Australia Pacific LNG Project

Volume 5: Attachments

Attachment 30: Greenhouse Gas Assessment – Gas Fields and Pipeline

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Executive summary

Natural gas is an abundant and low-polluting fuel; it plays a critical role in maintaining global energy security while the world phases out pollution-intensive energy sources. Here, Australia Pacific LNG Pty Limited (APLNG) proposes to supply its world-class coal seam gas (CSG) resources as a secure energy source to the international market. This entails a project (the Project) to (1) extract and process the CSG; (2) transport the CSG to an LNG facility and (3) convert the CSG into liquefied natural gas (LNG) for export.

The approval for the Project is being sought through this EIS. This technical report forms part of the EIS, and seeks to address specific Terms of Reference required by regulatory stakeholders, in particular, the assessment of greenhouse gas (GHG) emissions from the scheduled development i.e., construction, operation and decommissioning of the gas fields and gas pipeline. The GHG emissions are segmented according to international standards: (1) scope 1 GHG emissions are produced directly from combustion and fugitive GHG emission sources within the Project boundary, (2) scope 2 GHG emissions that arise from the generation of purchased grid electricity, heat and steam, and (3) scope 3 GHG emissions arise from other sources beyond the Project boundary. The GHG assessment is performed based on the CSG supply of approximately 1740 terajoules per day (TJ/d) at maximum production to the proposed LNG facility across a 30 year period. CSG that will be sourced from other fields falls beyond the scope of the EIS (and hence this technical report), although its contribution to the overall GHG footprint is considered.

The gas fields and the gas pipeline are forecast to produce 3.3 million tonnes CO_2 equivalent (Mt CO_2-e) per annum of direct GHG emissions during peak production, the majority of which originates from (1) CSG combustion for stationary equipment including compressors and dehydrators (approximately 42 %), (2) CSG combustion for generators (approximately 35%) and (3) CSG flaring (approximately 13%). This translates to a GHG emission intensity for the gas field and gas pipeline of 5.2 tonnes CO_2-e/TJ of CSG output. The Project generates electricity to meet its operational needs, and therefore scope 2 GHG emissions will be negligible. The Project's scope 3 GHG emissions are produced principally during the construction phase, and are associated with the embedded energy of purchased fuel and raw materials for construction, and the fuel consumption from third party transportation. Scope 3 GHG emissions are projected to contribute minimally (approximately 3.5%) to the total GHG emissions over the Project lifetime.

This report also identifies GHG mitigation measures, which primarily relate to CSG combustion and CSG flaring. These measures are estimated to save in excess of 16 Mt CO_2-e over the Project lifetime. Specific measures to achieve this saving include implementation of automated well control and installation of a low pressure pipeline network between GPFs. In general, the mitigation measures optimise process efficiency and minimise process interruptions and CSG flaring, the combined effect of which leads to GHG emission reductions.

Australia Pacific LNG is also committed to further mitigate GHG emissions; possible action includes considering the use of more fuel efficient process equipment.

This report quantified the impact of the Project, and found that the scope 1 GHG emissions associated with the gas field and gas pipeline increase national GHG emissions by approximately 0.6% and Queensland GHG emissions by approximately 1.8%.

A lifecycle GHG analysis was also performed that compares the GHG emissions associated with the combustion of LNG against that for coal and other fuels. This analysis considers the case where LNG used for natural gas-fired electricity generation substitutes for coal-fired electricity generation using the 18 Mtpa of LNG exported during peak production. The analysis clearly demonstrates the GHG emissions that could be avoided by substituting GHG intensive fuels such as coal with natural gas derived from LNG. The avoided emissions from substituting coal-fired power generation technologies with natural gas-fired CCGT technology is equivalent to reducing Australia's 2007 GHG emissions by between 5.9% and 13.4%, which compensates the GHG emissions across the LNG production chain. On a global scale, GHG emissions could be reduced by between 0.12% and 0.28%

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1. Introduction

Climate change is occurring and is likely to gather pace due to past greenhouse gas (GHG) emissions and accelerated emissions growth. The effects of climate change are global and largely detrimental to society and the environment (IPCC 2007). These include increases in the frequency and intensity of extreme weather events, the examples of which include flooding, drought, sea level rise, and storm surge. These events have potentially large economic, political, human and ecological costs. Climate change is thus an issue that requires urgent and appropriate global action.

Energy production and use accounts for 65% of the world's GHG emissions (IEA 2009). Efforts to tackle climate change must necessarily involve changes in the energy sector. The increasing difficulty in securing stable energy supplies and its associated impact on global economy and geopolitical security adds impetus to effect changes in the energy sector.

The challenges presented by the potential impacts of climate change require that new energy-intensive developments quantify their GHG emissions and consider the impact of their GHG emissions on the environment. For new developments in Australia, GHG assessments are a part of an Environmental Impact Statement (EIS) that is submitted for public scrutiny. This technical report specifically addresses the GHG-related portion of an EIS for a proposed energy-related development.

Australia Pacific LNG Pty Limited's proposed coal seam gas (CSG) to liquefied natural gas (LNG) venture, herein abbreviated as the Project.

This report will present a brief description on the Project's motivation, scope and timeline, followed by a detailed presentation of the official terms of reference that this report needs to address in order to comply with the EIS's requirements. The scope of GHG assessment will subsequently be discussed, followed by a brief introduction to the legislative and policy framework governing GHG emissions domestically and internationally.

This report also discusses the methodology underpinning the GHG emission estimations, considers the potential impact of the Project on the existing environment, and the mitigation measures proposed to minimise the impact. To gain a wider perspective, a lifecycle GHG analysis will be performed that compares GHG emissions associated with the LNG delivery chain (including production) against that for coal and other fuels.

A cumulative impact assessment is presented that compares the Project's GHG emissions against other developments (new projects and expansions of existing projects) within close geographical proximity.

1.1 The Project

Natural gas is an abundant and low-polluting fuel; it plays a critical role in maintaining global energy security while the world phases out GHG-intensive energy sources. For example, the Intergovernmental Panel on Climate Change (IPCC) has highlighted the importance of switching from coal-based energy sources to natural gas-based energy sources as an important GHG mitigation measure (IPCC 2001). Here, Australia Pacific LNG proposes to supply LNG as a low carbon transition fuel into the global energy market. Natural-gas fired power generation is a less GHG intensive alternative to traditional coal-fired electricity generation in the intermediate term. Natural gas is expected to be an invaluable companion to renewable energy sources in the future.

The LNG is produced by (1) extracting and processing CSG from Australia Pacific LNG's gas fields, (2) transporting the CSG to Australia Pacific LNG's LNG facility via a gas pipeline, and (3) converting the CSG into LNG for transport to the international energy market at the Project's LNG facility. The CSG is contained in reserves located in the Surat and Bowen basins (specifically, the Walloons Gas Fields Development area), is relatively abundant, and originates from a stable country with relatively small domestic energy needs. The Project thus has the added benefit of supplying a secure source of energy to meet international energy needs.

The Walloons gas fields will cover an area of approximately 570,000 hectares in Queensland's Darling Downs region. Australia Pacific LNG's development plan will include the drilling of approximately 10,000 wells over the Project's 30 year lifespan. Gas and water gathering systems will be developed to connect gas wells to gas processing facilities (GPFs) and water treatment facilities (WTFs). Associated infrastructure will include roads and access tracks, storage ponds, camps, communication infrastructures and other logistics support areas. A 450 km underground gas pipeline network will connect the gas fields with the LNG facility on Curtis Island and includes associated lateral pipelines.

Under the full-development scenario, the LNG facility comprises four LNG trains with the capacity to produce and ship approximately 18 million tonnes per annum (Mtpa) of LNG. The associated wharf and marine off-loading facilities are to be located near Laird Point within the Curtis Island Industry Precinct of the Gladstone State Development Area. The LNG facility will utilise ConocoPhillips' proprietary Optimized Cascade® technology for the CSG to LNG process.

1.2 Project timeline

Preliminary construction works are anticipated to begin in 2010 and construction will continue throughout the Project lifetime.

Projections suggest that the first GPF will come on-line in August 2011, with maximum CSG output achieved in 2023. Further, it is assumed that an estimated maximum of approximately 5,000 wells will be operational at a given point in time, while approximately 10,000 wells will be developed over the lifetime of the Project to replenish depleted wells and to sustain CSG output. Gas field operations are assumed to continue up to 2045. Decommissioning is assumed to occur in a brief period after 2045.

1.3 Purpose

The purpose of this report is to address the requirements of section 3.6.3 of the Terms of Reference, which requires the EIS to:

- Provide an inventory of projected annual emissions for each relevant greenhouse gas, with total emissions expressed in 'CO_2 equivalent' terms
- Estimate emissions from upstream activities associated with the proposed Project, including fossil fuel based electricity consumed
- Briefly describe the method(s) by which estimates were made. The emissions may be estimated using the methodology contained in the National Greenhouse Accounts Factors, Department of Climate Change (January 2008)
- Identify the contribution of the range of GHG mitigation measures incorporated in the plant design. These measures could include the addition of waste heat recovery, additional vapour recovery from ship loading, the use of high efficiency gas turbines and/or compressors, and the use of low BTU fuel.

GHG abatement issues should be described and discussed and include:

- Measures (alternatives and preferred) to avoid and/or minimise greenhouse gas emissions directly resulting from activities of the Project, including such activities as transportation of products and consumables, and energy use by the Project
- An assessment of how the preferred measures minimise emissions and achieve energy efficiency
- A comparison between preferred measures for emission controls and energy consumption with best practice environmental management in the relevant sector of industry
- A description of any opportunities for further offsetting greenhouse gas emissions through indirect means

1.4 Scope of assessment

This technical report presents the combined GHG inventory for activities related to the Project gas fields and the gas pipeline, expressed in tonnes CO_2-equivalent (tonnes CO_2-e). The LNG facility GHG emissions inventory is presented in a separate attachment of this EIS (Volume 5, Attachment 33).

The scope of this report covers the following:

- Projection of scope 1 (direct) GHG emissions that arise from fuel combustion, fugitive emissions and land clearing
- Projection of scope 2 (indirect) GHG emissions that arise from the purchase of grid electricity, steam and heat
- Projection of scope 3 (indirect) GHG emissions that arise from sources beyond the report boundary, including embedded energy in purchased fuel and construction raw material
- Identification and quantification of all activities that consume energy and emit GHGs
- Assessment of GHG mitigation measures included at the design phase of the project
- Discussion of GHG mitigation opportunities for possible future implementation

Figure 1.1 gives an overview of how the various GHG emissions inventories that will be developed in this EIS sit within the overall Project GHG footprint. For the Project, the following GHG emissions inventories are reported:

- A combined gas fields and gas pipeline GHG inventory (the subject of this study)
- An LNG facility GHG inventory (refer Volume 4, Chapter 14 and Volume 5, Attachment 33)

The GHG emissions from all relevant sources (and scopes) is assessed for each inventory, and the impact of these GHG emissions is determined.

In order to compare LNG to other fuels, the overall GHG footprint associated with converting CSG to LNG is used. To determine this footprint, sources of GHG emissions that are beyond Australia Pacific LNG's control but nonetheless contribute to the overall footprint are considered. In Figure 1.1 these sources include GHG emissions from other gas fields that supply CSG to the Project and GHG emissions associated with combusting natural gas by the final consumer. LNG shipping is assessed briefly (refer Volume 4, Chapter 14) as a scope 3 GHG emission source for the LNG facility. These sources of GHGs are not assessed in detail in this EIS but they are included in relation to a lifecycle GHG emissions analysis for CSG to LNG, presented in section 6.

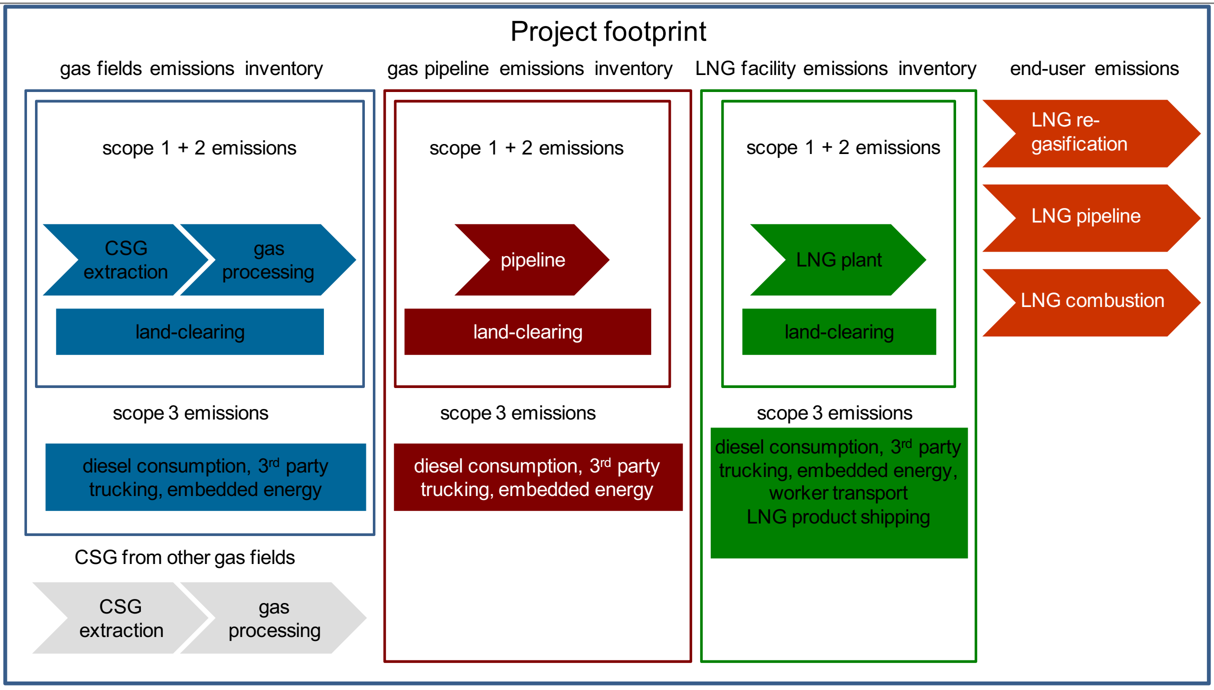

Figure 1.1 Overview of the Project GHG footprint

The activities within the reporting inventory for the gas fields and gas pipeline include construction, operation and decommissioning of the gas fields and the gas pipeline. The Project involves a complex sequence of overlapping phases, which includes:

- The construction and operation of the gas processing facilities (GPFs)
- The construction and operation of the water treatment facilities (WTFs)
- The construction and operation of the water transfer stations (WTSs)
- The development and operation of gas wells
- The construction and operation of the gas pipeline
- Decommissioning of the gas fields and the gas pipeline.

1.5 Legislative framework

GHG emissions are covered by a number of legislative and policy requirements at both the State and the Federal level, as well as international protocols to which Australia is signatory. These include:

- United Nations Framework Convention on Climate Change
- Kyoto Protocol, to which Australia is a signatory
- *Energy Efficiency Opportunities Act 2006*
- *National Greenhouse and Energy Reporting Act 2007*
- Queensland Greenhouse Strategy.

1.6 International policy

The Kyoto Protocol to the United Nations Framework Convention on Climate Change was signed in 1997 and ratified by Australia in December 2007. One of the aims of the Kyoto Protocol is to achieve the ‘stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.’

The Kyoto Protocol sets reduction targets on GHG emissions produced by Annex 1 countries, including Australia. Under the Kyoto Protocol, Australia has committed to reducing its GHG emissions to a level equivalent to 108% of 1990 levels by 2008–2012. For GHG emission reduction targets for the period beyond 2012, international negotiations remain in progress post the Copenhagen conference of parties.

1.6.1 Australian policy

The Australian Government’s proposed Carbon Pollution Reduction Scheme (CPRS) is an emissions trading scheme in which GHG emissions would be capped, permits would be allocated up to the cap, and emissions permits would be traded. Liable entities would be required to obtain carbon pollution permits to acquit their GHG emissions liabilities. The CPRS is the Australian Government’s central policy instrument for reducing the GHG emissions Australia produces. He Australian government intends that the CPRS commences on 1 July 2011 however this is dependent on the passage of a number of Bills (Australian Government 2009a) through the Senate.

The CPRS intends to encourage industry to reduce GHG emissions. The scheme will include a long-term GHG reduction target of 60% of 2000 levels by 2050 (Australian Government 2008a). If the CPRS Bills are passed, the legislation may be different to what is proposed in the current CPRS Bills.

The Australian Government has set the following medium-term 2020 GHG emission reduction target:

- An unconditional target of a 5% reduction below 2000 levels by 2020
- A conditional target of up to 15% reduction below 2000 levels by 2020 in the context of a global agreement under which all major developing economies commit to substantially restrain emissions and advanced economies take on reductions comparable to Australia; or
- A conditional target of 25% reduction below 2000 level by 2020 “if Australia is a party to a comprehensive agreement which is capable of stabilising atmospheric concentrations of GHG at around 450 parts per million of CO_2-e or lower” (Australian Government 2009a))

The proposed CPRS includes measures designed to reduce the immediate impact of the price of carbon on emission-intensive trade-exposed (EITE) industries. LNG production has been identified as an EITE industry; consequently, the aforementioned assistance is directly relevant to the Project. The initial assistance depends on the GHG emissions intensity per million dollars of revenue. The GHG emissions intensity of the LNG industry is between 1000-2000 t CO2-e/$m revenue [CO2 equivalent emissions per million dollars of revenue] (Petroleum Exploration Society of Australia 2009), suggesting assistance would cover 66% of GHG emissions.

1.6.2 Energy Efficiency Opportunities Act 2006

The Energy Efficiency Opportunities (EEO) legislation (Australian Government 2006) was introduced by the Department of Resources, Energy and Tourism (DRET). It requires significant energy users, consuming over 0.5PJpa of energy, to take part in a transparent process of energy efficiency assessment and reporting. The program’s requirements are set out in the EEO legislation, which came into effect on 1 July 2006. Participants in the program are required to assess their energy use and report publicly on cost effective opportunities to improve energy efficiency. In particular, corporations must report publicly on opportunities with a financial payback period of less than four years. Australia

Pacific LNG joint venture owners Origin Energy and ConocoPhillips have been reporting under the EEO scheme since 2006 and 2007 respectively.

1.6.3 National Greenhouse and Energy Reporting Act 2007

The *National Greenhouse and Energy Reporting Act* (Australian Government 2008b) establishes a national framework for Australian corporations to report GHG emissions, and energy consumed and produced from 1 July 2008. The Act and supporting systems have been designed to provide a robust, quantitative database for the proposed CPRS.

From 1 July 2008, corporations are required to report scope 1 and scope 2 GHG emissions if:

- They control facilities emitting more than 25 kilotonnes (kt) CO_2-e, or produce or consume more than 100 terajoules (TJ) of energy or
- Their corporate group emits more than 125 kt CO_2-e, or produces or consumes more than 500 TJ of energy.

Lower thresholds for corporate groups will be phased in by 2010-11. The final thresholds will be 50 kt CO_2-e or 200 TJ of energy produced or consumed for a corporate group. Companies must register by 31 August and report by 31 October following the financial year in which they meet a threshold. A report must be submitted every year once registered even in those years where the threshold is not triggered. Origin and ConocoPhillips have both recently made their first reports under the NGER Act, and so both partners in Australia Pacific LNG are familiar with NGER Act requirements.

1.6.4 Queensland policy and initiatives

The Queensland Government's ClimateSmart 2050 strategy (2007) outlines key long-term climate change targets. The Queensland Government has agreed to the national target of achieving a 60% reduction in national GHG emissions by 2050, compared with 2000 levels. This will involve cuts in GHG emissions of more than 30 Mt CO2-e over 10 years and save the Queensland economy about $80 million each year.

To help achieve this target, the Queensland government has developed the Queensland Gas Scheme, where Queensland electricity retailers and large users of electricity are required to source at least 13% of their electricity from gas-fired generators.

The Gas Scheme is aimed at reducing Queensland's emission intensity from 0.917 t CO_2-e/MWh (2000-2001 levels) to 0.794 t CO_2-e/MWh by 2011-2012. The 13% target under this scheme has been increased to 15% by 2010 with the provision to increase it to 18% by 2020.

In 2008, the Queensland Government commenced a review of Queensland's climate change strategies in response to national and international developments in climate change science and policy. In August 2009, the Queensland Government released *ClimateQ: toward a greener Queensland* (Queensland Government 2009).

This strategy consolidates and updates the policy approach outlined in ClimateSmart 2050 and Queensland's ClimateSmart Adaptation Plan 2007-12. The revised strategy presents investments and policies to ensure Queensland remains at the forefront of the national climate change response.

1.7 Australia Pacific LNG position on GHG emissions

Australia Pacific LNG recognises that climate change poses significant risks and opportunities to its business. Australia Pacific LNG will be pro-active in building a business that will be well-positioned in a low-carbon economy. Origin's and ConocoPhillips' established corporate strategies on climate change will underpin Australia Pacific LNG's response to the challenges of climate change.

Origin has long recognised the need to address the global issues of climate change, and has built a business that is well-positioned in a more carbon-constrained regulatory, social and investment environment. Origin has a strong portfolio of natural gas reserves in Australia and New Zealand and invests in renewable energy sources including wind, solar and geothermal. Origin has developed a series of retail offerings, such as GreenPower, to encourage customer participation in GHG reductions.

Origin has engaged strongly in the development of government policy in relation to mitigating GHG emissions and reducing the impacts of climate change. This includes contributions to the Garnaut Review (Garnaut 2008), the CPRS and other government processes, and participation in the media and public debate. Origin has also taken significant measures to understand and reduce its carbon footprint.

ConocoPhillips fully supports mandatory national frameworks to address GHG emissions and has joined the U.S. Climate Action Partnership, a business-environmental leadership group dedicated to the quick enactment of strong legislation to require significant reductions of GHG emissions.

ConocoPhillips has operations around the globe and seeks, at the international level, to encourage external policy measures which deliver the following principles;

- Slowing, stopping and ultimately reversing the rate of growth in global GHG emissions.
- Establishment of a value for carbon emissions, which is transparent and relatively stable and sufficient to drive the changed behaviours necessary to achieve targeted emissions reductions.
- Development and deployment of innovative technology to help avoid or mitigate GHG emissions at all stages of the product's life.
- Energy efficiency at all stages of the product's life.
- Consumer preference toward less GHG-intensive consumption.
- Deployment of carbon capture and storage as a practical near-term solution if technically and economically feasible.
- Development of processes that are less energy and material intensive.
- Building the price of carbon into base-case business evaluations.
- Energy and materials efficiency in Project development/value improvement processes.

The Project will use the commitment and technical strengths of both of its co-venturers to develop and implement a GHG Management Plan that includes GHG mitigation measures, monitoring and reporting, and assessment of business-specific actions.

2. Methodology

2.1 Greenhouse gas accounting and reporting principles

The forecast GHG inventory developed in this study was based on the principles outlined in the Greenhouse Gas Protocol (the Protocol) (World Business Council for Sustainable Development and the World Resource Institute 2004) and the methodologies provided by the National Greenhouse Accounts (NGA) Factors (Australian Government 2009c). The guiding principles for compiling a GHG inventory are:

- Relevance
- Completeness
- Consistency
- Transparency
- Accuracy

Specifically, the GHG Protocol advocates defining a reporting boundary for an inventory, and subsequently segmenting the GHG producing sources within that boundary according to their scope. For the combined gas fields and gas pipeline GHG inventory, the GHG emissions from the construction, operations and decommissioning phases of the Project are considered. The scopes of these GHG emissions are:

- Scope 1 GHG emissions are produced directly from combustion and fugitive sources that are within the Project's boundary (that is, gas fields and the gas pipeline activities).
- Scope 2 GHG emissions arise from purchased electricity, heat and steam. These emissions are generated outside of the Project boundary. Note that the Project will purchase negligible amounts of electricity, heat or steam therefore scope 2 GHG emissions are negligible.
- Scope 3 GHG emissions are related to the activities of the reporting entity but arising from sources beyond the reporting boundary – for example, extraction, processing and transport of purchased fuels. Note that the Project does not purchase electricity, heat or steam.

These sources are subsequently quantified, after which multiplication by appropriate emission factors is performed to generate GHG emission quantities.

The reporting boundary is presented in Section 1.4. The sources and the emission factors used in this report will be elaborated in the relevant sections within this report. The GHG emission sources that lie within the reporting boundary for the gas fields and the gas pipeline, and their respective scopes, are given in Table 2.1

Table 2.1 Classification of GHG emission sources within the reporting boundary

Scope 1 (direct emissions)	Scope 2 (indirect)	Scope 3 (indirect)
CSG combustion for power generation	none – electricity needs are met by CSG-fuelled power generation	extraction, production and transportation of purchased fuels
CSG combustion by other stationary equipment		extraction, production and transportation of construction raw materials
CSG flaring		third party transport of consumables to the Project site
CSG venting		
CSG leakages		
CSG fugitive emissions specific to pipelines		
diesel combustion for transportation		
diesel combustion for power generation		
diesel combustion by other stationary equipment		
land-clearing		

The activities are further segmented by development phase, including (1) construction and drilling; (2) operations; and (3) decommissioning .These are elaborated in the succeeding sections.

2.1.1 Construction and drilling

Diesel combustion for on-site transportation and earth moving

Scope 1 GHG emissions arise from the diesel consumed by on-site construction-related transport, earth moving and drilling-related transport:

- Construction-related transport is associated with equipment hauling
- Earth moving during construction of the gas wells, GPFs and WTFs and the gas pipeline.
- Drilling-related transport is associated with transporting equipment and personnel to remote drilling locations.
- Machinery associated with handling gas pipeline sections.

Scope 3 GHG emissions are also associated with diesel combustion. These GHG emissions arise from the extraction, production and processing, and transport of the purchased fuel. These GHG emissions are essentially the embedded energy associated with diesel production and transport. Other scope 3 emissions arise from the embedded energy in construction raw material and third party transport of consumables.

Diesel combustion from transport of consumables

Scope 3 GHG emissions are incurred from the transportation of consumables from off-site locations to the project site. These consumables include diesel, pipe sections and other materials that will be used during the construction phase of the Project. This transportation is provided by third parties which are not controlled by Australia Pacific LNG.

Diesel combustion for power generation

Scope 1 GHG emissions arise from the diesel consumed by power generators in the construction of the GPFs, WTFs, wells, gathering and high pressure pipelines and various temporary accommodation facilities. Scope 3 GHG emissions arise from the embedded energy associated with diesel production and transport.

Diesel combustion by other stationary equipment

Scope 1 and scope 3 GHG emissions arise from diesel consumed in operating drilling equipment.

CSG flaring

Scope 1 GHG emissions arise from gas flaring. Gas flaring is carried out during well development activities, including well drilling, drill seam testing, well completions and well production pilot operation prior to deployment of a gas processing facility.

Land clearing

Scope 1 GHG emissions arise from the vegetation cleared during the construction of the gas fields and gas pipeline. Briefly, the emissions are attributed to the release of GHG as biomass decomposes, and the decrease in the carbon sequestering potential of the ecosystem.

2.1.2 Operations

Diesel combustion for transportation

Scope 1 GHG emissions arise from combustion of diesel for transport. Operators will use on-site diesel-fuelled transport daily to perform physical well-site inspections. Scope 1 GHG emissions also arise from transport associated with gas processing facility operations.

Scope 3 GHG emissions arise from the extraction, production and transport of purchased diesel to the project site.

Diesel combustion from transport of consumables

Scope 3 GHG emissions are incurred from the transportation of consumables from off-site locations to the project site. These consumables include diesel, chemicals and other miscellaneous materials that will be required throughout the life of the Project. This transportation is provided by third parties which are not controlled by Australia Pacific LNG.

Diesel combustion for power generation

Scope 1 GHG emissions arise from the diesel consumed by power generators in temporary accommodation facilities, and by backup power generators in GPFs and WTFs.

CSG combustion for power generation

Scope 1 GHG emissions arise from the CSG consumed by power generators in well sites, GPFs, WTFs and WTSs.

CSG combustion by other stationary equipment

Scope 1 GHG emissions arise from the CSG consumed by other stationary equipment including compressors and dehydrators.

CSG flaring

Scope 1 GHG emissions arise from the CSG flared during operation and during maintenance downtime. Flaring is performed to counter minor process variations in order to maintain optimal process conditions.

Flaring minimises the global warming potential of released CSG during maintenance downtime as combustion converts methane, which has a global warming potential of approximately 21 tonnes CO_2-e/tonne CSG), to carbon dioxide, which has a global warming potential of 1.

CSG venting and leakages

Scope 1 GHG emissions arise from the CSG vented and leaked during operations. Vent sources include (but are not limited to) valves and emergency purges. GHG emissions due to gas leaks during operations are extremely low.

CSG fugitive emissions in pipeline

Scope 1 GHG emissions arise from fugitive emissions during transport in the pipelines. This includes the transport of CSG in the high pressure pipeline network and the 450 km gas pipeline that transports CSG from the gas fields to the LNG facility. This source explicitly covers vented release and leaked release of CSG during CSG transport. In practice, GHG emissions due to gas leaks from pipelines are extremely low

Decommissioning

Scope 1 GHG emissions arise from shutting down depleted gas wells, removing all gas field and gas pipeline infrastructure and site rehabilitation. These have not been estimated in detail due to uncertainties that arise from the complex sequence of gas well commissioning and decommissioning that will take place throughout the lifetime of the gas field activities. The GHG emissions for decommissioning are assumed to be the same as those for the construction phase.

2.2 GHG emissions estimation methodology

Scope 1 GHG emission factors (other than land clearing)

Scope 1 GHG emissions for the construction and the operations of the gas fields and the gas pipelines are estimated using the default GHG emission factors given in the National Greenhouse Accounts Factors (Australian Government 2009c).

GHG emission factors for estimating the quantities of GHGs are expressed in terms of the quantity of a GHG per unit of energy consumed (kg CO_2-e/GJ) or per unit of mass (for example, tonnes CO_2-e/t gas flared).

The general method for estimating GHG emissions is to multiply the activity data of an emission source (i.e., m^3 of CSG combusted for power generation) by the energy content of the CSG (GJ/m^3). The product is in units of energy (GJ) which is in turn multiplied by the GHG emissions factor (kg CO_2-e/GJ). Scope 1 GHG emission factors for combustion of all liquid and gaseous fuels, and for fugitive (i.e., flared, vented and leaked) sources, were obtained from the NGA Factors (Australian Government 2009c). The GHG emissions associated with CSG leakage from the high pressure pipeline are also estimated using NGA Factors, where the factor (t CO_2-e/pipeline km) is multiplied by the length of the pipeline to give the scope 1 GHG emissions. In practice gas leakages from pipelines are extremely small, and this estimation method is likely to provide an overestimate.

Table 2.2 summarises the GHG emissions factors used for estimating the scope 1 GHG emissions arising from all gas field and pipeline related activities.

Table 2.2 Default GHG emission factors from the NGA Factors

Emission source	Energy content	Emission factor (kg CO2-e/GJ)			
		CO2	CH4	N2O	Total
CSG combustion (m3)	37.7 x 10-3 GJ/m3	51.1	0.2	0.03	51.33
scope 1 diesel combustion - stationary	38.6 GJ/kL	69.2	0.1	0.2	69.5
scope 1 diesel combustion - transport	38.6 GJ/kL	69.2	0.2	0.5	69.9
scope 3 diesel combustion – transport and stationary	38.6 GJ/kL	-	-	-	5.3
	Emission factor (t CO2-e/t gas flared)				
CSG flaring (drilling)	-	2.8	0.7	0.03	3.53
CSG flaring (operation)	-	2.7	0.1	0.03	2.83
	Emission factor (t CO2-e/t throughput)				
CSG leakages (for CSG production)	-	-	0.0012	-	0.0012
	Emission factor (t CO2-e/pipeline km)				
CSG leakages (for CSG transmission)	-	0.2	8.7	-	8.72

CSG venting has no prescribed emission factor. To quantify GHG emissions from this source requires detailed knowledge of operating conditions and equipment, which is impractical at this stage. GHG emissions from CSG venting are thus estimated based on an operational understanding of existing CSG facilities.

GHG emissions factors for land-clearing

The following flow diagram maps out the steps used to estimate the GHG emissions due to land-clearing.

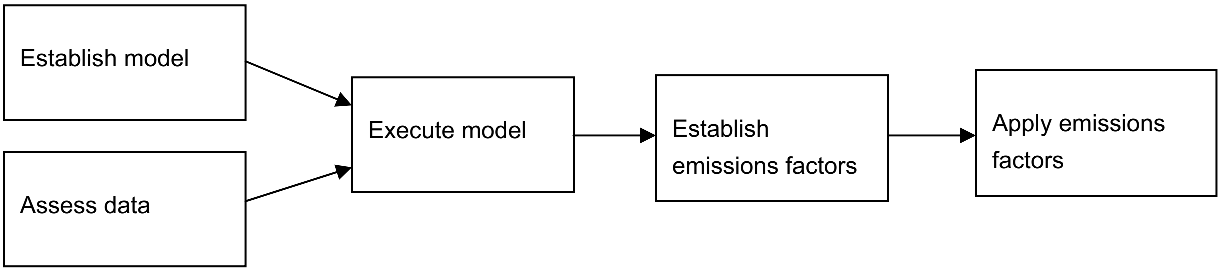

Figure 2.1 Flow diagram showing methodology used to assess GHG emissions due to land-clearing

The steps in the modelling were:

a) Establish the basic parameters of the FullCAM model (Australian Government 2008c). These included the timespan and the tree yield formula (this governs the production of new trees). A mixed multi-layer forest plot type was assumed because of the transition from forest to cleared land.

b) Examine the spatial data which included the maps of the regional ecosystems and the mapping of the possible sites for the infrastructure associated with the gas fields and the gas pipeline. This included land clearances associated with the infrastructure.

c) Spatial point data co-ordinates were used to download specific information on a site from the Department of Climate Change server. This data included: soil, forest biomass, forest productivity index, rainfall, temperature, evaporation data, forest topsoil moisture deficit, and tree-species groups for the specified location. The model was run for various locations representing different regional ecosystems and vegetation clearances associated with the gas field and gas pipeline infrastructure. Results were obtained in tonnes of carbon per hectare (t CO_2-e/ha).

d) The mass of carbon (tonnes carbon per hectare, t C/ha) for the vegetation in each site was calculated in the model runs. The results from each model run were averaged according to the regional ecosystem or infrastructure clearance. This established a GHG emissions factor for each type of vegetation. The emissions factor was then converted from a carbon basis (t C/hectare) into a carbon dioxide equivalent basis (t CO_2-e/hectare).

e) The derived GHG emission factors were multiplied by the total area to be cleared for each regional ecosystem and/or vegetation clearance associated with an infrastructure development.

For specific data on land clearances, refer to the Terrestrial Ecology report for the gas fields in Chapter 8, Volume 2, and for the gas pipeline refer to the report in Chapter 8, Volume 3 of this EIS.

GHG emission factors were estimated for each regional ecology type using the FullCAM model as described above. Variations in the GHG emission factors result from the wide range of vegetation types within the gas fields. The GHG emission factors obtained apply to the South Brigalow IBRA (Interim Biogeographic Regionalisation of Australia) region.

The GHG emissions associated with each regional ecosystem or vegetation type were summed to give the total GHG emissions associated with land clearing.

Scope 3 GHG emission factors

For scope 3 (indirect) GHG emissions associated with transport from sources beyond the boundary of the gas field and gas pipeline activities, the methodology was similar to that used for scope 1 GHG emissions. The total number of kilometres travelled by all vehicles was multiplied by the fuel efficiency of each vehicle (for example, tanker trucks and semi-trailers). This yielded the volume of fuel consumed by each form of transport. The quantity of fuel was multiplied by the energy content of the fuel and the GHG emission factor as per scope 1 GHG emissions.

For purchased fuels, there are scope 3 GHG emissions associated with the extraction, production and transport of the fuels. To account for these emissions, the energy content and scope 3 GHG emissions factor for diesel was sourced from the NGA Factors.

GHG emissions related to the energy embedded in the major material components required to construct the gas fields were also assessed in this study. Materials considered include steel used for well casings and piping, concrete and high density polyethylene (HDPE) piping as these make up the largest proportion of materials used. The data was based on the engineering estimates of the tonnes of steel, concrete and HDPE required for the gas fields and the gas pipeline. To determine the GHG emissions associated with the embedded energy in the materials, embedded carbon factors (kg CO_2-e/kg) from Hammond and Jones (2008) were used. These embedded energy factors do not include transport related emissions. These factors are shown in Table 2.3.

Table 2.3 GHG emission factors for embedded energy related GHG emissions

Material	kg CO_2-e/kg
Steel pipe	2.70
Steel plate	3.19
Concrete	0.13
HDPE	2.00

The embedded GHG emission for each material is estimated by multiplying the mass of each material by the embedded GHG emission factors.

3. Existing environment

This section details the Queensland, Australian and global GHG emission inventories in order to ascertain the potential impact of the Australia Pacific LNG's gas fields and gas pipeline GHG emission inventories.

Data from the UNFCCC estimates that aggregate GHG emissions from Annex I[1] (including Australia) countries in 2007 were 18,112 Mt CO_2-e excluding land use, land use change and forestry (LULUCF), and 16,547 Mt CO_2-e including LULUCF (UNFCCC 2009). LULUCF is a net sink for GHG emissions; hence its inclusion reduces the GHG inventories. For non-Annex I countries, aggregate GHG emissions in 1994 (the latest year in which these estimates were compiled) were 11,700 Mt CO_2-e excluding LULUCF and 11,900 Mt CO_2-e including LULUCF (UNFCCC 2005).

The total GHG emissions from Annex I and non-Annex I countries is estimated at 29,812 Mt CO_2-e excluding LULUCF and 28,447 Mt CO_2-e including LULUCF.

Australia's net GHG emissions across all sectors (Australian Government 2009d) in 2007 were reported as 597 Mt CO_2-e (approximately 2% of global GHG emissions). The energy sector was the largest source of Australian GHG emissions at 408 Mt CO_2-e (68.3% of net emissions). GHG emissions in Queensland for 2007 accounted for 182 Mt CO_2-e (Australian Government 2009c).

[1] Annex I Parties include the industrialised countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition including the Russian Federation, the Baltic States, and several Central and Eastern European States. Non-Annex I countries are mostly developing nations.

4. Potential impacts

This section describes the annualised GHG emissions estimates for the gas fields and gas pipeline across the Project life span, segmented by emissions scopes and Project phases.

4.1 Modelling results

Scope 1 GHG emissions

The Project's gas fields and gas pipeline scope 1 GHG emissions are shown in Figure 4.1, where:

- CSG combustion corresponds to the operation phase
- CSG flaring refers to flaring during well development, operation and maintenance
- Diesel combustion refers to combustion for transportation, for power generation and by other stationary equipment, the vast majority of which corresponds to the construction and drilling phases
- CSG venting and leakages encompasses the leaked and vented emissions for the gas fields and the gas pipeline.

The GHG emission sources identified and the GHG emission factors used to compile the GHG emission inventory collectively confirm that the specific GHGs underpinning the GHG emission inventory for the gas fields comprise only carbon dioxide, methane and nitrous oxide. It is expected that emissions of synthetic GHGs identified in the NGA factors, including sulphur hexafluoride and specific types of hydrofluorocarbons and perfluorocarbons, will be negligible.

Note that all GHGs reported in this chapter are aggregated GHG emissions in terms of CO2-e. Emissions of methane and nitrous oxide, as shown by the GHG emissions factors in Figure 4.1, are relatively small compared with the carbon dioxide emissions from the major emissions sources such as CSG and diesel combustion. The exception is for CSG leaks, where methane is the most significant GHG, but in terms of the overall GHG inventory, the emissions of methane are still relatively minor. For all emissions sources, nitrous oxide represents a very small contribution. For these reasons, methane and nitrous oxide emissions are not reported separately, but their emissions are aggregated into the total CO2-e emission estimates.

CSG combustion by stationary equipment, particularly compressors, is expected to be the main source of emissions. This is followed by CSG combustion for power generation during the operation of GPFs, WTFs, WTSs and well sites. CSG flaring is the third biggest source of emissions. The contribution of diesel combustion to the GHG emissions inventory diminishes over time. The majority of GHGs emitted by diesel combustion are attributed to the various construction activities, which decrease as the gas field matures. Land clearing takes place progressively in accordance with the development of the CSG wells over the Project lifetime.

Figure 4.1 shows the annual contribution of land clearing GHG emissions to the gas fields GHG inventory. The GHG emissions reach a peak value in 2023, approximately coinciding with the projected maximum field CSG output. From 2041 to 2045, production is assumed to remain static (at 2041 levels) and hence the GHG emissions will remain constant.

GHG emissions due to decommissioning occur after 2045, and are hence not shown in Figure 4.1. This GHG emission source is considered in the Project lifetime GHG emissions (see later in Table 4.2).

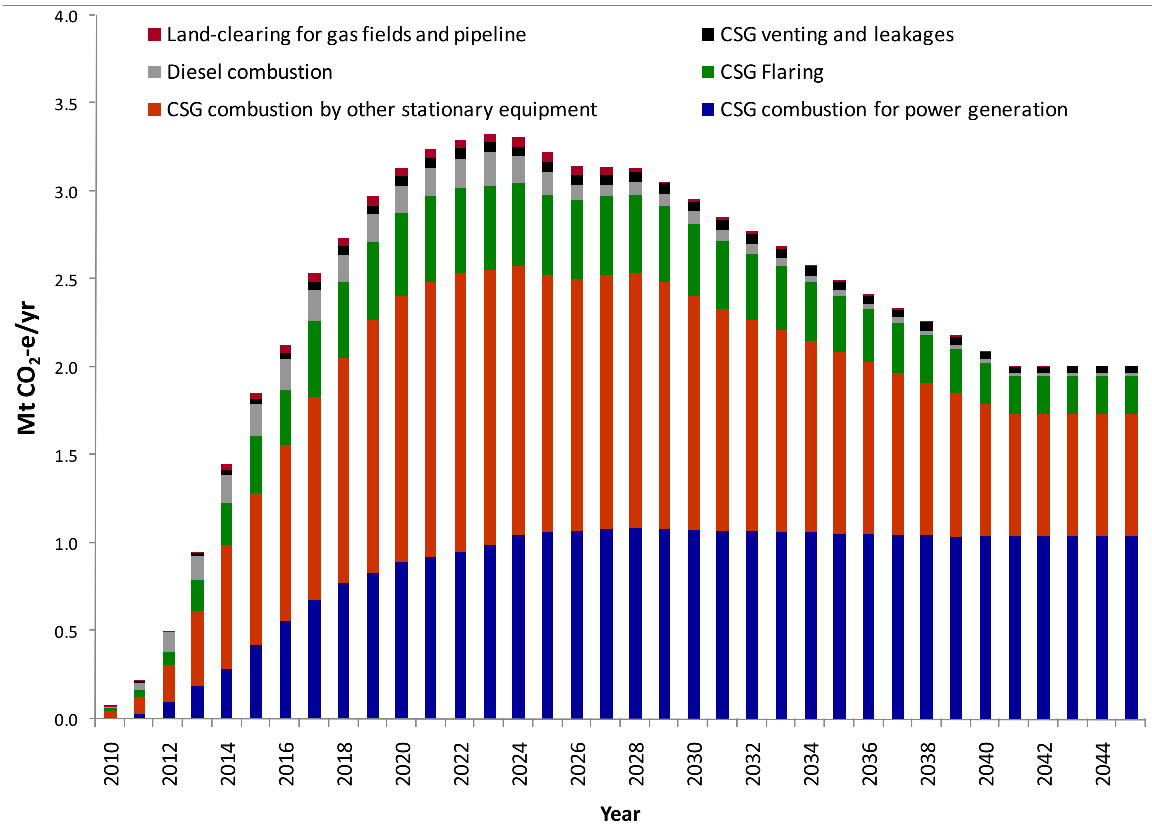

Figure 4.1 Projected annual scope 1 GHG emissions for the gas fields

The contribution of GHG emissions from the gas pipeline due to fugitive CSG emissions (leakages and vents) and gas pipeline construction related emissions are shown in Figure 4.2. The methodology from the NGA Factors estimates that gas pipeline related GHG emissions depend only on the length the pipeline, and hence the constant level of GHG emissions over time during the operations phase.

Note that while land-clearing activities for the gas pipeline (including the lateral pipelines) are assumed to take place in 2012 and last for 18 months, for GHG modelling purposes, all land-clearing activities for the gas pipeline are assumed to take place in 2012. Construction related activities for the gas pipeline will have been completed by 2012, resulting in zero GHG emissions in 2023.

Gas pipeline-related GHG emissions are minimal compared with the GHG emissions for combustion of CSG (see Table 4.1).

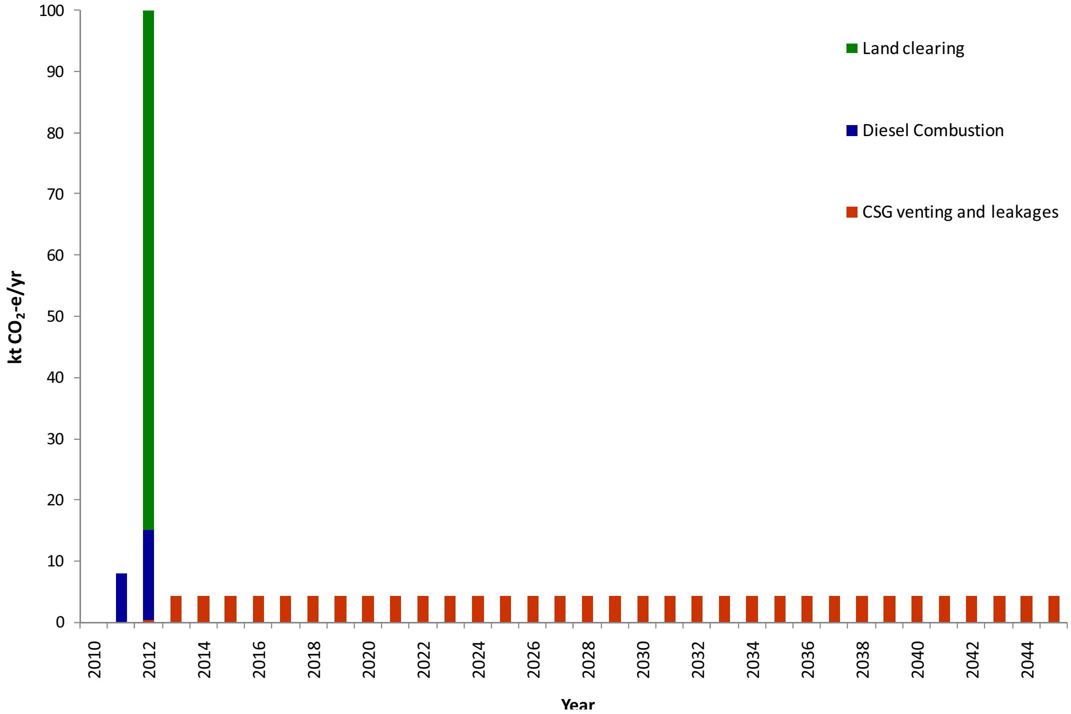

Figure 4.2 Projected Annual scope 1 GHG emissions from the gas pipeline

Table 4.1 shows the annual scope 1 GHG emissions from the Project gas fields and the gas pipeline during 2023, the projected year for peak CSG production. This includes construction of well sites and the various gas processing facilities. The transportation GHG emissions relate to the scope 1 GHG emissions generated by equipment hauling. GHG emissions also arise from earth moving and pipe handling machinery. Note that land-clearing activities will have been completed earlier in the gas fields and pipeline development, resulting in zero emission in 2023. GHG emissions due to flaring during well development are expected to be minimal as many GPFs will be operational in 2023.

The GHG intensity at peak production is based on approximately 1740 TJ/d of sales gas production per day or 633 PJ pa. The GHG intensity for the gas fields and the gas pipeline is 5.2 tonnes CO_2-e/TJ of CSG output.

Table 4.1 Scope 1 GHG emissions from the gas fields and the gas pipeline at 2023

Source	Sum of GHG emissions (tonnes CO_2-e/yr)
Construction and Drilling – gas fields	
Diesel combustion for transportation	40,000
Diesel combustion for power generation	43,000
Diesel combustion by other stationary equipment	72,000
Operations –gas fields	
Diesel combustion for transportation	11,000
Diesel combustion for power generation	11,000
CSG combustion for power generation	991,000

Source	Sum of GHG emissions (tonnes CO_2-e/yr)
CSG combustion for other stationary equipment	1,560,000
CSG flaring	483,000
CSG leakages	14,000
CSG fugitive emissions – high pressure pipeline	10,000
CSG Venting	30,000
Operations – gas pipeline	
CSG fugitive emissions – gas pipeline	5,000
Approximate total	3,270,000

4.2 Estimate of GHG emissions from land clearing

This section presents the results of estimations of the GHG emissions associated with clearing of vegetation along the pipeline easement and for the gas field infrastructure. The Terrestrial Ecology studies prepared for the gas fields and the gas pipeline have shown that all remnant vegetation to be cleared is represented by the regional ecology types. This assumption is used as the basis for the GHG assessment for land-clearing. For specific data on land clearances for the gas fields, see Chapter 8, Volume 2; for the gas pipeline, see Chapter 8, Volume 3 of this EIS.

For the gas fields, clearance of approximately 6000 hectares of remnant vegetation is projected for the various infrastructure items (well sites, GPFs and WTFs and service roads). Applying relevant the GHG emission factors to the land clearances gives total GHG emissions of approximately 720,000 tonnes CO_2-e over the project lifetime due to clearance of remnant vegetation.

Approximately 815 hectares of re-growth vegetation will also be cleared. Clearance of re-growth vegetation results in an estimated 90,000 tonnes CO_2-e of emissions over the project lifetime. For the gas pipeline, it was assumed that a 50 m ROW will be cleared along the total length of the easement (approximately 450 km), giving a total cleared area for the pipeline of approximately 2200 ha. However, a substantial amount (approximately 75%) of the vegetation has already been cleared, resulting in the clearance of 563 ha, equating to total GHG emissions of 90,000 tonnes CO_2-e over the project lifetime.

The major contribution to the emissions from land clearing is from the removal of eucalypt and acacia woodland. After the construction of the gas pipeline, much of the pipeline route will be allowed to revegetate. It is anticipated that soon after construction; approximately 75% of the gas pipeline easement width will be allowed to return to natural vegetation, with the remaining easement returned to natural vegetation when the pipeline is decommissioned.

Total GHG emissions associated with land clearing for the gas fields and the gas pipeline is approximately 900,000 tonnes CO_2-e over the project lifetime.

4.2.1 Estimate of scope 1 GHG emissions over the Project lifetime

Table 4.2 shows the scope 1 GHG emissions for the construction, operation and decommissioning phases for the gas fields and the gas pipeline (including land clearing) over the Project lifetime. Construction occurs throughout the lifetime of the Project through continuous drilling and well development. For decommissioning related GHG emissions, it is assumed that the amount of liquid fuel required for power and transport during the decommissioning phase will be the same as that required for the construction phase. This phase is assumed to be completed in a brief period after 2045.

As shown in Table 4.2, the gas production and processing operations are the dominant sources of GHG emissions for the gas fields and gas pipeline. GHG emissions from land-clearing represent approximately 1.0% of the GHG inventory over the lifetime of the Project. Construction and drilling represents approximately 3.4% of the inventory, and decommissioning approximately 1.6%.

A detailed breakdown of the relative contributions of each GHG emissions source is given in Section 4.3. The total Projected scope 1 GHG emissions for the combined gas fields and gas pipeline inventory is approximately 87 Mt CO_2-e.

Table 4.2 Scope 1 Projected GHG emissions for the gas fields and the gas pipeline over the Project lifetime

Phase of the Project	Gas fields GHG emissions (tonnes CO_2-e)	Gas pipeline GHG emissions (tonnes CO_2-e)	Sum of gas field and gas pipeline GHG emissions (tonnes CO_2-e)
Construction and drilling	1,600,000	30,000	1,630,000
Operations	82,600,000	150,000	82,750,000
Land clearing	810,000	90,000	900,000
Decommissioning	1,340,000	30,000	1,370,000
Approximate totals	86,300,000	300,000	86,700,000

4.3 Modelling results - scope 3 GHG emissions

GHG emissions from diesel consumption

Estimates have been made of the scope 3 GHG emissions arising from the consumption of diesel fuel for on-site power and transport for the gas fields and the gas pipeline. These GHG emissions are a result of the consumption of diesel but arise from the extraction, processing and transport of the fuel for use in gas field and gas pipeline related activities. The scope 3 GHG emissions factor from the NGA Factors (5.3 kg CO_2-e/GJ) is used. During the year of peak production, the scope 3 GHG emissions were 13 kt CO_2-e/yr or 0.4% of the scope 1 GHG inventory. Over the Project lifetime, these scope 3 GHG emissions are estimated to be 235 kt CO_2-e. This represents approximately 0.3% of scope 1 GHG emissions over the Project lifetime.

GHG emissions from third party trucking

Scope 3 GHG emissions have also been estimated for consumables import from off-site locations to the project site using third party truck transport over the Project lifetime for the gas field infrastructure. This includes the importation of fuels, concrete ingredients, imported water, gravel and pipeline sections. The estimated vehicle kilometres travelled for all trips over the Project lifetime is approximately 720 million km (refer Traffic and Transport Technical Reports, Chapter 17, Volume 2 and Chapter 17, Volume 3). Assuming all trucks run on diesel with a fuel efficiency of 0.35 L/km (Australian Road Transport Suppliers Association 2009) this leads to an estimated consumption of 252 million litres of diesel. Using relevant GHG emission factors, the consumption translates to total GHG emissions of 741 kt CO_2-e over the Project lifetime. These GHG emissions represent approximately 0.9% of the total scope 1 GHG emissions over the Project lifetime.

Estimate of embedded energy related GHG emissions

Table 4.3 presents the estimated tonnages of major consumables likely to be used in the gas fields and the gas pipeline over the Project lifetime. The embedded energy related GHG emissions were estimated by multiplying the tonnes of materials by the relevant GHG emissions.

Compared with the scope 1 GHG emissions, embedded energy related GHG emissions are approximately 2.7% of the scope 1 GHG emissions over the Project lifetime. A substantial amount of the embedded energy related GHG emissions are associated with the steel used in the construction of the gas and high pressure gas pipelines. Also significant are the GHG emissions associated with the high density polyethylene (HDPE) pipelines.

Table 4.3 Embedded energy related GHG emissions for major consumables over the Project lifetime

Materials required	tonnes materials	tonnes CO_2-e
Steel tubing for wells	24,000	65,000
Steel casing for wells	97,000	262,000
Concrete for wells	534,000	69,000
Concrete for construction camps	83,000	11,000
Concrete for operational camps	83,000	11,000
Gas gathering HDPE pipes (all wells)	150,000	300,000
Water gathering HDPE pipes (all wells)	150,000	300,000
Gas network steel pipe (HP network)	138,000	372,000
Water network steel pipe (HP network)	176,000	474,000
Main pipeline (steel pipe)	201,000	543,000
Condabri lateral (steel pipe)	17,000	46,000
Wolleebee lateral (steel pipe)	11,000	29,000
Approximate total		2,500,000

Summary of scope 1 and scope 3 GHG emissions

Table 4.4 shows the scope 1 and scope 3 GHG emissions for the activities associated with the gas fields and the gas pipeline over the Project lifetime.

Table 4.4 scope 1 and scope 3 GHG emissions for the gas fields and the gas pipeline over the Project lifetime

Emissions Source	Scope of emissions	Gas field GHG emissions t CO_2-e	Gas pipeline GHG emissions t CO_2-e	Sum of GHG emissions t CO_2-e
Construction and drilling	Scope 1	1,600,000	30,000	1,630,000
Operations	Scope 1	82,600,000	150,000	82,750,000
Land clearing	Scope 1	810,000	90,000	900,000
Decommissioning	Scope 1	1,340,000	30,000	1,370,000
Liquid fuel extraction and processing	Scope 3	233,000	2,000	235,000
Third party trucking transport	Scope 3	740,000	1,000	741,000
Embedded energy emissions of construction materials	Scope 3	1,870,000	620,000	2,500,000
Approximate totals		89,200,000	925,000	90,100,000

In terms of the total gas fields and gas pipeline inventory, the scope 3 GHG emissions are relatively minor at approximately 3.7% of the GHG inventory over the Project lifetime.

5. Mitigation measures

This section discusses the measures to minimise GHG emissions, assesses how the measures minimise GHG emissions, benchmarks the effect of the measures and describes future offset opportunities.

5.1 Immediate measures

Combustion and flaring of CSG are the primary sources of GHG emissions in the inventory. Mitigation opportunities have been identified that reduce the quantity of gas flared during normal operations. The quantity of gas flared per day during normal operations in the current design is approximately 1% of CSG production for each GPF. In the initial concept design, flaring during normal operations was estimated to be 3% of CSG sales gas per day, based on Australia Pacific LNG's current operations. In the current design, the quantity of gas flared per day during normal operations has been reduced to approximately 1% of CSG production for each GPF. This planned reduction in operational flaring was achieved through automated well control, the ability to re-route CSG when a GPF is off-line for maintenance and improvements in maintenance procedures. These measures will reduce both the frequency of flaring and the volume of gas flared. Over the Project lifetime, total GHG savings from this modified design are estimated to be in excess of 16 Mt CO_2-e..

The first measure incorporated in the current design to reduce flaring is the automated control over CSG production from individual wells. Installation of automated well control will allow operation of individual wells from a central control room. This will provide more precise control over the amount of production gas going to flare by adjustment of the well flow to better match sales gas requirements in real time. The improved control translates to a more rapid response to process upsets and hence less flaring. Additionally, given the large number of wells, road vehicle use by maintenance personnel will be substantially reduced, hence less petrol and diesel will be consumed.

The second measure that will mitigate flaring is the re-routing of CSG to other GPFs when a GPF is off-line due to maintenance. This can be done via a series of low pressure gas pipelines that interconnect groups of GPFs. Extra CSG can generally be accommodated as GPFs usually have spare capacity to accept extra CSG in the event of a GPF shut-down.

A strategy to minimise plant shutdowns and leak detection and repair program will be developed to further limit fugitive releases of CSG.

Biodiversity offsets can be generated by tree planting or by the protection of previously unprotected parts of the ecosystem, and various other means (these are the 'offset areas'). The draft Biodiversity strategy will seek to minimise GHG emissions associated with land-clearing by increasing the habitat value of the offset areas through tree planting, which increases the biomass and the carbon sequestration potential of the forest sink. Thus, biodiversity offsets can generate GHG offsets. At this stage, the full range of activities that can generate biodiversity offsets is still being developed, and the GHG offsets associated with the biodiversity offsets cannot be quantified at this time.

5.2 Comparison with international industry practice

The mitigation action to reduce operational flaring from 3% to 1% was compared with international industry practice and found to be consistent. This commitment to reduce flaring will be undertaken voluntarily by Australia Pacific LNG.

5.3 Potential Future Mitigation Measures

The following opportunities have been identified for potential future implementation subject to detailed engineering analysis:

- Utilisation of high grade waste heat from the compressor exhaust gases to provide heat for process requirements
- Reducing the glycol regeneration stripping rate (unburnt fuel gas) in winter - 5% to 10% reductions may be feasible, reducing energy requirements and yielding GHG savings
- Utilisation of solar energy and electric drives at well heads and gas plants
- Design of generation systems to avoid the potential for dumping of excess generation through load banks

6. Comparison of lifecycle GHG emissions for LNG, coal and other fuels

This section presents a lifecycle GHG analysis that compares the GHG emissions associated with the production and use of LNG with coal and other fuels. For LNG, the GHG emissions across the LNG lifecycle (that is, the GHG footprint) are considered, which is illustrated by Figure 1.1. The GHG footprint consists of the Project GHG inventories developed for this EIS which include the gas fields, the gas pipeline, and the LNG facility GHG inventories. Other sources of GHG emissions that are associated with the LNG lifecycle but are beyond Australia Pacific LNG's control include supply of CSG from other gas fields, LNG product transport, external processing such as LNG re-gasification, natural gas transport and product consumption. These are not part of the Project GHG inventories for this EIS but they are considered here as part of the GHG footprint.

In 2023, the Project's gas fields will produce a forecast maximum of 633 PJpa, with projected scope 1 GHG emissions totalling 3.3 Mt CO_2-e/yr. At maximum LNG output, the Project requires additional CSG from other fields, with a forecast contribution of 462 PJpa of CSG in 2023. These non-Project fields will produce additional scope 1 GHG emissions totalling approximately 2.4 Mt CO_2-e/yr. The scope 1 GHG contribution from the Project gas pipeline is relatively insignificant at approximately 5000 t CO_2-e/yr.

The LNG facility is estimated to produce approximately 5.5 Mt CO_2-e/yr at maximum production (refer to the LNG Facility GHG assessment, Chapter 14, Volume 4.

Table 6.1 details the GHG emissions from sources within the Project and those sources not controlled by Australia Pacific LNG but which make up the GHG footprint. These GHG emissions occur during full LNG production.

Table 6.1 Breakdown of the Project's GHG footprint in 2023

Emissions source	Emissions (Mt CO_2-e/yr)	GHG intensity Mt CO_2-e/GJ delivered
Project gas fields (scope 1)	3.300	0.003
Project gas pipeline (scope 1)	0.005	0
Project LNG plant (scope 1)	5.500	0.006
Total Project GHGs (scope 1)	8.800	0.009
Other gas fields (scope 1)	2.400	0.002
Total GHGs to produce 18 Mtpa LNG	11.200	0.011
LNG shipping	2.000	0.002
LNG re-gasification and natural gas pipeline emissions	3.600	0.004
End user combustion of 18 Mtpa LNG	51.600	0.051
Total GHG footprint emissions for 18 Mtpa	68.400	0.068

Table 6.2 presents a GHG emission intensity comparison between lifecycle GHG emissions for LNG, coal, and other fuels. The total GHG emissions related to the LNG extraction and processing activities

within Australia are 11.2 Mt CO_2-e/yr. Table 6.2 shows that (1) GHG emissions from the extraction, processing and product transport for LNG are higher than for coal, and (2) GHG emissions from the external processing and power generation activities for LNG are significantly lower than for coal. Overall, the coal delivery and power generation activities produce 43% more GHG emissions than LNG per GJ of energy delivered. Diesel and fuel oil produce approximately 10-15% more GHG emissions than LNG.

Table 6.2 Comparison of GHG emission intensities between LNG, coal and other fuels

Activity	Emissions intensity (t CO_2-e/GJ)			
	Coal	Diesel	Fuel oil	LNG
Extraction and processing activities in Australia	0.004	0.005*	0.005*	0.011
Product transport - international activities	0.003			0.002
External processing and combustion	0.090	0.070	0.073	0.055
Total	0.097	0.075	0.078	0.068

Data sources: Pace Global Energy Services (2009), WorleyParsons (2008) and the Australian Government (2009c).
*Note that extraction and transport emissions for diesel and fuel oil are summed together and presented as a single line item.

One of the main uses for fuels like LNG and coal is for power generation. The analysis carried out above neglects the efficiencies associated with specific power generating technologies. Table 6.3 shows the GHG emission intensities on an electricity production (MWh) basis for LNG combusted in a combined-cycle gas turbine (CCGT) plant compared with a variety of coal-fired power plants. This analysis includes the power generation efficiencies of each type of power plant.

Table 6.3 Comparison of LNG and coal GHG emission intensities for power generation

Activity	Emissions intensity (t CO_2-e/MWh)			
	Coal - sub-critical	Coal - super-critical	Coal - ultra super-critical	LNG - CCGT
Extraction and processing activities in Australia	0.04	0.03	0.03	0.08
Product transport - international activities	0.03	0.02	0.02	0.01
External processing and power generation activities	0.95	0.71	0.67	0.39
Total	1.02	0.76	0.72	0.48
GHG emissions compared to LNG-CCGT	112%	57%	50%	-

Data sources: Pace Global Energy Services (2009), WorleyParsons (2008) and the Australian Government (2009c)

On this basis, LNG combustion in a CCGT is a substantially lower GHG emission generation option than coal combustion in a sub-critical power plant which produces 112% more GHG emissions. The more advanced coal-fired generation such as super-critical and ultra super-critical power plants still produce 57% and 50% more GHG emissions, respectively, than LNG combusted in a CCGT. This clearly shows that LNG can be a key fuel in assisting international efforts in the transition to a low-carbon economy.

7. Project's potential impact on the existing environment

This section details the Queensland, Australian and global GHG emission inventories to ascertain the potential impact of the GHG emissions arising from the Australia Pacific LNG gas fields and gas pipeline. The scope 1 GHG emissions during peak LNG production from the gas fields and gas pipeline is 3.3 Mt CO_2-e. To gain a meaningful perspective on the Project's impact, this section also shows the GHG emissions across the entire Project, encompassing the gas fields, the gas pipeline, and the LNG facility (and excluding the GHG emissions from the other gas fields, which are not part of this Project). This is illustrated in Figure 1.1. These GHG emissions total approximately 8.8 Mt CO_2-e (see Table 6.1).Table 7.1 shows the maximum impact of Project GHG annual emissions in the context of Queensland, Australia and global annual GHG emissions (from section 3).

Table 7.1 The maximum impact of Project scope 1 GHG annual emissions in 2023

	Annual GHG emissions (Mt CO_2-e)	% contribution from gas fields	% contribution from the gas pipeline	% contribution from Project	% contribution on a lifecycle GHG basis
Queensland	182	1.81	0.003	4.84	N/A
Australia	597	0.55	0.001	1.48	N/A
Global	29,000	0.011	0.00001	0.03	-0.28

The above analysis assumed that 18 Mtpa LNG, or approximately 1000 PJpa of energy, was produced, exported and combusted. On this basis, the combustion of 1000 PJpa of natural gas in a CCGT releases approximately 71 Mt CO_2-e per year. Combusting 1000 PJpa of coal in a sub-critical coal fired power plant releases approximately 151 Mt CO_2-e per year and an ultra super-critical coal-fired power plant releases 106 Mt CO_2-e per year. Thus, the end-use of the Project's LNG output could avoid the release of between 35 and 80 Mt CO_2-e of GHG emissions per year. The avoided emissions from substituting these coal-fired power generation technologies with natural gas-fired CCGT technology is equivalent to reducing Australia's 2007 GHG emissions by between 5.9% and 13.4%, which compensates the GHG emissions across the LNG production chain. On a global scale, GHG emissions could be reduced by between 0.12% and 0.28%.

Over the lifetime of the Project, substituting LNG for coal could avoid between 960 and 2200 Mt CO_2-e of GHG emissions depending on the coal-fired generation technology used.

8. Cumulative impacts

For this cumulative impact assessment, the impact of all of the major projects in the region on state and national GHG emissions inventories was assessed in comparison to the year 2007. The impact on Australia's projected GHG emissions for 2030 was also considered. Table 8.1 shows the scope 1 (and where relevant, scope 2) GHG emissions of the Australia Pacific LNG Project and other major projects in the region, specifically those projects currently undergoing expansion and new projects (including CSG developments) not yet operating. For the Australia Pacific LNG Project, GHG emissions from activities associated with the gas fields and gas pipeline, the other gas fields and the LNG facility were considered.

For the other major projects, GHG data were sourced from EISs where they were publicly available.

Data for the Gladstone Steel Plant, the East End Mine Expansion, the Wiggins Island Coal Terminal and the Yarwun Alumina Refinery were either not available or not reliable for use in this analysis.

Data on the estimated GHG emissions for the proposed Shell LNG project were not publically available at this time. Scope 1 GHG emissions data for the Shell LNG project were therefore estimated based on the average GHG emissions intensity for the Australia Pacific LNG, GLNG, QCLNG and Gladstone LNG projects which is 0.3 Mt CO_2-e/Mtpa. The estimated LNG production capacity of the Shell LNG plant is 16 Mtpa LNG; therefore, the estimated GHG emissions are 4.8 Mt CO_2-e/yr. The gas field GHG emissions were estimated for the Shell LNG and Gladstone LNG (Fisherman's Landing) projects on the basis that the ratio of gas fields/LNG plant GHG emissions is about 1:1 on average.

Note that some GHG emissions estimates are for peak annual GHG emissions (for example, Australia Pacific LNG, Gladstone LNG and QCLNG), GLNG GHG emissions data is an annual average and the Shell LNG data are coarse estimates. Complexities due to differing CSG production ramp-up periods for each project were not considered in this analysis.

It should be emphasised that the data presented in Table 8.1for Shell LNG and Gladstone LNG projects are estimates. A comparison of the GHG intensity data for the proposed Australia Pacific LNG, Gladstone LNG, GLNG and QCLNG LNG facilities is presented in more detail in Volume 4 Chapter 14 and Volume 5 Attachment 33.

The total GHG emissions for these major projects in the Gladstone region are approximately 39 Mt CO_2-e/yr. These projects would represent 6.5% of Australian GHG emissions in 2007 (597 Mt CO_2-e). In terms of Queensland state GHG emissions in 2007 (182 Mt CO_2-e), these projects represent 21.4% of state GHG emissions.

A second scenario considers if all projects were operational in 2030. From the Garnaut Report (Garnaut 2008), Australia's GHG emissions under a business as usual scenario without a CPRS could reach approximately 800 Mt CO_2-e. If it is assumed that all facilities would continue their GHG emissions at their current or presently projected levels then total GHG emissions from the major projects in the Gladstone region represent 4.9% of Australia's net GHG emissions. Of this 4.9%, 3.2% is related to LNG projects. Based on the analysis conducted in section 6, the combined LNG projects could avoid global emissions of 190 Mt CO_2-e/yr based on 42 Mtpa of export LNG substituting for coal-fired electricity generation. This equates to a reduction of 24% of Australia's emissions in 2030.

Table 8.1 Summary of GHG emissions for major projects in the Gladstone region

Project	Emissions data Mt CO_2-e/yr	
Australia Pacific LNG	3.3	Estimated annual scope 1 GHG emissions for the Project gas fields and the gas pipeline during peak LNG production.
	2.4	Estimated annual scope 1 GHG emissions from other gas fields during peak LNG production.
	5.5	Estimated annual scope 1 GHG emissions for the Australia Pacific LNG facility with four-train operations producing 18 Mtpa of LNG
Boulder Steel	n/a	Gladstone Steel Plant project. EIS due to be lodged; GHG data not publically available (refer Boulder Steel 2009)
Boyne Smelters Reduction Line Expansion	3.1	Total scope 1 and 2 GHG emissions for the expansion of plant's 3 reduction lines (refer Boyne Smelters 2002)
East End Mine Expansion	n/a	GHG data is not publically available
GLNG Facility	3.7 3.5	Average annual scope 1 GHG emissions for the 10 Mtpa case using the upper limit GHG emissions; covers operations and land-clearing (refer GNLG 2009) Average annual scope 1 emissions (10 Mtpa) assuming CoP OCP technology is adopted
Gladstone LNG (Fisherman's Landing)	0.6 0.6	Estimated scope 1 GHG emissions for gas field and pipeline operations carried out by Arrow Energy/AGL (refer Gladstone LNG 2008). Estimated maximum annual scope 1 and 2 GHG emissions for 2 Trains (3 Mtpa)
Gladstone Pacific Nickel	0.2 0.6	Stage 1 emissions: scope 1 and 2 GHG emissions per annum (refer Gladstone Pacific Nickel 2009, Appendix M) Stage 2 emissions: scope 1 and 2 GHG emissions per annum

Project	Emissions data Mt CO_2-e/yr	
Moura Link Railway	0.5	Scope 1 and 2 GHG emissions per annum (refer Queensland Rail 2008, section 10)
QCLNG	2.5	Maximum annual scope 1 GHG emissions for gas field and pipeline emissions scaled by 1.5 for three train operations (refer QGC Limited 2009)
	3.0	Maximum annual scope 1 GHG emissions for 11 Mtpa operations (includes commissioning phase).
Shell LNG (with Arrow Energy)	4.8	Estimated scope 1 GHG emissions. Only initial advice statements available at this time (DIP 2009)
	4.8	Estimated scope 1 GHG emissions for a 16 Mtpa LNG facility with 4 LNG trains
GPC Western Basin Dredging	0.3	Data provided in EIS, assumed to be scope 1 emissions (refer Gladstone Ports Corporation 2009a, Appendix T)
GPC Fisherman's Landing Northern Expansion	0.03	Data provided in EIS, assumed to be scope 1 emissions (refer Gladstone Ports Corporation 2009b, Appendix F)
Wiggins Island Coal Terminal	n/a	EIS released; GHG emissions data not reported (refer CQPA and QR 2006)
Yarwun Alumina Refinery	0.002	Stage 2 of the expansion will increase output to 3.4Mtpa. Reported GHG emissions data may not be reliable and are therefore not used in this analysis

9. Conclusions

A GHG emission inventory was compiled using internationally accepted and Australian government prescribed methodologies. The projection requires the identification of GHG emission sources and the application of appropriate emission factors, both of which are discussed extensively in this report. This study has addressed the Terms of Reference's relevant requirements:

- GHG emissions reported in tonnes CO_2-e/yr were presented. Scope 1 GHG emissions are approximately 3.3 Mt CO_2-e/yr during peak production, and are approximately 87 Mt CO_2-e across the Project lifetime; the latter figure increases to approximately 90 Mt CO_2-e/yr when taking into account relevant scope 3 GHG emissions. On the basis of identified GHG emission sources, this report found that relevant GHGs emitted include carbon dioxide, methane and nitrous oxide. There are no emissions of sulphur hexafluoride, perfluorocarbons and hydrofluorocarbons.
- GHG emissions are segmented and presented by their corresponding activities. Fossil fuel based electricity consumed is self-generated; hence scope 2 GHG emissions associated with the gas field and the gas pipeline are negligible.
- The GHG emission projection is performed according to methods prescribed in the NGA Factors.
- GHG emission mitigation measures have been implemented to minimise CSG flaring. This yields a GHG emission saving in excess of 16 Mt CO_2-e over the Project lifetime.

In addition, the projection has showed that the major sources of GHG emissions are CSG combustion (77%) and CSG flaring (13%). Collectively, the gas fields and the gas pipeline have a GHG emission intensity of 5.2 tonnes CO_2-e/TJ of CSG output at peak production.

GHG emission mitigation measures were discussed including:

- Measures that minimise GHG emissions principally through reducing CSG flaring and venting
- Specific ways in which the measures minimise GHG emissions through (1) improving process and energy efficiency, (2) minimising the probability of sudden and serious process variation, (3) ensuring rapid and automated well turn-down in the event of upsets, (4) minimising GPF shutdowns, (5) the ability to re-route CSG via the gas gathering lines when a GPF is off-line for maintenance and (6) improvements in maintenance procedures
- Comparing the CSG flaring performance against international industry practice
- Potential future mitigation strategies, through various measures to utilise/minimise waste heat and to continuously improve process efficiency.

The GHG emission inventory of the Project was benchmarked against the national and the state inventory. The GHG emissions associated with the Project gas fields and the gas pipeline represent 0.6% of Australia's 2007 national GHG emissions inventory and 1.8% of Queensland 's 2007 GHG emissions. In terms of global GHG emissions the gas fields and gas pipeline represent approximately 0.011%.

The Project's addition to the Queensland, Australian and global GHG emissions inventories is offset by the Project's potential reduction of global GHG emissions. This report shows the results of a lifecycle GHG assessment of natural gas-fired electricity generation compared with coal-fired generation. The primary conclusion was that LNG combustion in a CCGT is substantially lower in

GHG emissions than coal combustion in a sub-critical power plant which produces 112% more GHG emissions. The more advanced coal-fired generation such as super-critical and ultra super-critical power plants still produce 57% and 50% more GHG emissions, respectively. This clearly shows that LNG can be a key fuel in assisting international efforts in the transition to a low-carbon economy.

This study shows that global GHG emissions could be reduced by 0.28% if the Project's peak LNG output of 18 Mtpa is used to generate electricity in place of sub-critical coal-fired power generation.

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Appendix A Abbreviations and Glossary of Terms

Abbreviations

CO_2	carbon dioxide
CH_4	methane
N_2O	Nitrous oxide
CSG	Coal seam gas
CCGT	Combined cycle gas turbine
EITE	Emissions-intensive trade-exposed
GPF	Gas processing facility
WTF	Water treatment facility
WTS	Water transfer station
LNG	Liquefied natural gas
Mtpa	Millions tonnes per annum
PJpa	Petajoules per year
TJ/d	Terajoules per day
CO_2-e	Carbon dioxide equivalents
CPRS	Carbon Pollution Reduction Scheme
EEO	Energy Efficiency Opportunity Act (2006)
NGERS	National Greenhouse and Energy System
GHG	Greenhouse gas
TEG	Triethylene glycol
NCAT	National Carbon Accounting Toolbox
Mt	Million tonnes
kt	Kilotonnes
t	Tonnes

Glossary of terms

Scope 1 emission	Scope 1 GHG emissions are produced directly from combustion, fugitive and vented sources that are within the Project's boundary (that is, the gas field and gas pipeline activities).
Scope 2 emission	Scope 2 GHG emissions arise from purchased electricity, heat and steam. These emissions are generated outside of the Project boundary.
Scope 3 emission	Scope 3 GHG emissions are related to the activities of the reporting entity but arising from sources beyond the reporting boundary – for example, extraction, processing and transport of purchased fuels.
Transition fuel	As the world moves toward cleaner energy sources such as renewable energy (e.g. solar, wind and wave power), fossil fuels will continue to be used to provide energy generation. Black coal is currently the most greenhouse gas intensive fuel, but LNG is much less intensive and is seen as part of the transition to cleaner, renewable energy sources.
LULUCF	Land use, land use change and forestry. Under the UNFCCC this is a greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities