6.9 Greenhouse Gas Emissions

6.9.1 Introduction

Climate change is a global issue requiring significant resources to meet complex environmental, energy, economic and political challenges. As a global stakeholder in the energy business, Santos recognises that one of its most important environmental responsibilities is to pursue strategies that address the issue of greenhouse gas (GHG) emissions. A clean energy strategy is the cornerstone of Santos' Climate Change Policy published in December 2008 (Climate Change Policy). The Policy is based on Santos' vision "to lower the carbon intensity of its products".

The GLNG Project will include development of Santos' coal seam gas (CSG) fields near Roma and Injune in south-west Queensland. The CSG field development to supply feed gas for the first stage of the LNG facility will include the drilling of sufficient exploration and development wells to supply approximately 5,300 petajoules (PJ) (equivalent to 140 billion m^3) of CSG over the project life. CSG field development for the GLNG Project will focus on the regions of Fairview, Roma and Arcadia Valley.

Staged development of the CSG fields is likely to consist of 1,200 development wells being established prior to 2015, with the potential for 1,450 or more additional development wells after 2015. The GLNG Project is anticipated to have a 25-year production life. Additional supporting infrastructure including field gathering lines and compressors will also be installed.

Given that GHG emissions must be inventoried and assessed as a total from the entire GLNG Project, this section will include emission totals and impacts from the CSG fields, gas transmission pipeline and LNG facility. The specific data sources and emission factors used in developing the totals for the gas transmission pipeline and LNG facility will however be discussed only in Sections 7.9 and 8.9 respectively.

The organisational boundary of the GLNG Project is delineated by the physical LNG facility site on Curtis Island, the gas transmission pipeline easement, and the CSG field development activities.

The construction of the bridge, access roads and operation of accommodation facilities has been included in the inventory. Auxiliary infrastructure such as water management systems and wastewater treatment facilities are not included within the project organisational boundary. Third-party shipping and end use of the LNG product are also outside the project organisational boundary, though included as part of the discussion of Scope 3 emissions.

This section applies to the entire GLNG Project with the exception of Section 6.9.4.3, which discusses CSG field emissions sources and factors exclusively. Emissions sources and factors used for the gas transmission pipeline and LNG facility are presented in Sections 7.9.4 and 8.9.4 respectively.

This section comprises a summary of relevant GHG policies, the methodology used for developing the inventory, the GHG inventory and a comparison of the emissions from the GLNG Project as a whole with Queensland, Australian and global emissions.

6.9.2 Methodology

The GHG emission calculation methodology described in this section applies to the entire GLNG Project, including the CSG field, the gas transmission pipeline and the LNG facility.

6.9.2.1 Accounting and Reporting Principles

The GHG inventory for the GLNG Project is based on the accounting and reporting standards of *The Greenhouse Gas Protocol: a Corporate Accounting and Reporting Standard* (Protocol). The Protocol provides a step-by-step guide for companies to use in quantifying and reporting their GHG emissions. The Protocol states that GHG accounting and reporting shall be based on the following principles:

- **Relevance**: Ensure the GHG inventory appropriately reflects the GHG emissions of the company and serves the decision-making needs of users, both internal and external to the company;
- **Completeness**: Account for and report on all GHG emission sources and activities within the chosen inventory boundary. Disclose and justify any specific exclusions;
- **Consistency**: Use consistent methodologies to allow for meaningful comparison of GHG emissions over time. Transparently document any changes to the data, inventory boundary, methods or any other relevant factors in the time series;
- **Transparency**: Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used; and
- **Accuracy**: Ensure that the quantification of GHG emissions is systematically neither over nor under actual emissions, as far as can be judged, and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information.

The GHG emissions inventory for the GLNG Project has been prepared in accordance with the methodology set out in the Protocol, the relevant emissions factors in the National Greenhouse Accounts (NGA) Factors (November 2008), the *Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006 – Energy (Fugitive Fuel Emissions)* and the Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance.

A spreadsheet model has been specifically developed for the GLNG Project and uses the data sources and emission factors detailed below in order to calculate project emissions for every year of construction and operation.

The main GHGs emitted during the activities of the GLNG Project will be carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). To report these emissions, they are converted to carbon dioxide equivalents (CO_2-e) as specified under the Kyoto Protocol. The global warming potential (GWP) is a measure of the amount of infrared radiation captured by a gas in comparison to an equivalent mass of CO_2, over a fixed lifetime. GHG inventories in this report are expressed as tonnes of CO_2-e released following this convention. The GWP adopted for each GHG emitted are as follows: carbon dioxide GWP of 1, methane GWP of 21; and nitrous oxide GWP of 210, as detailed in the NGA Factors.

Materiality

Materiality is a concept used in accounting and auditing to minimise the time spent verifying data that does not impact a company's accounts or inventory in a material way. The materiality threshold that is used in GHG emissions accounting and auditing is subjective and dependant on the context of the site and the features of the inventory.

For the GLNG Project, emissions have been assumed to be immaterial if they are likely to account for less than 5 % of the overall emissions profile. This materiality threshold has been chosen as a standard measure in GHG inventories. An example of emissions not included in the inventory on the basis of materiality is consumption of unleaded fuel (ULP) or LPG in site vehicles. This is because most site vehicles run on diesel fuel, which is included in the inventory and only a small percentage of vehicles, such as private cars belonging to site personnel, will consume unleaded fuel.

6.9.2.2 Inventory Operational Boundaries

The Department of Infrastructure and Planning (DIP) Coordinator-General's (CG) Terms of Reference (ToR) require that direct emissions (Scope 1 and Scope 2) from the project should be assessed.

The Protocol further defines direct and indirect emissions through the concept of emission "scopes".

Scope 1: Direct GHG Emissions

Scope 1 emissions are the release of GHGs into the atmosphere as a direct result of an activity or series of activities that constitute a facility controlled by a company. This includes emissions from combustion in boilers, furnaces and vehicles, fugitive emissions of GHGs and emissions from on-site power generators.

Scope 2: Electricity Indirect GHG Emissions

Scope 2 emissions are the release of GHGs as a result of one or more activities that generate electricity, heating, cooling or steam that is consumed by the facility but do not form part of the facility. This accounts for GHG emissions from the generation of purchased electricity consumed by the company.

Scope 3: Other Indirect GHG Emissions

Scope 3 emissions are GHG emissions that occur outside the boundary of a facility as a result of activities at the facility and are not Scope 2 emissions including transportation of products and end use of products.

This is an optional reporting class that accounts for all other indirect GHG emissions resulting from a company's activities, but occurring from sources not owned or controlled by the company. Examples include transportation of products and end use of sold products and services.

6.9.3 Regulatory Framework

6.9.3.1 Australia's Climate Change Regulation and Policy

The Commonwealth Government's climate change policy, which is managed by the Department of Climate Change, is based on three pillars:

- Reducing Australia's GHG emissions;
- Adapting to climate change that we cannot avoid; and
- Helping to shape a global solution that both protects the planet and advances Australia's long-term interests.

The Government has a long-term target of reducing GHG emissions by 60% below 2000 levels by 2050.

Kyoto Protocol

Australia ratified the Kyoto Protocol in December 2007. The Kyoto Protocol is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC) which is intended 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 imposes binding commitments for the reduction of GHGs produced by Annex 1 countries (developed countries), as well as general commitments for all member countries. Australia has ratified the Kyoto Protocol. Under the Kyoto Protocol, Australia has committed to reducing national GHG emissions to a level equivalent to 108 % of 1990 levels by 2008 - 2012. International negotiations are continuing in relation to the international framework for GHG emissions for the period beyond 2012.

Carbon Pollution Reduction Scheme

The Government is proposing to introduce a cap-and-trade emissions trading scheme in Australia which is to be known as the Carbon Pollution Reduction Scheme (CPRS).

Under the CPRS as proposed by the Government, liable entities will be required to surrender permits in December each year to match their GHG emissions in the preceding financial year. If a liable entity fails to surrender sufficient permits, it will be subject to penalties. Santos will be required to surrender permits in respect of the GHG emissions from the LNG facility, although it is expected to qualify as an emissions-intensive trade-exposed (EITE) activity. This means that Santos will receive a free allocation of some, but not all, of the permits required. Santos will be able to purchase the remainder of the permits at auction or in the secondary market (both domestic and international). Santos will also be able to obtain permits from the Government at a fixed price during the initial phases of the CPRS.

The Government originally proposed that the CPRS would commence on 1 July 2010. The Government has recently announced that it will defer the introduction of mandatory obligations under the CPRS until 1 July 2011. This means that upon commencement of the CPRS liable entities will be required to surrender permits for the first time in December 2012 (for GHG emissions during the 2011-2012 financial year). From 1 July 2011 to 30 June 2012, the Government will make available to liable entities an unlimited number of permits at a price of $10 each. Full market trading is proposed to commence on 1 July 2012. The Government has also announced that it will increase the amount of assistance that will be provided to liable entities undertaking EITE activities.

The Government confirmed its previously announced medium-term target of:

- An unconditional reduction in emissions of 5% from 2000 levels by 2020; or
- A reduction in emissions of 15% from 2000 levels by 2020 if the outcome of the international negotiations is such that there is an agreement for major developing economies to substantially restrain emissions and advanced economies take on commitments comparable to Australia's commitments.

However, the Government has now also committed to reducing emissions by 25% from 2000 levels by 202 if the global agreement goes as far as stabilising levels of carbon dioxide equivalent in the atmosphere at 450 parts per million or less by 2050.

Legislation is required for the implementation of the CRPS. In December 2008, the Government released a White Paper which outlined its policy on the design of the CPRS. The Government has published an exposure draft of the CPRS legislation and is intending to introduce legislative bills into Parliament during 2009. There is no certainty that the bills will pass through the Senate or that the CPRS will commence in its presently proposed form or within the timeframe proposed by the Government.

National Greenhouse and Energy Reporting Act

The *National Greenhouse and Energy Reporting Act 2007* (Cth) (NGER Act) provides a national framework for the reporting and audit of information related to Scope 1 and Scope 2 GHG emissions, energy consumption and energy production. The NGER Act will provide the starting framework for monitoring, reporting and assurance under the CPRS.

The controlling corporation of a corporate group will be required to register and report if:

- It, or a member of its group, has operational control of one or more facilities emit 25 kilotonnes (kt) or more of CO_2-e, or produce or consume 100 terajoules (TJ) or more of energy annually; or
- The corporate group emits 125 kt or more of CO_2-e, or produces or consumes 500 TJ or more of energy annually.

Lower thresholds for corporate groups will be phased in by 2010/2011. The final thresholds will be emissions of 50 kt of CO_2-e or 200 TJ of energy production or consumption for a corporate group. Following the financial year in which one of the thresholds is met, the controlling corporation must register by 31 August and submit their report by 31 October.

Companies with reporting obligations under NGERS are required to register with the Commonwealth Government by 31 August 2009 and lodge a GHG emissions report before 31 October 2009. Santos will be registering and reporting under NGERS and the LNG facility will form part of the reporting obligations at the relevant project times.

Energy Efficiency Opportunities Act

The *Energy Efficiency Opportunities Act 2006* (Cth) (EEO Act) requires large energy users (those corporate groups with annual energy consumption of 0.5 PJ or more) to register with the Government and prepare energy efficiency assessment plans identifying energy efficiency opportunities with a payback period of four years or less.

Santos is a registered participant and the GLNG Project will be included in Santos' planning and reporting obligations under EEO.

Greenhouse Challenge Plus

Greenhouse Challenge Plus program is a voluntary program enabling Australian companies to form working partnerships with the Government to improve energy efficiency and reduce GHG emissions. Santos is a member of Greenhouse Challenge Plus and is required to:

- Measure and monitor GHG emissions;
- Deliver maximum practical GHG abatement;
- Continuously improve management of GHG emissions and sinks;
- Works towards any specific milestones set out under individual agreements;
- Provide timely annual reports with agreed content on GHG emissions and emission reduction activities;
- Make an accurate annual statement about participation in the program including basic GHG emissions information;
- Promote industry participants' activities in terms of GHG management and importantly in terms of their membership in the program; and
- Participate in independent verification of annual progress reports.

Santos is a member of the Greenhouse Challenge Plus program, and the GLNG Project will therefore be included in Santos' Greenhouse Challenge inventories and reporting.

6.9.3.2 Queensland Policy and Initiatives

The Queensland Government created the Office of Climate Change in October 2007 in order to lead the development of a whole-of-government policy framework to meet the challenge of climate change. The GLNG Project will need to adhere to any Queensland Government requirements.

ClimateSmart 2050

ClimateSmart 2050 establishes Queensland's long term climate change goals and provides a platform for the Queensland Government, the community and industry to move to a low carbon future. It is the short, medium and long-term plan designed to improve Queensland's emissions profile and contribute to the national target of reducing GHG emissions by 60 % below 2000 levels by 2050. Its initiatives include:

- The investment of $55 million in the Smart Energy Savings Program which target will require large energy users to undertake energy efficiency audits and implement energy savings measures that have a three year or less payback period;
- The allocation of $300 million from the Queensland Future Growth Fund to develop clean coal technologies; and
- Changes to the Queensland Gas Scheme which will require major industries to source 18 % of all power from Queensland based gas-fired generation.

6.9.3.3 Santos Policy and Initiatives

Santos has a range of projects based on producing natural gas which play a pivotal role in helping Australia's economy move to a cleaner energy portfolio. Natural gas has approximately half the emissions intensity and only uses a minute fraction of the water that coal-fired electricity requires. This is more fully discussed in Section 6.9.5.8.

Santos is involved in the following programs and initiatives:

- Santos is a member of the Australian Business and Climate Change Group, which comprises nine major organisations that have come together to identify how Australia can accelerate the development and deployment of low emission technologies. The group is seeking to stimulate debate in Australia between government, industry and the community to determine appropriate policies and measures to trigger a transformation of the energy market towards low emission technologies, while leveraging national comparative advantage.
- Santos remains a supporter of efforts to develop Carbon Capture and Storage (CCS) technology, as reflected in our support for the Prime Minister's Global Carbon Capture and Storage Institute, and our innovative efforts to develop projects such as the Moomba Carbon Storage (MCS) project. The MCS Project has the long-term objective of establishing a large-scale underground carbon storage hub at Moomba. The storage facility could eventually store up to 20 million tonnes of CO_2 per year and 1 billion tonnes over the life of the MCS Project. By injecting CO_2 into the depleted and/or depleting oil and gas reservoirs of the Cooper Basin, it could provide a secure storage solution for major carbon emitters in Queensland, New South Wales and South Australia.

Santos' Climate Change Policy states:

Our Climate Change Vision:

"Santos will lower the carbon intensity of its products"

Climate change is a long-term issue, requiring urgent but informed action to stabilise atmospheric greenhouse gas concentrations. As a global stakeholder in the energy business we recognise that one of our key social and environmental responsibilities is to pursue strategies that address the issue of climate change.

To achieve these commitments we will:

- Continue to reduce the carbon intensity of Santos' products by focusing on energy efficiency, technology development and by embedding a carbon price in all activities.
- Use energy more efficiently by identifying opportunities to implement energy efficiency projects and report their progress.
- Examine the commercial development of low emission technologies, including storage solutions, which will contribute towards long-term aspirational greenhouse gas emission reduction targets.
- Pursue no flaring or venting of associated gas, unless there are no feasible alternatives.
- Continue to publicly disclose Santos' greenhouse emissions profile and carefully examine forecast emissions.
- Understand, manage and monitor climate change risk and develop appropriate adaptation strategies for our business.
- Assist governments and engage with other stakeholders on the design of effective and equitable climate change regulations and policy.

Santos will inform employees about its commitment to climate change and ensure climate change initiatives continue to be implemented. The Santos Board will review progress against this policy quarterly.

As reported in its 2007 Sustainability Report, Santos is currently on track to meet its previous GHG emissions intensity reduction target of 20 % reduction from 2002 levels by 2008. This has been achieved by continuing participation in a number of projects including the Yellowbank Gas Flare project in partnership with Origin Energy and numerous energy efficiency improvements throughout Santos operations.

6.9.4 Existing Environmental Values

6.9.4.1 Emissions Sources

The Scope 1 emission sources from the CSG fields included in this inventory are:

- Fuel consumption in process equipment;
- Diesel fuel consumption in vehicles for all stages of the GLNG Project;
- Flaring and venting of gas;
- Fugitive emissions of gas from process equipment and drilling activities; and
- Land clearing during all stages of the GLNG Project.

Scope 2 emissions are considered to be immaterial as there will be no significant purchases of electricity for the CSG field operations. Field operations will primarily be gas or diesel-powered.

GHG emissions have been estimated for drilling activities on both an average annual basis and a total lifetime basis. The estimates assume that drilling activities continue for 25 years in Roma, 12 years in Arcadia Valley and 16 years in Fairview. All CSG field compressor stations have been assumed to operate for the entire 25 year life span of the GLNG Project.

Carbon sequestration due to rehabilitation of cleared areas has not been included in the inventory.

GHG emissions for construction of the field have not been separately accounted for, as the construction of wells will be ongoing throughout the life of the project. These emissions have been incorporated into the emissions during operation of the CSG fields.

Fuel Consumption in Process Equipment

Field process equipment consists of the gas compressor stations along the infield gas gathering pipelines, which connect the CSG wells to the main gas transmission pipeline. These compressors are powered by various engines running on gas taken from the product stream. Emissions estimates from the compressor stations were provided by Santos.

Drilling rigs used in well construction have been included in this category for ease of reporting. An average rate of diesel fuel consumption per well during drilling in each CSG field was provided by Santos based on operating experience.

Electrical power generation for the compressor stations will be provided by the compressor engines and have also been included in this category. These emissions have been captured under “fuel consumption in process equipment”. Electrical power needs for the remainder of the field operations are assumed to be immaterial.

Fuel Consumption in Vehicles

Diesel fuel is consumed by vehicles during well drilling, exploration and operations. Estimates of diesel fuel consumption per well drilled were provided by Santos field personnel. These estimates were combined with the schedule of drilling provided to calculate both annual and total GHG emissions from drilling equipment. No information was available on fuel consumption during exploration or operation of the CSG fields.

Flaring and Venting

Gas will be flared during drilling activities and well development, before the well is connected to the in-field gathering pipeline network, to reduce the GHG impacts from fugitive gas releases. Flaring and venting will be minimised as much as practical. Flaring will convert the GHG content of the released gas from CH_4 to CO_2 which has a lower GWP. Santos has provided an average flaring rate for well development activities based on its experience.

Of the 12 compressor stations assessed, 10 included flares which will be utilised in the case of emergency shutdown or maintenance. The remaining two will use cold vents, which will vent the gas stream directly to the atmosphere without flaring. The cold vents will only be used in case of emergency shutdown or maintenance.

Fugitive Emissions

Minor amounts of gas will be lost to the atmosphere during well development and operation, as well as from the in-field gas gathering pipeline network and associated equipment. Venting of gas may take place during well drilling, though flaring will be preferred if at all possible due to its reduced GHG impact. A conservative estimate of 0.1 % gas lost has been made, based on industry accepted practices.

Land Clearing

Trees and other vegetation metabolise carbon and store a portion of it as permanent, woody biomass as they grow. When vegetation is cleared the stored carbon is typically lost to the atmosphere as CO_2 along with small amounts of carbon monoxide (CO) and CH_4. Estimates of the area of cleared land resulting from the GLNG Project have been provided by Santos. This information, as well as vegetation studies, was inputted into the FullCAM model from the Department of Climate Change's National Carbon Accounting Toolbox.

The estimate of the GHG emissions from land clearing has been based on a worst case scenario of the amount of land clearing and the types of vegetation present for each well lease. For the CSG fields, it was assumed that Santos will clear all vegetation (assumed to be mature Eucalypt woodland) surrounding all drilling locations. In practice, however, Santos will avoid land clearing to the greatest extent possible by actively seeking drilling locations that have already been cleared and minimising the land clearing in areas where it is required. The assessment is based on a cleared area of 4 ha for each well lease, which represents the maximum footprint including construction laydown areas, access road construction and other activities that will not be required at all locations. Cleared areas will generally be much smaller than 4 ha, as detailed in the project description which notes that appraisal and operational wells are typically no more than 1.1 ha. However, the assessment is based on a worst case clearing scenario of 4 ha for each site. Further, the evaluation of GHG emissions from land clearing does not account for the revegetation of the well lease once the well is operational or on final decommissioning of the site.

6.9.4.2 Emission Factors

Detailed engineering calculations of emission rates have been provided for most of the major sources in the CSG field operations based on the figures for existing operations. For the remaining sources, emission factors (the amount of GHG emissions per unit of activity) have been used in accordance with the methodology set out in the Protocol.

Emission factors used to calculate GHG emissions (as CO_2-e) from the combustion of diesel and natural gas have been sourced from the NGA Factors as indicated in Table 6.9.1 below.

Table 6.9.1 Emission factors used in the Formation of the Project GHG Inventory

Emission Source	Emission Factor	Units	Source
Scope 1 Emissions			
Combustion emission factor diesel	2.7	t CO_2-e/kL	NGA Factors. Table 4, (fuel combustion for transport)
Consumption of Natural Gas (or CSG) – Queensland	51.3	t CO_2-e/GJ	NGA Factors. Table 2 (consumption of natural gas)

Emission factors for the carbon loss associated with land clearing activities specific to locations in the CSG field areas were obtained using FullCAM in combination with data on vegetation types and amounts in those locations. Specific emission factors are as follows:

- 42.25 t C/ha (155 t CO_2-e/ha) for the Roma area;
- 43.41 t C/ha (159 t CO_2-e/ha) for Fairview; and
- 26.09 t C/ha (96 t CO_2-e/ha) for Arcadia Valley.

Estimates of release rates for elemental carbon (C) were converted to CO_2-e by using the molecular weights of CO_2 and C (44 and 12, respectively).

6.9.4.3 Summary of Scope 1 and Scope 2 Emissions

These are calculated using estimates including values for diesel fuel consumption per well drilled, amount of gas flared, amount of land cleared per well during well construction, and the types and number of engines in field compressor stations. Field GHG emission rates are average values as field operations will vary from year to year, with drilling starting at different times in Roma, Fairview and Arcadia Valley as well as continuing for different lengths of time in each field. Emission rates were therefore calculated on a "per well" basis then multiplied by the average number of wells drilled per year in each field to provide an overall average.

CSG field emissions have been assumed to be the same for all facility designs. Calculations of GHG emission rates per well from diesel fuel consumption are shown in Table 6.9.2 below.

Table 6.9.2 Average GHG Emissions per Well from Fuel Consumption during Drilling

Location	Activity	Diesel Consumed (L)	Emission Factor (t CO_2-e/kL)	Emissions (t CO_2-e per well)
Fairview	Vehicles	9,250	2.7	25
	Process Equipment	22,000	2.7	59
Roma	Vehicles	9,250	2.7	25
	Process Equipment	16,200	2.7	44
Arcadia Valley	Vehicles	9,250	2.7	25
	Process Equipment	16,200	2.7	44

Emissions from flaring were calculated using a base assumption of 1 MMscf of gas flared per well during construction. This figure was converted to GJ of gas flared and multiplied by the emission factor for gas consumption in Table 6.9.2 to give an emission rate per well.

For modelling purposes, Santos estimates a maximum of 4 ha of land is cleared per well, including access roads and pipeline easements. This clearing activity will take place as the wells are progressively developed over the duration of the CSG field development program.

Scope 1 emissions from compressor stations were calculated in a separate study provided by Santos and are based on the total amount of gas compressed, the fuel gas usage per unit of gas compressed and the precise composition of the fuel gas.

Electrical power consumption in the CSG fields will be minimal and primarily occurring at the compressor stations, where it will be generated on site rather than taken from the grid. Emissions from the on site power generation have been captured as Scope 1 as described above. Consequently Scope 2 emissions in the field have been assumed to be immaterial.

Each train in the LNG facility will require 5,300 PJ of gas delivered from the CSG fields. For the 3 Mtpa case this has been assumed to require 2,650 wells (see Section 3.6 for further details) in the RFD area. This assumption is highly conservative and intended to encompass the significant uncertainties regarding actual gas production rates present in the field development program. While it is likely that far less than 2,650 wells will ultimately be required for the 3 Mtpa case, the actual number required cannot be known until the field development program is substantially progressed. Should development in the RFD area provide more than 5,300 PJ, the excess could be used for supply to Trains 2 and 3.

Well development figures for the 10 Mtpa case are highly uncertain as they depend not only on production in the RFD area but also on future CSG field development areas about which little is known. Consequently, GHG emissions from the field for the 10 Mtpa case will be reported as a range of values. This range is based on an assumption of between 2,650 and 6,625 total wells being required to supply all three trains, with 6,625 wells being used as an extremely conservative figure intended to represent the worst case development that is highly unlikely to occur. The figure of 6,625 wells has been assumed only for the purposes of making an assessment of GHG emissions from the 10 Mtpa case and does not represent an estimate of the actual number of wells planned for the GLNG Project. As for the 3 Mtpa case, the final number of wells required for the 10 Mtpa case cannot be known until the field development program is complete.

The GHG inventory presented below assumes that the gas required for the 10 Mtpa case will be supplied from Santos-operated gas wells, hence GHG emissions are reported as Scope 1. Future gas needs may also be met through purchase of gas from other suppliers, which will result in a decrease in Scope 1 emissions but an increase in Scope 3 GHG emissions from the purchased gas. Since the extent of any gas purchase is currently unknown, all gas well development has been assessed as Scope 1 emissions.

GHG emission totals for the entire GLNG Project are presented in Table 6.9.3 as an average value over 25 years.

Table 6.9.3 Summary of Average Annual GHG Emissions during Operation (tonnes CO_2-e per year)

Project Section	Activity Type	Scope 1		
		3 Mtpa	10 Mtpa	
Facility	Fuel Consumption in Process Equipment	825,764	2,471,724	
	Power Generation	102,735	319,196	
	Fugitive Emissions	653	1,959	
	Flaring and Venting	233,570	679,642	
CSG fields [1]	Fuel Consumption in Process Equipment	1,401,047	1,401,047	3,502,618
	Fuel Consumption in Vehicles	3,549	3,549	8,873
	Fugitive Emissions	1,486	1,486	3,715
	Flaring and Venting	23,994	23,994	59,985
	Land Clearing	57,902	57,902	144,755
Total		**2,650,700**	**4,960,500**	**7,192,467**

[1] CSG field emissions for the 10 Mtpa case will be revised for Train 2 and 3 gas (10 Mtpa case) for both Scope 1 and Scope 3, if relevant, when the detailed well field development program is available. The estimated minimum and maximum range of GHG emissions are presented in this table, as described in the text.

A summary of the total GHG emissions resulting from construction activities for the LNG facility and the pipeline are presented in Table 6.9.4 and Table 6.9.5 respectively, for emissions over the duration of construction. The methodology for these emissions is presented in Sections 8.9 and 7.9 respectively. Field construction activities are not included as they will continue over most of the life of the project and are thus better presented as annual emissions in Table 6.9.6. LNG facility construction emissions are reported for both the base case, which includes construction of a bridge to Curtis Island, and the option of no bridge. Construction of the pipeline also involves two options, with an option of replacing some truck movements for delivery of construction materials with rail movements. Only emissions for Scope 1 and Scope 2 are reported here, as both the delivery trucks and the rail are considered as Scope 3 emissions.

Table 6.9.4 Total Scope 1 Greenhouse Gas Emissions from Construction of the LNG Facility (tonnes CO_2-e)

Construction scenario	Emissions Source	3 Mtpa Scope 1	10 Mtpa Scope 1
Bridge (Base Case)	Facility Construction Equipment	38,000	76,000
	Accommodation	13,738	27,476
	Land Clearing	30,184	30,184
	Passenger Ferry	11,621	23,242
	Barge Transport, Facility Materials	16,140	32,280
	Bridge Construction Equipment	8,133	8,133
	Transport, Bridge Material	8,076	8,076
	Subtotal	**125,892**	**205,391**
Barge Option	Facility Construction Equipment	38,000	76,000
	Accommodation	13,738	27,476
	Land Clearing	30,184	30,184
	Passenger Ferry	11,621	11,621
	Barge Transport, Facility Materials	16,140	16,140
	Subtotal	**109,683**	**161,421**

Table 6.9.5 Total Scope 1 and Scope 2 Greenhouse Gas Emissions from Construction of the Pipeline (tonnes CO_2-e)

	Scope 1 Emissions	Scope 2 Emissions
Construction Equipment	2,962	0
Land Clearing	171,588	0
Accommodation	0	4,095
Total	**174,550**	**4,095**

Greenhouse emissions were also calculated as a total over a 25 year period in order to capture the project's full impact and eliminate the averaging used to produce the annual emission rates. Values for two possible development scenarios are presented in Table 6.9.4 including the base case of building an access bridge to Curtis Island and the option of not building the bridge. Development of the facility will be staged, with the initial 3 Mtpa configuration operational by 2014, the second stage operational for 4 years and the final 10 Mtpa configuration operational as early as 2022. The figures given here for estimating the emissions over the project lifetime account for the current projections of the project development schedule.

Scope 2 emissions are not included for the project operation as they are immaterial in the context of total emissions.

Table 6.9.6 Total Greenhouse Gas Emissions over Project Lifetime during operation (tonnes CO_2-e)

	Scope 1	
	3 Mtpa	10 Mtpa [1]
Base Case – Bridge	66,449,911	110,367,394 - 165,989,546
No Bridge Option	66,433,702	110,351,185 - 165,973,337

[1]. The estimated minimum and maximum range of GHG emissions are due to uncertainty in the CSG field emissions, as detailed in Section 6.9.4.3.

6.9.4.4 Summary of Scope 3 Emissions

For this project, Scope 3 emissions from construction, transport to and operation of the LNG facility and end use have been investigated and indicative estimates developed using numerous assumptions. Scope 3 construction and operation emissions have been estimated for four scenarios, encompassing options for not constructing a bridge to Curtis Island and using rail to deliver materials to laydown points along the pipeline ROW. These emissions have been calculated as total emissions based on a 25 year project lifespan and are shown below in Table 6.9.7.

Table 6.9.7 Total Scope 3 Emissions from Construction and Transport (tonnes CO_2-e)

Scenario	3 Mtpa	10 Mtpa
Bridge, no rail	24,612	37,390
Bridge, rail	23,047	35,825
No bridge, no rail	19,415	19,415
No bridge, rail	17,850	17,850

The majority of Scope 3 emissions from the GLNG Project are due to the end use of the gas, most likely by retail consumers or for electricity generation. The most likely destinations for export of the LNG are in Asia, specifically Japan, China and Korea. An indicative estimate of Scope 3 emissions resulting from transport of the GLNG product to Japan and combustion in a power plant has been made. The estimates provided in Table 6.9.8 assume a one-way distance of roughly 5,950 km from Gladstone to Japan and make use of emission factors published in the National Greenhouse Gas Inventory from Japan.

Table 6.9.8 Scope 3 Emissions due to Transport and Combustion of GLNG Product

Scope 3 Activity	3 Mtpa Case (tonnes CO_2-e/year)	10 Mtpa Case (tonnes CO_2-e/year)
Transport	312,182	936,545
Combustion for Power Generation	20,205,000	67,350,000

For the purpose of comparison, emissions from the combustion of coal and oil in Japan to produce the equivalent amount of power as for the 3 Mtpa and 10 Mtpa cases were estimated. The results are shown in Table 6.9.9.

Table 6.9.9 Comparative Scope 3 Combustion Emissions

Scope 3 combustion source	3 Mtpa Case Equivalent (tonnes CO_2-e/year)	10 Mtpa Case Equivalent (tonnes CO_2-e/year)
LNG	20,205,000	67,350,000
Oil	34,130,000	113,800,000
Coal	43,920,000	146,400,000

6.9.4.5 Australian Emissions

The National Greenhouse Gas Inventory 2006 (National Inventory) provides the latest estimates of Australia's GHG emissions based on the accounting rules that apply to Australia's target under the Kyoto Protocol. The National Inventory has been prepared in accordance with the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* and the principles of the IPCC 2000 *Good Practice Guidance for Land Use, Land Use Change and Forestry.* Where appropriate, elements of the 2006 IPCC *Guidelines for National Greenhouse Gas Inventories* have been progressively implemented. The IPCC guidance defines six sectors that represent the main human activities that contribute to the release or capture of GHGs into or from the atmosphere:

1) Energy;
2) Industrial Processes;
3) Solvent and Other Product Use;
4) Agriculture;
5) Land Use, Land Use Change and Forestry (LULUCF); and
6) Waste.

Australia's net GHG emissions across all sectors totalled 576 Mt CO_2-e in 2006, with the energy sector being the largest emitter at 400.9 Mt CO_2-e. Emissions from LNG facilities are captured under the energy category of the IPCC methodology. Approximately 34.5 Mt of energy sector emissions were attributable to fugitive emissions, representing approximately 6 % of national emissions.

Table 6.9.10 shows average annual Scope 1 emissions from the GLNG Project as a percentage of Australian energy sector emissions and total Australian emissions taken from the National Inventory. The figures shown for the 10 Mtpa case will not start until approximately 2022 and represent an overestimate of the GLNG Project's contribution to Australian emissions when compared to 2006 data based on current growth in Australian emissions.

Table 6.9.10 GLNG Project GHG Emissions as a Percentage of Australian Emissions in 2006

	Scope 1	
	3 Mtpa	10 Mtpa
Australian Energy Sector Emissions	0.66 %	1.24 % - 1.79 % [1]
Total Australian Emissions	0.46 %	0.86 % - 1.25 % [1]

[1]. The estimated minimum and maximum range of GHG emissions are due to uncertainty in the CSG field emissions, as detailed in Section 6.9.4.3.

6.9.4.6 Queensland Emissions

Table 6.9.11 shows average annual Scope 1 emissions from the GLNG Project as a percentage of Queensland energy sector emissions taken from the *State and Territory Greenhouse Gas Inventories 2006.*

Queensland total emissions were 170.9 Mt CO_2-e and energy sector emissions were 94.9 Mt CO_2-e. The operation of the 10 Mtpa case will not commence until approximately 2022, and these data represent an overestimate of the GLNG Project's contribution to Queensland emissions when compared to 2006 data based on current growth in Queensland GHG emissions.

Table 6.9.11 GLNG Project GHG Emissions as a Percentage of Queensland Emissions

	Scope 1	
	3 Mtpa	10 Mtpa
Queensland Energy Sector Emissions	2.79 %	5.23 % - 7.58 % [1]
Total Queensland Emissions	1.55 %	2.90 % - 4.21 % [1]

[1]. The estimated minimum and maximum range of GHG emissions are due to uncertainty in the CSG field emissions, as detailed in Section 6.9.4.3.

6.9.5 Potential Impacts and Mitigation Measures

6.9.5.1 Impact of the Project on Queensland Emissions Targets

The Queensland government has committed to contribute to the national target of reducing GHG emissions by 60 % below 2000 levels by 2050. This equates to a reduction of approximately 98 Mt CO_2-e.

At peak average annual GHG emissions, Scope 1 emissions from the GLNG Project will be 5.0 – 7.2 Mt CO_2-e. These Scope 1 emissions will be equal to 2.9 % - 4.2 % of the state inventory. GLNG Project emissions are likely to have a small impact on the Queensland Government's emissions targets.

6.9.5.2 Impact of the Project on Emissions from Product Use

LNG is typically used for domestic gas supply (e.g. transport, cooking and heating) and industrial gas supply (e.g. manufacturing and power generation). No end-use contracts have been entered into by Santos, but it is expected that the LNG will be shipped to Asia, specifically Japan, China and Korea, for use in power generation and industrial settings. As a primary energy source, LNG has numerous benefits over competing fuels such as coal and oil including lower emissions of nitrogen oxides, sulphur dioxide, and particulate matter as well as lower GHG emissions. A recent life cycle analysis of power generation systems based on conditions in Japan calculated the emission factors in Table 6.9.12.

Table 6.9.12 Life Cycle CO_2 Emission Factors for power generation

Source Type	Direct Emission Factor (g CO_2/kWh)	Indirect Emission Factor (g CO_2/kWh)	Total Emission Factor (g CO_2/kWh)
Coal-fired	887	88	975
Oil-fired	704	38	742
LNG-fired	478	130	608
LNG-Closed Cycle	407	111	518

Based on the total emission factors above, a closed-cycle LNG power plant produces 53 % of the GHG emissions of an equivalent coal-fired plant and 70 % of an oil-fired plant.

The emission factors provided by the Department of Climate Change for burning black coal for electricity average 95.85 kg CO_2-e/GJ for the full fuel cycle. The average full fuel cycle emission factor for natural gas is 60.24 kg CO_2-e/GJ, or 63 % of the emission factor for coal.

Consequently, while emissions from the GLNG Project will lead to a small increase in Australian emissions, the net effect is a saving in global GHG emissions assuming the LNG displaces another more emissions-intensive fuel such as coal. The benefits of LNG in terms of ecologically sustainable development are discussed in Section 16.3.

6.9.5.3 Comparison with World Emissions

According to the UNFCCC, aggregate emissions from Annex I countries in 2005, including the contribution from LULUCF was approximately 16,700 Mt CO_2-e. Emissions from non-Annex I countries including LULUCF were 11,900 Mt CO_2-e in 1994, the most recent year for which data from non-Annex I countries is available.

Using these two figures, annual global GHG emissions can be estimated as 28,600 Mt CO_2-e. The GLNG Project's maximum GHG emissions are 5.0 Mt to 7.2 Mt CO_2-e operating at 10 Mtpa. This represents 0.017 % to 0.025 % of annual global GHG emissions.

6.9.5.4 Benchmarking GHG Emission Performance

Benchmarking facilitates the comparison of the emissions intensity (the ratio of the volume of GHG emissions produced for each tonne of LNG produced) to other LNG developments around the world.

Benchmark data is not widely published and where available, it is restricted to the emissions intensity of the LNG manufacturing alone. The data often does not represent the full suite of GHG emissions for a particular development as it does not include emissions from exploration or construction.

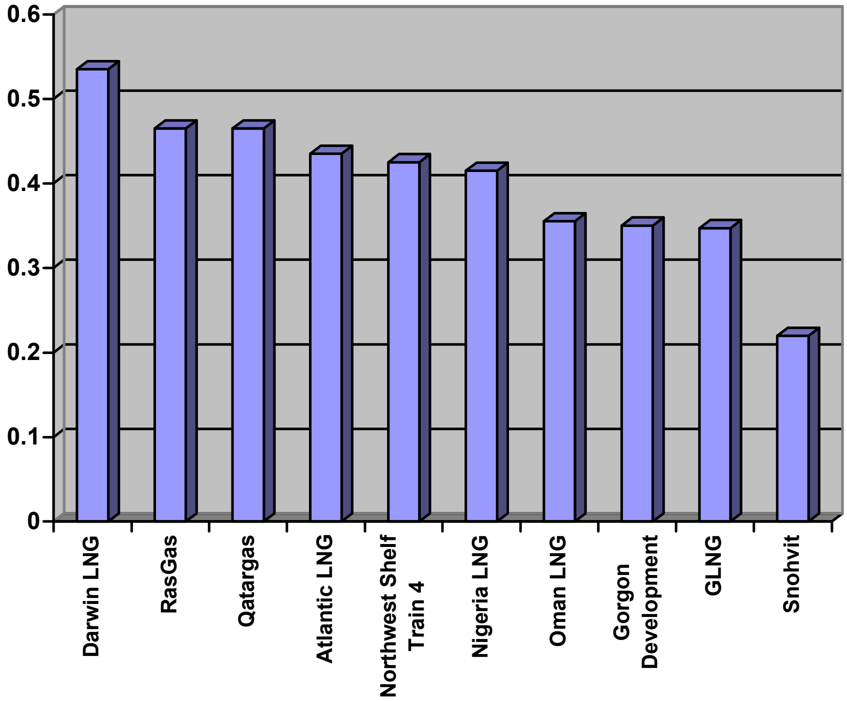
Emissions data from LNG facilities is variable for a number of reasons including:

- The complexity of the facility (e.g. number of equipment and power generation requirements);
- The degree to which GHG emissions from supporting infrastructure have been included in the estimates;
- The CO_2 concentration of the incoming gas stream; and
- The amount of CO_2 re-injection and the amount of energy required for re-injection.

GHG emission intensity is an industry recognized benchmark by which comparisons can be made between LNG facilities. A recent EIS for a similar LNG project in Australia documented the GHG emission intensity for LNG plants (Chevron Australia, 2005). These LNG facilities are designed with a range of operating conditions, as highlighted above, and thus direct comparisons between the facilities can only be taken as indicative of plant performance nor can the data be audited for completeness or accuracy. For the purpose of this report, the GHG emissions intensity has been compared with published data from the following developments:

- Northwest Shelf Train 4 Project – Australia;
- Darwin LNG Project – Australia;
- Gorgon Development – Australia;
- Snohvit – Norway;
- Oman LNG – Oman;
- Nigeria LNG – Nigeria;
- RasGas – Qatar;
- Qatargas – Qatar; and
- Atlantic LNG – Trinidad.

Figure 6.9.1 shows the LNG GHG emissions intensity of the LNG facility benchmarked against these other LNG facilities. The LNG efficiency includes reservoir CO_2 emissions vented to atmosphere.



Data source: Chevron Australia (2005)

Figure 6.9.1 Benchmarked GHG Efficiency (tonnes CO_2-e / tonne LNG)

The emission intensity of the LNG facility is estimated at 0.347 tonnes of CO_2-e per tonne of LNG produced. This efficiency is based on 10 Mtpa LNG production and includes only the emissions related to the production at the facility. As depicted in Figure 6.9.1, the GLNG emission intensity compares favourably against other worldwide LNG facilities including recent developments in Australia. The exception is the Snohvit facility, which is a Norwegian production facility that incorporates separation and subsurface injection of reservoir CO_2. Snohvit also has the advantage of a significantly cooler operating environment which results in more efficient turbine and LNG liquefaction operation.

6.9.5.5 Santos Mitigation Objectives

Santos has produced a comprehensive company policy on GHG emissions as detailed in Section 2.4. This policy consolidates the actions and values needed for Santos to meet its climate change obligations, both required and voluntary. The results of Santos' actions as well as ongoing and future efforts are reported in Santos' annual Sustainability Report, which is publicly available. This policy includes requirements for new projects, which are being followed during design and planning of GLNG; specifically:

- Require all operations to develop energy efficiency and greenhouse management plans with site-specific targets;
- Identify and promote opportunities for natural gas to replace higher GHG emitting fuels; and
- Carefully examine the forecast GHG emissions and energy use in planned new projects and acquisitions, to ensure emission intensity and energy efficiency levels are consistent with the Company's goals.

Santos has also produced a philosophy of design for the GLNG Project that explicitly requires that environmental considerations, including minimizing GHG emissions, be given priority in the design of the

GLNG Project. The requirements include both strict quantitative guidelines and general qualitative goals. As a result of this philosophy, careful analysis and planning of the GLNG equipment and processes made it possible to identify opportunities to reduce greenhouse emissions and improve energy efficiency. Some of the opportunities identified and incorporated into the design are as follows:

- Gas liquefaction processes that are highly efficient and minimise flaring of gas;
- High-efficiency compressor and power generation turbines at the LNG facility running on CSG, reducing energy consumption and reliance on coal-based electricity from the grid;
- Use of boil-off gas in the LNG facility as fuel rather than venting or flaring to improve overall plant energy efficiency;
- As part of the carbon dioxide removal process, careful selection of solvent to minimise the co-release of methane;
- One of the key factors in determining the GHG emissions from the LNG facility is the use of aeroderivative turbines for the LNG Facility due to the higher thermal efficiency and improved fuel efficiency compared to frame-type turbines that were traditionally used for gas compression in LNG plants, resulting in GHG emissions that are lower than the frame turbines;
- Gas-fired in-field pipeline compressor station engines (in place of diesel fuel) with the possibility of electrically powered compressor engines using power generated by Santos' own gas-powered generators; and
- Field operation protocols designed to minimise flaring, venting and other emissions sources.

Equipment to be installed at the LNG facility will be compared against best practice environmental performance as each stage undergoes the detailed FEED stage,to ensure that the most up-to-date technologies are used. In particular, this will focus on maximising the energy efficiency of operations and minimising the overall GHG emissions from the plant.

All actions undertaken and goals set to reduce greenhouse emissions at GLNG facilities will be assessed, reported and verified as required under the various agreements and programs of which Santos is a member as well as the company's policy. Emissions from GLNG operations will be reported and verified as well under NGER and Greenhouse Challenge Plus requirements.

It is the understanding of the LNG industry that the emissions trading scheme will recognise LNG as qualifying for Emissions Intensive Trade Exposed (EITE) Assistance, which will involve an allocation of free emissions units for approximately 60 % of emissions associated with LNG production. In these circumstances permits for the remaining approximate 40 % of the emissions units associated with LNG production would need to be purchased.

6.9.5.6 Queensland Mitigation Objectives

Queensland state climate change policies are briefly described in Section 6.9.3. Many of these programs are similar to national programs and Santos will be in compliance through participation in the EEO and Greenhouse Challenge Plus programs and reporting energy use and greenhouse emissions in accordance with NGER requirements. Additionally, state objectives include increasing the share of Queensland electricity produced in gas-fired generation to 18 % by 2020. As a major energy consumer that will generate nearly all of its own electricity from gas, GLNG will be assisting in reaching this goal.

6.9.5.7 International and National Mitigation Objectives

Under the Kyoto Protocol, Australia has committed to reducing national GHG emissions to a level equivalent to 108% of 1990 levels by 2008-2012. Australia is currently on track to meet its Kyoto commitments. However, the Government has also set a long-term target of a reduction in GHG emissions of 60% below 2000 levels by 2050.In order to meet this target, the Government has proposed the introduction of the CPRS. There is also in place the NGER Act, the EEO Act and the Greenhouse Challenge Plus program. The requirements of each of these initiatives have been presented in Section 6.9.3.

Santos is also registered with the EEO program, which requires thorough assessments of energy use patterns and opportunities for reduced energy consumption every five years. Santos registered in March 2007 and has submitted their EEO assessment and reporting schedule for this cycle. The GLNG Project will be included in EEO assessments, and will therefore be carefully examined for opportunities to reduce energy consumption in accordance with EEO guidelines and requirements. The EEO provides an assessment framework that is based on the Australian/New Zealand Energy Audit Standard (3598:2000) and includes six key elements that all assessments must address:

- Leadership support for the assessment and the improvement of energy use;
- The involvement of a range of skilled and experienced people, and people with a direct and indirect influence on energy use during the assessment process;
- Information and data that is appropriately, comprehensively and accurately measured and analysed;
- A process to identify, investigate and evaluate energy efficiency opportunities with paybacks of four years or less;
- Business decision making and planning for opportunities that are to be implemented or investigated further; and
- Communicating the outcomes of the assessment and the investment decisions made regarding the opportunities identified and proposed business response, to senior management, the board and personnel involved.

The results of EEO assessments are reported publicly and independently verified in conjunction with the Greenhouse Challenge Plus program.

Santos has been a participant in the voluntary Greenhouse Challenge program via the Australian Petroleum Production and Exploration Association (APPEA) since 1998, in the Greenhouse Challenge Plus program via APPEA since 2005 and as an individual member since 2007. As part of their Greenhouse Challenge Plus Cooperative Agreement, Santos has pledged to pursue a target of 20 % reduction from 2002 levels in greenhouse emissions intensity (tonnes of greenhouse emissions per tonnes of product) by 2008. Santos has steadily reduced its GHG intensity and as of the latest available report is forecast to meet its target. As part of their Cooperative Agreement, Santos is also committed to achieving effective emission reduction targets, to the pursuit of energy efficiency strategies and to the identification and implementation of opportunities to use either less greenhouse emitting or renewable sources of energy. This will be achieved through identifying and promoting opportunities for natural gas to replace higher GHG emitting fuels, investing in energy and process research and development and examining forecast GHG emissions for new projects and acquisitions.

6.9.5.8 Cumulative Impacts

Cumulative impacts are specific impacts in any particular location or region that can be attributed to the sum of past, current and reasonably foreseeable future activities in that location. Inherent in this concept is the assumption that emissions from a project can be shown to have specific and direct local impacts. Conversely, GHG emissions contribute to a global pattern of climate change for which there is currently no accepted method to determine a link between a specific project or group of projects and climate change impacts on a particular location. However, the GLNG Project will contribute to climate change through its GHG emissions and therefore can be considered to be a part of cumulative impacts on a global scale.

Predictions of Climate Change Impacts

The global pattern of climate change and contribution from cumulative anthropogenic sources are considered and discussed in the IPCC Assessment Reports, with discussion of these impacts on Australia appearing in the Garnaut Climate Change Review (2007), the CSIRO Climate Change in Australia report (2007), and in various documents published by the Department of Climate Change. These sources represent the scientific consensus on global and Australian impacts and form the basis for governmental action in Australia.

The IPCC's Fourth Assessment Report (FAR, 2007) finds that anthropogenic GHG emissions are very likely (90 to 99 % probability) to be responsible for most of the observed increase in global average temperatures since the mid-20th century. The FAR further states that many natural systems have been observed being affected by climate changes, especially temperature increases, with many more emerging as data is gathered and models improved. Projected impacts are provided for specific sectors, systems, and regions, with the following impacts projected for Australia:

- As a result of reduced precipitation and increased evaporation, water security problems are projected to intensify by 2030 in southern and eastern Australia.
- Significant loss of biodiversity is projected to occur by 2020 in some ecologically rich sites including the Great Barrier Reef and Queensland Wet Tropics. Other sites at risk include Kakadu wetlands, south-west Australia, sub-Antarctic islands and the alpine areas.
- Ongoing coastal development and population growth in areas such as Cairns and South-east Queensland are projected to exacerbate risks from sea-level rise and increases in the severity and frequency of storms and coastal flooding by 2050.
- Production from agriculture and forestry by 2030 is projected to decline over much of southern and eastern Australia due to increased drought and fire.
- The region has substantial adaptive capacity due to well-developed economies and scientific and technical capabilities, but there are considerable constraints to implementation and major challenges from changes in extreme events. Natural systems have limited adaptive capability.

The CSIRO report "Climate Change in Australia" combines the weighted results of 23 climate models to produce projected climate changes in Australia. These projections include different scenarios as developed by the IPCC, most notably a low emissions scenario (B1) and a high emissions scenario (A1F1), and therefore result in a range for most projections. The effects of these impacts can be further evaluated on various sectors of Australia, as has been done in the Garnaut Review. Specific sectors or areas considered include:

- Resource-based industries and communities;
- Critical infrastructure;
- Human health;
- Ecosystems and biodiversity;
- Changes in demand and terms of trade;
- Geopolitical stability;
- Catastrophic events as affect Australia; and
- Severe weather events in Australia.

Full discussion of the impacts on all of these sectors is beyond the scope of this report, but impacts on Queensland assuming no mitigation of GHG include severe damage to coral populations in the Great Barrier Reef and extreme infrastructure impacts on coastal settlements due to increased storm surge and localised flash flooding by 2100.

Santos' contribution to global GHG emissions is very small, less than 0.025 % under the most conservative estimate for the 10 Mtpa case. Santos will mitigate the project's contribution to cumulative climate change impacts through measures including:

- Participation in the CPRS;
- Implementation of energy efficiency measures throughout the project life; and
- Continuous improvement in the efficiency of extracting CSG.

Table 6.9.13 below provides a summary of potential GHG impacts and mitigation measures for the CSG fields.

Table 6.9.13 Potential GHG Impacts and Mitigation Measures

Aspect	Potential Impact	Mitigation Measures	Objective
Construction			
Significant GHG emissions.	Generation of GHG into the atmosphere.	• Monitor and maintain infrastructure and equipment. • Participate in the national greenhouse and energy reporting system and carbon pollution operating scheme. • Continue to meet Santos' GHG intensity reduction target.	Reduce GHG emissions.
Well blow out.	Uncontrolled release of CSG into the atmosphere.	• Ensure a Blow out Preventer (BOP) is implemented on site in conjunction with a flare. • Ensure appropriated processed and procedures are development and implemented for dealing with such an event on site. For example appropriate Job Safety Analysis (JSA) and Santos Standard Operating Procedures (SOP). • Ensure competence of drillers and operators.	Reduce GHG emissions.
Operation			
Significant GHG emissions.	Generation of GHG into the atmosphere.	• Refer to the construction section above.	Reduce GHG emissions.
Well blow out.	Uncontrolled release of CSG into the atmosphere.	• Refer to the construction section above.	Reduce GHG emissions.
Decommissioning			
Significant GHG emissions	Generation of GHG into the atmosphere.	• Refer to the construction section above.	Reduce GHG emissions.
Well blow out.	Uncontrolled release of CSG into the atmosphere.	• Refer to the construction section above.	Reduce GHG emissions.

6.9.6 Summary of Findings

Total Scope 1 GHG emissions for the LNG facility operating at 3 Mtpa averaged 2.6 million tonnes CO_2-e a year and total 66.4 million tonnes of CO_2-e over 25 years for the base case. This represents 0.46 % of annual Australian emissions and 1.55 % of Queensland emissions. For the LNG facility operating at 10 Mtpa, the annual average GHG emissions are estimated to be between 4.96 million tonnes and 7.19 million tonnes of CO_2-e and total emissions are 110.4 to 166.0 million tonnes of CO_2-e over 25 years. This represents 0.86 – 1.25 % of annual Australian emissions and 2.9 – 4.2 % of Queensland emissions. While the GLNG Project will be a relatively large producer of GHG emissions, Santos has taken steps at every point to reduce emissions. This is reflected in the benchmarking results which place GLNG in the ranks of the most GHG efficient LNG facilities in the world. Additionally, LNG is in itself a low-emissions fuel, producing roughly half the GHG emissions of coal when used to produce an equivalent amount of power. Consequently, the GLNG Project represents a lower power generation GHG emissions intensity should its product be used in place of other fossil fuels such as coal or oil.

Santos remains a supporter of efforts to develop CCS technology.