Australia Pacific LNG Project

Volume 3: Gas Pipeline

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 hinges on the corporate, social and environmental feasibility of extracting and processing CSG from the gas fields, transporting CSG along the main gas transmission pipeline (gas pipeline) to the LNG facility where it is converted into LNG prior to export. These steps make up the Australia Pacific LNG Project (the Project).

This chapter addresses the requirements of the terms of reference for the Project's environmental impact statement (EIS), which are to:

- Quantify the greenhouse gas (GHG) emissions associated with the construction, operation and decommissioning of the gas pipeline
- Describe the methods by which estimates were made
- Assess immediate and potential mitigation steps to mitigate the GHG emissions.

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

This chapter identifies measures to minimise the gas pipeline's 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 the gas pipeline 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 ha 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 and water treatment facilities. Associated infrastructure will include roads and access tracks, storage ponds, temporary accommodation facilities, communication infrastructures and other logistics support areas. Of particular relevance to this chapter, an underground gas pipeline, approximately 450km in length, 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 EIS chapter is to describe the GHG emissions that are expected to arise from the gas pipeline 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 pipeline 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 gas pipeline:

- Projection of scope 1 (direct) GHG emissions that arise from 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 GHG
- 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 Project's overall GHG footprint. For the Project, three GHG emissions inventories are reported:

- A gas fields GHG inventory (Volume 2 Chapter 14)
- A gas pipeline GHG inventory (this chapter)
- An LNG facility GHG inventory (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, sources of GHG emissions that are beyond Australia Pacific LNG's control but nonetheless contribute to the overall footprint are considered. 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, presented in Section 14.5.2.

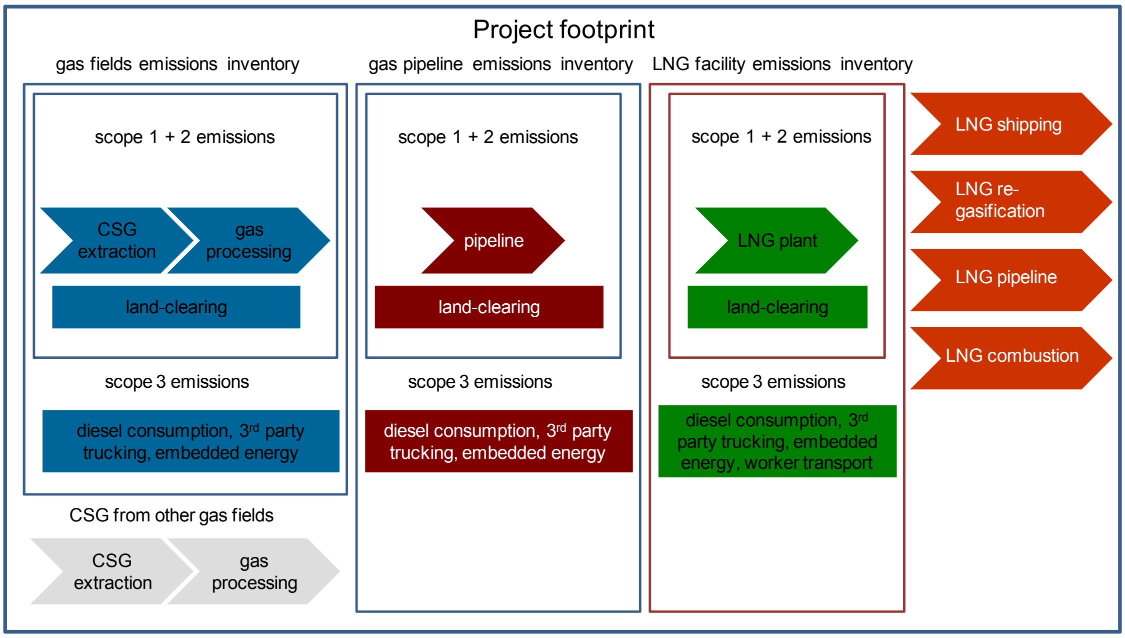

Figure 14.1 Overview of the Project's GHG footprint

The activities within the reporting inventory relevant to this chapter include construction, operation and decommissioning of the gas pipeline.

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 however this is dependent 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 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 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 (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 1000-2000t CO_2-e/$m revenue ($CO_2$ equivalent emissions per million dollars of revenue) (Petroleum Exploration Society of Australia (PESA) 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 if:

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

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 (the 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 GHG 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 pipeline 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
- 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 GHG emission quantity. The reporting boundary is presented in Section 14.2.2. The sources and the emission factors used in this report are discussed in more detail in the relevant sections of this chapter.

14.2.2 GHG emission sources for the gas pipeline

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

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

Scope 1 (direct emissions)	Scope 2 (indirect)	Scope 3 (indirect)
CSG fugitive emissions specific to gas pipeline	None – electricity needs are met by CSG-fuelled power generation	Extraction, production and transportation of purchased fuels
Diesel combustion for transportation		Extraction, production and transportation of construction raw materials
Diesel combustion for power generation		3rd party transport of consumables to the project site
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 below.

14.2.3 Construction

Diesel combustion for onsite transportation and earth moving

Scope 1 GHG emissions arise from the diesel consumed by onsite construction-related transport, earth moving and other machinery:

- Construction-related transport is associated with equipment hauling and pipe section handling
- Earth moving during construction of the gas pipeline.

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 pipe sections.

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 and pipe sections 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 gas pipeline. Scope 3 GHG emissions arise from the embedded energy associated with diesel production and transport.

Land clearing

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

14.2.4 Operations

CSG fugitive emissions in the gas pipeline

Scope 1 GHG emissions arise from the fugitive emissions during CSG transport in pipelines. This includes the 450km pipeline that supplies CSG to the LNG facility. In practice, GHG emissions due to gas leaks from gas transmission pipelines are extremely low.

14.2.5 Decommissioning

Scope 1 GHG emissions arise from decommissioning (i.e., removal of surface infrastructure and site rehabilitation).

14.3 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 pipeline are estimated using the default GHG emission factors given in the National Greenhouse Accounts Factors (DCC 2009a).

GHG emission factors for estimating the quantities of GHGs are expressed in terms of the quantity of a GHG per unit of pipeline length (e.g. t CO_2-e/km) or per unit of energy consumed (kg CO_2-e/GJ). The GHG emissions associated with CSG leakage from the gas pipeline are 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.

The method for estimating GHG emissions from diesel combustion is to multiply the volume (in kilolitres or kL) of diesel combusted by the energy content of the diesel (GJ/kL). 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 diesel fuel, and for fugitive source, were obtained from the NGA Factors (DCC 2009a).

Table 14.2 summarises the GHG emissions factors used for estimating the scope 1 GHG emissions arising from gas pipeline 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
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/pipeline km)				
CSG fugitive emissions in pipeline	-	0.02	8.7	-	8.72

Scope 1 GHG emissions factors for land-clearing

Figure 14.2 maps out the steps used to estimate the GHG emissions due to land clearing.

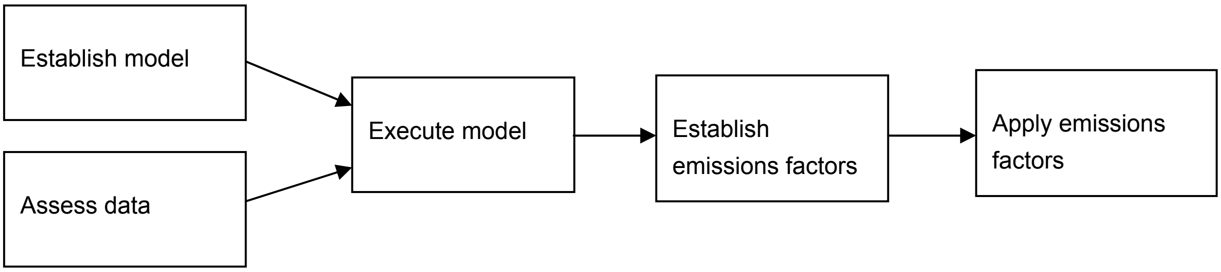

Figure 14.2 Methodology used to assess GHG emissions due to land-clearing

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 maps of the regional ecosystems and the mapping of the possible sites for the infrastructure associated with the gas pipeline. This included land clearances associated with the infrastructure.

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 pipeline infrastructure. Results were obtained in tonnes of carbon per hectare (t CO_2-e/ha).

The mass of carbon for the vegetation in each site (i.e. tonnes carbon per hectare or t C/ha) 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. Specific data on land clearances is available in Volume 3 Chapter 8.

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 pipeline. 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.

Scope 3 GHG emission factors

For scope 3 (indirect) GHG emissions associated with transport from sources beyond the boundary of the 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 (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.

GHG emissions related to the energy embedded in the major material components required to construct the gas pipeline were also assessed in this study. The data was based on the engineering estimates of the tonnes of steel required for the gas pipeline. To determine the GHG emissions associated with the embedded energy in the steel pipe, 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.

Table 14.3 GHG emission factors for embedded energy-related GHG emissions

Material	kg CO_2-e/kg
Steel pipe	2.70

The embedded GHG emission for steel pipe is estimated by multiplying the mass of steel pipe by the embedded GHG emission factors.

14.4 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 gas pipeline 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

[*] 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.

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).

14.5 Projected GHG emissions

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

14.5.1 Modelling results

Scope 1 GHG emissions

The Project's gas pipeline scope 1 GHG emissions are shown in Figure 14.3, where:

- CSG fugitive emissions from the gas pipeline encompass vented releases and leaked releases of CSG during CSG transmission to the LNG facility
- Diesel combustion refers to combustion for transportation and for power generation, corresponding to the construction phase.

The GHG emission sources identified and the GHG emission factors used to compile the GHG emission inventory collectively confirmed that the specific GHGs underpinning the gas pipeline's GHG emission inventory comprises only carbon dioxide and methane. 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 section 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 is 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.

Construction related activities will have been completed by 2012, resulting in zero construction related GHG emissions beyond this year. While land-clearing activities for the gas pipeline (including the lateral pipelines) are expected to take place in 2012 and last approximately 18 months, for GHG modelling purposes, all land-clearing activities are assumed to take place in 2012. GHG emissions related to decommissioning occur after 2045, and are hence not shown in Figure 14.3. This GHG emission source is considered for project lifetime GHG emissions (see Table 14.5).

Fugitive CSG emissions from the gas pipeline are the only source of emissions in the long term.

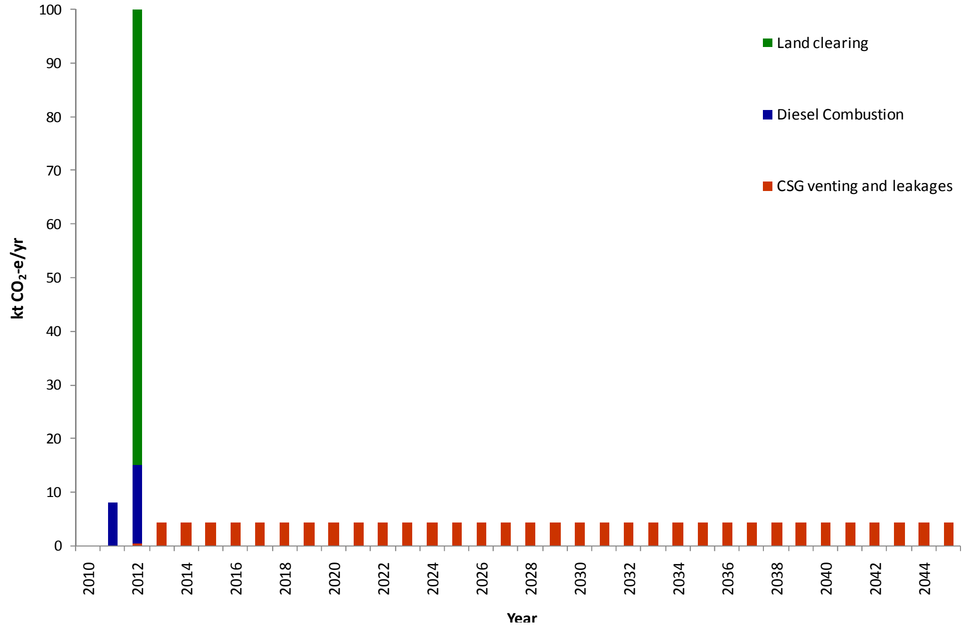

Figure 14.3 Projected scope 1 GHG emissions for the gas pipeline

Table 14.4 shows the annual scope 1 GHG emissions from the gas pipeline during the pipeline operations phase (from 2013 to 2045).

Table 14.4 Scope 1 GHG emissions from the gas pipeline during its operations phase

Source	Sum of GHG emissions (t CO_2-e/yr)
Operations	
CSG fugitive emissions from gas pipeline	5,000
Approximate total	5,000

Scope 1 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. The Terrestrial ecology studies prepared for the gas pipeline (Volume 5 Attachment 15) 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 the gas pipeline, it was assumed that a 40m right of way will be cleared along the 450km length of the easement, giving a total cleared area for the pipeline of approximately 2200ha. However, a substantial amount (approximately 75%) of the vegetation has already been cleared, resulting in the clearance of 560ha, equating to total GHG emissions of approximately 90,000t CO_2-e over the project lifetime.

The major contribution to the emissions from land clearing arise chiefly 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 easement width will be allowed to return to natural vegetation, with the remaining easement returned to natural vegetation when the pipeline is decommissioned.

Scope 1 GHG emissions over the Project lifetime

Table 14.5 shows the scope 1 GHG emissions for the construction, operation and decommissioning phases for the gas pipeline (including land clearing) over the Project lifetime. 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 14.5, GHG emissions from pipeline gas leaks are the dominant source of GHG emissions. These contribute approximately 52% of the inventory. GHG emissions from land clearing represent approximately 32% of the GHG inventory over the lifetime of the Project, while construction and decommissioning GHG emissions each represent approximately 8% of the inventory.

A comparison of the data in Table 14.5 with the project lifetime GHG emissions for the other project elements shows that the gas pipeline GHG emissions are relatively negligible (refer to Volume 2 Chapter 14 and Volume 4 Chapter 14). The gas fields' GHG emissions are approximately 87Mt CO_2-e and the LNG facility emissions are approximately 166Mt CO_2-e, compared with approximately 0.3Mt CO_2-e for the gas pipeline.

Scope 3 GHG emissions over the Project lifetime

Estimates have been made of the scope 3 GHG emissions arising from the consumption of diesel fuel for power and transport. These GHG emissions are a result of the consumption of diesel for gas pipeline activities, but arise from the extraction, processing and transport of fuel to the Project site. These scope 3 GHG emissions are estimated to be approximately 2kt CO_2-e. This represents approximately 0.7% of pipeline scope 1 GHG emissions over the Project lifetime.

Scope 3 GHG emissions have been estimated for importing pipe sections and other consumables using third party truck transport over the Project lifetime. The GHG emissions were estimated to be approximately 1kt CO_2-e over the Project lifetime. These GHG emissions represent approximately 0.3% of the total pipeline scope 1 GHG emissions over the Project lifetime.

Embedded energy related GHG emissions were treated in detail in Volume 5 Attachment 30 for the gas fields and gas pipeline. The embedded energy related to the GHG emissions from steel pipes was estimated as this was the primary construction material expected to be used. This includes the 450km of pipe sections for the main gas pipeline, and the Woleebee and Condabri lateral pipelines. The total GHG emissions due to embedded energy were approximately 620kt CO_2-e.

Compared with the scope 1 GHG emissions, embedded energy-related GHG emissions are 2.5 times larger than the scope 1 GHG emissions over the project lifetime. This indicates the substantial amount of embedded energy that is associated with the steel pipe used in the construction of the gas pipeline.

Table 14.5 below summarises the scope 3 GHG emissions over the project lifetime.

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 pipeline over the project lifetime.

In terms of the total gas pipeline inventory, the scope 3 GHG emissions are significant at approximately 72% of the GHG inventory over the project lifetime.

Table 14.5 Scope 1 and scope 3 GHG emissions for gas pipeline over project lifetime

Emissions source	Scope of emissions	Emissions t CO_2-e
Construction	Scope 1	30,000
CSG fugitive emissions from pipeline	Scope 1	150,000
Land clearing	Scope 1	90,000
Decommissioning	Scope 1	30,000
Approximate total of scope 1 GHGs		300,000
Purchased diesel extraction and processing	Scope 3	2,000
Third party trucking transport	Scope 3	1,000
Embedded energy emissions of construction materials	Scope 3	620,000
Approximate total scope 3 GHGs		625,000
Approximate total scope 1 and 3 GHGs		925,000

14.5.2 Comparing lifecycle GHG footprint intensities for LNG and coal

A lifecycle GHG analysis is presented 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, which is illustrated by 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, and this is discussed in 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 facility (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 GHG emissions related to the LNG extraction and processing activities within Australia are 11.2Mt CO_2-e/yr. Table 14.7 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 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 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 gas pipeline. The scope 1 GHG emissions during the pipeline operations phase (including peak LNG production) are 0.005Mt CO_2-e per annum. To gain a meaningful perspective on the Project's impact, this section also shows the maximum annual 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 GHG annual emissions in the context of Queensland, Australia and global annual GHG emissions (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 pipeline	% contribution from Project	% contribution from Project on a lifecycle GHG basis
Queensland	182	0.003	4.84	N/A
Australia	597	0.001	1.48	N/A
Global	29,000	0.00001	0.03	-0.28

End-users in the international market are expected to replace the energy produced from GHG emission-intensive coal with energy produced from the Project's LNG output (Section 14.5.2). A comparison was performed between lifecycle GHGs from the LNG and coal delivery chain, encompassing production in Australia, transport to an international market and end-use combustion.

The above analysis assumed that 18Mtpa LNG, or approximately 1000PJpa of energy, was produced, exported and combusted. On this basis, the combustion of 1000PJpa of natural gas in a CCGT releases approximately 71Mt CO_2-e per year. Combusting 1000PJpa 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 2200Mt CO_2-e of GHG emissions depending on the coal-fired generation technology used.

14.7 Mitigation and management

The GHG emissions associated with the gas pipeline are relatively small compared to those of the other Project components. Therefore, GHG mitigation efforts on the Project focus on the gas fields and the LNG facility. Nonetheless, weld inspection and hydrotesting during gas pipeline construction will identify any leaks associated with weld or material defects. During operations, corrosion monitoring, leak detection monitoring, intelligent pigging, and regular patrols will be completed to check for any evidence of gas leakage, prompting necessary repairs.

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 offset 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.

14.8 Conclusions

14.8.1 Assessment outcomes

An analysis was performed to identify the key sustainability principles and the potential impacts of the gas pipeline 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 to reduce the impact of the risk and the residual risk. The residual risk is categorised as either low, medium, high, or very high.

A full description of the risk assessment methodology is given 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 wellbeing 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	Operation of construction machinery and transport (equipment hauling)	Optimise transport logistics to minimise energy consumption and use the most fuel efficient vehicles and machinery	Negligible
			Coal seam gas leaks from the pipeline	Develop and implement a leak detection and repair program to reduce venting	Low
			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	Low
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	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
	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.				
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 pipeline 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 GHG emissions
- Develop and implement a leak detection and repair program
- 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.

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