The Australia Pacific LNG Project

Volume 2: Gas Fields

Chapter 14: Greenhouse Gases

Contents

Figures

Tables

14. Greenhouse gases

14.1 Introduction

Australia Pacific LNG proposes to introduce its considerable coal seam gas (CSG) resources into the international market in the form of liquefied natural gas (LNG). The proposal depends on the corporate, social and environmental feasibility of first extracting and processing CSG from the gas fields, then transporting the CSG from the gas fields to the LNG facility, and finally converting the CSG into LNG prior to export. These processes constitute the Australia Pacific LNG Project (the Project).

This chapter addresses the requirements outlined in the environmental impact statement (EIS) terms of reference for the Project. This chapter will:

- Quantify the greenhouse gas (GHG) emissions associated with the construction, operation and decommissioning of the Project's gas fields
- Describe the methods by which the GHG estimates were made
- Assess immediate and potential mitigation GHG mitigation measures.

This chapter outlines the scope of work and the GHG assessment boundary, followed by a brief overview of the GHG-related legislative frameworks. The methodology used to quantify the GHG emissions, the sources of GHG emissions and the GHG emission projections are then discussed. The potential impacts of the Project stemming from the gas fields' GHG emissions are then quantified and discussed.

This chapter identifies measures to minimise the project gas fields' GHG emissions by addressing the major sources of GHG emissions within the appropriate boundary, and the immediate and potential mitigation steps to alleviate the impact are discussed. The mitigation actions are guided by Australia Pacific LNG's sustainability objectives.

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. The analysis estimates the GHG emissions that could be avoided by substituting GHG intensive fuels, such as coal, with natural gas derived from LNG. Finally, Australia Pacific LNG's future commitments to minimise the GHG emissions from gas fields' activities are presented.

14.1.1 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. LNG provides a less GHG intensive alternative to coal and other fossil fuels in the intermediate term, and is expected to be an invaluable companion to renewable energy sources in the future.

The LNG is produced by first extracting and processing CSG from Australia Pacific LNG's gas fields, then transporting the CSG to Australia Pacific LNG's LNG facility via a gas pipeline, and finally converting the CSG into LNG at the Project's LNG facility, for transport to the international energy market. The CSG is contained in reserves located in the Surat and Bowen basins (specifically, the

Walloons gas fields' development area) which are relatively abundant, and originate 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, temporary accommodation facilities, communication infrastructures and other logistics support areas. A 450km underground gas pipeline will connect the gas fields with the LNG facility on Curtis Island.

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

14.1.2 Purpose

The purpose of this chapter is to describe the GHG emissions that are expected to arise from the gas fields during the construction, operations and decommissioning phases of the Project.

Of Australia Pacific LNG's 12 sustainability principles, key principles in relation to GHG emissions for the gas fields include:

- Minimising adverse environmental impacts and enhancing environmental benefits associated with Australia Pacific LNG's activities, products or services; conserving, protecting, and enhancing where the opportunity exists, the biodiversity values and water resources in its operational areas
- Reducing the greenhouse gas intensity through the development of an energy source less carbon intensive than the world average for the majority of fuel providers for power generation; and implementing a greenhouse gas mitigation strategy for its operations to continuously seek opportunities to further reduce greenhouse gas emissions
- Identifying, assessing, managing, monitoring and reviewing risks to Australia Pacific LNG's workforce, its property, the environment and the communities affected by its activities.

Under these principles, the GHG emissions inventory is developed and the GHG mitigation measures assessed and quantified. Future GHG mitigation measures are also identified with these sustainability principles as the basis.

14.1.3 Scope of work

This chapter presents the gas fields' GHG emission inventory, expressed in tonnes CO_2-equivalent (t CO_2-e). The scope of this chapter covers the following in relation to the Project's gas fields:

- Projection of scope 1 (direct) GHG emissions that arise from fuel combustion, fugitive emission and land clearing
- Projection of scope 2 (indirect) GHG emissions that arise from the purchase of 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
- Discussion of GHG mitigation opportunities for possible future implementation.

Figure 14.1 gives an overview of how the various GHG emissions inventories described in this EIS sit within the overall project GHG footprint. For the Project, three GHG emissions inventories are reported:

- A gas fields GHG inventory (this chapter)
- A gas pipeline GHG inventory (refer Volume 3 Chapter 14)
- An LNG facility GHG inventory (refer Volume 4 Chapter 14).

The GHG emissions from all relevant sources (and scopes) are 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, consideration has been given to sources of GHG emissions that are beyond Australia Pacific LNG's control but contribute to the overall footprint. As shown in Figure 14.1, 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 in 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. They are presented in Section 14.5.3.

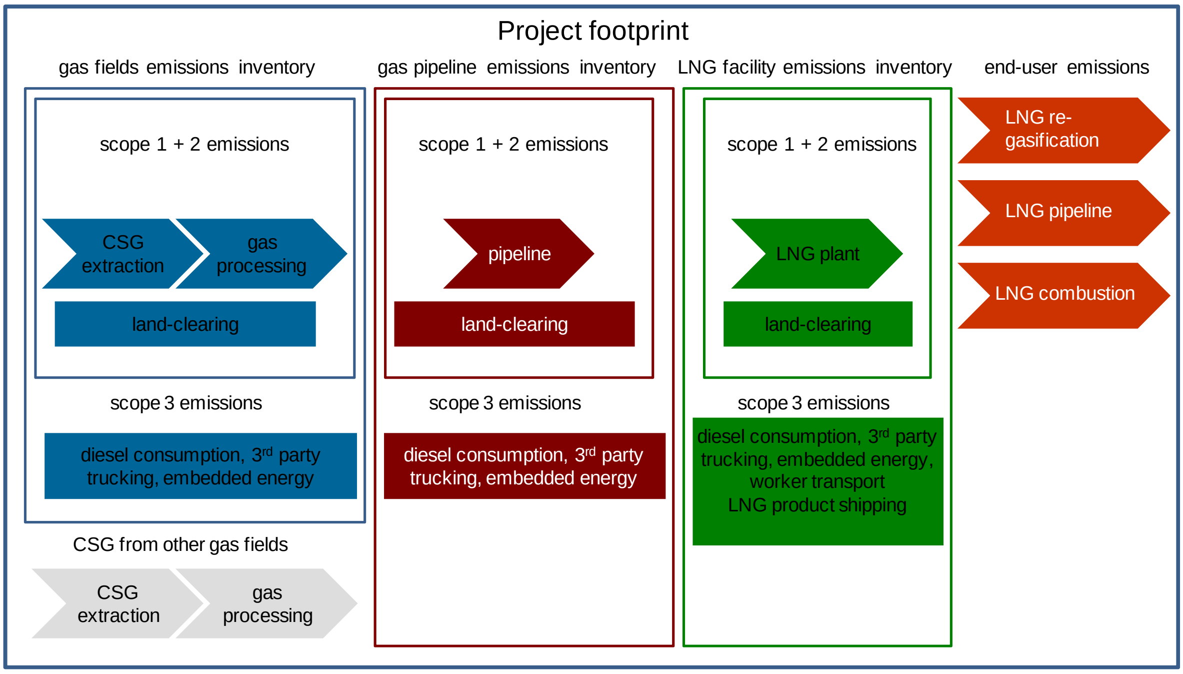

Figure 14.1 Overview of the Project's GHG footprint

The specific activities within the GHG reporting inventory for the gas fields include construction, operation and decommissioning of the gas fields, including:

- 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
- The development and operation of gas wells
- Decommissioning of the gas fields.

14.1.4 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.

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.

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. The Australian government intends that the CPRS commences on 1 July 2011, but this will depend on the passage of a number of Bills (Australian Government 2009) 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 2008). 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 levels 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 2008; Department of Climate Change (DCC) 2009d).

The proposed CPRS includes measures designed to reduce the immediate impact of the price of carbon on 'emission-intensive trade-exposed' industries. LNG production has been identified as such an industry, so the assistance is directly relevant to this 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 1,000 and 2,000t CO_2-e/$m revenue ($CO_2$ equivalent emissions per million dollars of revenue) (Petroleum Exporters Society of Australia 2009), suggesting assistance would cover 66% of GHG emissions.

Energy Efficiency Opportunities Act

The *Energy Efficiency Opportunities Act 2006* was introduced by the Department of Resources, Energy and Tourism. 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 Act, 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 Energy Efficiency Opportunities scheme since 2006 and 2007 respectively.

National Greenhouse and Energy Reporting Act

The *National Greenhouse and Energy Reporting Act 2007* 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 in the following situations:

- If they control facilities emitting more than 25 kilotonnes (kt) CO2-e, or produce or consume more than 100 terajoules (TJ) of energy
- If their corporate group emits more than 125kt CO2-e, or produces or consumes more than 500TJ of energy
- Lower thresholds for corporate groups will be phased in by 2010-11. The final thresholds will be 50kt CO_2-e or 200TJ 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 Act and so both partners in Australia Pacific LNG are familiar with its requirements.

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 30Mt CO_2-e over 10 years and save the Queensland economy about $80 million each year (Queensland Government 2007).

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 0.917t CO_2-e/MWh (2000-2001 levels) to 0.794t 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'.

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 (Queensland Government 2009).

14.1.5 Australia Pacific LNG’s position on GHG emissions

Australia Pacific LNG recognises that climate change poses significant risks and opportunities to its business. Australia Pacific LNG will be proactive 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 issue 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 Carbon Pollution Reduction Scheme 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. It 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.

With operations around the globe, ConocoPhillips seeks to encourage external policy measures at the international level that deliver the following principles:

- Slow, stop and ultimately reverse the rate of growth in global GHG emissions
- Establish a value for carbon emissions, which is transparent and relatively stable and sufficient to drive the changed behaviours necessary to achieve targeted emissions reductions
- Develop and deploy innovative technology to help avoid or mitigate GHG emissions at all stages of the product's life
- Ensure energy efficiency is implemented at all stages of the product's life
- Recognise consumer preference for reduced GHG-intensive consumption, and work towards meeting these expectations
- Deploy carbon capture and storage as a practicable near-term solution if technically and economically feasible
- Develop processes that are less energy and material intensive
- Build price of carbon into base-case business evaluations
- Ensure energy and materials efficiency is part of the 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, reporting, and assessment of business-specific actions.

14.2 Methodology

14.2.1 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 (World Business Council for Sustainable Development and the World Resource Institute 2004) and the methodologies described in the National Greenhouse Accounts (NGA) Factors. The guiding principles for compiling a GHG inventory are:

- Relevance
- Completeness
- Consistency
- Transparency
- Accuracy.

Specifically, the Protocol advocates defining a reporting boundary for an inventory, and then segmenting the GHG producing sources within that boundary according to their scope. For this gas fields' GHG inventory, 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 in the gas fields

- 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.

These sources are subsequently quantified, after which multiplication with appropriate emission factors are performed to generate the GHG emission quantity. The reporting boundary is presented in Section 14.2.1. The sources and the emission factors used in this report are discussed in more detail in the relevant sections of this chapter.

GHG emission sources for the gas fields

The GHG emission sources associated with the gas fields and their respective scopes are given in Table 14.1.

Table 14.1 Classification of GHG emission sources associated with the gas fields

Scope 1 (direct emissions)	Scope 2 (indirect)	Scope 3 (indirect)
CSG combustion for power generation	Negligible – electricity needs are met by CSG-fuelled power generation	Extraction, production and transportation of purchased fuels
CSG combustion by other stationary equipments		Extraction, production and transportation of construction raw materials
CSG flaring		3rd party transport of consumables to the project site
CSG venting		
CSG leakages		
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 construction and drilling, operations and decommissioning. These are elaborated below.

14.2.2 Construction and drilling

Diesel combustion for on-site transportation and earth moving

Scope 1 GHG emissions arise from the diesel consumed by onsite construction-related transport, earthmoving and drilling-related transport:

- Construction-related transport is associated with equipment hauling
- Earthmoving during construction of the gas wells, GPFs and WTFs
- Drilling-related transport is associated with transporting equipment and personnel to remote drilling locations.

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, chemicals and other miscellaneous 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, 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 clearing of vegetation during the construction of the gas fields. The emissions are attributed to the release of GHG as biomass decomposes, and the decrease in the carbon sequestering potential of the ecosystem.

14.2.3 Operations

Diesel combustion for transportation

Scope 1 GHG emissions arise from combustion of diesel for transport. Operators will use onsite 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 that 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 water transfer stations.

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, to maintain optimal process conditions.

Flaring minimises the global warming potential of released CSG 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 pipelines

Scope 1 GHG emissions arise from fugitive emissions during transport in pipelines. This includes the transport of CSG in the high pressure pipeline. CSG leakages from the 450km gas pipeline that connects the gas fields to the LNG facility are assessed in Volume 4 Chapter 14. GHG emissions due to gas leaks from high pressure transmission pipelines are extremely low.

This source explicitly covers vented release and leaked release of CSG during CSG transport.

14.2.4 Decommissioning

Scope 1 GHG emissions arise from shutting down depleted gas wells, and removing all gas field 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. For estimation purposes, the GHG emissions for decommissioning are assumed to be the same as those for the construction phase.

14.3 GHG emissions estimation methodology

14.3.1 Scope 1 GHG emission factors (other than land clearing)

Scope 1 GHG emissions for the construction and the operations of the gas fields are estimated using the default GHG emission factors given in the National Greenhouse Accounts Factors (Department of Climate Change (DCC) 2009a).

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 (e.g. t 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 (DCC 2009a).

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 14.2 summarises the GHG emissions factors used for estimating the scope 1 GHG emissions arising from all gas fields related activities.

Table 14.2 Default GHG emission factors from National Greenhouse Accounts factors

Emission source	Energy content	Emission factor (kg CO_2-e/GJ)			
		CO_2	CH_4	N_2O	Total
CSG combustion	37.7×10^{-3} GJ/m^3	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 CO_2-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 CO_2-e/t throughput)				
CSG leakages (for CSG production)	-	-	0.0012	-	0.0012
	Emission factor (t CO_2-e/pipeline km)				
CSG leakages (for CSG transmission)	-	0.2	8.7		8.72

CSG venting has no prescribed emission factor, so GHG emissions from CSG venting are estimated based on an operational understanding of existing CSG facilities.

14.3.2 Scope 1 GHG emissions factors for land-clearing

The flow diagram in Figure 14.2 shows the steps used to estimate the GHG emissions due to land-clearing, which are described below.

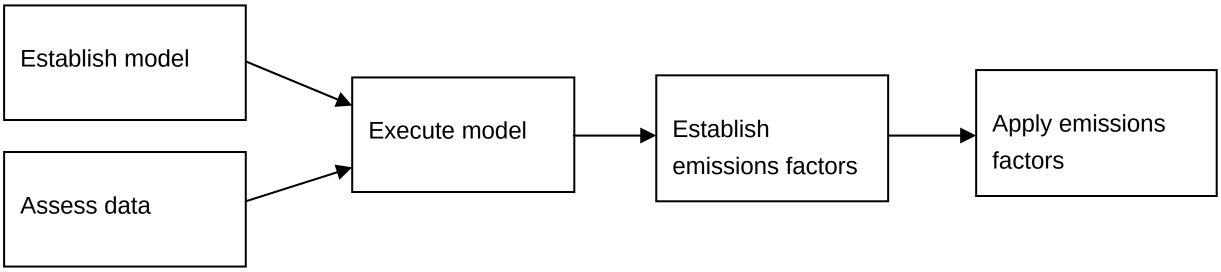

Figure 14.2 Methodology used to assess GHG emissions due to land-clearing

The first step in the assessment process was to establish the basic parameters of the FullCAM model (DCC 2009c). These included the time span 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.

The spatial data was then examined, including the maps of the regional ecosystems and the mapping of the possible sites for the infrastructure associated with the gas fields. This included land clearances associated with the infrastructure.

Spatial point data coordinates 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 infrastructure. Results were obtained in tonnes of carbon per hectare (t CO_2-e/ha).

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/ha) into a carbon dioxide equivalent basis (t CO_2-e/ha).

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 technical report for the gas fields in Volume 2 Chapter 8, and for the gas pipeline in Volume 3 Chapter 8.

GHG emission factors were then 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 then summed to give the total GHG emissions associated with land clearing.

14.3.3 Scope 3 GHG emission factors

For scope 3 (indirect) GHG emissions associated with transport from sources beyond the boundary of the gas fields' 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 (e.g. 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.

The 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. 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 14.3. The embedded GHG emissions for each material are estimated by multiplying the mass of each material by the embedded GHG emission factors.

Table 14.3 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

14.4 Existing environment

This section details the Queensland, Australian and global GHG emission inventories to determine the potential impact of the Project's gas fields GHG emission inventories.

Data from the United Nations Framework Convention on Climate Change (UNFCCC) estimates that aggregate GHG emissions from Annex I[*] (including Australia) countries in 2007 were 18,112Mt CO_2-e excluding land use, land use change and forestry (LULUCF), and 16,547Mt 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 11,700Mt CO_2-e excluding LULUCF and 11,900Mt CO_2-e including LULUCF (UNFCCC 2005).

The total GHG emissions from Annex I and non-Annex I countries is estimated at 29,812Mt CO_2-e excluding LULUCF and 28,447Mt CO_2-e including LULUCF. Australia's net GHG emissions across all sectors (DCC 2009b) in 2007 were reported as 597Mt CO_2-e (approximately 2% of global GHG emissions). The energy sector was the largest source of Australian GHG emissions at 408Mt CO_2-e (68.3% of net emissions). GHG emissions in Queensland for 2007 accounted for 182Mt CO_2-e (DCC 2009b).

[*] 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.

14.5 Projected GHG emissions

This section describes the GHG emissions estimates on an annual and project lifetime basis for the gas fields, segmented by emissions scopes and project phases.

14.5.1 Modelling results

Scope 1 GHG emissions

The scope 1 GHG emissions for the Project's gas fields are shown in Figure 14.3, 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.

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 CO_2-e. Emissions of methane and nitrous oxide, as shown by the GHG emissions factors in Table 14.2, 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 CO_2-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, water transfer stations 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.

Maximum GHG emissions occur between 2021 and 2024, coinciding with the projected maximum gas fields output. From 2041 to 2045, production is assumed to remain static (at 2041 levels) and hence the GHG emissions will remain constant.

Figure 14.3 shows the projected scope 1 GHG emissions for the Project. GHG emissions due to decommissioning occur after 2045, so are not shown, but this emission source is considered across the life of the Project.

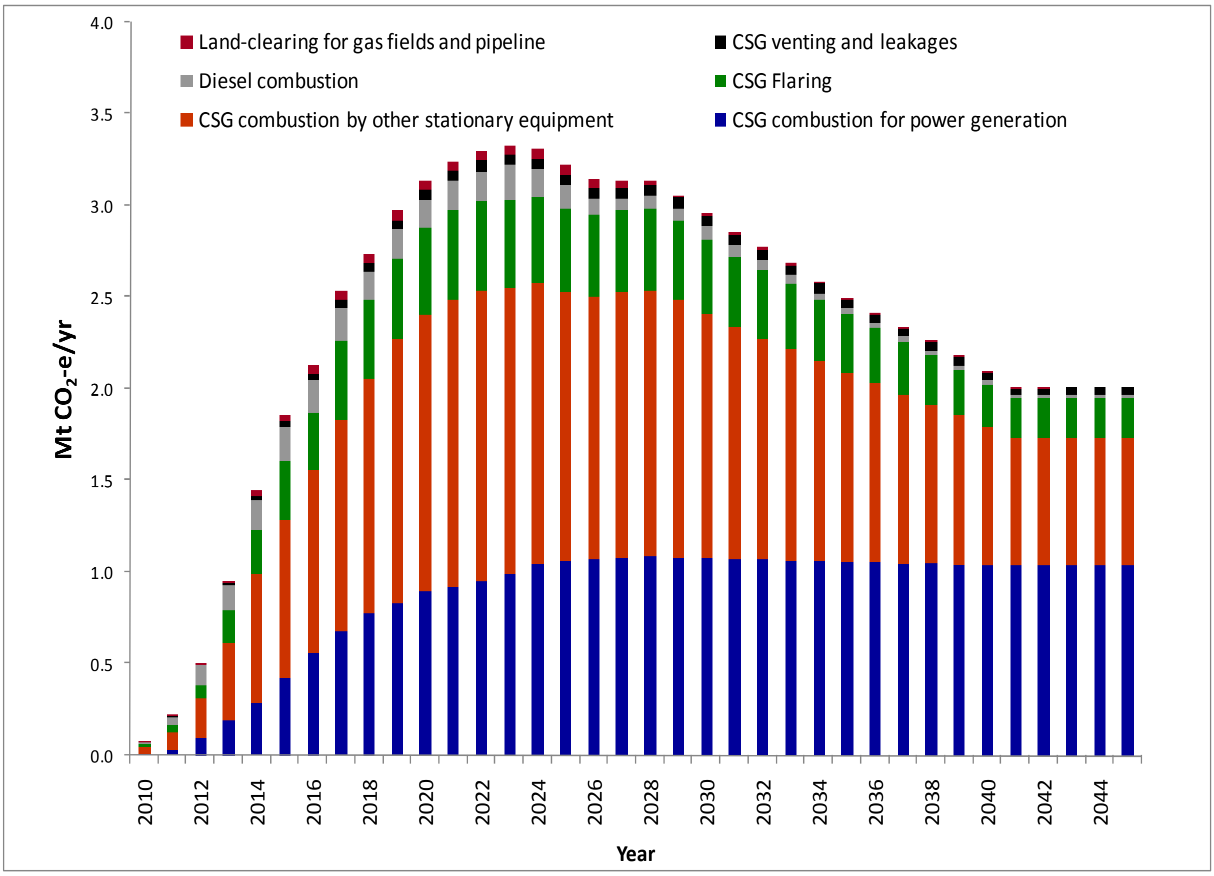

Figure 14.3 Projected scope 1 GHG emissions for the gas fields

Table 14.4 shows the annual scope 1 GHG emissions from the Project's gas fields during 2023, the modelled year of peak CSG production. This includes construction of well sites and the various gas production facilities. The transportation GHG emissions relate to the scope 1 GHG emissions generated by equipment hauling and earthmoving machinery. Note that land-clearing activities will have been completed earlier, resulting in zero emissions from this source in 2023. GHG emissions due to flaring during well development are expected to be minimal as many GPFs will be operational by 2023.

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

Table 14.4 Scope 1 GHG emissions from the gas fields at 2023

Source	Sum of GHG emissions (t CO_2-e/yr)
Construction and drilling	
Diesel combustion for transportation	40,000
Diesel combustion for power generation	43,000
Diesel combustion by other stationary equipments	72,000
Operations	
Diesel combustion for transportation	11,000

Source	Sum of GHG emissions ($t\ CO_2$-e/yr)
Diesel combustion for power generation	11,000
CSG combustion for power generation	991,000
CSG combustion for other stationary equipments	1,560,000
CSG flaring	483,000
CSG leakages	14,000
CSG fugitive emissions – high pressure pipeline	10,000
CSG venting	30,000
Approximate total	3,265,000

Scope 1 GHG emissions from land clearing

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

Approximately 815ha of regrowth vegetation will also be cleared. Clearance of regrowth vegetation results in an estimated 90,000t CO_2-e of emissions over the project lifetime.

The major contribution to the emissions from land clearing is from the removal of eucalypt and acacia woodland. Total GHG emissions associated with land clearing for the gas fields are approximately 810,000t CO_2-e over the project lifetime.

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.

Scope 1 GHG emissions over project lifetime

Table 14.5 shows the scope 1 GHG emissions for the construction, operation and decommissioning phases for the gas fields (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 14.4 the gas production and processing operations are the dominant sources of GHG emissions for the gas fields. 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%.

Scope 3 GHG emissions over Project lifetime

Table 14.5 presents the scope 3 GHG emissions associated with the consumption of purchased diesel, third party trucking and embedded energy of construction materials.

Estimates have been made of the scope 3 GHG emissions arising from the consumption of diesel fuel for power and transport for the gas fields. Over the Project lifetime, these scope 3 GHG emissions are estimated to be 233kt CO_2-e. This represents approximately 0.3% of scope 1 GHG emissions over the Project's lifetime.

Table 14.5 Scope 1 and scope 3 GHG emissions for the gas fields over the Project's lifetime

Emissions source	Scope of emissions	Emissions t CO_2-e
Construction and drilling	Scope 1	1,600,000
Operations	Scope 1	82,600,000
Land clearing	Scope 1	810,000
Decommissioning	Scope 1	1,340,000
Approximate total of scope 1 GHGs		86,350,000
Purchased diesel extraction and processing	Scope 3	233,000
Third party trucking transport	Scope 3	740,000
Embedded energy emissions of construction materials	Scope 3	1,870,000
Approximate total of scope 3 GHGs		2,850,000
Approximate total of scope 1 and 3 GHGs		89,200,000

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. Using relevant GHG emission factors, the consumption translates to total GHG emissions of 740kt CO_2-e over the Project's lifetime. These GHG emissions represent approximately 0.8% of the total scope 1 GHG emissions over the Project's lifetime.

Embedded energy related GHG emissions were estimated for the likely types and tonnages of construction materials to be used in the gas fields. The embedded energy related GHG emissions were estimated by multiplying the tonnes of materials by the relevant GHG emissions factors in Table 14.3. The GHG emissions from embedded energy amount to 1.9Mt CO_2-e. Compared with the scope 1 GHG emissions, embedded energy related GHG emissions are approximately 2.2% of the scope 1

14.5.2 Summary of scope 1 and scope 3 GHG emissions

Table 14.5 shows the scope 1 and scope 3 GHG emissions for the activities associated with the gas fields over the Project's lifetime. In terms of the total gas fields' inventory, the scope 3 GHG emissions are relatively minor at approximately 3.2% of the gas fields' GHG inventory over the Project lifetime.

14.5.3 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 (i.e. the GHG footprint) are considered. These are shown in Figure 14.1. 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 (here assumed to be for power generation). 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 633PJpa, with projected scope 1 GHG emissions totalling 3.3Mt CO_2-e/yr. At maximum LNG output, the Project requires additional CSG from other fields, with a forecast contribution of 462PJpa of CSG in 2023. These non-Project fields will produce additional scope 1 GHG emissions totalling approximately 2.4Mt CO_2-e/yr. The contribution from the Project gas pipeline is relatively insignificant at approximately 5000t CO_2-e/yr.

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

Table 14.6 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 14.6 Breakdown of the Project's GHG footprint in 2023

Emissions source	Emissions (Mt CO_2-e/yr)	GHG intensity t CO_2-e/GJ delivered
Project gas fields (scope 1)	3.3	0.003
Project gas pipeline (scope 1)	0.005	0
Project LNG plant (scope 1)	5.5	0.006
Total Project GHGs (scope 1)	8.8	0.009
Other gas fields (scope 1)	2.4	0.002
Total GHGs to produce 18Mtpa LNG	11.2	0.011
LNG shipping	2.0	0.002
LNG re-gasification and natural gas pipeline emissions	3.6	0.004
End user combustion of 18Mtpa LNG	51.6	0.051
Total GHG footprint emissions for 18Mtpa	68.4	0.068

Table 14.7 presents a GHG emission intensity comparison between lifecycle GHG emissions for LNG, coal, and other fuels. The total scope 1 GHG emissions related to the LNG extraction and processing activities within Australia are 11.2 Mt CO_2-e/yr. The table shows that:

- GHG emissions from the extraction, processing and product transport for LNG are higher than for coal
- 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 to15% more GHG emissions than LNG.

Table 14.7 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 DCC (2009b).
*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 14.8 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 accounts for the power generation efficiencies of each type of power plant.

Table 14.8 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 DCC (2009b)

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.

14.6 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's gas fields. The scope 1 GHG emissions during peak LNG production from the gas fields are 3.3Mt 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 shown in Figure 14.1. These GHG emissions total approximately 8.8Mt CO_2-e, as was shown in Table 14.6.

Table 14.9 shows the maximum impact of the Project's annual GHG emissions in the context of Queensland, Australia and the world (from Section 14.4).

Table 14.9 Maximum impact of project GHG annual emissions in 2023

	Annual GHG emissions (Mt CO_2-e)	% contribution from gas fields	% contribution from the Project	% contribution from the Project on a lifecycle GHG basis
Queensland	182	1.81	4.84	N/A
Australia	597	0.55	1.48	N/A
Global	29,000	0.01	0.03	-0.28

The above analysis assumed that 18Mtpa LNG, or approximately 1,000PJpa of energy, was produced, exported and combusted. On this basis, the combustion of 1,000PJpa of natural gas in a CCGT releases approximately 71Mt CO_2-e per year. Combusting 1,000PJpa of coal in a sub-critical coal fired power plant releases approximately 151Mt CO_2-e per year and an ultra super-critical coal-fired power plant releases 106Mt CO_2-e per year. Thus, the end-use of the Project's LNG output could avoid the release of between 35 and 80Mt 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 2,200Mt CO_2-e of GHG emissions depending on the coal-fired generation technology used.

14.7 Mitigation and management

Australia Pacific LNG has an objective to reduce the GHG intensity of its production processes in accordance with the Project's overall sustainability objectives. 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.

14.7.1 Immediate measures

Combustion and flaring of CSG are the primary sources of GHG emissions in the GHG inventory. Australia Pacific LNG has assessed international industry practice for GHG mitigation in flaring. As a result, GHG mitigation opportunities have been identified that reduce the quantity of gas flared during normal operations. 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 offline 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 16Mt 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 therefore less flaring. Additionally, given the large number of wells, road vehicle use by maintenance personnel will be substantially reduced, so 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 offline due to maintenance. This can be done via a series of low pressure gas gathering 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. Development of a strategy to minimise plant shutdowns and leak detection and repair program will be developed to further limit fugitive releases of CSG.

14.7.2 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.

14.7.3 Potential future mitigation measures

As part of its objective to reduce GHG emissions, Australia Pacific LNG has identified the following opportunities for potential future implementation subject to detailed engineering analysis:

- Using 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
- Using solar energy and electric drives at well heads and gas plants
- Designing generation systems to avoid the potential for dumping of excess generation through load banks.

As part of its sustainability objectives, Australia Pacific LNG will continually assess opportunities to reduce energy consumption and increase the energy efficiency of gas compression as the Project develops.

14.8 Conclusions

14.8.1 Assessment outcomes

An analysis was performed to identify the key sustainability principles and the potential impacts of the Project's gas fields in terms of the GHG emissions on third parties, property and the environment in general.

Table 14.10 summarises the key potential risks, the mitigation actions and the residual risk. A full description of the risk assessment methodology is provided in Volume 1 Chapter 4.

Table 14.10 Summary of environmental values, sustainability principles, potential impacts and mitigation measures

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
Reduce the risk of the impacts of climate change Improve health and well-being of people	Minimising adverse environmental impacts and enhancing environmental benefits associated with Australia Pacific LNG's activities, products or services; conserving, protecting, and enhancing where the opportunity exists, the biodiversity values and water resources in its operational areas	GHG emissions to the atmosphere; potential long term climate change impacts	Operating construction machinery and transport (equipment hauling)	Optimise transport logistics to minimise energy consumption and use the most fuel efficient vehicles and machinery	Negligible
			Flaring and venting coal seam gas during maintenance and process upsets	Implement automatic well control to allow turn down of gas field production in the event of process upsets and maintenance Re-route coal seam gas via low pressure pipelines if a GPF is offline due to process upsets and maintenance Develop and implement a leak detection and repair program to reduce venting	Low
			Operating gas processing facilities.	Investigate implementation of high efficiency gas compressors that produce less GHG emissions	Low

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
				Investigate the installation of waste heat recovery units on gas compressor exhaust stacks to meet process heat requirements	
			Embedded energy in materials	Consider less energy intensive construction materials during design phase of the Project	Low
		Land clearing (releases CO_2 and reduces CO_2 uptake). Reduces biodiversity, causes land degradation	Land clearing	Progressively rehabilitate cleared areas as described in Volume 2 Chapter 8. Develop a biodiversity offset strategy which may generate GHG offsets	
Reduce the risk of the impacts of climate change. Improve health and well-being of people	Reducing the greenhouse gas intensity through the development of an energy source less carbon intensive than the world average for the majority of fuel providers for power generation; and implementing a greenhouse gas mitigation strategy for its operations to continuously seek opportunities to further reduce greenhouse gas emissions.	GHG emissions to the atmosphere; potential long term climate change impacts	Widespread combustion of coal as an energy source	Promote LNG as a cleaner fuel.	Low

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
Reduce the risk of the impacts of climate change. Improve health and well-being of people	Identifying, assessing, managing, monitoring and reviewing risks to Australia Pacific LNG's workforce, its property, the environment and the communities affected by its activities.	GHG emissions to the atmosphere; potential long term climate change impacts	GHG emissions from gas field processes and other indirect emissions such as third party transportation	Develop and implement GHG management measures to monitor and assess GHGs from the Project on an ongoing basis.	Low

14.8.2 Commitments

Australia Pacific LNG will:

- Develop ongoing processes for minimising energy consumption and greenhouse gas (GHG) emissions within the Project, by:
  - Investigating the use of solar and electric drives for production equipment
  - Improving the energy efficiency of gas compression through better technology
  - Minimising operational coal seam gas flaring and venting
- Develop a biodiversity offset strategy, which will take into account GHG offsets
- Measure and report GHG emissions in compliance with the National Greenhouse and Energy Reporting System
- Work with government on developing measures to address GHG emissions.

References

Australian Government 2008, *Carbon pollution reduction scheme, Australia's Low Pollution Future, White Paper, Volume 1, December 2008,* Commonwealth of Australia, Barton, ACT.

Australian Government 2009, *Carbon Pollution Reduction Scheme (Charges – General) Bill 2009,* Bills Digest, Department of Parliamentary Services – Parliament of Australia.

Department of Climate Change (DCC) 2009a, *National Greenhouse Accounts Factors, June 2009,* Department of Climate Change, Canberra ACT.

Department of Climate Change (DCC) 2009b, *National Greenhouse Gas Inventory-Kyoto Protocol Accounting Framework, Reporting year 2007*, viewed September 2009, <http://www.ageis.greenhouse.gov.au/>

Department of Climate Change (DCC) 2009c, *National Carbon Accounting Toolbox*, viewed September 2009, <http://www.climatechange.gov.au/en/government/initiatives/ncat.aspx>

Department of Climate Change (DCC) 2009d, *Conditions for 2020 targets,* viewed November 2009, <http://www.climatechange.gov.au/government/conditions-for-2020-targets.aspx>

Garnaut, R 2008, *The Garnaut climate change review,* Cambridge University Press, Melbourne.

Hammond, GP and Jones, CI 2008, *Inventory of embodied carbon and energy (ICE)*, Department of Mechanical Engineering, University of Bath, United Kingdom.

Intergovernmental Panel on Climate Change (IPCC) 2001, 'Chapter 3: Technological and Economic Potential of Greenhouse Gas Emissions Reduction, in Moomaw, WR and Moreira, JR (eds.) *Climate Change, 2001. A Report of working group III of the Intergovernmental Panel on Climate Change, Chapter 3,* Cambridge University Press, Cambridge UK and New York, USA.

Pace Global Energy Services 2009, *Life Cycle Assessment of GHG Emissions from LNG and Coal Fired Generation Scenarios: Assumptions and Results*, prepared for Center for Liquefied Natural Gas (CLNG).

Queensland Government 2007, *ClimateSmart 2050: Queensland climate change strategy 2007: a low carbon future,* Queensland Government, Brisbane.

Queensland Government 2009, *ClimateQ: toward a greener Queensland*, Department of Environment and Resource Management (DERM), Queensland Government, Brisbane.

United Nations Framework Convention on Climate Change (UNFCCC) 2005, *Sixth compilation and synthesis of initial national communications from Parties not included in Annex I to the Convention,* United Nations Framework Convention on Climate Change, Germany, viewed October 2009, <http://unfccc.int/resource/docs/2005/sbi/eng/18a02.pdf>

United Nations Framework Convention on Climate Change (UNFCCC) 2009, *National Inventory greenhouse data for the period 1990-2007*, United Nations Framework Convention on Climate Change, Germany, viewed October 2009, <http://unfccc.int/resource/docs/2009/sbi/eng/12.pdf>

World Business Council for Sustainable Development (WBCSD) and the World Resource Institute (WRI) 2004, *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard,* World Business Council for Sustainable Development and the World Resource Institute, Geneva, Switzerland and Washington DC.

WorleyParsons 2008, Confidential report.