10

GREENHOUSE GAS EMISSIONS

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10 Greenhouse Gas Emissions

This chapter provides a description of the Greenhouse Gas (GHG) emissions that will be released as a result of the Project. The legislative and policy context, emissions estimation methodologies, emissions sources and likely impacts are described and discussed. The chapter also describes the abatement, management and mitigation commitments required by Arrow to minimise GHG emissions released from the Project.

The objectives of the assessment have been determined to meet the Project ToR. The primary objectives are:

- To estimate the GHG emissions resulting from construction, operation and decommissioning of the Project;
- Describe the potential impact of these emissions; and
- To identify methods to reduce or mitigate GHG emissions.

The impact of climate change on the Project is described in the Climate chapter (Section 8) of this EIS.

A cross reference to the locations where each of the requirements of the ToR has been addressed is given in Appendix B which references both the study chapters (Sections 1 through 34) and/or the Appendices (A through EE).

10.1 Legislative and Policy Context

10.1.1 International Legislation and Policy

10.1.1.1 The Kyoto Protocol

The Kyoto Protocol to the United Nations Framework Convention on Climate Change was signed in 1997 and entered into force in 2005. Australia ratified the Kyoto Protocol in December 2007. Its aim is to limit GHG emissions of countries that ratified the protocol by setting mandatory GHG emission targets in relation to those countries' 1990 GHG emissions. Australia has committed to meeting its Kyoto Protocol target of a maximum increase of 8% of 1990 emissions by 2008-2012.

10.1.1.2 The Copenhagen Accord

An international framework for mitigating the impacts of climate change after the Kyoto period was discussed at the 15th United Nations Conference of Parties (COP), Copenhagen, in December 2009. It concluded with an agreement that global temperature rise should be capped through significant emission reductions under the 'Copenhagen Accord' (the Accord). In January 2010, Australia officially presented its full target range under the Accord. However, the Accord is not legally binding to the extent of the Kyoto Protocol and the specification of national emissions reduction commitments for the period 2012-2020 are subject to further negotiation.

10.1.1.3 The Cancún Agreements

In 2010, the 'Cancún Agreements' (the Agreements) were developed at the 16th United Nations COP. While not legally binding, the Agreements anchor the mitigation pledges made by both developed and developing countries in the Accord under the United Nations Framework Convention on Climate Change (UNFCCC). This is seen as an important step in securing a new global treaty to replace the Kyoto Protocol post 2012. The COP also established a new Green Climate Fund to support developing countries with climate change adaption, and technology sharing mechanisms.

10.1.2 Australia's Climate Change Legislation

This Project will operate in accordance with the following climate change legislation: *National Greenhouse and Energy Reporting Act 2007* (NGER Act), the *Clean Energy Act 2011* and the *Energy Efficiency Opportunities Act 2006* (EEO Act).

10.1.2.1 The National Greenhouse and Energy Reporting Act 2007

The NGER Act established a national framework for Australian corporations to report GHG emissions, energy production, energy consumption and other data as required under the regulations following prescribed methodologies. This reporting requirement was introduced to provide a foundation for the establishment of a carbon price. Data reported in line with the requirements of the NGER legislation form the basis of Carbon liability under the Carbon Pricing Mechanism in the *Clean Energy Act 2011*.

Corporations have been required to register and report if:

- They control facilities that emit 25 kilotonnes (kt) or more of GHG (CO_2-e), or produce / consume 100 terajoule (TJ) or more of energy annually; or
- Their corporate group emits 125 kt or more GHG (CO_2-e), or produces / consumes 500 TJ or more of energy annually.

10.1.2.2 The Clean Energy Act 2011

The *Clean Energy Act 2011* provides a mechanism for Australian facilities to tackle climate change by encouraging the use of clean energy. The *Clean Energy Act 2011* will be implemented through the Australian Governments' Clean Energy Plan (CEP). The CEP incorporates a Carbon Pricing Mechanism (CPM), which is intended to impose a cap on emissions from covered sectors of the economy.

10.1.2.2.1 The Carbon Price Mechanism

The objective of the CPM is to diversify Australia's electricity generation by encouraging investment in renewable energy like wind and solar power but by also encouraging the use of cleaner fuels like CSG. From July 2012, eligible industries in Australia are required to pay for every tonne of covered GHG emissions released to the atmosphere. Covered GHG emissions emitting proponents, which includes Arrow, will be required to hold permits (each permit is the right to emit 1 tonne CO_2-e) equivalent to their covered GHG emissions during the compliance year. The CPM will operate in two

phases: a fixed price phase that commenced on 1 July 2012 and a floating price phase that will commence July 2015.

- For the first three years, **a fixed price stage will** operate with the price of all carbon permits set by the government. The carbon price will start at AUD 23 per tonne and rise by 2.5% a year allowing for an estimated inflation rate of 2.5%. During this fixed price period, businesses will be able to acquire as many permits at the set price as required to meet their obligations. Australia's carbon price will not be linked to international carbon markets during the fixed price period.
- A **flexible cap and trade emissions trading scheme** will follow the fixed price stage. However, before the flexible price period, the Government will set annual caps on covered GHG emissions for the first five years, which will be extended each year to assist businesses planning their strategy for compliance. Then a variable price as part of a 'cap and trade' system will be implemented where the carbon price will be set by the market. During the flexible price period, an unlimited amount of eligible Australian Carbon Credit Units can be surrendered for compliance, as opposed to the 5% limit set for the fixed price period.

The Clean Energy Plan is expected to cut pollution by a minimum of 5% below 2000 levels by 2020 and by 80% below 2000 levels by 2050.

The reporting threshold for facilities will be identical to that employed for NGER reporting. Facilities emitting more than 25 kt CO_2-e/year of covered emissions - (covered emissions exclude emissions from transport fuels and some synthetic GHGs) will be required to hold permits equivalent to emissions for year reporting period.

10.1.2.2.2 Implications for the Project

As part of the stationary energy sector, Arrow is a large supplier of gas and currently subject to NGER and will be a direct participant in the carbon price mechanism. This means that Arrow must report its emissions and hold emission permits equivalent to the emissions for each reporting period. As the cost of permits fluctuate, it may be more economically viable to pursue emission mitigation and avoidance measures than to obtain permits for all emissions. The extent of emissions reductions will largely be determined by market forces.

10.1.2.3 The Energy Efficiency Opportunities Act 2006

The EEO Act came into effect in July 2006 and Energy Efficiency Opportunities (EEO) will continue to run in conjunction with the CEP until at least 2016. The EEO requires large energy users (over 0.5 petajoules (PJ) of energy consumption per year) to participate in the program. The objective of this program is to drive ongoing improvements in energy consumption amongst large users and businesses are required to identify, evaluate and report publicly on cost effective energy savings opportunities under the EEO Act.

Arrow is registered with the EEO program and is therefore required to assess energy use patterns and opportunities for reduced energy consumption every five years. This will provide Arrow with opportunities to reduce energy consumption in accordance with EEO guidelines and requirements.

10.1.3 State Legislation and Policy

As a producer of GHG in Queensland, the Project will need to adhere to any requirements and guidelines promulgated by the Queensland Government. Details of these are provided below:

10.1.3.1 ClimateSmart 2050 (currently under review)

ClimateSmart 2050 is the Queensland Climate Change Strategy. It aims to reduce GHG emissions by 60% from 2000 levels by 2050 in line with the national target by building initiatives into the Queensland Government's *2000 Energy Policy*. Its initiatives include:

- The introduction of a Smart Energy Savings Program, which targets large energy users and requires them to undertake energy efficiency audits and implement energy savings measures that have a three year or less payback period;
- The Queensland Future Growth Fund for development of clean coal technologies; and
- Changes to the Queensland Gas Scheme, which will oblige major industries to source 18% of all power from Queensland based gas-fired generation.

10.1.3.2 ClimateQ (currently under review)

ClimateQ: toward a greener Queensland presents the next phase in Queensland's response to the challenge of climate change. The strategy presents investments and policies to ensure Queensland remains at the forefront of the national climate change response. One of the key policies in this strategy is that the approval of new coal-fired power stations will be conditional on meeting criteria relating to GHG emissions. These conditions include no approval for a new coal-fired power station unless:

- It uses world's best practice low emission technology in order to achieve the lowest possible levels of emissions; and
- It is carbon capture and storage (CCS) ready and will retrofit that technology within five years of CCS being proven on a commercial scale.

10.1.3.3 Queensland Gas Scheme

The Queensland Gas Scheme (QGS) began in 2005 and was established to boost the state's gas industry and reduce GHG emissions. Under the scheme, Queensland electricity retailers and other liable parties offered subsidies to source a prescribed percentage of their electricity from gas-fired generation instead of coal.

The scheme has operated successfully to diversify the state's energy mix towards the greater use of gas, and to reduce GHG emissions from the Queensland electricity sector. In particular, the policy's original requirement was that at least 13% of electricity sold in Queensland be from gas-fired generation, with an option to increase the target further to 18% by 2020. In the ClimateSmart 2050 strategy (Queensland Government, 2007), the Queensland Government announced its intention to transition the QGS into a national emissions trading scheme (ETS) as soon as practicable, provided the impact of an ETS on gas-fired generators is consistent with the intent of the scheme.

A summary of the relevant policies relating to emissions of GHGs and electricity consumption / generation from the Project is presented in Table 10–1.

Table 10-1 GHG Emissions Policies Relevant to the Project

Level	Policy	Project Participation
International	Kyoto Protocol	**None** As the Project is planned to be commissioned after 2013, emissions will not count towards Australia's Kyoto target for the 2008-2012 period.
Australia	NGER	**Mandatory** Arrow already participates in NGERs and will have to annually report GHG emissions and energy consumption / production associated with the Project.
	EEO Program	**Mandatory** It is expected that Arrow will report energy usage and energy efficiency opportunities associated with the Project.
	Carbon Price Mechanism	**Mandatory** Arrow is a participant in the Carbon Price Mechanism and will have to annually report emissions from the Project and hold emission permits equivalent to its covered emissions at the end of each period. Assistance from the government will potentially be given if gas production qualifies as an Emissions Intensive Trade Exposed industry.
Queensland	Smart Energy Savings Programme	**None** Arrow will have to report energy efficiency data from the Project if it does not do so under the EEO programme.
	Queensland Gas Scheme	**Indirect** The Project is not a direct participant in the trading of Gas Electricity Certificates.

The current climate change minimisation (ClimateSmart2050) and adaptation (ClimateQ) strategies are under review after the state election in March 2012. It is also possible that the policy review could lead to changes to the Smart Energy Savings Programme and Queensland Gas Scheme with implications for the Project.

10.2 Greenhouse Gas Emissions Estimation Methodology

A GHG emissions inventory (the Inventory) was developed for the life of the Project. The Inventory includes all Project activities delineated by the physical CSG field comprising; Authority to Prospect Applications (ATPA) licences ATPA 742, ATPA 749, and Authority to Prospect licences ATP 1103, ATP 759, ATP 1025P and ATP 1031P and the areas where associated gas gathering infrastructure is required by the Project. The inventory excludes emissions associated with the gas transmission pipeline to Gladstone and the liquefied natural gas facility, which are subject to separate environmental approvals.

A detailed description of the Inventory is provided in the Greenhouse Gas Technical Report (Appendix I) of this EIS. The inventory was developed using the methods outlined in the documents described below in Section 10.2.1 to Section 10.2.4.

10.2.1 The National Greenhouse and Energy Reporting System Measurement Technical Guidelines 2011 (Technical Guidelines)

The following accounting and reporting principles detailed in the NGER System Measurement Technical Guidelines were applied:

- Transparency – emission estimates must be documented and verifiable;
- Comparability – emission estimates using a particular method and produced by a registered corporation in an industry sector must be comparable with emissions estimates produced by similar corporations in that industry sector using the same method and consistent with the emission estimates published by the Department in the National Greenhouse Accounts;
- Accuracy – having regard to the availability of reasonable resources by a registered corporation and the requirements of the guideline, uncertainties in emission estimates must be minimised and any estimates must neither be over nor under estimates of the true values at a 95% confidence level; and
- Completeness – all identifiable emission sources within the energy, industrial process and waste sectors as identified by the National Inventory Report must be accounted for.

These Technical Guidelines were devised to satisfy emissions reporting obligations under the NGER Act. Furthermore, emissions are 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.

10.2.2 The National Greenhouse and Energy Reporting (Measurement) Determination 2008 as amended – Reporting Year 2011-12

The National Greenhouse and Energy Reporting Determination 2008 (Determination) provides for the measurement of:

- GHG emissions;
- The production of energy; and
- The consumption of energy.

The Determination provides guidance for the estimation of Scope 1 and Scope 2 emissions. Where possible, methods consistent with those described in the Determination related to Scope 1 and Scope 2 emissions have been employed.

10.2.3 The World Resources Institute / World Business Council for Sustainable Development Greenhouse Gas Protocol 2004

The Greenhouse Gas Protocol (GGP) establishes an international standard for accounting and reporting of GHG emissions. The GGP has been adopted by the International Organization for Standardization, implemented through GHG initiatives (such as the Carbon Disclosure Project).

Under the protocol, three emission "Scopes" are defined for GHG accounting and reporting purposes. This terminology has been adopted in Australian GHG reporting and measurement methods and is used in this assessment. The Scopes and associated GHG emission sources from the Project are defined in Sections 10.3.

10.2.4 The Australian Government Department of Climate Change National Greenhouse Accounts Factors 2011

The Australian Governments' National Greenhouse Accounts (NGA) Factors provide emission factors for use in a variety of emission reporting frameworks. The Department of Climate Change and Energy Efficiency (DCCEE), using the Australian Greenhouse Emissions Information System, has derived default emission factors, which have been applied in this assessment.

The NGA Factors are relevant for the purposes of estimating Scope 3 emissions, since they provide emission factors for grid supplied electricity by state and emissions associated with fuel cycles.

10.3 Greenhouse Gas Emission Estimates

Project emissions quantified in the Inventory were spilt between direct (Scope 1) and indirect (Scope 2) emissions. Non-Project emissions (Scope 3) were also estimated. This section describes the emissions sources, assessment scenarios and estimated emissions.

10.3.1 Emission Sources

10.3.1.1 Sources of Project Related Emissions (Scope 1 and Scope 2)

Scope 1 or direct GHG emissions are defined as emissions that occur from Project sources owned or controlled by the reporting entity. For estimation purposes it is assumed that the majority of electrical power requirements of the Project will be met through infield power generation using extracted CSG as a fuel source; however, it should be noted that where practical and feasible Arrow will explore connection of facilities to the electricity grid for power supply. Note that the Project has significant power requirements for both compression of gas and reverse osmosis water treatment. This will significantly contribute to Scope 1 emissions.

Scope 2 emissions are indirect GHG emissions from the generation of purchased energy products by the entity. For the Project, this will include purchased electricity. These emissions physically occur at the point of electricity generation, rather than the facility that generates the electricity.

The Scope 1 and Scope 2 GHG emission sources during and associated activities likely to be released during the construction, operation and decommissioning of the Project are shown in Table 10–2.

Table 10-2 Summary of Scope 1 and 2 Emissions Associated with the Project

Project Phase	Category	Source of Greenhouse Gas Emission
Construction, operation and decommissioning	Scope 1	• Water storage and treatment
Construction	Scope 1	• Power generation from generation sets, which provide power to construction activities; • Diesel fuel consumption during construction and drilling; • Vegetation losses as a result of land clearing for the gas wellheads, nodes and gas gathering infrastructure; • Production well installation; • Gas and water gathering infrastructure installation; • Water transmission infrastructure; • Road construction to production facilities; • Dam construction associated with each integrated processing facility; • Ramp up flaring; and • Accommodation camp construction.
Operation and maintenance	Scope 1	• Gas consumption in gas fired engines for infield power generation; • Diesel consumption in light and heavy vehicles for: — Well site operation and maintenance including well workovers; — Gathering infrastructure operation and maintenance (water and gas); and — Facility operation and maintenance. • Fugitive emissions through water gathering systems (high point vents, water dams), gas gathering lines, wells and production facilities; • Flaring during upset conditions at the facilities; and • Emissions associated with self-generated electricity production to power online wellheads; and • Power supply to facilities via transmission lines.
	Scope 2	• Electricity purchased from the grid.
Decommissioning and rehabilitation	Scope 1	• Earth moving and fuel usage; • Gathering infrastructure; • Facility site; and • Activities associated with decommissioning.

10.3.1.2 Sources of non-Project Related Emissions (Scope 3)

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity.

The Scope 3 GHG emissions likely to be released during the construction, operation and decommissioning of the Project are shown in Table 10–3.

Table 10-3 Summary of Scope 3 Emissions

Project Phase	Category	Source of Greenhouse Gas Emission
Construction, Operation and Decommissioning	Scope 3	• End use (consumption of gas); • Full fuel cycle (diesel); • Full fuel cycle (electricity); • Third party infrastructure – CSG transmission to Arrow LNG plant; and • Third party infrastructure – CSG downstream processing.

Identifiable Scope 3 emissions have been reported separately to Scope 1 and Scope 2 GHG emissions, in order to clearly distinguish between Project and non-Project emissions.

10.3.2 Key Assumptions

The following assumptions were made in the estimation of Project emissions:

10.3.2.1 General

- In compiling the inventory it was assumed that Project construction will commence in 2016 and the Project lifespan will be 47 years including decommissioning;
- Three distinct phases of the Project lifecycle were assumed in the assessment:
  - Ramp-up (2017 – 2022);
  - Operation (2023 – 2056); and
  - Ramp-down (2057 – 2062).

10.3.2.2 Conservative Assumptions

- A worst case scenario for power supply was adopted in the assessment. The scenario assumed infield CSG power generation based on gas usage of 10% of the gas production plateau (520 TJ/d) plus 100% power requirements of wellheads supplied from the electricity grid. However, in practice a portion of the gas production plateau might be used to produce power for the wellheads. This means that Scope 1 emissions are likely to be overestimated in this assessment. Additionally, if the locally produced power is used to supply a portion of power requirements of the wellheads, Scope 2 emissions will be reduced.
- The power requirement of 75 kilowatts was assumed to be the same for the lifetime of the wellheads, with a wellhead motor utilisation (capacity) factor of 28%. Furthermore, the wells were

assumed to be operational for the whole year. In practice, during the life of the Project, Arrow is likely to use more efficient equipment as it becomes available with lower power requirements. It is also unlikely that each wellhead will operate for the whole year.

- No rehabilitation of areas cleared for Project purposes was assumed, as this cannot be estimated at this time. However, Arrow is committed to progressively rehabilitate cleared areas during the life of the Project. Therefore, Scope 1 emissions from land clearing are likely to be significantly lower than those estimated in this assessment given the large number of wells to be drilled during the life of the Project.
- Based on the inventory estimates for each year of the Project lifecycle, a worst case year (year that generates the highest greenhouse emissions) was selected for each phase of the Project in order to represent the most conservative estimates.
- For conservatisms in estimating the Scope 3 emissions associated with the third party infrastructure, the Scope 1 and Scope 2 emissions associated with the worst-case emissions scenario for the Arrow LNG Plant were used. This worst case scenario is defined as the use of four liquefied natural gas trains sourcing power from the national grid exclusively.

10.3.3 Project Lifecycle Emissions

Figure 10–1 shows the estimated GHG emissions released for each year of the Project lifecycle.

Figure 10-1 Project (Scope 1 and Scope 2) GHG Emissions in t CO_2-e for each Year from 2016 to 2062

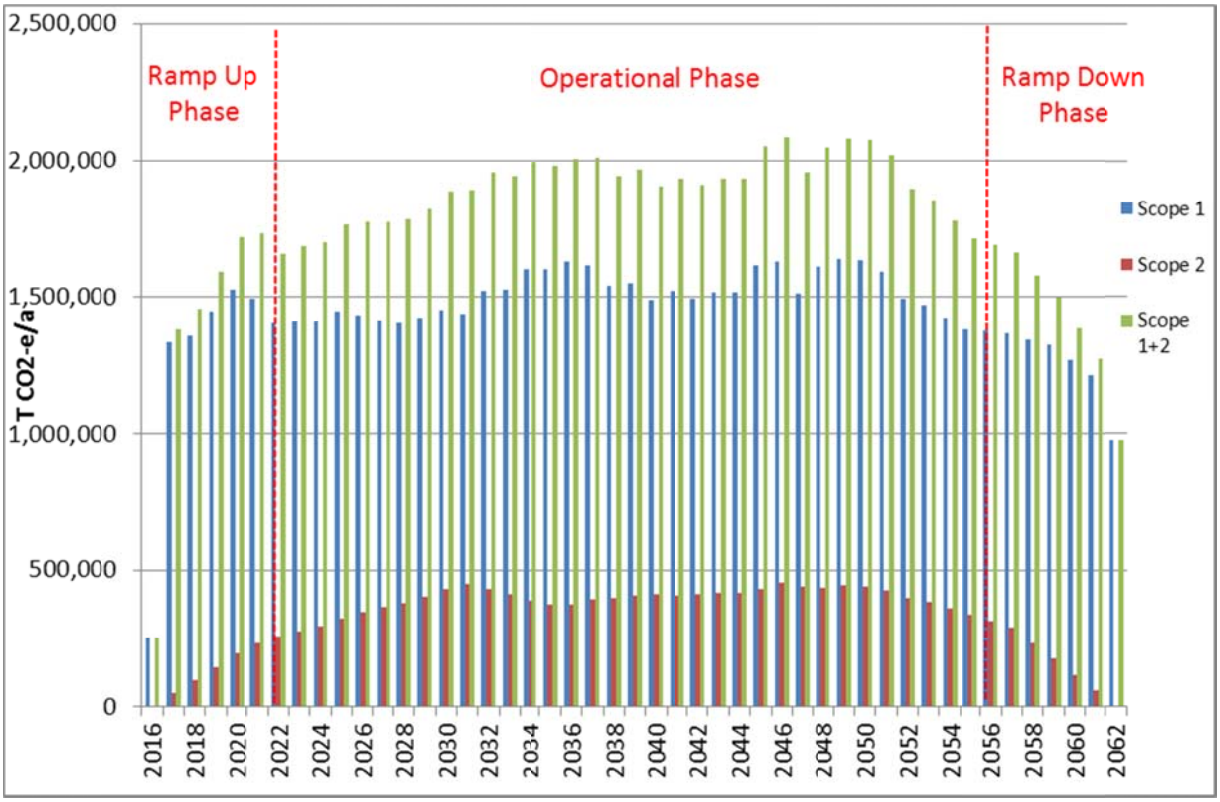

Figure 10–1 shows that the Scope 1 emissions are higher than Scope 2 emissions for the majority of the Project.

During the ramp-up phase, annual Scope 1 emissions are minimal in 2016 and then increase to 1.3 million tonnes (Mt) CO_2-e in 2017 as land is cleared for the Project and fuel combustion commences. From 2017, during the ramp-up phase, annual Scope 1 emissions vary between 1.3 Mt CO_2-e and 1.5 Mt CO_2-e as wells come on line at different rates each year. Scope 2 emissions gradually increase throughout the ramp-up period but do not exceed 0.3 Mt CO_2-e.

During the operational phase, annual Scope 1 Project emissions range from 1.4 Mt CO_2-e to 1.6 Mt CO_2-e. Scope 2 emissions are relatively consistent ranging from 0.3 Mt CO_2-e to 0.4 Mt CO_2-e per year.

During ramp-down phase, decline in GHG emissions is gradual for both Scope 1 and Scope 2 emissions. In the final year of the Project, 2062, direct (Scope 1) GHG emissions were estimated to be less than 1.0 Mt CO_2-e. An estimation of the uncertainty of the emissions estimates can be found in Section 4.8 of the Greenhouse Gas Technical Report (Appendix I) of this EIS.

10.3.4 Annual Project Emissions

Emission estimates for the worst-case year of the ramp-up, operational and ramp-down periods are presented in Table 10–4.

Table 10-4 Predicted Annual GHG Emissions for the Worst-Case Year (t-CO_2-e)

Emissions Category	Activity	Ramp-Up (2021)	Operational (2046)	Ramp-Down (2057)
Scope 1	Fuel combustion-gas power generation and drilling	980,608	981,057	974,243
	Fuel combustion-diesel used in vehicles for transport and construction energy	4,930	6,613	3,017
	Vegetation clearing	163,821	179,843	0
	Fugitive emissions – ramp-up flaring	0	0	0
	Gas transmission (in Project)	14,203	28,499	18,840
	Fugitive emissions (facility level) – production and processing	116,598	124,788	96,497
	Fugitive emissions – pilot lights and flaring due to upset conditions	215,040	307,754	277,048
Total Scope 1		**1,495,198**	**1,628,555**	**1,369,645**
Scope 2	Electricity consumption wellheads	236,028	455,220	292,202
Total Scope 2		**236,028**	**455,220**	**292,202**
Total (Scope 1 and Scope 2)		**1,731,226**	**2,083,775**	**1,661,847**

The annual Scope 1 and 2 GHG emissions associated with the ramp-up period (2016 – 2022) of the Project have been estimated to be 1.7 Mt CO_2-e for the worst-case ramp-up year 2021. For the

operational period (2023 – 2056) the annual Scope 1 and 2 emissions are estimate to be 2.1 Mt CO_2-e in 2046 and for the ramp-down period 1.7 Mt CO_2-e in 2057.

10.3.5 Annual Non-Project Emissions

Non-Project Scope 3 emissions are produced by full fuel cycles of diesel and electricity, the end-use of produced gas and the third party infrastructure required to export gas as LNG. Table 10–5 shows the estimated indirect Scope 3 emissions associated with the worst case year for the three phases of the Project.

Table 10-5 Predicted Annual Scope 3 Greenhouse Gas Emissions during Ramp-up, Operational and Ramp-Down Period Worst-Case Year 2021, 2046, 2057)

Activity	Ramp-up (2021) (t-CO_2-e/year)	Operational (2046) (t-CO_2-e/year)	Ramp-down (2057) (t-CO_2-e/year)
End use (consumption of gas)	9,067,958	9,704,963	7,504,703
Full fuel cycle (diesel)	374	501	229
Full fuel cycle (electricity)	34,868	67,248	43,166
Third party infrastructure – CSG transmission to Arrow LNG plant	5,232	5,232	5,232
Third party infrastructure – CSG downstream processing	1,349,829	1,444,659	1,117,110
Total Scope 3 Emissions	**10,458,261**	**11,222,604**	**8,670,440**

The annual Scope 3 GHG emissions associated with the ramp-up period (2016 – 2022) of the Project have been estimated to be 10.5 Mt CO_2-e for the worst-case ramp-up year 2021. For the operational period (2023 – 2056) the annual Scope 3 emissions are estimate to be 11.2 Mt CO_2-e in 2046 and for the ramp-down period 8.7 Mt CO_2-e in 2057.

10.3.6 Summary of Emissions

Table 10–6 summarises the estimated GHG emissions that will be generated during each phase and Scope 3 emissions over the life of the Project.

Table 10-6 Project Lifecycle Greenhouse Gas Emissions by Scope

Type	Scope	Ramp up Period 2016 - 2022-(t-CO_2-e)	Operational Period 2023 - 2056(t-CO_2-e)	Ramp Down Period 2057-2062 (t-CO_2-e)
Project (direct)	**1**	8,817,223	51,335,961	7,497,589
Project (indirect)	**2**	978,432	13,366,019	876,606
Total		9,795,655	64,701,980	8,374,196
Non-Project (indirect)	**3**	43,807,678	350,651,846	26,021,718

Table 10–6 shows that the non-Project, indirect GHG emissions from the transport and end use of the gas (Scope 3) are higher than both the Project direct (Scope 1) and indirect (Scope 2) emissions when added together. In the ramp-up period, Scope 3 emissions are 4.5 times higher, in the operational period 5.5 times higher and during ramp down 3.1 times higher than Project emissions (Scope 1 plus Scope 2).

10.4 Impact of Greenhouse Gas Emissions from the Project

The potential direct and indirect impacts of the Project on environmental values have been assessed using one of three impact assessment methods: significance assessment, risk assessment and compliance assessment. For the assessment of GHG, the significance assessment has been used. For further details see the Impact Assessment Method chapter (Section 6) of this EIS.

10.4.1 Potential Impacts

According to the Intergovernmental Panel on Climate Change (IPCC), global surface temperature has increased by 0.74 ± 0.18°C during the 100 years ending 2005, and that: “most of the observed increase in globally averaged temperatures since the mid-twentieth century is very likely due to the observed increase in anthropogenic GHG concentrations”. “Very likely” is defined as greater than 90% probability of occurrence.

Due to the complexity of the climate system, attributing potential climate change impact to a single source of GHG emissions is impossible. However, it can be assumed that the potential impacts associated with GHG emissions from the Project will be in proportion with its contribution to global GHG emissions. The total Scope 1 and Scope 2 emissions over the lifetime of the Project (2016-2062) were estimated to be 83 Mt CO_2-e. This equates to an annual average of approximately 1.8 Mt CO_2-e over the Project lifecycle. However, to compare the data against global, Australian and Queensland GHG emissions, the worst case year, 2046, was selected. In 2046, 2.1 Mt CO_2-e GHG emissions were predicted to be generated from the Project. Section 10.4.2 presents a comparison of the predicted Project emissions with the estimates of global (2009), Australia’s (2010), and Queensland (2010) emissions.

10.4.2 Comparison with Global, National and State Emissions

Table 10–7 shows the estimated global, national and state GHG emissions against which Project emissions have been compared.

Table 10-7 Estimates of Greenhouse Gas Emissions

Geographic Coverage	Source Coverage	Timescale	Emissions (Mt CO_2-e)
Global[1]	Consumption of fossil fuels	2009	30,086
Australia[2]	Total	2010	561.0
Australia[2]	Energy sector	2010	417.4
Queensland[2]	Total (including Land Use, Land Use Change and Forestry (LULUCF) activities)	2010	157.0
Queensland[2]	Energy sector	2010	98.0

10.4.2.1 Comparison with Global Emissions

The aggregate Scope 1 and Scope 2 emissions from the Project associated with the worst case year (2046) appear to be insignificant and represent approximately 0.007% of the global 2009 fossil fuel consumption emissions.

10.4.2.2 Comparison with Australia's Emissions

The National Greenhouse Gas Inventory 2010 (DCCEE, 2011) is the latest available national account of Australia's GHG emissions. The National Greenhouse Gas Inventory has been prepared in accordance with the Revised 1996 and 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Australia's GHG emissions across all sectors totalled 561 Mt CO_2-e in 2010, with the energy sector being the largest emitter at 417 Mt CO_2-e. Approximately 41 Mt of energy sector emissions were attributable to fugitive emissions from fuels, representing approximately 10% of the national total.

The total Project Scope 1 and Scope 2 emissions for 2046 equal approximately 0.4% of Australia's Emissions and 0.5 % of Australia's emissions from the energy sector.

10.4.3 Comparison with Queensland Emissions

In 2010, Queensland total emissions were 157 Mt CO_2-e and energy sector emissions were 97 Mt CO_2-e according to the National Greenhouse Inventory 2010.

When comparing the total Scope 1 and Scope 2 emissions for 2046 (2.1 Mt CO_2-e), it presents approximately 1.3% of the total GHG emissions for Queensland in the 2010 inventory and approximately 2.1% of the emissions from the Queensland Energy sector.

[1]Data for 2009 was the latest year of data available when the site was accessed on 16/7/2012. Australia's total emissions inventory in 2010 is therefore compared to the 2009 global inventory and should therefore be considered indicative (United Nations, 2009).
[2]DCCEE, 2011

10.4.4 Impact of the Project on Queensland Emissions

The Queensland government has proposed to reduce GHG emissions by 60% by 2050 based on 2000 levels in line with the national target (Queensland Government, 2007). This equates to a reduction of approximately 98 Mt CO_2-e.

For the peak year 2046, annual Scope 1 GHG emissions from the Project were predicted to be approximately 1.6 Mt CO_2-e. These Scope 1 emissions are equal to 1.0% of the current (2010) state inventory.

It should be noted that the Project emissions used in the analysis are conservative as they are based on the results for a year with the highest emissions and represent a worst case scenario. The Project emissions are likely to be lower than predicted in this assessment. Implementing abatement measures could also reduce direct GHG emissions from the Project. Therefore the potential impacts from the Project on climate change can be expected to be negligible.

10.4.5 Greenhouse Gas Intensities

GHG intensities are often used to benchmark projects and/or industries against other practices or facilities. GHG intensities are presented as the quantity of GHG emitted during delivery and supply of the product or service per unit of product or service provided. For the energy sector this is calculated as CO_2-e/GJ. The DCCEE provides Scope 3 emission factors for gaseous, liquid and solid fuels. These Scope 3 emission factors are in fact GHG intensities, i.e. the quantity of upstream emission per unit of energy supplied.

GHG intensities were calculated for each year of the Project lifecycle. The highest intensities were predicted for the ramp up and ramp down phases of the Project and are attributable to GHG emissions associated with vegetation losses and low gas production rates. The intensities shown in Table 10–8 were referenced from the DCCEE and compared to the Project lifecycle average emissions intensity.

Table 10-8 A Comparison of Emissions Intensity

Fuel	Emissions Intensity (kg CO_2-e /GJ)
Black coal (non-electricity use)	4.6
Gaseous Fuels (Queensland)	7.8 – 8.6
Liquid Petroleum Gas	5.0
Diesel Oil	5.3
Project lifecycle average	**11.7**

The GHG intensity averaged over the Project lifecycle of 11.7 kg CO_2-e/GJ falls outside the range expected for gaseous fuels extracted within Queensland. However, it should be noted that the DCCEE Scope 3 emission factors for gaseous, liquid and solid fuels do not include construction and commissioning emissions. The exclusion of these from the Project lifecycle emissions would reduce the Project lifecycle annual peaks and average emissions intensity.

Despite the fact that production of gaseous fuels has a greater potential for GHG emissions than other fuels, end-use of gas for electricity production results in much lower GHG emissions than other fossil fuels. For instance, each unit of electricity generated from gas produces significantly lower full-cycle GHG emissions than conventional coal-fired electricity. Full cycle emissions account for the emissions from the extraction, production and transport of the fuel, and the emissions associated with combustion.

Independent research commissioned by the Australian Energy Market Commission, as well as results achieved at Queensland's CSG-fired power stations, have shown that electricity generated from Queensland CSG is about 50 per cent cleaner than electricity produced from black coal in New South Wales and about 70 per cent cleaner than electricity produced from Victorian brown coal (EHP, 2012). Since the majority of Australia's electricity is currently produced by coal-fired power stations, use of CSG for electricity production presents a better option for Australia to reduce the overall GHG emissions.

Furthermore, by 2030 it is expected that world energy consumption will rise from 12 to 16 billion tonnes of oil equivalent with much of this growth being in China and India (Hardisty *et al*., 2012). Therefore, CSG exported as LNG has the potential to provide global GHG emissions savings.

10.5 GHG Abatement, Management and Mitigation Measures

10.5.1 Objectives

Arrow is subject to the *Clean Energy Act 2011* and as such will report Scope 1 and Scope 2 emissions and emission reduction measures, and energy consumption and production, as required by the NGER. As protocol, NGER does not require reporting of abatement or mitigation itself, however; Arrow will report abatement or mitigation of GHG as part of this report.

Queensland state climate change policies are described in Section 10.1.3. Many of these programs are similar to national programs and Arrow will participate in the relevant programs and report energy use and GHG 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 gas producer that will generate nearly all of its own electricity from gas, Arrow will be assisting Queensland in reaching this objective.

10.5.2 Direct Emissions Reduction

Process features that could minimise emissions from the Project are described in this section. It should be noted that the decision to implement emission reduction technologies will consider economic viability and other aspects such as community concerns.

Arrow's GHG management strategy involves two approaches to reducing the company's GHG emissions. The first approach seeks to identify the Project's major GHG emitting activities. This approach focuses on identifying measures to reduce GHG emissions from the various emissions

sources in Arrow's areas of operation. The second approach involves mitigation measures that Arrow can implement on a company-wide basis or support in the communities in which it operates.

10.5.3 Project Activities

Arrow is committed to applying a hierarchy of controls in order to minimise GHG emissions and, equipment that results in GHG emissions will be avoided, substituted out or procured and/or operated to minimise the impact.

The criteria for selecting equipment will include:

- Highest energy efficiency and fuel efficiency;
- Lowest generation of waste; and
- Lowest possible GHG emissions.

The impact of the Project's activities will also be considered during site selection. Arrow is developing standard operating procedures to avoid or eliminate, i.e. "design out" potential impacts and to minimise to the greatest extent practicable any impacts that cannot be eliminated through design. This will include measures relevant to minimising the emissions of GHG.

10.5.4 Mitigation Measures

Arrow has committed to the mitigation measures listed in Table 10–9 to minimise GHG impacts. These measures are included in the Project EM Plan.

Table 10-9 Mitigation Commitments

Mitigation Commitments	
Construction activities (production well, gathering line installation, production facilities)	• Land cleared for construction purposes will be kept to the minimum necessary, especially during the drier months of the year [B018].The cleared areas and stockpiles will be progressively rehabilitated through revegetation and/or mulching [B021]. • Select gaskets, seals and vehicle exhaust systems that are suitable for the task [B007]. • Ensure all engines, machinery equipment and pollution control mechanisms are operated and maintained in accordance with manufacturer's recommendations [B013]. • Prevent venting and flaring of gas as far as practicable and where safe to do so, in accordance with the P&G Act [B022]. • Clear areas progressively and implement rehabilitation as soon as practicable following construction and decommissioning activities [B033].
Operational Phase	• Select equipment with consideration for low emissions to air (NOx, SOx), high energy efficiency and fuel efficiency [B004].

Mitigation Commitments	
	• Implementation of a preventative maintenance program to ensure gas engines are operating efficiently to minimise emissions of incomplete combustion products – CO and hydrocarbons (primarily methane, with minor VOC emissions) [B024]. • Optimisation of gas driven generator operations to minimise time periods of operation at low efficiency levels that may result in excess greenhouse gas emissions and higher than normal levels of NOx emissions [B029]. • Implementation of a quantifiable monitoring and measuring program [B030]. • Selection of gaskets, seals and vehicle exhaust systems that are suitable for the task [B007]. • Ensure all engines, machinery equipment and pollution control mechanisms are operated and maintained in accordance with manufacturer's recommendations [B013]. • Equipment that deteriorates so that it no longer meets acceptable standards is to be shut down and intervention maintenance is to be conducted to return emissions to acceptable levels. Where practical, the equipment will not be brought back into service until normal operational emissions are achieved. • Prevent venting and flaring of gas as far as practicable and where safe to do so, in accordance with the P&G Act [B022].

10.6 Energy Efficiency and Offset Opportunities

Arrow will consider GHG emissions in the planning and preparation phase of the Project to reduce and mitigate their release. Measures relevant to energy efficiency are as follows:

- For the selection of all new equipment, energy efficiency and emissions to air will be considered prior to procurement;
- Potential sources of GHG emissions and management strategies to reduce emissions must be communicated to relevant personnel;
- All equipment is to be maintained as per manufacturer's standard, or other best practice guidelines, to ensure that all operations are conducted at maximum efficiency; and
- Equipment that becomes significantly less efficient over the course of its operation is to be shut down and intervention maintenance is to be conducted to return emissions to acceptable levels. Where practical, it will not be bought back in service until normal operational emission levels are achieved.

Arrow is committed to exploring options for offsetting GHG emissions from the Project. GHG emissions produced by the Project could be offset by investing in third party projects, such as forestry projects, that reduce emissions below a demonstrated baseline [B317].

10.7 Emissions Trading

Arrow will be able to trade emission permits to meet their permitting liabilities under the CPM if their internal costs of abatement are higher than the price of permits, and to directly reduce their emissions if their internal costs of abatement are lower than the price of permits.

10.8 Summary

In accordance with the Greenhouse Gas Protocol, a GHG emissions inventory was developed to include Project activities within the CSG fields and the areas where associated gas gathering infrastructure is required. The inventory excludes emissions associated with the gas transmission pipeline to Gladstone and the LNG facility which are subject to separate assessments. A conservative approach was adopted in the development of the inventory.

The potential direct and indirect GHG emissions from the Project were estimated for each year of the Project life. GHG emissions (Scope 1 and Scope 2) were identified for the ramp-up, operational and ramp-down phases of the Project, for which distinct emission profiles were demonstrated. Non-Project related emissions (Scope 3), which occur as a consequence of the production of the gas were also estimated.

Estimated Project emissions peak during operational year 2046. Therefore, 2046 was selected as the worst-case operational year on which annual emissions are reported. Estimated Project emissions for 2046 were shown to be equivalent to 0.4% of 2010 Australian total emissions and 0.5% of 2010 Australian emissions from the energy sector. The Project emissions equal approximately 0.007% of global 2009 fossil fuel consumption emissions.

A benchmarking exercise was undertaken to compare the quantity of upstream emissions per unit of energy produced by the Project (emissions intensity) to a range of fuels. The emissions intensity of the Project was shown to be higher than those for gaseous, liquid and solid fuels. Despite the fact that production of CSG has a greater potential for GHG emissions than other fuels, end-use of gas for electricity production results in much lower GHG emissions than other fossil fuels. The Queensland Government Gas Scheme objectives include increasing the share of electricity produced in gas-fired generators to 18% by 2020. As a major gas producer that will generate nearly all of its own electricity from gas, Arrow will be assisting Queensland in reaching this objective.

Arrow is committed to applying a hierarchy of controls in order to minimise and control GHG emissions, which will be described in the Project EM Plan. These controls will be applied during construction, operation and decommissioning of the Project. Furthermore, Arrow will consider GHG emissions in the planning and preparation phase of the Project to reduce and mitigate impacts of GHG emissions.

Arrow will be able to trade emission permits to meet their permitting liabilities under the carbon price mechanism if their internal costs of abatement are higher than the price of permits, and to directly reduce their emissions if their internal costs of abatement are lower than the price of permits.