction techniques for the underground pipeline including open trenching, HDD and thrust boring

1.4.2 Key operation activities

The project is expected to be in operation for approximately 20 years. Key activities relating to project operation include:

- receipt of up to 45 LNG carriers each year at Refinery Pier – the number and frequency of LNG carriers arriving each year would depend on their storage capacity and gas demand
- regasification of LNG onboard the FSRU using seawater as a heat source, which would then be reused within the refinery as cooling water (two proposed operational scenarios are described below)
- injection of nitrogen and odorant into the gas prior to distribution via the VTS
- monitoring and maintenance of the pipeline easement.

1.4.2.1 Operational regasification scenarios

For the project the usual regasification mode of the FSRU is for operation in open loop mode (using seawater to heat the LNG as shown in Figure 1-3), with the modification so that the FSRU seawater discharge from the regasification process can be redirected and reused within the adjacent refinery. The FSRU would also have the ability to operate in close loop mode (using a gas-fired boiler to generate steam to heat the LNG as shown in Figure 1-4). However, due to the environmental and economic implications, closed loop is not the preferred mode of regasification for the project and would only be used in in very limited instances where the FSRU was unable to discharge water through the seawater transfer pipe to the refinery for example, during FSRU maintenance or due to a pump or pipe failure.

The combined loop regasification process would potentially be used when the ambient seawater temperature is too low for open loop regasification to operate effectively. This would involve running two boilers to heat the seawater for up to 30 days a year.

The FSRU would deliver up to approximately 160 PJ of natural gas into the VTS annually. This equates to approximately 45 carriers of LNG per annum. The FSRU can operate at different send out rates (between 250 and 750 terajoules per day (TJ/day) to meet demand). However, the maximum send out rate proposed for the FSRU is 620 TJ/day.

The FSRU operational profile is described in Chapter 4: *Project description*.

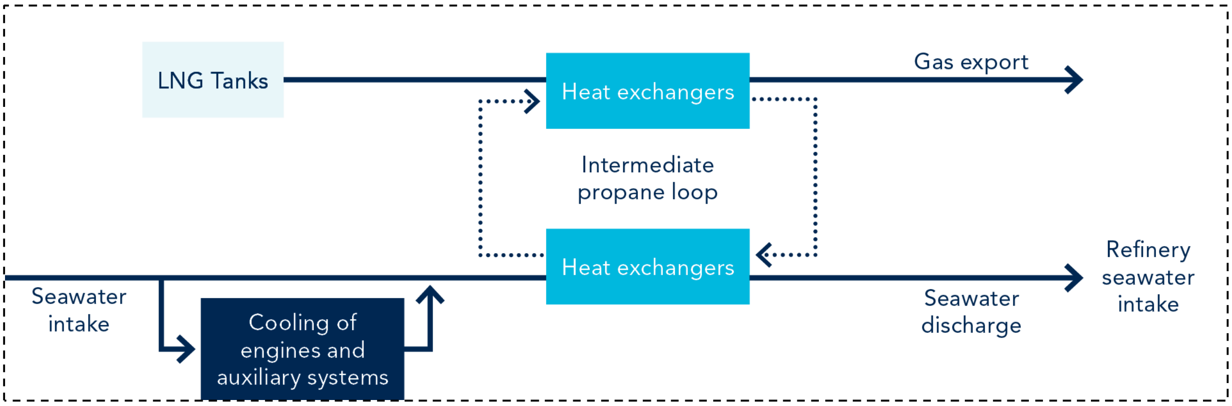

Figure 1-3 Simplified diagram of the open loop mode onboard the FSRU

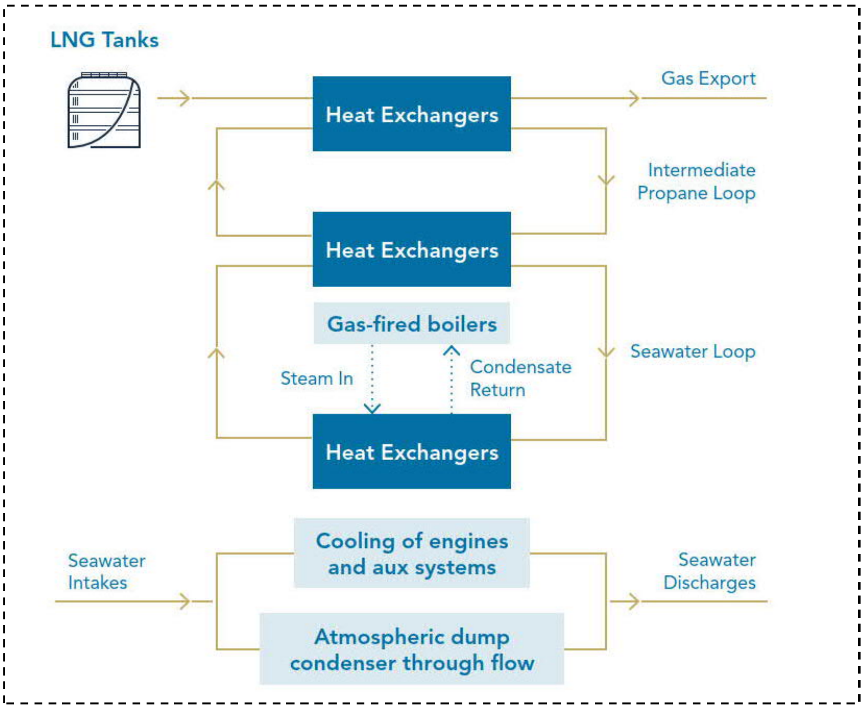

Figure 1-4 Simplified diagram of the closed loop mode onboard the FSRU

1.4.3 Key decommissioning activities

The FSRU, which continues to be an ocean-going vessel throughout the operation of the project, would leave Corio Bay on completion of the project life to be used elsewhere.

It is anticipated that the Refinery Pier berth and facilities would be retained for other port related uses. The underground pipeline would likely remain in situ subject to landholder agreements and either decommissioned completely or placed into care and maintenance arrangements.

Decommissioning activities may be subject to change, subject to legislative requirements at the time and potential repurposing of the infrastructure at the end of the project. Decommissioning activities are not included in the scope of this assessment.

1.5 Project activities relevant to the assessment

The scope of the greenhouse gas emissions assessment for the construction and operation activities of the project includes all direct (Scope 1), and indirect (Scope 2 and Scope 3) emissions within the proponent's ability to control (the operational boundary i.e., the scope of activities (during both construction and operation) that are within the proponent's ability to control).

As set out in the GHG Protocol Corporate Standard, a key criterion in determining an operational boundary for assessment was the proponent's ability to control or influence activity. Scope 3 emissions, such as those from embodied emissions relating to construction materials, transport of employees and materials, and from the disposal of waste, are determined to be within the proponent's ability to control or influence. It is determined that the proponent does not have the ability to control or influence the locations or processes involved in the production or transportation of gas prior to transfer from the LNG carrier to the FSRU. It is also determined that the proponent does not have the ability to control or influence the end-use consumption of gas. The methodology used to determine the operational boundary for the assessment is described in Section 4.0.

The construction phase and operation phase emissions sources, within, and outside, the operational boundary are illustrated in Figure 1-5 and Figure 1-6 respectively.

Despite exclusion from the project's operational boundary, Scope 3 emissions from the production and transportation of gas prior to transfer from the LNG carrier to the FSRU, and from the end-use consumption of the gas, are provided for context. These are presented separately from the impact assessment in Appendix A.

1.5.1 Construction activities and emission sources

The scope of the greenhouse gas emissions assessment of the construction phase of the project includes all direct (Scope 1), and indirect (Scope 2 and Scope 3) emissions within the proponent's ability to control associated with the construction and installation of equipment for the FSRU and Refinery Pier, treatment facility and pipeline (see Figure 1-5). This includes the following:

- localised dredging of seabed sediments for the new Refinery Pier berth
- construction of the temporary loadout facility at Lascelles Wharf
- construction of the new pier arm and berthing infrastructure
- transportation of FSRU vessel to Geelong
- construction of aboveground pipeline section along Refinery Pier and through the refinery to the treatment facility
- construction of the treatment facility
- construction of the underground pipeline section from the treatment facility to the SWP at Lara
- construction at the pipeline tie-in point at Lara City Gate
- embodied greenhouse gas emissions in construction materials and installed equipment
- transportation of construction materials and equipment
- construction worker transportation
- disposal of construction waste.

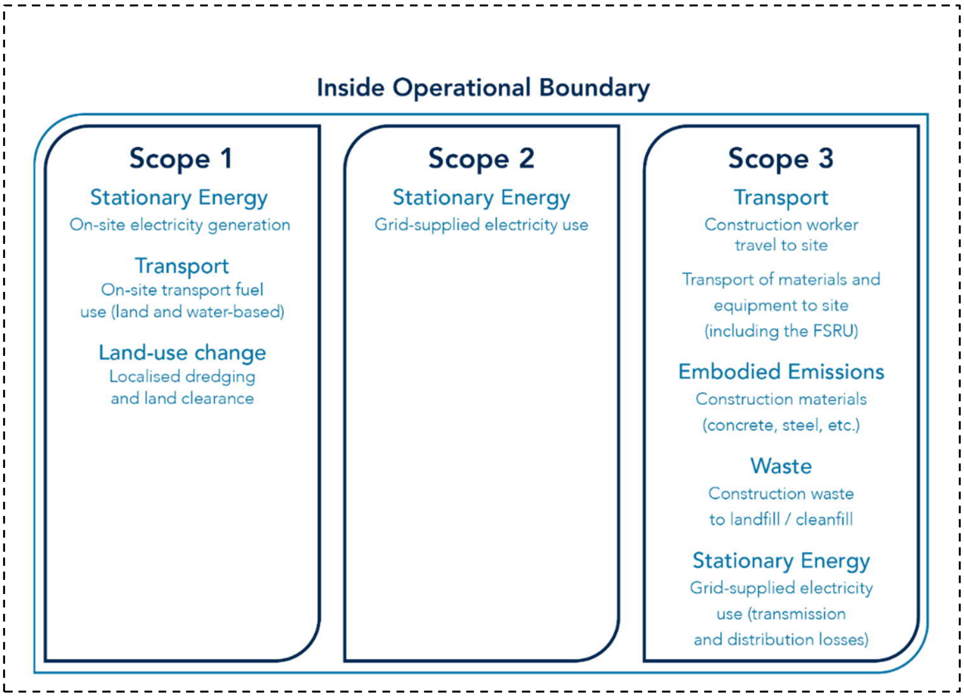

Figure 1-5 Construction phase emissions sources within the project's operational boundary

1.5.2 Operation activities and emission sources

The scope of the greenhouse gas emissions assessment of the operation phase of the project includes all direct (Scope 1) and indirect (Scope 2 and 3) emissions within the proponent's ability to control, associated with the operation of the FSRU and Refinery Pier, treatment facility, and pipeline (see Figure 1-6). This includes the following:

- operation of the FSRU and Refinery Pier
- operation of the treatment facility
- transport of odorant and nitrogen to the treatment facility
- operation of the pipeline
- fugitive emissions from the transfer of LNG from the LNG carriers to the FSRU, from the treatment facility, and from the pipeline
- transport of operators and other personnel to the gas terminal
- operational waste and wastewater disposal.

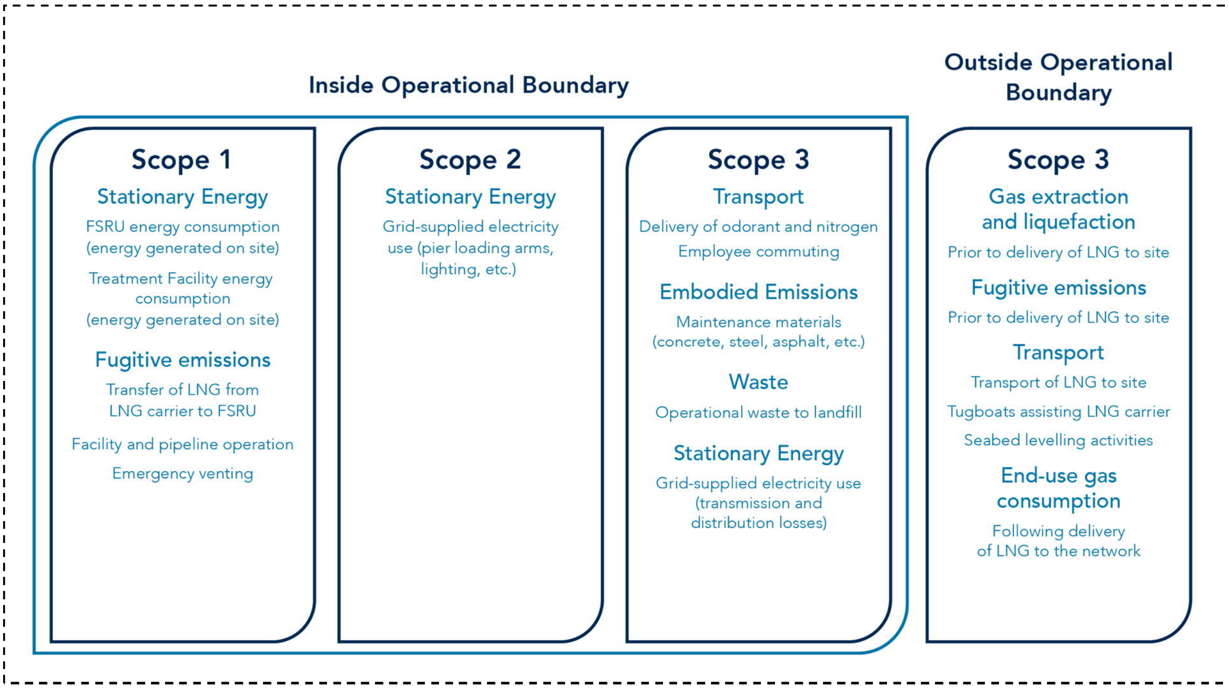

Figure 1-6 Operation phase emissions sources within the project's operational boundary

2.0 Scoping requirements

The scoping requirements for the EES set out the specific environmental matters to be investigated in the EES. The scoping requirements include a set of evaluation objectives. These objectives identify the desired outcomes to be achieved in managing the potential impacts of constructing and operating the project.

The following evaluation objective is relevant to the greenhouse gas impact assessment:

- **Waste management** – To minimise generation of wastes by or resulting from the project during construction and operation, including dredging, and accounting for direct and indirect greenhouse gas emissions

The scoping requirements of relevance to this greenhouse gas impact assessment and where they are addressed in the report are shown in Table 2-1.

Table 2-1: Scoping requirements relevant to greenhouse gas impact assessment

Aspect	Scoping requirement	Section addressed
Key issues	Potential for adverse environmental or health effects from waste materials/streams generated from project works.	Section 6.0 and Section 7.0 (Construction and Operational impact assessments)
	Potential for emissions of greenhouse gases to result from the project, including embodied emissions due to construction materials and processes as well as direct and indirect emissions from construction and operation.	
Existing environment	Nil	Section 5.0 (Existing conditions)
Likely effects	Quantify anticipated greenhouse gas emissions from the project relative to time including Scope 1 and Scope 2 emissions as well as an estimate of potential fugitive emissions through infrastructure spills or leakages.	Section 6.0 and Section 7.0 (Construction and Operational impact assessments)
Mitigation measures	Identify options for avoiding or reducing direct and indirect greenhouse gas emissions resulting from the construction and operation of the project.	Section 8.0 (Mitigation measures)
	Identify the measures to be taken in design, construction, and operational management to eliminate or minimise the likelihood or extent of fugitive emissions.	
Performance objectives	Describe proposed measures to avoid, reduce, monitor, and audit greenhouse gas emissions from the project.	Section 8.0 (Mitigation measures)

3.0 Legislation, policy, and guidelines

Table 3-1 to Table 3-4 summarises the key environmental legislation and policy that apply to the project in the context of this greenhouse gas impact assessment, as well as the implications for the project and the required approvals.

Table 3-1: International legislation and policy relevant to the assessment

Legislation/policy	Description	Implications for the project	Approval required
International			
Legislation			
Paris Agreement	The Paris Agreement builds upon the United Nations Framework Convention on Climate Change and aims to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. The central aim of the Paris Agreement 'is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius'.	The Paris Agreement is a driver for setting Commonwealth and State greenhouse gas legislation, policy and targets. The Paris Agreement has no direct impact on the approval decisions.	No approvals required.
Policy			
Greenhouse Gas Protocol by the World Business Council for Sustainable Development and the World Resources Institute (**Greenhouse Gas Protocol**)	The Greenhouse Gas Protocol provides guidance, standards, tools and training for government and businesses to measure and manage emissions and build effective programs to tackle climate change. The Greenhouse Gas Protocol establishes comprehensive global standardised frameworks for private and public sectors to measure and manage greenhouse gas emissions. It is a widely used international accounting tool for government and business leaders to understand, quantify and manage emissions.	The Greenhouse Gas Protocol methodology was used for this greenhouse gas impact assessment.	No approvals required.
ISO 14064-1:2018: Greenhouse Gases (**ISO 14064-1**)	ISO 14064-1 specifies principles and requirements at the organisational level for the quantification and reporting of greenhouse gas emissions and removals. ISO 14064-1 includes requirements for the design, development, management, reporting and verification of an organisation's greenhouse gas inventory.	ISO 14064-1 was used in the greenhouse gas impact assessment methodology as outlined in Section 4.3.	No approvals required.

Table 3-2: Commonwealth legislation and policy relevant to the assessment

Legislation/ policy	Description	Implications for the project	Approval required
Commonwealth			
Legislation			
National Greenhouse and Energy Reporting Act 2007 (Cth) ('NGER Act') National Greenhouse and Energy Reporting (Measurement) Determination 2008	The NGER Act establishes the legislative framework for the NGER Scheme which is a national framework for reporting greenhouse gas emissions and projects and energy consumption and production by corporations in Australia. Several legislative instruments sit under the NGER Act including this Determination. This Determination describes the methods, standards and criteria to be applied when estimating greenhouse gas emissions, energy production and energy consumption.	Methodology described in the Determination was used for the greenhouse gas impact assessment. Viva Energy are required to annually report energy use and greenhouse gas emissions under the NGER Act.	No approvals required.
National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (NGER Rule)	The NGER Rule is a legal mechanism aimed at preventing significant increases in emissions above business as usual from major facilities (i.e., facilities with direct (Scope 1) greenhouse gas emissions greater than 100,000 t (CO_2-e a year).	The proposed regasification mode of the FSRU is for operation in open loop mode. Greenhouse gas emissions for open loop mode would not trigger requirements under the NGER rule, as direct (Scope 1) greenhouse gas emissions are not expected to be greater than 100,000 t (CO_2-e a year). The closed loop operational mode would trigger requirements under the NGER rule, as direct (Scope 1) greenhouse gas emissions are expected to be greater than 100,000 t (CO_2-e a year) The proponent would be required to submit an application for a calculated-emissions baseline determination to the regulator. This application would require the quantity of emissions and emissions intensity expected per annum for the facility.	No approvals required.
Policy			
Emissions Reduction Fund (**ERF**) as part of the	The ERF came into effect on 13 December 2014 and involves a 'reverse auction' mechanism, where businesses can sell their carbon	The aim of the ERF is to encourage businesses to invest in the most cost-efficient emissions reduction	No approvals required.

Legislation/ policy	Description	Implications for the project	Approval required
Direct Action Plan	abatement, with the government purchasing the lowest cost per tonne of abatement. In February 2019, the Commonwealth Government established a Climate Solutions Fund to provide an additional $2 billion to continue purchasing low-cost abatement.	methods, and while it does not have any implications for the project, it is part of the broader policy context for the project.	

Table 3-3: State policy and legislation relevant to the assessment

Legislation/policy	Description	Implications for the project	Approval required
State			
Legislation			
Environment Protection Act 2017 (Vic) ('Environment Protection Act')	The Environment Protection Act aims to protect Victoria's air, water and land by adopting a 'general environment duty' (GED) which imposes a broad obligation on entities and individuals to take proactive steps to minimise risks of harm to human health and the environment from pollution or waste. The Environment Protection Authority administers the Environment Protection Act and subordinate legislation.	The Environment Protection Act regulates discharges to air, land, surface water or groundwater by a system of Development and Operating Licenses. Any discharge during the construction or operation of the project must be in accordance with the requirements of the Environment Protection Act. The GED requires all reasonably practicable steps to be taken to minimise impacts from the construction and operation of the project. The Environment Protection Act follows the provisions of the *Climate Change Act 2017(Vic)* whereby account must be given to GHG emissions as a result of project construction and operation.	The FSRU component of the project would require a Development and Operating Licence. The Geelong Refiner would require a Development Licence or exemption.
Pipelines Act 2005 (Vic) ('Pipelines Act')	This is the primary act governing the construction and operation of pipelines in Victoria. The Pipelines Act covers 'high transmission' pipelines for the conveyance of gas, oil, and other substances. The Department of Environment, Land, Water and Planning (DELWP) and Energy Safe Victoria (ESV) are responsible for administering the Pipelines Act and the Pipelines Regulations 2017.	The project requires a Pipeline Licence(s) under the Pipelines Act for the construction and operation of the pipeline.	Approval required.

Legislation/policy	Description	Implications for the project	Approval required
Climate Change Act 2017 (Vic) ('Climate Change Act')	The Climate Change Act provides Victoria with a legislative foundation to manage climate change risks and drive the transition to a climate resilient community and economy with net zero emissions by 2050. The Act embeds the 2050 net zero emissions target and provides for the setting of five-yearly interim greenhouse gas emissions reduction targets, climate change strategies, and adaptation action plans to ensure the 2050 target is achieved and vulnerabilities to climate change impacts are reduced while potential opportunities are realised.	A person making certain decisions or taking specified actions must have regard to— (a) the potential impacts of climate change relevant to the decision or action (b) the potential contribution to the State's greenhouse gas emissions of the decision or action (c) any guidelines. The decisions listed in the Schedule to the Climate Change Act that are relevant, are the decisions by the EPA Victoria as to whether a Development Licence or Operating Licence should be granted under the Environment Protection Act.	No approvals required
Guidelines			
EPA Victoria, Guideline for managing greenhouse gas emissions *Draft for consultation, January 2022*	The guideline forms part of the 'state of knowledge' intended to provide guidance on minimising risks as far as reasonably practicable, in line with the Environment Protection Act. The guidance is designed to provide information to help compliance obligations be understood and met but does not impose new compliance obligations. The guideline outlines a risk management approach that can be applied to GHG emissions, by providing guidance in how to identify, assess, control and check GHG emissions.	The approach outlined in the guideline to identify, assess and propose measures to minimise emissions is consistent with the approach undertaken for this GHG impact assessment.	No approvals required

Table 3-4: Local policy relevant to the assessment

Legislation/ policy	Description	Implications for the project	Approval required
Local			
Policy			
City of Greater Geelong Sustainability Framework, Action Plan 2020 - 2022	This document sets out the objectives and actions for the council and community for three key priority areas. Of relevance includes the objective to support the community and the city to reduce carbon emissions.	The project should consider the objectives set out in the action plan.	No approval required
City of Greater Geelong Zero Carbon Emissions Strategy (2017 – 2020)	The City of Greater Geelong have set the objective to support community sector greenhouse gas emissions reductions. The City has a goal to be carbon neutral by 2047. The strategy identifies that 6.2% of community emissions were from industrial processes in 2015 and is projected to decrease to 4.7% in 2035 due to planned closures of heavy manufacturing sites.	The project should consider the emission reduction targets set out in the strategy.	No approval required

4.0 Methodology

This section describes how the greenhouse gas assessment was conducted to understand the existing environment, and potential impacts of the project on greenhouse gas emissions. The following sections outline the assessment methodology.

4.1 Existing conditions assessment method

The existing conditions assessment considered state level greenhouse gas emissions using the 2019 reporting reference year. This provided a base case against which the emissions from the project could be compared. The project is intended to facilitate supply of a new source of gas for the South-East Australian gas market where there is a projected supply shortfall in coming years. As such, the State level emissions context and was considered as the most relevant to the scope.

Victorian emissions data was sourced from *Australian National Greenhouse Accounts: State and Territory Greenhouse Gas Inventories, 2019* report (Commonwealth of Australia, 2021).

4.2 Risk screening method

A risk-based screening approach has been used for the EES assessment in accordance with the requirements outlined in the 'Ministerial guidelines for assessment of Environmental Effects under the *Environment Effects Act 1978 (Vic)'* (page 14). The risk screening is undertaken to ensure that the level of investigation conducted in each technical study is adequate to inform an assessment of the significance and acceptability of the project's potential environmental impacts.

An environmental, social, and economic issues risk screening tool has been used to prioritise and focus the proposed investigations, assessments, and approaches to avoiding, minimising, or managing potential impacts. The issue screening process involved an evaluation of the potential environmental, social, and economic issues associated with the project based on the information collected through a series of initial assessments undertaken into the potential effects of the project.

A risk workshop convened by a qualified risk practitioner and comprising technical specialists from the proponent, project design team and EES team conducted the initial risk screening. The risk screening process utilised knowledge of the project infrastructure and design, existing environment and land use setting to assess potential risks based on the specialised knowledge of the technical experts.

The purpose of the issues screening approach was to assist in identifying:

- Significant issues, uncertainties and/or potential impacts that require more detailed characterisation and/or assessment within the EES
- Matters or potential impacts considered to be already well understood or less significant.

A high, medium, or low screening value was assigned to potential issues to determine the level of assessment required to identify and investigate impacts.

Each potential issue was given a score (1, 2 or 3) against the categories of:

- Community and stakeholder interest
- Significance of assets, values and uses
- Potential impact (spatial, temporal and severity).

The scores were added together, or the highest score across the three contributing categories was used, to give a 'screening value' of high, medium or low, which gives an indication of the level of impact assessment that is required. Issues that were assigned a screening value of high or medium required detailed assessment in the EES at a level commensurate with them being considered primary level issues.

Issues that were assigned a screening value of low were proposed to be documented and managed with some investigation and assessment in the EES at a level commensurate with them being considered secondary level issues.

4.2.1 Criteria and consequence ratings

Risks, issues, and potential impact pathways were identified for both construction and operation of the project. Table 4-1 defines the criteria and consequence ratings for each of the three categories that have been used to inform the issues screening. The sum of the scores against each of the three categories or the highest rating across any of the three contributing categories gives the 'screening value'.

Table 4-1: Issues screening criteria and consequence ratings

Rating	Community and stakeholder interest	Significance of assets, values and uses	Potential impact (spatial, temporal and severity)
1	Low interest and perceived impact	Locally significant asset, value, or use	Potential for localised, temporary impact
2	Some interest and targeted perceived impacts	Regionally significant asset, value, or use	Potential for significant temporary, or localised permanent impact
3	Broad community and stakeholder interest or impacts	State or nationally significant asset, value, or use	Potential for significant permanent impact

The screening values are then used to determine the level of assessment required as shown in Table 4-2.

Table 4-2: Issue investigation categories

Screening score	Screening value	Potential consequences	Complexity of mitigation	Level of assessment
7, 8 or 9 or the highest rating across any one of the three contributing categories is 3	High	Potential for elevated, longer term impacts, significant assets or values may be affected with enduring changes. Considers both impacts and benefits, or Issue may not be well defined and insufficient information is available for the impact assessment, or High level of community interest.	Stringent management measures may be required	Detailed assessment required
4, 5 or 6 or the highest rating across any one of the three contributing categories is 2	Medium	Potential for moderate level impacts, significant assets or values may be affected over an extended time frame with some resultant changes. Considers both impacts and benefits, or Issue may be moderately understood, and some information is available, however more is required for the impact assessment, or Medium level of community interest.	Standard management measures are available that can be adopted with some modification	Moderate assessment required
3 or the highest rating across any one of the three contributing categories is 1	Low	Potential for short term and localised impact. Asset or values may be temporarily affected but recovery expected, or Issue is well understood and there is enough information available for the impact assessment, or Low level of community interest.	Standard management measures are available.	Some assessment required

Further information about the risk screening process is detailed in Chapter 7: *Assessment framework.*

Outcomes from the risk screening process are outlined in Section 4.2.2 below.

4.2.2 Risk screening results

Table 4-3 provides the key potential issues related to greenhouse gas emissions identified as part of the risk screening process for the project and presents the screening value for each issue.

Table 4-3 Greenhouse gas issues screening results

Aspect	Issue	Community & stakeholder perceived impacts	Significance of assets, values & uses	Potential impact (spatial, temporal & severity)	Screening Score	Screening Value
Construction						
Greenhouse gas	GHG emissions from construction plant and equipment	1	1	1	3	Low
Operation						
Greenhouse gas	Operation of the FSRU (closed loop) results in generation of GHG emissions	3	3	3	9	High
Greenhouse gas	Operation of the FSRU (open loop) results in generation of GHG emissions	2	2	2	6	Medium
Greenhouse gas	GHG emissions from unplanned activities, incidents or emergencies	2	1	1	4	Medium

4.3 Impact assessment method

The greenhouse gas impact assessment methodology followed the principles set out in the following documents:

- *NGER (Measurement) Determination 2008 (as amended)* under the NGER Act, Commonwealth Department of Environment and Energy
- *The Greenhouse Gas Protocol (GHG Protocol),* the World Business Council for Sustainable Development and the World Resources Institute
- *American Petroleum Institute (API) Compendium of GHG Emissions Methodologies for the Oil and Natural Gas Industry,* August 2009
- *ISO 14064-1:2018 Greenhouse gases – Part 1: Specification with guidance at the organisation level for quantification and reporting of greenhouse gas emissions and removals*
- *ISO 14040:2006 Environmental management – Lifecycle assessment – Principles and framework and ISO 14044:2006 Environmental management – Lifecycle assessment – Requirements and guidelines*. These standards are applicable to the calculation of materials lifecycle impacts using the Infrastructure Sustainability (IS) Materials Calculator.
- *Guideline for managing greenhouse gas emissions,* Environment Protection Authority Victoria, Draft for consultation, January 2022.

4.3.1 Greenhouse gas emission scopes

Greenhouse gas emissions were estimated in accordance with the principles of the internationally accepted GHG Protocol. According to the GHG Protocol, greenhouse gas emissions are split into three categories, known as ‘Scopes’. Scope 1, Scope 2, and Scope 3 are defined by the GHG Protocol as:

- Scope 1 – Direct emissions of greenhouse gas from sources that are owned or operated by a reporting organisation (examples include combustion of diesel in company-owned vehicles or used in on-site plant and equipment)
- Scope 2 – Indirect emissions associated with the import of energy from another source (examples include import of electricity from the grid, or heat)
- Scope 3 – Other indirect emissions, other than energy imports (above) which are a direct result of the operations of the organisation, but from sources not owned or operated by them and due to upstream or downstream activities (examples include indirect upstream emissions associated with the extraction, production and transport of purchased construction materials; and business travel (by ship, air or rail)).

Figure 4-1 illustrates the various activities that are relevant to each of the Scope categories.

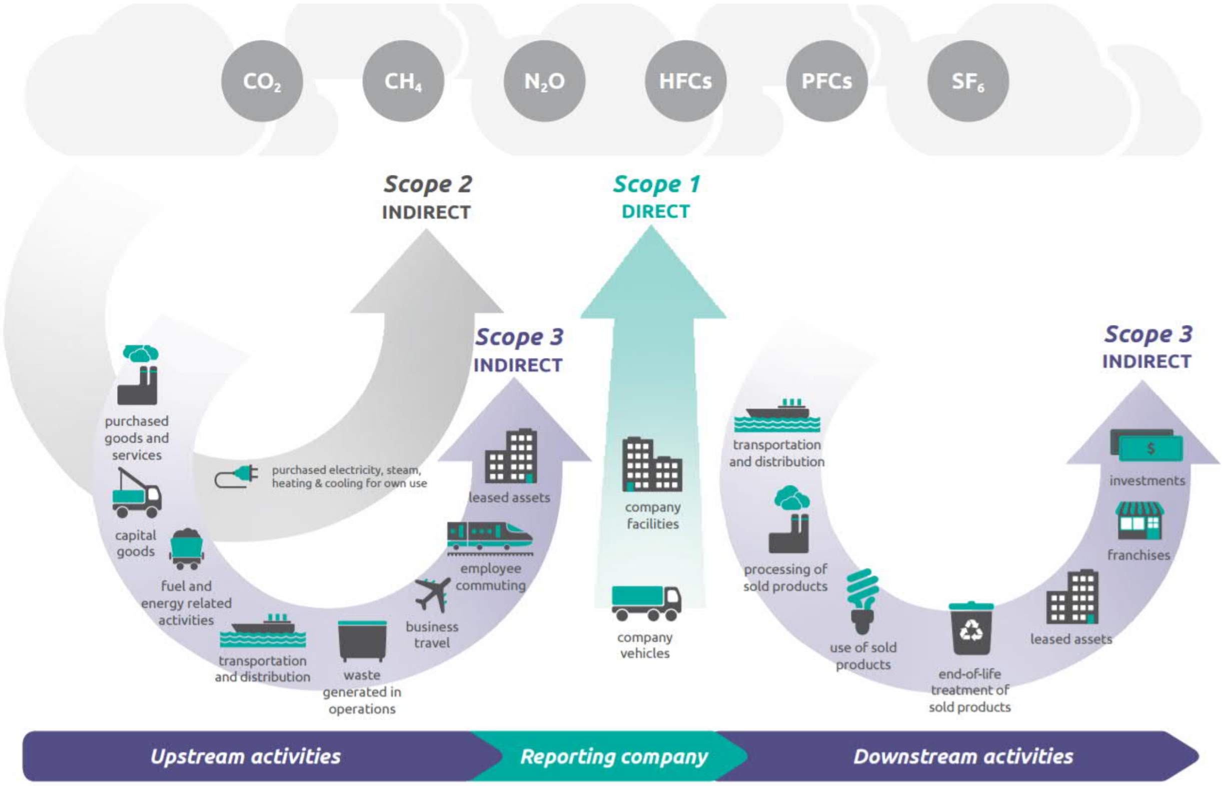

Figure 4-1 Direct and indirect emissions as defined by the GHG Protocol (Source: GHG Protocol, 2013)

For the purpose of this assessment, Scope 1, Scope 2, and significant Scope 3 emissions have been determined for the assessed construction and operation scenarios. All Scope 1 and Scope 2 direct and indirect emissions are required to be reported under both the NGER and GHG Protocol reporting schemes. Some Scope 3 emissions have been included as they represent a material contribution to the overall greenhouse gas construction and operational footprints and are determined to be within the proponent's ability to control or influence.

Determining which Scope 3 emissions to include in the inventory (i.e., setting the operational boundary) is an important decision in the inventory process. The GHG Protocol Corporate Standard allows companies flexibility in choosing which, if any, Scope 3 activities to include in the GHG inventory when the company defines its operational boundaries. The GHG Protocol Scope 3 Standard is designed to create additional completeness and consistency in Scope 3 accounting and reporting by defining Scope 3 boundary requirements.

The criteria for including Scope 3 emissions within the project's operational boundary, according to the GHG Protocol, are outlined in Table 4-4, which has been used to identify material and immaterial emissions for the project.

Table 4-4: GHG Protocol criteria for inclusion of Scope 3 emissions in the operational boundary

Criteria	Description
Size	They contribute significantly to the company's total anticipated Scope 3 emissions
Influence	There are potential emissions reductions that could be undertaken or influenced by the company
Risk	They contribute to the company's risk exposure (e.g., climate change related risks such as financial, regulatory, supply chain, product and customer, litigation, and reputational risks)
Stakeholders	They are deemed critical by key stakeholders (e.g., customers, suppliers, investors, or civil society)
Outsourcing	They are outsourced activities previously performed in-house or activities outsourced by the reporting company that are typically performed in-house by other companies in the reporting company's sector
Sector guidance	They have been identified as significant by sector-specific guidance
Other	They meet any additional criteria for determining relevance developed by the company or industry sector

4.3.2 Construction emission sources

The sources of greenhouse gas emissions included in the construction phase are provided in Table 4-5. A 'dot' (○) denotes whether the emission is Scope 1, Scope 2, or Scope 3. The rationale for exclusion of activities in the assessment is detailed in Table 4-7 with explanation in Section 4.4.2

Table 4-5: Summary of construction greenhouse gas emissions included in assessment

Source of greenhouse gas emission	Activity	Direct	Indirect	
		Scope 1	Scope 2	Scope 3
Stationary energy	Fuel consumed by construction plant and equipment	○		○
	Electricity consumed by construction plant and equipment		○	○
Transport fuel	Fuel consumed by construction plant and equipment	○		○
	Fuel consumed for construction material delivery			○
	Fuel used in the transportation of the FSRU			○
	Employee commute from home to site			○
	Employee air travel			○
Embodied emissions	Embodied emissions of materials used in Lascelles Wharf, Refinery Pier extension and pipeline construction (e.g., steel and concrete)			○
	Embodied emissions of materials used in treatment facility construction (e.g., steel and concrete)			○
Waste	Construction waste disposed in landfill			○
Land use, land use change and forestry	Land clearing	○		
	Emissions associated with sediment removal during localised dredging at Refinery Pier			○

4.3.3 Operation emission sources

The sources of greenhouse gas emissions included in the operational phase are provided in Table 4-6. A ‘dot’ (○) denotes whether the emission is Scope 1, Scope 2, or Scope 3. The rationale for exclusion of activities in the assessment is detailed in Table 4-7.

Table 4-6: Summary of operational greenhouse gas emissions included in assessment

Source of greenhouse gas emission	Activity	Direct	Indirect	
		Scope 1	Scope 2	Scope 3
Stationary energy	Fuel consumed by FSRU during operation	○		○
	Electricity consumed by onsite plant and equipment (including Refinery Pier ancillary infrastructure such as MLAs, and within the treatment facility)		○	○
	Fuel consumed for operational supply and material delivery			○
	Employee commute to and from home to site			○
	Employee air travel			○
Fugitive emissions	Fugitive emissions from transfer of LNG from carrier to FSRU	○		
	Fugitive emissions from plant and pipeline operations	○		
	Fugitive emissions from maintenance and emergency venting	○		
Waste	Operational liquid waste disposal			○

4.3.4 Calculation methods and emissions factors

The following sub-sections briefly outline the calculation methods and emissions factors used in the impact assessment. A detailed list of emission factors is included in Appendix C.

4.3.4.1 Stationary energy emissions

Stationary energy emissions relate to the fuel consumed by plant / equipment during construction and fuel consumed by the FSRU reciprocating gas engines and boilers during operation. The calculation methodology applied for the combustion of natural gas were determined in accordance with the NGER Scheme (Measurement) Determination 2008, Division 2.2.2, 2.3.2 and 2.4.2, Method 1. Emissions factors related to fuel consumption were drawn from the National Greenhouse Account Factors (NGAF) August 2021, Section 2.1.

4.3.4.1.1 Indirect emissions from grid electricity

On-grid electricity generation emissions are included as Scope 2 emissions and are related to the consumption of electricity sourced from the Victorian electricity grid. The calculation methodology applied for grid supplied electricity were determined in accordance with the NGER Scheme (Measurement) Determination 2008, Section 7.2 using method 1. Emissions factors for the consumption of grid electricity were drawn from the National Greenhouse Account Factors (NGAF) August 2021, Section 2.3 and Appendix 4.

4.3.4.2 Transport fuel emissions

Construction transport fuel emissions relate to general staff movements and the transport of materials and equipment. Operational transport fuel emissions relate to the transport of LNG to the Refinery Pier via LNG carriers, nitrogen and odorant delivery vehicles and general staff movements to Viva Energy

Geelong Refinery. The calculation methodology applied for the combustion of natural gas was determined in accordance with the NGER Scheme (Measurement) Determination 2008, Division 2.2.2, 2.3.2 and 2.4.2, Method 1. Emissions factors related to fuel consumption were drawn from the National Greenhouse Account Factors (NGAF) August 2021, Section 2.2.

4.3.4.3 Embodied emissions

Embodied emissions are the emissions produced and released during manufacture of materials. Embodied emissions from concrete / cement and steel (such as for the pipeline and the new pier arm) have been calculated in this assessment. Embodied emissions are calculated using the emissions factors and methodology determined in the Infrastructure Sustainability (IS) Materials Calculator.

4.3.4.4 Waste emissions

Waste emissions from municipal solid waste, commercial and industrial waste, and construction and demolition waste, during construction, were determined in accordance with the NGER Scheme (Measurement) Determination 2008, Division 5.3.4, Method 3. Emissions factors related to waste transportation fuel consumption were drawn from the National Greenhouse Account Factors (NGAF) August 2021, Appendix 4.

Wastewater emissions were calculated using an emissions factor for commercial wastewater from the Greenhouse Gas Protocol. This generic emission factor was chosen due to the relative immateriality of wastewater emissions for this project.

4.3.4.5 Fugitive emissions

Fugitive emissions (i.e., gas leaking from pipes or valves) related to the transmission of natural gas in the pipeline were determined in accordance with the NGER Scheme (Measurement) Determination 2008, Section 3.76 using Method 1. Fugitive emissions related to the FSRU operations and the treatment facility were determined in accordance with the NGER Scheme (Measurement) Determination 2008, Section 3.77 using Method 2.

These methods require adoption of the emission factors and methodology in American Petroleum Institute’s (API) Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Natural Gas Industry 2009, with reference to Sections 5 and 6.1.2.

4.3.4.6 Land use, land use change and forestry

Within this assessment, land use, land use change, and forestry emissions include emissions related to dredging of the seabed and removal of vegetation for the construction of the pipeline and facilities. Calculations have been developed based on ecology reports for the relevant areas, the carbon content of land and seabed cover, and guidance from the Transport Authorities Greenhouse Group (2013).

4.4 Impact assessment assumptions and limitations

Activities excluded from the scope of calculations, and key assumptions and limitations relating to this impact assessment are provided below. Further detailed assumptions and inputs used in the impact assessment are outlined in Appendix B.

4.4.1 Activities excluded

This section includes a list of items that were not included within the scope of the assessment, as per the guidance set out in Table 4-4. A rationale for exclusion of select emissions sources is provided in Table 4-7.

Table 4-7: Rationale for exclusion of select emissions sources

Emissions category	Emissions description	Rationale for exclusion
Construction		
Stationary energy	Fuel consumed by offsite construction plant and equipment	Immaterial due to expected Scope 3 emissions contribution of less than 1%.
Stationary energy	Electricity used in onsite and offsite project offices	Immaterial due to expected Scope 2 and 3 emissions contribution of less than 1%.
Transport fuel	Change in road traffic use by the public due to traffic impacts around construction zones	Immaterial due to expected Scope 3 emissions contribution of less than 1%.
Operation		
Stationary energy	Electricity used in project offices	Immaterial due to expected Scope 2 and 3 emissions contribution of less than 1%.
Transport	Fuel emissions associated with maintenance activities	Immaterial due to expected Scope 1 and Scope 3 emissions contribution of less than 1%
Fugitive emissions	Fugitive emissions from vent stacks during maintenance and the FSRU operation	The FSRU captures boil-off gas, rather than venting it during operations. Cold venting may occur during non-routine maintenance or disruption to normal operating parameters.

4.4.2 Key assumptions and limitations

4.4.2.1 Construction equipment

Equipment frequency of use (days/use) and duration of use (hrs/day) was provided by the proponent. Refinement of the predicted usage of equipment may result in a reduction in associated emissions due to the use of a 'maximum-usage' approach in calculation of emissions. The assessment was also limited by availability of equipment specifications to understand more accurate fuel and power demands.

4.4.2.2 Embodied emissions

Embodied emissions of materials (concrete and steel) for the construction of the Refinery Pier, aboveground and below ground pipeline, Refinery Pier equipment, temporary loadout facility at Lascelles Wharf and the Treatment Facility have been calculated using data provided by the proponent. The assessment was limited by availability of equipment specifications to understand equipment weight and therefore the proportion of fuel consumption during transport. Where assumptions are made, such as with estimating the weight of equipment, a worst-case approach is taken to ensure that GHG emissions are not underestimated.

4.4.2.3 Transportation of construction equipment and FSRU to Geelong Refinery

The origin of equipment and the FSRU, and mode of transport was provided by the proponent. For equipment originating overseas and being transported by ship, it has been assumed that each piece of equipment will travel separately. The assessment was limited by availability of equipment specifications to understand equipment weight and therefore the proportion of fuel consumption during transport. Where assumptions are made, such as with estimating the weight of equipment, a worst-case approach is taken to ensure that GHG emissions are not underestimated.

Transport of the FSRU assumes that the vessel will return to its origin at the end of its operating life. Transport of equipment assumes the mode of transport (i.e., truck) will return to origin after delivery of materials.

4.4.2.4 Staff and construction worker transport

Staff and construction workers during construction would travel to Geelong Refinery from Melbourne and Geelong. For this assessment, it is assumed that 50 per cent of workers would travel from Melbourne, and 50 per cent from within the Geelong local government area. A return distance of 133 km (Melbourne) and 76 km (outer Geelong) have been assumed.

The origin and amount of interstate construction employee travel has been provided by the proponent. It has been assumed that there will be 50 interstate flights for the entire campaign (25 from Perth and 25 from Brisbane). It is assumed that there will be no international travel related to the construction of this project.

4.4.2.5 Construction and operation waste

Construction waste volume data has been provided by the proponent. Three waste types have been provided, construction materials, waste from equipment and material deliveries, and general site office waste.

Operational wastewater volume was provided by the proponent. A Greenhouse Gas Protocol emissions factor per volume of commercial wastewater was used to estimate wastewater emissions. Further study could improve accuracy of this emissions calculation based on the specific wastewater produced and the method of treatment. It is deemed that due to the immateriality of the expected emissions from wastewater, this is not necessary for this emissions impact assessment.

4.4.2.6 Operation of FSRU

The assessment of stationary energy emissions for the operation of the FSRU was limited by the FSRU equipment specifications and operational data provided by Höegh and Viva Energy. Fuel demand during open loop at a send out rate of 620 terajoules (TJ)/day has been calculated using linear interpolation. Fuel demand during closed loop operation has used linear interpolation of publicly available data from a similar project.

4.4.2.7 Maintenance activities

Equipment and material required for maintenance activities of the FSRU, Refinery Pier, treatment facility, and pipeline have not been included due to the unavailability of information covering these activities. Emissions from these sources are considered to be immaterial compared to other emission sources in the assessment.

Equipment emissions associated with ongoing dredging requirements (seabed levelling required every 5 years for a duration of 7 days to maintain level) has been calculated and is incorporated in Appendix A. No emissions associated with the release of carbon from disturbed sediment due to ongoing dredging have been calculated.

4.5 Stakeholder and community engagement

Stakeholders and the community were consulted to support the preparation of the project's EES and to inform the development of the project and understanding of its potential impacts. EES Chapter 6: *Stakeholder and community engagement* provides a summary of the project's key engagement activities.

In accordance with the scoping requirements, a Technical Reference Group (TRG) was convened and chaired by Department of Environment, Land, Water and Planning on behalf of the Minister for Planning. The TRG has provided input throughout the EES process.

4.6 Linkages to other technical studies

The greenhouse gas impact assessment should be read in conjunction with other relevant technical reports prepared in support of the project EES.

Impacts associated with non-greenhouse gas waste, including waste spoil are addressed in Technical Report G: *Contamination and acid sulfate soils impact assessment*. Other air quality impacts relating to non-greenhouse gas emissions during construction and operation of the project have been considered and addressed in Technical Report H: *Air quality impact assessment*. Consideration of the implications of climate change on the design, construction, and operation of the project are addressed in Attachment II: *Risk to the project from climate change*.

Data for vegetation type and extent is included in Technical Report D: *Terrestrial ecology impact assessment*.

5.0 Existing conditions

5.1 Victorian greenhouse gas emissions

In the *State and Territory Greenhouse Gas Inventories* 2019 report, Victoria's total Scope 1 and 2 greenhouse gas emissions were 91 million-tonnes of carbon dioxide equivalent (Mt CO_2-e). Table 5-1 provides a breakdown of emissions by source and sink category. The total consisted of emissions from energy industries, manufacturing, transport, other energy sectors, fugitive emissions from fuels, industrial processes and produce use, agriculture, land use, land use change and forestry, and waste. The operational Scope 1 and 2 emissions associated with the project would primarily contribute to the energy industries and transport categories presented in the table.

The project greenhouse gas emissions (from construction and annual operation) are compared to Victoria's annual emissions in Section 6.6 and 7.5.

Table 5-1: Victorian greenhouse gas emissions by source for 2019 (Commonwealth of Australia, 2021)

Emissions source and sink category	Annual greenhouse gas emissions (Mt CO_2-e)	Percentage (%)
Energy industries	46.88	51
Manufacturing	4.77	5
Transport	22.69	25
Other energy sectors	9.68	11
Fugitive emissions from fuels	2.97	3
Industrial processes and product use	3.34	4
Agriculture	15.57	17
Land use, land use change, and forestry	-17.40[1]	-19
Waste	2.83	3
Total	**91.33**	**100**

[1] Land use, land use change and forestry in this reporting year is a net-emissions sink, and therefore a negative value is representative of emissions absorbed rather than emitted.

6.0 Construction impacts

This section presents the greenhouse gas emissions associated with the construction of the project. The total construction Scope 1, 2 and Scope 3 emissions within the project's operational boundary for the project is estimated to be 62,168 t CO_2-e. Scope 1 and 2 emissions during the construction period is estimated to be 6,878 t CO_2-e. A summary of the total greenhouse gas emissions for the construction of the project are presented in Table 6-1.

Detail on the total emissions for each emission source are outlined in Sections 6.1 to 6.5. All summaries of the emissions totals have been rounded to the nearest 1 t CO_2-e.

Emission factors and detailed inputs and assumptions are provided in Appendix B and C.

Table 6-1: Summary of greenhouse gas emissions associated with the construction of the project

Emissions category	Total emissions (t CO_2-e)		
	Scope 1	Scope 2	Scope 3
Stationary energy	537	391	71
Transport fuel	3,466	-	19,879
Embodied emissions	-	-	35,264
Waste	-	-	76
Land use, Land use change and Forestry	2,484	-	-
Total	6,487	391	55,290

6.1 Stationary energy

Table 6-2: Stationary energy emissions during construction

Emissions source	Project activity	Total emissions (t CO_2-e)		
		Scope 1	Scope 2	Scope 3
Diesel fuel	Fuel consumed by plant/equipment during Refinery Pier infrastructure construction works	349	-	18
Electricity	Electricity consumed by plant/equipment during Refinery Pier infrastructure construction works	-	346	38
Diesel fuel	Fuel consumed by construction plant/equipment during pipeline and treatment facility construction works	189	-	10
Electricity	Electricity consumed during pipeline and treatment facility construction works	-	45	5
Total		538	391	71

6.2 Transport fuel

Table 6-3: Transport fuel emissions during construction

Emissions source	Project activity	Total emissions (t CO_2-e)		
		Scope 1	Scope 2	Scope 3
Diesel fuel	Fuel consumed by vessels / equipment associated with dredging activities	749	-	38
Fuel oil and diesel	Fuel consumed for transport of Refinery Pier infrastructure construction equipment to/from Geelong	-	-	117
Fuel oil and diesel	Fuel consumed for transport of Refinery Pier and Treatment Facility materials to Geelong	-	-	779
Diesel fuel	Fuel consumed by vehicles/equipment during Refinery Pier infrastructure construction works	1,126	-	58
Diesel fuel	Fuel consumed for transport of pipeline and treatment facility construction equipment to/from Geelong	-	-	21
Diesel fuel	Fuel consumed for transport of pipeline and treatment facility materials to Geelong	-	-	441
Diesel fuel	Fuel consumed by vehicles/equipment during pipeline and treatment facility construction works	1,591	-	82
Bunker fuel	Fuel consumed for transport of FSRU to Geelong	-	-	15,901
Diesel fuel	Fuel consumed by employee travel to and from Geelong project site	-	-	2,428
Aviation Fuel	Fuel consumed by employee air travel to and from Geelong project site	-	-	14
Total		**3,466**	**-**	**19,879**

6.3 Embodied emissions

Table 6-4: Embodied emissions during construction

Emissions source	Project activity	Total emissions (t CO_2-e)		
		Scope 1	Scope 2	Scope 3
Embodied carbon	Embodied carbon in concrete and steel Refinery Pier infrastructure	-	-	28,696
Embodied carbon	Embodied carbon in concrete and steel pipeline infrastructure	-	-	5,299
Embodied carbon	Embodied carbon in concrete and steel of Treatment facility infrastructure	-	-	1,269
Total		**-**	**-**	**35,264**

6.4 Waste

Table 6-5: Emissions from construction waste materials

Emissions source	Project activity	Total emissions (t CO_2-e)		
		Scope 1	Scope 2	Scope 3
Diesel fuel	Fuel consumed for transport of waste from construction of Refinery Pier extension, pipeline, and treatment facility	-	-	< 1
Landfill	Waste from construction of Refinery Pier extension, pipeline, and treatment facility	-	-	76
Total				**76**

6.5 Land use, Land use change and Forestry

Table 6-6: Emissions associated with vegetation removal and dredging during construction

Emissions source	Project activity	Total emissions (t CO_2-e)		
		Scope 1	Scope 2	Scope 3
Carbon sink	Carbon sequestration lost due to cleared vegetation during construction	1,122	-	-
Seabed carbon	Emissions associated with sediment removal during dredging and trenching	1,362	-	-
Total		**2,484**	**-**	**-**

6.6 Summary of residual construction impacts

Residual impacts are defined as those impacts that remain following the implementation of mitigation measures. Without the impact of mitigation measures, the total Scope 1, 2 and Scope 3 construction emissions within the project's operational boundary for the project is estimated to be 62,168 t CO_2-e. Scope 1 and 2 emissions during the construction period is estimated to be 6,878 t CO_2-e which equates to 0.01 per cent of Victoria's annual Scope 1 and 2 greenhouse gas emissions.

To reduce the total emissions produced during construction, the project should implement the recommended mitigation measures as described in Section 8.0. The recommendations enable the proponent to develop clear, actionable, and measurable outcomes to reduce the emissions associated with construction.

The majority of total Scope 1 and Scope 2 emissions for construction are those associated with transport fuel. Diesel fuel consumed by vehicles, vessels and plant and equipment during construction of the Refinery Pier extension, treatment facility and pipeline, as well as dredging activities are the key contributing activities to greenhouse gas emissions during the construction phase. While the use of plant and equipment is unavoidable, environmental management measures will be implemented including the consideration of fuel-efficient plant and equipment and transport distances where appropriate (MM-GG07 and MM-GG03).

Removal of vegetation in the pipeline construction corridor also contributes to Scope 1 emissions. It was assessed that the pipeline construction corridor contained approximately 0.09 hectares (ha) of native vegetation and approximately 10.11 ha of non-native vegetation. The majority of the cleared vegetation would be exotic grassland. Following installation of the pipeline, the construction corridor would be revegetated and rehabilitated to its pre-existing condition.

The majority of the Scope 3 emissions are associated with fuel consumed for the transport of the FSRU to Geelong and the embodied emissions in concrete and steel for Refinery Pier and pipeline infrastructure.

Other recommended measures to minimise emissions include utilising low embodied energy and locally sourced materials where practicable to minimise embodied and transport emissions (MM-GG01). To enable the best emissions outcome, the project should develop criteria that considers the proportion of supplementary cementitious material content in concrete, recycled steel, and recycled aggregates, the location materials are being sourced from, and maintenance requirements of materials (MM-GG01 and MM-GG02). To further reduce transport emissions, the project should engage a local workforce where possible (MM-GG06) and source local plant and equipment (MM-GG03).

Additionally, construction activities should be coordinated to reduce unnecessarily extending the construction period and to avoid inefficient use of equipment (MM-GG04). The selection of plant and equipment should also consider fuel / energy efficiency. Together, this would reduce plant and equipment stationery and transport emissions associated with construction.

To ensure sustainable procurement and resource management practices the proponent should refer to ISO 20400:2017 Sustainable procurement which provides guidance on integrating sustainability within procurement (MM-GG05).

The implementation of recommended mitigation measures would enable the reduction of construction-related greenhouse gas emissions. The extent of the emissions reduction and residual impacts would only be able to be measured following implementation of recommended mitigation measures during the construction phase of the project. Following implementation of the above mitigation measures, consideration should be given to developing a strategy to offset emissions (e.g., offsetting Scope 1 and 2 emissions) (MM-GG11). This would ensure that the residual impacts of emissions produced during construction are quantified and offset.

7.0 Operation impacts

This section presents the greenhouse gas emissions associated with the operation of the project. Greenhouse gas emissions for the FSRU have been assessed based on the three operational scenarios, open loop, closed loop, and a combined system as defined in Section 1.4.2.1.

The proposed operating mode for the FSRU is open loop but closed loop has also been assessed on the basis that it represents the 'worst case' GHG scenario as it utilises gas fired boilers to generate steam for the regasification process.

The open and closed loop scenarios assumed the supply of natural gas at 250 TJ/day during summer (90 days per year), 350 terajoules per day (TJ/day) during spring and autumn (183 days per year), 500 TJ/day during the winter (86 days per year) and 620 TJ/day during peak demand days in winter (6 days per year), delivering a total of up to 45 cargos of liquefied natural gas (LNG) into the VTS. This equates to approximately 160 petajoules (PJ) of natural gas delivery per annum.

The combined loop regasification process would potentially be used when the ambient seawater temperature is too low for open loop regasification to operate effectively. This has been assumed to be 30 days a year. Should the combined loop be required it would lead to a further 17,374 t CO_2-e per annum in addition to the emissions associated with the open loop mode

The total annual Scope 1, 2 and Scope 3 operational emissions within the project's operational boundary for the project would be as follows:

- Open loop – 47,906 t CO_2-e
- Closed loop – 178,985 t CO_2-e
- Combined system – 65,280 t CO_2-e

A summary of the total annual greenhouse gas emissions for the operation of the project are presented in Table 7-1. Detail on the total emissions for each emission source are outlined in Sections 7.1 to 7.3. Emission factors and detailed inputs and assumptions are provided in Appendix B and C.

Table 7-1: Summary of annual operational greenhouse gas emission for the project

Emissions category	Total annual emissions (t CO_2-e)		
	Scope 1	Scope 2	Scope 3
Open loop			
Stationary energy	41,235	3,268	359
Transport fuel	-	-	1,600
Fugitive emissions	1,442	-	-
Waste	-	-	3
Total	**42,676**	**3,268**	**1,962**
Closed loop			
Stationary energy	172,313	3,268	359
Transport fuel	-	-	1,600
Fugitive emissions	1,442	-	-
Waste	-	-	3
Total	**173,755**	**3,268**	**1,962**
Combined loop			
Stationary energy	58,608	3,268	359
Transport fuel	-	-	1,600
Fugitive emissions	1,442	-	-

Emissions category	Total annual emissions (t CO_2-e)		
	Scope 1	Scope 2	Scope 3
Waste	-	-	3
Total	**60,050**	**3,268**	**1,962**

7.1 Stationary energy

The stationary energy use during the operation of the project is provided for the three different operational scenarios, detailed in Section 1.4.2.1.

The change in Scope 1 emissions between the operational scenarios is related to the gaseous fuel consumed by the FSRU during the different operational scenarios.

The emissions related to electricity use at the Refinery Pier and treatment facility are not dependent on the operational scenario and therefore are the same.

The closed loop operational mode would trigger requirements under the *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015* as direct (Scope 1) greenhouse gas emissions are expected to be greater than 100,000 t (CO_2-e a year). The proponent would be required to submit an application for a calculated-emissions baseline determination to the regulator.

Table 7-2: Stationary energy emissions during operation (open loop)

Emissions source	Project activity	Total annual emissions (t CO_2-e)		
		Scope 1	Scope 2	Scope 3
Fuel gas	Gaseous fuel consumed by the FSRU during open loop operation	41,235	-	-
Electricity	Electricity consumed at Refinery Pier	-	534	59
Electricity	Electricity consumed at the treatment facility	-	2,734	300
Total		**41,235**	**3,268**	**359**

Table 7-3: Stationary energy emissions during operation (closed loop)

Emissions source	Project activity	Total annual emissions (t CO_2-e)		
		Scope 1	Scope 2	Scope 3
Fuel gas	Gaseous fuel consumed by the FSRU during closed loop operation	172,313	-	-
Electricity	Electricity consumed at Refinery Pier	-	534	59
Electricity	Electricity consumed at the treatment facility	-	2,734	300
Total		**172,313**	**3,268**	**359**

Table 7-4: Stationary energy emissions during operation (combined loop)

Emissions source	Project activity	Total annual emissions (t CO_2-e)		
		Scope 1	Scope 2	Scope 3
Fuel gas	Gaseous fuel consumed by the FSRU during combined system operation	58,608	-	-
Electricity	Electricity consumed at Refinery Pier	-	534	59
Electricity	Electricity consumed at the treatment facility	-	2,734	300
Total		**58,608**	**3,268**	**359**

7.2 Transport fuel

Table 7-5: Transport fuel emissions during operation

Emissions source	Project activity	Total annual emissions (t CO_2-e)		
		Scope 1	Scope 2	Scope 3
Diesel fuel	Fuel consumed by operators and staff travel to and from site	-	-	559
Diesel fuel	Fuel consumed by supply delivery vehicles to the treatment facility	-	-	1,041
Total		-	-	1,600

7.3 Waste

Table 7-6: Waste emissions during operation

Emissions source	Project activity	Total annual emissions (t CO_2-e)		
		Scope 1	Scope 2	Scope 3
Waste	Operational wastewater	-	-	3
Total		-	-	3

7.4 Fugitive emissions

Table 7-7: Fugitive emissions during operation

Emissions source	Project activity	Total annual emissions (t CO_2-e)		
		Scope 1	Scope 2	Scope 3
Fugitive	Fugitive emissions from transfer of LNG from LNG carrier to FSRU	1,411	-	-
Fugitive	Fugitive emissions from the treatment facility	29		
Fugitive	Fugitive emissions from the transmission pipeline	2	-	-
Fugitive	Fugitive emissions from emergency venting	< 1	-	-
Total		1,442	-	-

7.5 Summary of residual operation impacts

Residual impacts are defined as those impacts that remain following the implementation of mitigation measures.

Table 7-8 presents a comparison of the project's annual operational Scope 1 and 2 emissions without the implementation of mitigation measures to Victoria's annual greenhouse gas emissions. The project's estimated Scope 1 and Scope 2 emissions during operation are estimated to contribute the equivalent of 0.05 per cent (open loop), 0.19 per cent (closed loop), and 0.07 per cent (combined system) of Victoria's annual greenhouse gas emissions per annum.

Table 7-8: Comparison of the project's operational greenhouse gas emissions to Victoria's annual emissions

Emissions source	Total annual greenhouse gas emissions (kt CO_2-e)	% of Victoria's annual total greenhouse gas emissions
Victoria 2019 (Scope 1 + 2)	**91,330.0**	**100**
Open loop (Scope 1 + 2)	47	0.05
Closed loop (Scope 1 + 2)	179	0.19
Combined system (Scope 1 + 2)	65	0.07

To reduce the total emissions produced during operation, the project should implement the recommended mitigation measures as described in Section 8.0. The most significant opportunity to minimise operation emissions from the project would be, as proposed, to adopt an open loop as the usual mode of operation of the FSRU, as this would emit four times less greenhouse gas emissions than closed loop.

The measures recommended include selection of plant and equipment (i.e., choice of FSRU) based on fuel efficiency and quality to reduce associated stationary and transport emissions. Additionally, engaging a local workforce where possible will reduce transport emissions associated with air travel (MM-GG06). Safety controls and emergency management practices should be put in place in the case of unplanned activities, incidents, and emergencies (i.e., unplanned maintenance or venting) to reduce the likelihood of releasing fugitive greenhouse gas emissions (MM-GG10).

The implementation of recommended mitigation measures would enable the reduction of operational greenhouse gas emissions. The extent of the emissions reduction and residual impacts would only be able to be measured following implementation of recommended mitigation measures during the operational phase of the project. Therefore, following implementation of the above measures to avoid or minimise emissions, consideration should be given to developing a strategy to offset emissions (e.g., offsetting Scope 1 and 2 emissions) (MM-GG11). This would ensure that the residual impacts of emissions produced during operation are quantified and offset.

8.0 Mitigation measures

8.1 Recommended mitigation measures

This report details recommended mitigation measures that, if adopted, would reduce the emissions impact of this project both in construction and operation. These recommendations enable the proponent to develop clear, actionable, and measurable mitigation measures to reduce the emissions impact of this project.

The recommended mitigation measures should be incorporated into the Environmental Management Framework (EMF) for the project. The EMF would be implemented as described in Chapter 14: *Environmental Management Framework* to effectively manage the environmental performance of the project.

Mitigation measures recommended to avoid, minimise, and mitigate potential adverse effects are listed in Table 8-1. It is anticipated that the project would adopt mitigation measures utilising the mitigation hierarchy and therefore offsets would be considered for project emissions after measures that aim to avoid or minimise emissions have been adopted. All efforts to reduce emissions should be considered given the ongoing impact of climate change on society.

Table 8-1: Proposed mitigation measures

MM ID	Mitigation measure	Project phase
MM-GG01	**Minimise embodied and transport emissions of materials** Low embodied energy and locally sourced materials should be considered and used where practicable to minimise embodied and transport emissions. The proponent could develop criteria for a minimum proportion of supplementary cementitious material content in concrete, recycled steel, and recycled aggregates. The criteria should consider where the location materials are being sourced from to minimise associated transport emissions.	Design and construction
MM-GG02	**Managing quality of materials** Materials that are low maintenance and durable should be selected to avoid unnecessary replacement. The quality of key materials (i.e., pipe and mooring infrastructure) should be inspected before supplying to site to avoid additional transport and handling of materials.	Construction
MM-GG03	**Source local plant and equipment** Locally sourced plant and equipment (i.e., within Victoria) should be considered and used where practicable to reduce emissions associated with transport. Sourcing local plant and equipment where practicable should be included in the selection criteria for tendering of works associated with plant and equipment.	Construction
MM-GG04	**Coordination of construction activities** Construction activities should be coordinated to reduce unnecessarily extending the construction period and to avoid inefficient use of equipment.	Construction

MM ID	Mitigation measure	Project phase
MM-GG05	**Sustainable procurement and resource management practices** Sustainable procurement and resource management practices should be adopted to avoid the inefficient use of materials, fossil fuels, and electricity. The proponent should refer to ISO 20400:2017 Sustainable procurement which provides guidance on integrating sustainability within procurement.	Construction
MM-GG06	**Local workforce** Local workforce should be engaged where possible. Interstate and international travel should be minimised and where appropriate replaced by virtual engagement. The proponent could complete a transport plan to detail how fuel emissions from employee transport would be minimised.	Construction and operation
MM-GG07	**Plant and equipment fuel efficiency** Selection of plant and equipment should incorporate consideration of fuel efficiency to reduce the consumption of fossil fuels.	Construction and operation
MM-GG08	**Waste – avoid, reduce, reuse** Design should reduce the total quantum of materials required through design refinement and incorporate reuse materials during construction and operation of the project. The proponent could develop a waste management plan that considers waste reduction, segregation of waste, and disposal of waste to ensure that waste is correctly separated and diverted from landfill where appropriate.	Design, construction, and operation
MM-GG09	**Implementation of Energy Management Systems** An energy management system will be implemented in accordance with the International Organisation for Standardisation (ISO) 50001 *Energy Management Systems* (ISO 50001) for the operation of the FSRU. The ISO 50001 provides a framework for organisations to take a systematic approach to achieve continual improvement of energy performance and efficiency and reductions in greenhouse gas emissions. This framework is considered global best practice, and involves: • developing energy use baselines • developing energy management plans • identifying performance indicators • setting targets for improvement. Progress will be regularly monitored, reported, and reviewed. Implementation of this system will also involve external certification by ISO-accredited auditors (typically on a three year cycle) in which both compliance with the ISO standard and performance improvement will need to be demonstrated to maintain certification.	Operation

MM ID	Mitigation measure	Project phase
MM-GG10	**Emergency management procedures** Safety controls and emergency management practices should be put in place in the case of unplanned activities, incidents, and emergencies (i.e., unplanned maintenance or venting) to minimise the release of fugitive greenhouse gas emissions.	Operation
MM-GG11	**Certified carbon offsets** The project could consider purchasing certified carbon offset to compensate for emissions produced during construction and annual emissions produced during operation. A strategy to offset certain emissions could be implemented (e.g., offsetting all Scope 1 and 2 emissions). Note that offsets would only be considered for project emissions after measures that aim to avoid or minimise emissions have been adopted.	Construction and operation

8.2 Offsetting emissions

The National Carbon Offset Standard and Carbon Neutral Program was launched by the Australian Government in 2010 and rebranded under the Climate Active name in 2019. The standard(s) provide a credible framework for managing emissions and achieving carbon neutrality.

The Climate Active Standard(s) provide a list of eligible offset units that have been assessed using a decision framework based on offset integrity principles outlined in the standard(s). These principles are designed to ensure that eligible offset units represent genuine and credible emission reductions. Offset options described included:

- Australian Carbon Credit Units (ACCUs) issued by the Clean Energy Regulator
- Certified Emissions Reductions (CERs) issued as per rules of the Kyoto Protocol from Clean Development Mechanism projects
- Verified Emissions Reductions (VERs) issued by the Gold Standard
- Verified Carbon Units (VCUs) issued by the Verified Carbon Standard
- GreenPower®

9.0 Pipeline-only impacts

This section presents the greenhouse gas emissions for the construction and operation of the pipeline. This estimate has been done to inform decision making for a Pipeline Licence under the *Pipelines Act 2005 (Vic).*

It has been assumed that 50% of emissions from sources covering the construction and operation of the pipeline and facility are due to the construction and operation of the pipeline only. These emissions have then been added to pipeline-only emission sources as shown in Table 9-1.

Table 9-1 Summary of greenhouse gas emissions associated with the construction and operation of the pipeline

	Total emissions (t CO_2-e)		
	Scope 1	Scope 2	Scope 3
Construction	1451	23	5,616
Operation (annual)	2	-	-

10.0 Conclusion

A greenhouse gas emissions impact assessment has been undertaken to determine the potential impacts of the project and to identify recommended mitigation measures where appropriate to reduce the potential impacts of the project on the receiving environment.

10.1 Construction impacts

The estimated emissions from construction activities associated with the project are summarised in Table 10-1. The total construction Scope 1, 2 and Scope 3 emissions within the project's operational boundary for the project is estimated to be 62,168 t CO_2-e. Scope 1 and 2 emissions during the construction period is estimated to be 6,878 t CO_2-e.

Table 10-1 Summary of greenhouse gas emissions associated with the construction of the project

Emissions category	Total emissions (t CO_2-e)		
	Scope 1	Scope 2	Scope 3
Stationary energy	537	391	71
Transport fuel	3,466	-	19,879
Embodied emissions	-	-	35,264
Waste	-	-	76
Land use, Land use change and Forestry	2,484	-	-
Total	**6,487**	**391**	**55,290**

10.2 Operation impacts

This assessment calculated the emissions associated with three operational scenarios of the FSRU and emissions associated with other operational activities.

The total annual Scope 1, 2 and Scope 3 operational emissions within the project's operational boundary for the project would be as follows:

- Open loop – 47,906 t CO_2-e
- Closed loop – 178,985 t CO_2-e
- Combined system – 65,280 t CO_2-e

The closed loop operational mode is anticipated to be the highest greenhouse gas emitting operational scenario related to the project. The closed loop operational mode would trigger requirements under the *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015* as direct (Scope 1) greenhouse gas emissions are expected to be greater than 100,000 t (CO_2-e a year). The proponent would be required to submit an application for a calculated-emissions baseline determination to the regulator.

A summary of the total annual greenhouse gas emissions for the operation of the project are presented in Table 10-2.

Table 10-2 Summary of the operational greenhouse gas emissions

Emissions category	Total annual emissions (t CO_2-e)		
	Scope 1	Scope 2	Scope 3
Open loop			
Stationary energy	41,235	3,268	359
Transport fuel	-	-	1,600
Fugitive emissions	1,442	-	-
Waste	-	-	3
Total	**42,676**	**3,268**	**1,962**
Closed loop			
Stationary energy	172,313	3,268	359
Transport fuel	-	-	1,600
Fugitive emissions	1,442	-	-
Waste	-	-	3
Total	**173,755**	**3,268**	**1,962**
Combined Loop			
Stationary energy	58,608	3,268	359
Transport fuel	-	-	1,600
Fugitive emissions	1,442	-	-
Waste	-	-	3
Total	**60,050**	**3,268**	**1,962**

10.3 Impact on Victoria's annual emissions

The context of the existing conditions for the greenhouse gas impact assessment was the current Victorian emissions profile. In the 2018/2019 NGER reporting year, Victoria's total Scope 1 and 2 emissions were 91.33 Mt CO_2-e. Energy industries (i.e., direction combustion) accounted for 51 per cent of Victoria's total Scope 1 and 2 emissions or 46.88 Mt CO_2-e.

To enable comparison, the project's total Scope 1 and 2 emissions are compared with Victoria's annual Scope 1 and 2 emissions. The total Scope 1 and 2 emissions during the construction period equates to 0.01 per cent of Victoria's annual greenhouse gas emissions, which is negligible.

The project's estimated Scope 1 and Scope 2 emissions during operation are estimated to contribute the equivalent of 0.19 per cent (closed loop), 0.05 per cent (open loop) and 0.07 per cent (combined system) of Victoria's annual greenhouse gas emissions per annum. Table 10-3 presents a comparison of the project's annual operational emissions to Victoria's annual greenhouse gas emissions.

Table 10-3 Comparison of the project's operational greenhouse gas emissions to Victoria's annual emissions

Emissions source	Total greenhouse gas emissions (kt CO_2-e)	% of Victoria’s annual total
Victoria 2019 (Scope 1+2)	**91,330**	**100**
Open loop (Scope 1 + 2)	47	0.05
Closed loop (Scope 1 + 2)	179	0.19
Combined system (Scope 1 + 2)	65	0.07

To reduce the total emissions produced during construction and operation, the project should implement the recommended mitigation measures. It is anticipated that the project would adopt mitigation measures utilising the mitigation hierarchy in order to first avoid or minimise emissions produced during construction and operation. Such measures include utilising low embodied energy materials, sourcing materials, plant and equipment locally and of a high quality, engaging a local workforce, implementing sustainable procurement, avoiding or minimising waste and coordinating construction activities. The most significant opportunity to minimise emissions during operation would be as proposed to adopt open loop as the usual mode during FSRU regasification operation, as this would emit four times less greenhouse gas emissions than closed loop. The extent to which mitigation measures would reduce emissions, is not quantifiable at this time. However, following implementation of measures to avoid or minimise emissions, the project should consider developing and implementing an offset strategy. This would ensure that the residual impacts of emissions produced during construction and operation are offset.

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Appendix A

Scope 3 emissions outside of the operational boundary

Appendix A Scope 3 emissions outside of the operational boundary

This section presents an estimate of Scope 3 emissions which are outside the project's operational boundary. While outside the scope of the study, the emissions from the production and transportation of the LNG and the end-use consumption of the natural gas have been estimated for context.

The decisions around the sourcing of LNG cargoes will be made by the customers of the terminal and not by Viva Energy as the operator. The proponent has no ability to control or influence where, or how, the gas is produced or the distance over which the LNG is transported to reach the terminal. Terminal customers will however be commercially driven to source the most economic cargoes of LNG, with the cost of these being determined by a number of factors including the shipping distance from the terminal. In reality it is likely that there will be a mix of sourcing including from Australian locations, other regional locations such as Malaysia and Papa New Guinea, and further afield such as from the Middle East. For the purposes of this estimation, two sourcing scenarios have been selected. The first scenario assumes that all gas will be sourced from Qatar, and the second assumes that all gas will be sourced within Australia, with producers in Darwin, Gladstone, and Dampier each supplying a third.

It is estimated that the annual emissions associated with the production of 160 PJ range between 942,400 t CO_2-e for the Australian sourcing scenario, and 1,064,000 t CO_2-e for gas sourced from Qatar. The emissions associated with these activities would represent Scope 1 emissions for the company that undertakes the production activities, and it is assumed that the extraction and liquefaction of gas would be undertaken irrespective of the project.

Estimated emissions from transportation of gas to the terminal range from 165,500 t CO_2-e for the Australian sourcing scenario, to 553,400 t CO_2-e for gas sourced from Qatar. It is estimated that emissions associated with the end use of natural gas equivalent to the project's maximum annual supply are 8,884,800 t CO_2-e. The objective of the project is to meet an expected shortfall in natural gas availability in Victoria rather than create a higher demand. If the project does not proceed it is assumed that another gas provider would fill the forecast shortfall by the mid-2020s.If the project proceeds, the proponent would not have any ability to influence the end-use consumption of the gas.

Emissions from port-related activities outside the scope of the study have also been estimated. Emissions from the fuel consumed by tugboats assisting LNG carriers berthing at Refinery Pier are 77 t CO_2-e and emissions from fuel consumed during seabed levelling for maintenance of the depth of the Refinery Pier berth are 1 t CO_2-e. These activities are not controlled by the proponent but are directly linked to the operation of the project.

The inputs and assumptions for these calculations can be found in Appendix B.

Appendix B

Inputs and assumptions

Appendix B Inputs and assumptions

Inputs and assumptions were collected from a number of sources including equipment and technical specifications, websites, calculators, and Viva Energy directly. To determine inputs, Viva Energy used a conservative approach and estimated values based on the design of the project and construction methodologies selected. In addition, Viva Energy sought advice from equipment providers and construction contractors.

Table 11-1 Construction stationary energy inputs and assumptions

Item/input	Units	Value	Source
Fuel / electricity consumed by construction plant/equipment to build Refinery Pier extension			
Generator fuel demand	L/day	100	Item list provided by Viva Energy, fuel / electricity consumption assumed based on publicly available information
Compressor fuel consumption	L/day	250	
Pumps fuel consumption	L/day	139	
Welding machine power	kW	32	
Hydraulic torque wrench power	kW	1	
Angle grinder power	kW	2.5	
Fuel / electricity consumed by construction plant/equipment to build pipeline and treatment facility			
Genset equipment fuel demand	L/day	100	Item list provided by Viva Energy; fuel / electricity assumed based on publicly available information
Compressor fuel consumption	L/day	250	
Pumps power	kW	1	

Table 11-2 Construction Transport fuel inputs and assumptions

Item/input	Units	Value	Source
Fuel consumed for FSRU vessel transportation to Geelong			
Shipping distance from Egypt to Geelong	Nautical miles	19,076	Distance sourced from ports.com
Shipping speed	Knots	18	Hoegh specifications
Average fuel consumption of FSRU	t/day	103.2	Hoegh specifications
Fuel consumed by employee travel to and from project site			
Labour force breakdown: Local/Melbourne	#	50/50	Viva Energy
Total staff movements across construction program	#	73,467	Viva Energy
Local/Melbourne transport mode	-	Passenger Vehicle	Assumption
Fuel consumed by employee air travel to and from project site			
Brisbane to Melbourne (return)	Total journeys	25	Viva Energy
Perth to Melbourne (return)	Total journeys	25	Viva Energy
Fuel consumed by vehicles / equipment during dredging			
Equipment type	#	-	Viva Energy
Equipment fuel demand	L/day	-	Assumption

Item/input	Units	Value	Source
Operating period, variable	days/month & hours/day	-	Viva Energy
Total fuel consumption (Diesel)	kL	276	AECOM Calculation
Fuel consumed by vehicles / equipment during construction of Refinery Pier extension			
Equipment type	#	-	Viva Energy
Equipment fuel demand	L/day	-	Assumption
Construction period, variable	day/month	-	Viva Energy
Total fuel consumption (Diesel)	kL	415.55	AECOM Calculation
Fuel consumed by equipment during treatment facility and pipeline construction			
Equipment type	#	-	Viva Energy
Equipment fuel demand	L/day	-	Assumption
Construction period, variable	day/month	-	Viva Energy
Total fuel consumption (Diesel)	kL	587	AECOM Calculation
Fuel consumed by vehicles/ships bringing materials to site			
Steel source location	-	China	Viva Energy
Transportation method	-	Ship	Viva Energy
Transportation distance (return)	km	9,427	ports.com
Pipeline steel shipping weight	Tonnes	1,727	Viva Energy
Refinery Pier extension steel shipping weight	Tonnes	8,388	Viva Energy
Temporary loadout facility at Lascelles Wharf Steel	Tonnes	150	Viva Energy
Treatment Facility steel	Tonnes	194	Viva Energy
Concrete source location	-	Geelong LGA	Assumption
Pipeline concrete	m^3	347	Viva Energy
Refinery Pier precast concrete	m^3	1,221	Viva Energy
Refinery Pier cast in-situ concrete	m^3	2,007	Viva Energy
Temporary loadout facility at Lascelles Wharf concrete	m^3	66	Viva Energy
Treatment Facility concrete	m^3	1,392	Viva Energy
Transportation distance (return)	km	38	Assumption

Table 11-3 Construction embodied emissions inputs and assumptions

Component	Material	Volume (m^3)	Embodied emissions (t CO_2-e)	Source
Embodied carbon in Refinery Pier infrastructure				

Component	Material	Volume (m^3)	Embodied emissions (t CO_2-e)	Source
Precast concrete	Ready mix – 50 MPa	2006.9	1,166	Viva Energy
Cast in-situ	Strength grade – 50MPa	1221.4	710	Viva Energy
Steel pipe and tube – imported	-	8,388.16 (Tonnes, total mass)	26,171	Viva Energy
Embodied carbon in temporary loadout facility at Lascelles Wharf				
Precast concrete	Strength grade – 50MPa	66	26	Viva Energy
Steel	-	150 (Tonnes)	468	Viva Energy
Embodied carbon in pipeline				
Pipeline DN600	Steel	220.04	5,132	Viva Energy
Precast concrete	Strength grade – 50MPa	347	168	Viva Energy
Embodied carbon in treatment facility				
Precast concrete	Strength grade – 50MPa	1,392	673	Viva Energy
Steel	-	194	596	Viva Energy
Embodied carbon in seawater transfer pipeline				
Pipeline DN1200	HDPE	149 (Tonnes)	469	Viva Energy

Table 11-4 Construction land clearing inputs and assumptions

Vegetation type	Area to be cleared (ha)	Emissions factor[2] (t CO_2-e/ha)	Carbon sink lost (t CO_2-e)	Source
Carbon sink emissions				
Exotic vegetation	10.11	110	1112.1	Technical Report D: *Terrestrial ecology impact assessment*
Native vegetation (Plains Grassland)	0.09	110	10	
Total	**10.20**	**-**	**1,122**	

[2] Emissions factors sourced from the VicRoads Carbon Gauge GHG Model v01.8, 2014

Table 11-5 Construction waste inputs and assumptions

Waste type	Weight of material (tonnes)	Fuel consumption (L/year)	Emissions factor[3] (t CO_2-e/t) waste	Landfill emissions (t CO_2-e)	Source
Construction materials	10	3,112	0.2	2	Viva Energy
Equipment and material deliveries	20	3,112	1.3	26	
General site office waste	30	6,223	1.6	48	

Table 11-6 Construction dredging and trenching inputs and assumptions

Type	Hectare	Mg (megagrams of carbon)	Emissions in the study area (t CO_2)	Source
Sediment removal from dredging	3.74	80	1,101	Viva Energy
Sediment removal from trenching	0.88	80	261	Viva Energy

Table 11-7 Operation stationary fuel emissions inputs and assumptions

Item/input	Units	Value	Source
LNG carrier delivery globally to Geelong			
Total natural gas delivery	PJ	160	Viva
Total LNG carriers	per annum	45	Viva Energy
Carrier volume	m^3 of LNG	125,000	Viva Energy
Time to transfer one cargo	Hours	36	Viva Energy
LNG carriers received at FSRU at 250 mmscf/d send out rate	number of	8	AECOM calculator
LNG carriers received at FSRU at 350 mmscf/d send out rate	number of	21	AECOM calculator
LNG carriers received at FSRU at 500 mmscf/d send out rate	number of	14	AECOM calculator
LNG carriers received at FSRU at 620 mmscf/d send out rate	number of	2	AECOM calculator
FSRU demand whilst LNG carrier unloading; closed loop			
250 mmscf/d send out rate	tonne/hr	5.39	AECOM calculator
350 mmscf/d send out rate	tonne/hr	7.55	AECOM calculator
500 mmscf/d send out rate	tonne/hr	10.79	AECOM calculator
620 mmscf/d send out rate	tonne/hr	13.37	AECOM calculator
FSRU demand whilst LNG carrier not unloading; closed loop			
250 mmscf/d send out rate	tonne/hr	5.29	AECOM calculator

[3] Emissions factors sourced from the VicRoads Carbon Gauge GHG Model v01.8, 2014

Item/input	Units	Value	Source
350 mmscf/d send out rate	tonne/hr	7.41	AECOM calculator
500 mmscf/d send out rate	tonne/hr	10.59	AECOM calculator
620 mmscf/d send out rate	tonne/hr	13.13	AECOM calculator
FSRU demand whilst LNG carrier unloading; open loop			
250 mmscf/d send out rate	tonne/hr	1.23	AECOM calculator
350 mmscf/d send out rate	tonne/hr	1.73	AECOM calculator
500 mmscf/d send out rate	tonne/hr	2.46	AECOM calculator
620 mmscf/d send out rate	tonne/hr	3.06	AECOM calculator
FSRU demand whilst LNG carrier not unloading; open loop			
250 mmscf/d send out rate	tonne/hr	1.28	AECOM calculator
350 mmscf/d send out rate	tonne/hr	1.73	AECOM calculator
500 mmscf/d send out rate	tonne/hr	2.56	AECOM calculator
620 mmscf/d send out rate	tonne/hr	3.18	AECOM calculator
Additional fuel demand by FSRU when running in combined loop			
Fuel demand of two boilers	tonne/hr	9.52	Assumed using publicly available data from a similar project. This assumes a high demand case.

Table 11-8 Operational transport activities inputs and assumptions

Item/input	Units	Value	Source
Nitrogen delivery vehicles to and from Geelong			
Nitrogen delivery return trip Dandenong to Geelong Refinery (33%)	km	197	Viva Energy
Nitrogen delivery return trip Altona to Geelong Refinery (33%)	km	114	Viva Energy
Nitrogen delivery return trip Port Kembla to Geelong Refinery (34%)	km	1794	Viva Energy
Trucks per year	#	960	Viva Energy
Fuel efficiency of nitrogen delivery vehicle	L/100km	53.1	Budget direct latest fuel consumption in Australia[4]
Odorant delivery vehicles to and from Geelong			
Odorant delivery return trip	km	197	Viva Energy
Trucks per year	#	10	Viva Energy
Fuel efficiency of odorant delivery vehicle	L/100km	53.1	Budget direct latest fuel consumption in Australia[5]

[4] https://www.budgetdirect.com.au/car-insurance/research/average-fuel-consumption-australia.html, accessed 28/06/2021
[5] https://www.budgetdirect.com.au/car-insurance/research/average-fuel-consumption-australia.html, accessed 28/06/2021

Item/input	Units	Value	Source
Staff travel to Geelong			
Driven return distance (combined)	km	217,360	Viva Energy
Fuel consumption	kL	24.13	AECOM calculator
Dubai to Melbourne (return)	Total return journeys / year	338	Viva Energy
Perth to Melbourne (return)	Total return journeys / year	39	Viva Energy

Table 11-9 Operational fugitive emissions inputs and assumptions

Item/input	Units	Value	Source
Unloading of LNG to FSRU			
Number of flanged connections	#	12	2 liquid and 2 vapour hoses - Viva Energy
Hours of operation	per annum	1,548	Based on 45 carriers
Transfer of natural gas from FSRU to treatment facility			
Pipeline length	km	3.0	Viva Energy
Hours of operation	per annum	8,760	Viva Energy
Treatment facility			
Number of metering stations	#	1	Viva Energy
Hours of operation	per annum	8,760	Viva Energy
Pipeline			
Pipeline length	km	4.0	Viva Energy
Hours of operation	per annum	8,760	Viva Energy

Table 11-10 LNG carrier delivery globally to Geelong inputs and assumptions (presented separately to the impact assessment in Appendix A)

Item/input	Units	Value	Source
LNG carrier delivery globally to Geelong			
Total LNG carriers	per annum	45	Viva Energy
Carrier size	m^3 of LNG	125,000	Volume size assuming 45 LNG carriers
Average transport distance return ocean voyage from Ras Laffan Port, Qatar	Nautical miles	16,220	Ports.com
Average transport distance return ocean voyage from Port of Darwin	Nautical miles	6,412	Ports.com
Average transport distance return ocean voyage from Port of Gladstone	Nautical miles	2,836	Ports.com

Item/input	Units	Value	Source
Average transport distance return ocean voyage from Port of Dampier	Nautical miles	5,304	Ports.com
Average LNG carrier speed	Knots	17	Assumption
Average fuel consumption of LNG carrier	MMBtu/trip	Ras Laffan Port, Qatar 203,161 Port of Darwin: 80,313 Port of Gladstone: 35,522 Port of Dampier: 66,435	AECOM calculator
Fuel used in LNG carrier	-	LNG and MDO pilot fuel	Assumption

Table 11-11 Exploration, extraction, and liquefaction of gas upstream inputs and assumptions (presented separately to the impact assessment in Appendix A)

Item/input	Units	Value	Source
Qatar (High-emissions scenario)	Emission factor	0.35	https://www.qatargas.com/english/sustainability/Sustainability%20Reports/Sustainability%20Report%202019_English.pdf
Woodside (Low-emissions scenario)	Emission factor	0.31	https://files.woodside/docs/default-source/investor-documents/major-reports-(static-pdfs)/2020-sustainable-development-report/sustainable-development-report-2020.pdf

Table 11-12 End use consumption inputs and assumptions (presented separately to the impact assessment in Appendix A)

Item/input	Units	Value	Source
Total annual gas supply	PJ/year	160	Viva Energy
Emission factor	kg CO2e/GJ	Scope 1 – 51.53 Scope 4 – 4	National Greenhouse Accounts Factors 2021

Appendix C

Emission Factors

Appendix C Emission Factors

Viva Energy Refinery Pier Works
GHG Emissions Factors

Revision	R01
Completed By	A.S./T.M
Checked By	L.L
Checked date	19/10/2021

National Greenhouse Account Factors - August 2021
https://www.industry.gov.au/sites/default/files/August%202021/document/national-greenhouse-accounts-factors-2021.pdf

2.1 Stationary Energy emissions (non-transport)
2.1.2 Fuel combustion emissions - gaseous fuels

Fuel combusted	Energy content factor GJ/m3	Emission factor (kg CO_2e/GJ)					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
Natural gas distributed in a pipeline	0.0393	51.40	0.10	0.03	51.53	0.00	4.00
Liquefied natural gas	25.3 GJ/kL	51.40	0.10	0.03	51.53	0.00	0.00

2.1.3 Fuel combustion emissions - liquid fuels

Fuel combusted	Energy content factor GJ/kL	Emission factor (kg CO_2e/GJ)					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
Diesel oil	38.60	69.90	0.10	0.20	70.20	0.00	3.60
Petroleum based products other than me	34.40	69.80	0.02	0.10	69.92	0.00	3.60

2.2 Transport fuel emissions (post-2004)

Fuel combusted	Energy content factor GJ/kL	Emission factor (kg CO_2e/GJ)					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
Gasoline (other than for use as fuel in an	34.20	67.40	0.02	0.20	67.62	0.00	3.60
Diesel oil	38.60	69.90	0.01	0.50	70.41	0.00	3.60
Liquefied petroleum gas	26.20	60.20	0.50	0.30	61.00	0.00	3.60
Diesel oil - Euro iv or higher (Heavy vehic	38.60	69.90	0.07	0.40	70.37	0.00	3.60

2.3 Indirect emissions from electricity

State or Territory		Emission factor (kg CO2e/kWh)					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
Victoria					0.00	0.91	0.10

2.4.2.7 Natural gas transmission
Transmission mains are defined as high-pressure pipelines greater than 1050 kilopascals, as used in the Energy Supply Association of Australia natural gas statistics.

Operation or process source		Emission factor (tonnes CO_2-e/km pipeline length)					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
Natural gas transmission tCO2e/km pipe		0.02	11.60	0.00	11.62	0.00	0.00
Gas flared tCO2e/t flared		2.70	0.13	0.03	2.86	0.00	0.00

3.19 Industrial processes - emissions of hydroflurocarbons and sulphur hexaflouride gases

Equipment type	Default HFCs annual leakage rates of gas			
Commercial air conditioning—chillers	0.09			
Commercial refrigeration - supermarket systems	0.23			
Industrial refrigeration including food processing and cold storage	0.16			

Appendix 4 - Emissions from waste disposal to landfill and wastewater treatment

Operation or process source		Emission factor (t CO_2-e/t waste)					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
Municipal solid waste							1.6
Commercial and industrial waste							1.3
Construction and demolition waste							0.2

API Compendiminium

Table 6-6. Fugitive emissions factors for natural gas transmission and storage equipment (American Petroleum Institute (API), Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry, p6-17)

Equipment basis	Units	Emission factor					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
					CO_2-e		
Compressor stations	t/station-hr		0.00702000		0.17550000		
Storage Stations	t/station-hr		0.01720000		0.43000000		
Metering/regulation stations	t/station-hr		0.00013100		0.00327500		
Metering/regulation stations transmission	t/station-hr		0.00318000		0.07950000		
Gas transmission pipeline	**t/km-hr**	**0.00000029**	**0.00000120**		**0.00003029**		
CO2 from oxidation	t/km-hr	0.00000024			0.00000024		
CO2 from leaks	t/km-hr	0.00000005			0.00000005		

Table 13. Default Methane Emission Factors per Component Population For LNG Storage and Import/Export Terminals (American Petroleum Institute (API), 2015, Liquefied Natural Gas (LNG) Operations Consistent Methodology for Estimating Greenhouse Gas Emissions (api-lng-ghg-emissions-guidelines-05-2015.pdf, p61)					
Equipment basis	Units	scf	m3		tCO_2-e/hr/component
Valve	scf/hour/component	1.19	0.034		0.381

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Pump Seal	scf/hour/component	4	0.113		1.281
Connectors, flanges, threaded fittings	scf/hour/component	0.34	0.010		0.109
Other	scf/hour/compressor	1.77	0.050		0.567
Vapor Recovery Comprerssors	scf/hour/compressor	4.17	0.118		1.336

Source: (American Petroleum Institute (API), 2015, Liquefied Natural Gas (LNG) Operations Consistent Methodology for Estimating Greenhouse Gas Emissions (api-lng-ghg-emissions-guidelines-05-2015.pdf, p61)

Appendix B - Unit Conversion		
From	Multiply by	to obtain
Average Emissions		
Combustion of 1 tonne of LNG	2.5372	t CO_2

Table 15. GHG Emission Factors for Combustion of Fuels for LNG Transportation

Operation or process source	Units	Emission factor					
		CO_2	CH_4	N_2O			CO_2-e
Ocean Tanker							
Bunker fuel	tonnes/TJ	80.11	0.00434				80.2185
Diesel	tonnes/TJ	73.59	0.00434				73.6985
Natural Gas / Boil-off gas	tonnes/TJ	54.57	0.08684				56.741
Ocean Tanker							
Bunker fuel	tonnes/Mmbtu	0.0845	0.0000046				0.084615
Diesel	tonnes/Mmbtu	0.0776	0.0000046				0.077715
Natural Gas / Boil-off gas	tonnes/Mmbtu	0.0576	0.0000916				0.05989

Source: (American Petroleum Institute (API), 2015, Liquefied Natural Gas (LNG) Operations Consistent Methodology for Estimating Greenhouse Gas Emissions (api-lng-ghg-emissions-guidelines-05-2015.pdf, p61)

Embodied Carbon in Materials - ISCA Materials Calculator	
	tCO2/tonne of material
Steel pipe and tube - international	3.12

Source: IS_Materials_Calculator_Version 2.0

Heogh Speed / Fuel consumption of FSRU

Source: Hoegh Giant FORM C (002).pdf		
	Maximum fuel consumption (kg/hour)	
Speed (knots)	Laden	Ballast
13.5	2700	2600
16	3700	3500
18	4600	4300

Fuel properties

Source: DEFRA 2019		
Fuel Type		Unit conversion
Fuel Oil	40.66	GJ/tonne
LNG	452.49	kg/m^3
Natural Gas	0.799	kg/m^3

Air travel

Source: DEFRA 2019 International non-uk Economy (with Radiative forcing)		Source
0.138445	kg/km	

Fuel combustion emission factors (transport energy)

Source: NGAF - https://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-august-2019		
Fuel Type	Energy content factor	Unit
Fuel Oil	39.7	GJ/kL
	39.3	GJ/Tonne

Emission factor (kg CO_2e/GJ)					
CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
73.60	0.07	0.60	74.27	0.00	3.60

Viva Energy Gas Pipeline and Facility Works
GHG Emissions Factors

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National Greenhouse Account Factors - August 2021
https://www.industry.gov.au/sites/default/files/August%202021/document/national-greenhouse-accounts-factors-2021.pdf

2.1 Stationary Energy emissions (non-transport)

2.1.2 Fuel combustion emissions - gaseous fuels

Fuel combusted	Energy content factor GJ/m3	Emission factor (kg CO_2.e/GJ)					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
Natural gas distributed in a pipeline	0.0393	51.40	0.10	0.03	51.53	0.00	4.00
Liquefied natural gas	25.3 GJ/kL	51.40	0.10	0.03	51.53	0.00	0.00

2.1.3 Fuel combustion emissions - liquid fuels

Fuel combusted	Energy content factor GJ/kL	Emission factor (kg CO_2-e/GJ)					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
Diesel oil	38.60	69.90	0.10	0.20	70.20	0.00	3.60
Petroleum based products other than mentioned in the item	34.40	69.80	0.02	0.10	69.92	0.00	3.60

2.2 Transport fuel emissions (post-2004)

Fuel combusted	Energy content factor GJ/kL	Emission factor (kg CO_2.e/GJ)					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
Gasoline (other than for use as fuel in an aircraft)	34.20	67.40	0.02	0.20	67.62	0.00	3.60
Diesel oil	38.60	69.90	0.01	0.50	70.41	0.00	3.60
Liquefied petroleum gas	26.20	60.20	0.50	0.30	61.00	0.00	3.60
Diesel oil - Euro iv or higher (Heavy vehicles conforming to	38.60	69.90	0.07	0.40	70.37	0.00	3.60

2.3 Indirect emissions from electricity

State or Territory		Emission factor (kg CO_2.e/kWh)					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
Victoria					0.00	0.91	0.10

2.4.2.7 Natural gas transmission

Transmission mains are defined as high-pressure pipelines greater than 1050 kilopascals, as used in the Energy Supply Association of Australia natural gas statistics.

Operation or process source		Emission factor (tonnes CO_2-e/km pipeline length)					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
Natural gas transmission tCO2e/km pipe length		0.02	11.60	0.00	11.62	0.00	0.00
Gas flared tCO2e/t flared		2.70	0.13	0.03	2.86	0.00	0.00

3.19 Industrial processes - emissions of hydroflurocarbons and sulphur hexaflouride gases

Equipment type	Default HFCs annual leakage rates of gas			
Commercial air conditioning—chillers	0.09			
Commercial refrigeration - supermarket systems	0.23			
Industrial refrigeration including food processing and cold storage	0.16			

Appendix 4 - Emissions from waste disposal to landfill and wastewater treatment

Operation or process source		Emission factor (t CO_2-e/t waste)					
		CO_2	CH_4	N_2O	Scope 1	Scope 2	Scope 3
Municipal solid waste							1.6
Commercial and industrial waste							1.3
Construction and demolition waste							0.2

API Compendiminium

Table 6-6. Fugitive emissions factors for natural gas transmission and storage equipment (American Petroleum Institute (API), Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry, p 6-17)

Equipment basis	Units	Emission factor					
		CO_2	CH_4	N_2O	Scope 1 (CO_2-e)	Scope 2	Scope 3
Compressor stations	t/station-hr		0.0070200		0.1755000		
Storage Stations	t/station-hr		0.0172000		0.4300000		
Metering/regulation stations	t/station-hr		0.0001310		0.0032750		
Metering/regulation stations transmission interconnects	t/station-hr		0.0031800		0.0795000		
Gas transmission pipeline	**t/km-hr**	**0.0000003**	**0.0000012**		**0.0000303**		
CO2 from oxidation	t/km-hr	0.0000002			0.0000002		
CO2 from leaks	t/km-hr	0.0000000			0.0000000		

LNG Operations Consistent Methodology for Estimating Greenhouse Gas Emissions (Source: International Maritime Organization (IMO), 2009, Second IMA GHG Study 2009: Table 9.1 page 131)

Operation or process source	Units	Emission factor					
		CO_2	CH_4	N_2O	Scope 1 (CO_2-e)	Scope 2	Scope 3
Transport of LNG (Liquefied natural gas) by tanker	kg/tonne-km travelled	14.5	0.02	0.1	0.0448		